REFRAMING EARLY MATH LEARNING

A FrameWorks MessageMemo

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Introduction

Early math advocates know that the earlier children begin to develop math skills, the more likely they are to perform well academically when they begin formal schooling. Advocates also understand the advantages early math skills offer children extend far beyond kindergarten. Early math learning opportunities can act as a leveling agent between higher- and lower-income communities and between white children and children of color, counterbalancing other inequity-driven outcomes and reducing the effects of socioeconomic and racial disparities in academic and later life outcomes.

As such, increasing access to quality early math learning opportunities for all children, especially those most lacking those opportunities, should be an obvious policy choice. But the path to policy action leads through the hearts and minds of the public, and the public does not fully appreciate the importance of early math learning and the need for our society to invest in making it a reality for all children. That's because engrained cultural perspectives about this issue block public understanding of and support for the policies needed to address it.

Changing the way the public thinks about early math will require changing the ways advocates talk about early math. In recognition of this point, the Heising-Simons Foundation sponsored a multi-method, multidisciplinary investigation of effective framing strategies for early math advocacy. Researchers first studied the shared cultural assumptions the US public uses to reason about early math learning and then developed and tested framing strategies designed to negotiate those assumptions in ways that effectively moved people's knowledge of and support for early math learning issues.

This report is the culmination of that investigation. The research presented here first summarizes FrameWorks' findings about the patterns evident in everyday Americans' views on early math learning and then provides recommendations for responding to the communications challenges resulting from those widely held perceptions and beliefs. The result is a set of experimentally tested framing strategies for advancing the conversation on early math learning in more productive directions.

The MessageMemo unfolds in four parts:

- *What Does It Take to Reframe Early Math?* explains the theory and methodology behind the research recommendations.
- *Anticipating Public Thinking* outlines the differences between expert and public perspectives on early math learning and pinpoints the implications

of the public's overarching assumptions for advancing an informed public conversation about investing in early math learning.

- *Redirections* outlines a series of thoroughly tested communications tools and techniques for reframing early math learning and provides examples of how to use them in advocacy messages.
- *Moving Forward* offers concluding thoughts and a call to action.

What Does it Take to Reframe Early Math?

- **What does the research on early math say?** To distill expert consensus on early math, FrameWorks researchers conducted interviews from May to June 2017 with 11 experts on early math learning. These data were supplemented by a review of relevant academic and advocacy literature and refined during a feedback session with stakeholders in the field.
- **How do members of the public think?** FrameWorks researchers conducted in-depth cognitive interviews from June to July 2017 with 10 members of the public in Atlanta, Georgia, and Chicago, Illinois. These were supplemented by 20 interviews conducted for FrameWorks' research on public thinking about informal STEM (science, technology, engineering, and math) learning. Researchers analyzed the transcripts of all 30 interviews to identify implicit, shared understandings and assumptions that structure thinking about early math learning among members of the public.
- **Which frames shift thinking?** To identify effective ways of framing early math, FrameWorks researchers developed and tested a set of potential messages. Three primary methods were used to explore and refine possible reframes:
  - On-the-street interviews involving rapid, face-to-face testing of frames and framing strategies for their ability to prompt productive discussions about early math. A total of 54 interviews were conducted in April 2018.
  - Two experimental surveys, involving a nationally representative total sample of 6,311 respondents, that tested the effectiveness of a variety of frames on public understanding, attitudes, and support for policies.

- One experimental survey completed by 1,249 respondents testing how different terminology (e.g., "early math" vs. "early childhood math") affected understanding of early math learning.[1]
- A series of qualitative, group-based tests with a total of 54 people to explore how the frames that emerged from the research described above worked in conversational settings.

All told, more than 7,709 people from across the United States were included in this research. See the Appendix for a more detailed discussion of research methods.

Anticipating Public Thinking

Members of the public share deeply rooted cultural assumptions and habits of thought that shape their understanding of early math learning: what it is, why it matters, how it works, and who is responsible for ensuring children have early math learning opportunities. A systematic assessment of where and how public understanding of early math learning differs from that of early math advocates is the first step to developing framing recommendations that can help to increase public support for policies and programs to improve early math access and outcomes for children. The summary below highlights the most important gaps in thinking between early math advocates and the public, as well as their implications for a reframing strategy to communicate effectively about early math learning.

Note, however, that not all of the public's patterns of thinking about early math are unproductive. Several widely shared assumptions surfaced in the cultural models research that suggested promising avenues for further frame development, and those are likewise summarized below.

FRAMING CHALLENGES

What is early math learning?

- **Purposeful, relevant, and fun for all children vs. passive, irrelevant, and only fun for some.** Early math advocates stress that young children both *want* and *need* to do math before kindergarten. In contrast, the public often assumes that math is neither particularly interesting nor relevant to children during early childhood—in part because of a perception that early math is limited to basic numeracy, rather than critical to the development of higher-level skills, such as problem-solving, critical thinking, and making relational comparisons among numbers, objects, and spaces. This perspective weakens the salience of early math among the public and leads people to assume that math-related play is a way of motivating children to do something they otherwise would not want to do, rather than a way of engaging them in something in which they are naturally interested.
- **Skills that are essential to develop as early as possible vs. nice but not necessary pre-kindergarten.** Advocates name early math learning as one of the strongest predictors of later success in school and life, and they stress

the long-term, hard-to-repair consequences of weak math skills in early childhood. Though members of the public agree that math can and ideally should be learned before kids start school, they don't see it as essential to children's later academic success and are less aware of early math's long-term consequences—a knowledge gap that further weakens their support for prioritizing early math learning access.

How do early math skills develop?

- **In conjunction with other skills vs. at odds with and distinct from other skills.** Advocates understand both that math is connected to other skills such as literacy and socio-emotional development and that it is essential to and highly predictive of learning in most other areas. The public, however, compartmentalizes skills, seeing math learning as distinct from, and even at odds with, other types of learning they associate with creativity and flexibility. When reasoning from this perspective, people have difficulty sharing advocates' enthusiasm for early math's role in young children's development.
- **Through essential "math talk" vs. invisible processes.** Advocates stress that hearing and using math-related language from a very young age is critical to math learning. Though members of the public see the value in math-related activities like counting games during playtime and in everyday life, the true importance of math talk is simply off people's radar. As a result, early math advocates need a framing strategy that can help people understand how simply hearing and talking about math regularly from birth on is vital to children's math skills development.
- **Dependent on structural factors and societal values vs. dependent on individual families' values and resources.** Early math advocates understand that environmental or structural factors, such as differences in funding for early childhood education and the resource and time constraints of parents as a result of their socioeconomic conditions, influence both resources for and access to early math opportunities. While members of the public likewise know that resources affect outcomes, they tend to blame families' cultural differences for differences in resource availability and children's math outcomes rather than broader social forces. When people reason that families are the cause of poor math outcomes, they fail to see how policies or other collective action can help, limiting their support for the kinds of changes to early math access that advocates know are necessary.

Why does early math learning matter?

- **Long-term and collective vs. short-term and individual-level benefits.** Early math advocates understand early math learning outcomes as an equity issue with long-term consequences: There is no substitute for early math learning. Children who do not have opportunities to learn math skills early lack the foundation they need for later academic success, and catching up to their peers is more difficult as time goes on, leading to larger and persistent disparities. Advocates argue that eliminating those disparities would benefit us collectively, for example, by reducing socioeconomic disparities, improving society's ability to advance, and increasing individual citizens' ability to reason critically about policy and other civic issues.

The public, on the other hand, sees few if any severe consequences when children lack early math learning, in part because they believe children can make up for it when they enter formal schooling. As they do with math education more generally, members of the public recognize strong math learning has financial or career implications for individual children but tend not to consider its impacts on society at large. As a result, they do not share early math advocates' sense of urgency about improving early math access for all children. Communicators need a strategy to raise the stakes for the public.

What can we do to improve early math learning access and outcomes?

- **Society is responsible vs. parents and families are responsible.** Proponents of early math learning argue that it is a collective issue that all of society should be invested in and feel responsibility for. Advocates identify several types of solutions that can improve early math learning, including better training for early childhood educators, the integration of more math into formal early childhood education curricula, and equitable funding for early childhood education across all communities.

  In contrast, the public attributes responsibility for early math learning almost exclusively to parents, overlooking the importance of systems-level solutions. When parents are the solution, the public struggles to see why collective action is necessary or appropriate. Communicators need a framing strategy that expands the number and range of solutions the public is willing to entertain for improving early math outcomes.

FRAMING OPPORTUNITIES

In conversations with FrameWorks researchers, members of the public also spoke and thought about early math in productive ways that communicators should leverage through their framing choices:

- **Social progress:** Participants in FrameWorks' cultural models research expressed their belief in the value of advancing society and some identified strong math skills as an important factor in our continuing ability as a nation to contribute to social and technological advancements. It's important to note that this way of thinking about math was less frequently articulated by respondents, but its existence suggests that communications that intentionally foreground the "strong math skills = social progress" model can shore up people's support for investing in early math.

- **Hands-on learning:** Participants identified hands-on learning as a valuable and necessary component of skills-building activities for young children, a perception that can foster people's ability to understand early math as an interactive, inquiry-based activity.
- **Numerical necessity:** Participants understood that math skills are necessary to function in everyday life—a potentially productive perspective. This view, however, also feeds the belief that math involves only numbers and numeracy, and that most people need only basic math skills. Other, and more complex or higher-order skills are necessary for or important only to those who are "naturally" gifted in math or have a special interest in it. Thus, for this cultural model to be productive, it needs to be contextualized within a deeper understanding of the many ways all of us use and need math in our lives.
- **Everyone learns differently:** Participants discussed different "learning styles" and shared a belief that different types of learning activities are more or less useful for different people. This model has the potential to be either productive or counterproductive. On one hand, this perception can encourage an understanding that early math learning opportunities should be flexible (i.e., multiple and varied). On the other, it can discourage people's understanding that there may be best practices or standardized approaches to early math that can and should be adopted on a large scale. In appealing to this way of thinking, communicators should take care not to reinforce unproductive assumptions about standardized curricula.
- **Boundless curiosity:** Many participants voiced a belief that children are inherently curious and ready to learn, a perception that, if activated, may help people get past the unproductive belief that math is boring or only fun for some children.
- **Second nature:** Participants shared the assumption that learning any skill, including math skills, from an early age gives children an advantage because developing skills early leads those skills to become ingrained in an individual—intuitive or like an instinctual habit. Reasoning from this belief helps people to appreciate the importance of early math to children's later math-related abilities.

These promising models of reasoning guided the development of the candidate strategies tested in the prescriptive phase of the research.

Redirections

Strategic framing is about making intentional communications choices designed to highlight aspects of an issue that can help public audiences see why the issue matters, how it works (or isn't working), and what can be done—and by whom—to shape outcomes, improve conditions, or implement solutions. The recommendations below offer early math advocates a set of strategies and tools they can use to engage the public more deeply and effectively in conversations about early math learning and why it's crucial that all children have access to early math learning opportunities from birth.

To arrive at these framing recommendations, FrameWorks researchers designed a series of qualitative studies and quantitative experiments that tested the effectiveness of different frame elements in communicating about early math. The frame elements tested included explanatory metaphors, values, examples, and messengers.

Qualitative studies tested the ways that certain frames related to early math affect perception and, potentially, behavior. By analyzing how participants responded to and adopted into their own speech the language of particular messages, researchers were able to differentiate between more and less effective frames and to identify the specific features of messages that were most productive.

In three survey experiments, FrameWorks researchers quantitatively tested the effects of frames, two of which were completed by large, nationally representative samples of US residents. In each experiment, participants were randomly assigned to a treatment group or a control. Those assigned to treatment groups received a message about early math learning framed in a particular way, while those assigned to the control group either did not receive a message or received an unframed description of a policy proposal. After reading an assigned message (or, in the case of the null control, no message), participants were asked a set of randomly ordered questions probing their knowledge, attitudes, and policy preferences about issues related to early math. By comparing treatment and control groups, researchers were able to determine whether a frame "works"—i.e., whether it led to desirable shifts on these outcomes. The outcomes, along with sample questions, are listed in Table 1 below.

Table 1: Desired Communications Outcomes: Improved Knowledge, Attitudes, and Policy Preferences

Scales	Sample questions
Support for Principle of Early Math Learning	How necessary do you think it is that all children begin learning math before they start kindergarten? (*Not necessary at all*; *Slightly necessary*; *Moderately necessary*; *Very necessary*; *Extremely necessary*)
Causal Attributions	Which of the following do you think best explains why some children excel in math and others struggle? (*Some children begin learning math earlier in life than others*; *Some children are just naturally better at math than others*)
Salience	In your opinion, how concerned should the country as a whole be about whether children begin learning math before they start kindergarten? (*Not at all concerned*; *Slightly concerned*; *Moderately concerned*; *Very concerned*; *Extremely concerned*)
Understanding of Consequences	When children don't begin learning math before they start kindergarten, how much of an effect do you think it has on their success in school later on? (*No effect at all*; *A very small effect*; *A small effect*; *A moderate effect*; *A large effect*; *An extremely large effect*)
Understanding of Process of Early Math Learning	Which of the following do you think is most important to focus on in helping children learn math from birth until kindergarten? (*The meaning behind numbers and shapes, e.g., why 3 is different from 5, and how a triangle is different from a rectangle*; *How to count off numbers in order and the names of different shapes*; *I don't think children need to learn math before they start kindergarten*)
Support for Policies to Advance Early Learning	How willing or unwilling would you be to pay more in taxes for programs that help children learn math from birth until kindergarten? (*Not at all willing*; *Slightly willing*; *Moderately willing*; *Very willing*; *Extremely willing*)
Attitudes about Racial/Ethnic Disparities	In your opinion, how concerned should the country as a whole be about whether Black and Latino children start kindergarten with a stronger or weaker understanding of math than white children? (*Not at all concerned*; *Slightly concerned*; *Moderately concerned*; *Very concerned*; *Extremely concerned*)
Support for Policies to Reduce Racial/Ethnic Disparities	When it comes to helping Black and Latino children learn math from birth until kindergarten, do you think government should be doing more, doing less, or doing about the same as it is now? (*Doing much less*; *Doing less*; *Doing slightly less*; *Doing about the same as it is now*; *Doing slightly more*; *Doing more*; *Doing much more*)
Attitudes about Socioeconomic Disparities	In your opinion, how concerned should the country as a whole be about whether children from lower-income families start kindergarten with a stronger or weaker understanding of math than children from higher-income families? (*Not at all concerned*; *Slightly concerned*; *Moderately concerned*; *Very concerned*; *Extremely concerned*)
Support for Policies to Reduce Socioeconomic Disparities	Do you think government funding for programs that help children from lower-income families learn math from birth until kindergarten should be increased, decreased, or kept about the same? (*Significantly decreased*; *Decreased*; *Slightly decreased*; *Kept about the same*; *Slightly increased*; *Increased*; *Significantly increased*)

In the analysis, researchers controlled for a range of demographic variables (including age, race, class, and gender of participants) by conducting a multiple regression analysis to assure that the effects observed were driven by the frames rather than demographic variations in the sample. A breakdown of the sample by demographics is included in the Appendix.

The resulting recommended framing strategies, detailed below, are grouped into three overarching framing goals that together can shift the story communicators tell about early math learning:

- Strategically situate early math's role in overall learning and society
- Deepen the public's understanding of what early math learning is and how it happens
- Put equity on the public's radar by connecting early math learning to broader social disparities.

STRATEGICALLY SITUATE EARLY MATH'S ROLE IN LEARNING AND SOCIETY.

The public in general tends not to see all the connections that exist between one issue and another. That's often because the most prevalent stories about social issues neglect to make these connections visible. For example, education advocates might readily see how poor housing conditions in some communities contribute to poor education outcomes for the children who live there, but the link is much less apparent to members of the public without a background in the housing, health, or education sectors.

Early math learning is no exception. Members of the public are less familiar with the role that early math learning plays in children's later developmental and academic outcomes, which in turn play a role in our communities' future social and economic outcomes. The first step to building support for early math learning opportunities for all children is to reveal more clearly and intentionally the implications of early math learning for us all. FrameWorks tested several strategies to accomplish this goal and found the following strategies to be effective.

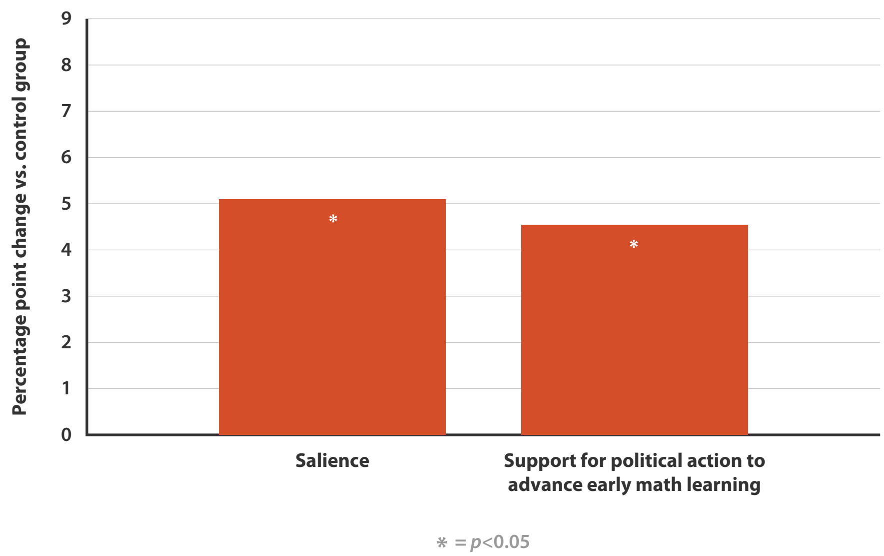
Recommendation 1: Use an early childhood development frame to showcase the many effects of early math.

Situating early math learning within the broader framework of early childhood development has meaningful implications for early math advocates. It effectively raises the salience of early math learning for public audiences and makes it easier for people to reason about the individual and social implications of having—or not having—early access to math learning opportunities.

In peer discourse sessions (qualitative testing) conducted by FrameWorks researchers with members of the public, connecting early math to young children's cognitive, social, emotional, and general brain development increased the importance people attached to early math and broadened the range of outcomes they were able to identify for individuals as well as for society as a whole. It also helped expands people's understanding of math as a form of critical thinking and problem-solving, and not merely basic numeracy skills such as counting and multiplication tables. Participants introduced to the developmental frame were better able to explain how children entering kindergarten with math skills were more likely to experience academic success later in their education.

Finally, in a survey experiment, researchers tested the effects of framing early math as a critical component of early childhood development. Figure 1 below shows that this kind of message increased both the salience of early math learning to participants and their support for taking political action to advance early math learning.

Figure 1: Effects of Early Childhood Development Frame on Salience and Political Support for Early Math Learning



Placing early math within the "big picture" of children's overall early development is effective because it helps people consider math in the context of other kinds of skills development that could apply to many aspects of life. The developmental frame helps communicators argue successfully that, over the long term, children with exposure to early math learning experience the benefits of early math throughout their lives and, in turn, pass those benefits on to society as a whole. In other words, the early childhood development frame helps people to see the collective benefits of early math learning.

How to use this recommendation:

Communicators can use these guidelines to apply the **early childhood development issue frame:**

- Spell out the sets of skills that develop in early childhood—cognitive, social, and emotional—to reinforce people's association of early math with these more general skills and abilities.
- Use the developmental frame to position early math as a long-term investment in children and in society.

- Be sure to include the developmental frame in messages with a call to action: it works especially well in mobilizing support for policy change.

Embedding early math learning in the larger issue frame of early childhood development can be as simple as a short explanation like this one:

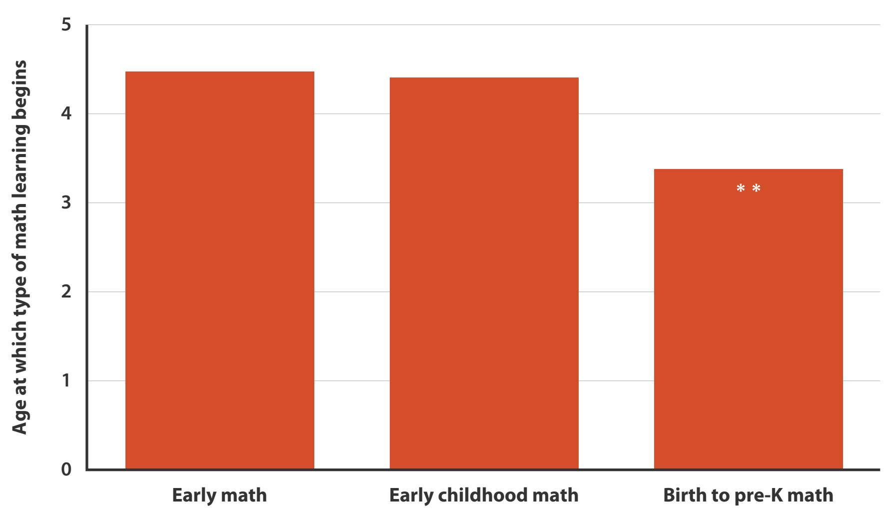
> *Learning math early—from infancy onwards—helps to develop children's cognitive, social, and emotional skills. Over a lifetime, those positive effects compound, and we all benefit from investing in children's early math learning.*

Recommendation 2: Be explicit that "early" means "from birth."

It isn't enough to stress the importance of early math learning. Communicators should take care to define what they mean by "early." Name the age group explicitly or say "from birth on," in order to cement audiences' understanding that early means *early*—really early. By specifying which ages are meant in conversations with the public about early math learners, communicators can improve audiences' capacity for associating math learning with very young children.

Through an experimental survey, FrameWorks researchers found that explicitly defining "early math" as "birth to pre-K math" generally helped to lower the average age at which participants thought that early math learning begins. Changing people's perceptions about when children can and should begin to learn math—and what exactly "early" means—can be accomplished by intentionally and consistently defining the age range covered in specific, forward-oriented terms, rather than in vaguer, backwards-oriented terms (e.g., "early" means "from birth to pre-K" as opposed to "before kindergarten").

Figure 2: Effects of Specifying "Early" on Perceptions of When Early Math Learning Begins



** = p<0.01 relative to all other conditions

Redirections

How to use this recommendation:

Communicators should cultivate a practice of **defining the early math age group** as "birth through age 5," or variations thereof:

- "Early math learning begins at birth."
- "Early math learning is for children aged 0 to 5."
- "Children should be introduced to math from birth and have opportunities to develop their math skills throughout their first five years."
- "Adults should ensure children have plenty of exposure to math from birth through age 5, in order to get them ready for kindergarten."
- "Math skills begin to develop from infancy onward, long before children start school."

Repetition is key in framing. The more frequently communicators specify the age group included in early math learning, the more effectively they can shift public thinking about the age at which children should be introduced to mathematical concepts.

Recommendation 3: Amplify concern about early math by emphasizing the existence of widespread bipartisan support for early math learning opportunities.

The early childhood education field has sometimes adopted a framing strategy of highlighting bipartisan support for investments in early childhood education. FrameWorks researchers hypothesized that this practice might work for messages about early math learning and found that communicating about the presence of widespread bipartisan support for early math learning is indeed an effective strategy.

The results of an experimental survey reveal that this strategy raises the salience of early math learning, i.e., the importance and concern that people attach to it. In the survey, a group of respondents received a message about the public's bipartisan support for strengthening early math learning in early childhood development. Figure 3 shows that compared to those in the control group, people who received the bipartisan support message reported a stronger belief in the importance of children learning math before kindergarten. In other words, emphasizing bipartisan support for early math makes audiences more likely to find early math learning both personally and collectively concerning and to support political action on early math policies.

Figure 3: Effects of Source Cues on Attitudes, Understanding, and Political Support for Early Math Learning

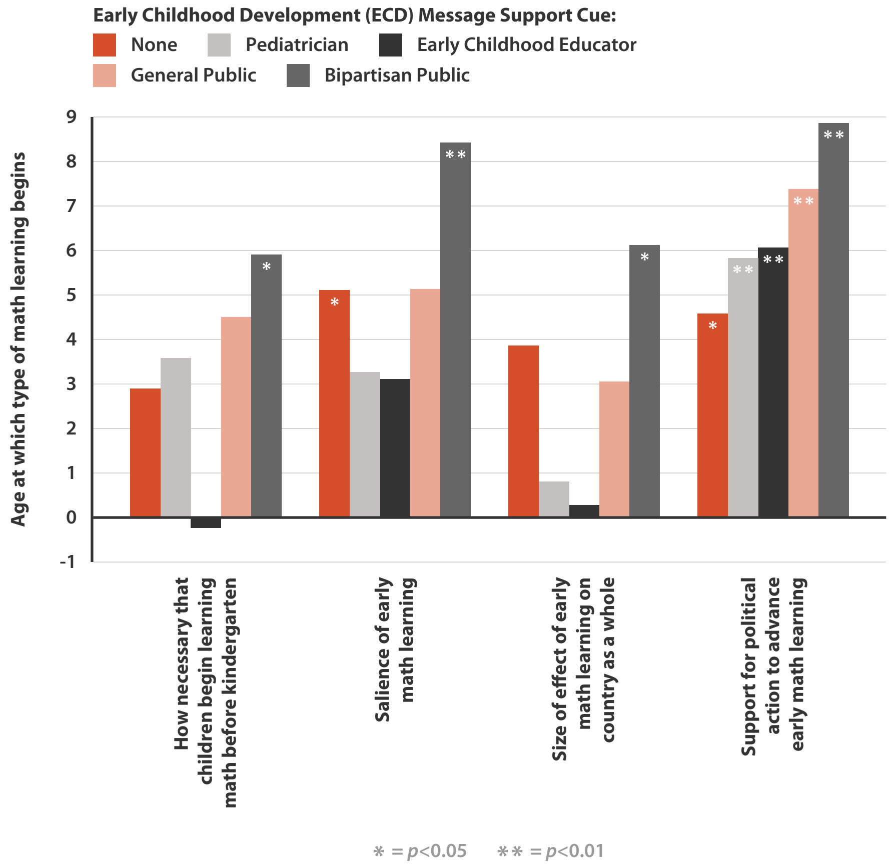


Figure 3 shows that a bipartisan support frame also leads people to attribute greater significance to the effects of children's early math outcomes on the country as a whole, an indicator that reinforcing this frame activates the productive association of math skills with social progress.

One reason this strategy works may be the power of "social norming," a concept that social scientists use to explain why populations or communities may adopt a new belief or practice in large numbers. Communicating about the popularity or acceptability of an idea, practice, or behavior, especially across perceived, sharp social divisions (e.g., partisanship) can heighten people's sense of its value and social acceptability. In turn, they are more likely to accept and adopt it as well, thus swelling the ranks of supporters and, ultimately, creating a new social norm.

How to use this recommendation:

Communicators may take inspiration from the broader early childhood education field, which has used a bipartisan support framing strategy for some time. The excerpt below from a call to action recently published online, for example, uses bipartisan poll results to support its appeal for investment in birth-through-five education:

> *According to [a] 2018 national poll, conducted in the days immediately following the 2018 midterm elections, Democratic and Republican voters are less interested in seeing partisans stand their ground than they are seeing them stand up for young children and their families. Public support for investing in quality early childhood education from birth through age 5 remains strong.*[2]

A more general citation of bipartisan support for early math might look like this:

> *Investing in early math learning has broad bipartisan support among Americans. Polls show that people across the political spectrum recognize the importance of giving children opportunities early in life to develop math skills. That's because, whatever our differences, early math education is about counting on our children's future, not counting votes.*

DEEPEN THE PUBLIC'S UNDERSTANDING OF HOW EARLY MATH SKILLS DEVELOP AND HOW ADULTS CAN HELP CHILDREN LEARN MATH BEFORE THEY START SCHOOL.

Early math learning is an abstract concept for most people, so it's important for communicators to explain both *why* it's important for children to learn math starting from birth, and *how* they learn math. Explanatory metaphors can help with this by comparing early math learning to more familiar, concrete concepts, in order to help people use something they already know to process and reason about a new idea.

Through both qualitative and quantitative research, FrameWorks found that two metaphors, *Language of Math* and *Math Lens*, can improve people's understanding of what "early math" means, why it's important for young children to learn math, and how to support children's early math learning. In testing, the two metaphors showed similarly robust frame effects, but each accomplishes a particular communications task:

- The *Language of Math* metaphor works especially well to explain both why early math learning is so important and how learning math from birth sets up children's later math success.
- The *Math Lens* metaphor is a powerful tool for illustrating how adults can support and participate in children's early math learning.

Recommendation 4: Talk about *Math as a Language* to boost understanding of how math learning works and why it's important for children to learn math early.

The *Language of Math* metaphor improves people's understanding both of the importance of children's early exposure to mathematical concepts and of how children learn math. Here's the idea:

> *Math is a language: It's a form of communication with its own words, symbols, and grammar that people use to express their thoughts and ideas to one another. Just like language, all people are born with the capacity to learn math. But, as with any language, the later that people begin hearing, seeing, and using the language of math, the more challenging it is to become completely fluent. That's why it's so important that kids begin learning math from birth.*

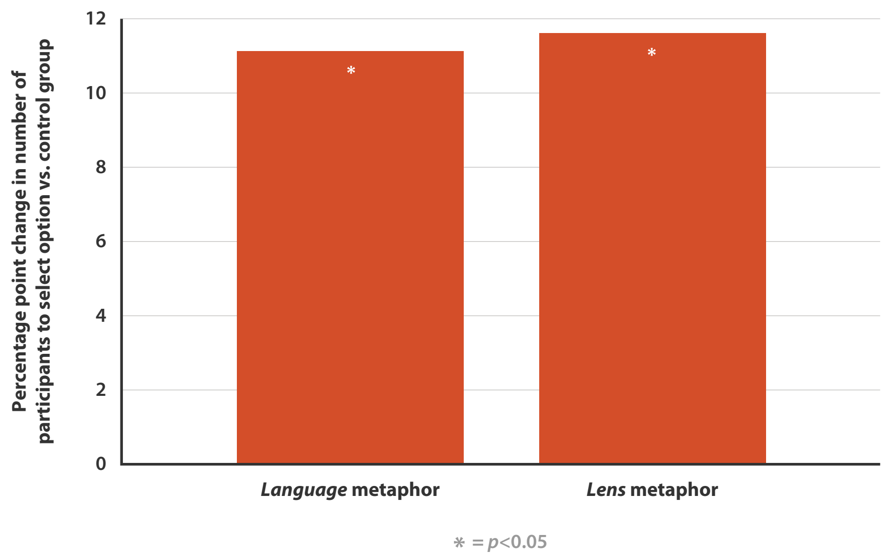
The *Language of Math* metaphor is a concrete way to explain how very young children learn math. It works by applying people's common knowledge about young children's language acquisition to math learning. In prior research, FrameWorks researchers found that a metaphor comparing informal STEM (science, technology, engineering, and math) learning to becoming fluent in another language improved people's knowledge and attitudes about informal STEM.[3] They hypothesized that a language metaphor might be similarly effective in talking about early math learning.

Both qualitative and quantitative research findings supported the hypothesis. In peer discourse sessions, the metaphor of language was already a familiar way of talking about math to many participants and proved to be "sticky" or memorable, passing easily from participant to participant. Several useful associations also emerged in the sessions. Participants readily understood language acquisition as a skill that children can and should begin to develop from birth—one that becomes more natural to users the earlier they learn it. Comparing learning math to how children first learn language helped participants to imagine or explain how math talk, or communicating in math-related language, could facilitate young children's understanding of math in the same way that speaking a language to children helps them to acquire it themselves.

The metaphor helps in other ways, too. During discussions, reasoning about math as a language effectively boosted people's understanding of the importance of early math learning. The comparison of math to a language gave participants a way to explain the serious consequences of delaying children's exposure to math: As with other languages, the longer children must wait to learn math, the more difficult it becomes to learn. Consequently, reasoning with the *Language* metaphor increased participants' support for enabling access to math learning opportunities for all children prior to beginning kindergarten.

An experimental survey confirmed these findings; in that experiment, respondents who received the *Language* metaphor treatment were more likely to adjust the earliest age at which they believed children should begin learning math downward—by a full year, on average. Moreover, as Figure 4 illustrates, mapping math acquisition onto the idea of learning a language made participants more likely to explain disparate outcomes in math learning as a function of early exposure rather than of natural aptitude, a big framing "win" given entrenched cultural biases about who is or is not good at math. The *Lens* metaphor (discussed below) yielded similar results.

Figure 4: Effects of Metaphors on Explanations for Math Learning Outcomes



In addition, the survey experiment found that respondents who encountered the *Language* metaphor assigned greater importance to informal learning methods such as playing math-related games, using math talk, and making math part of everyday activities. They were also more likely to believe that explaining answers is a better way to learn math before kindergarten than memorizing and quickly recalling correct answers. Overall, respondents' knowledge about how children learn math at a young age improved.

In sum, the *Language* metaphor is effective because it steers people away from unproductive patterns of thinking about math as a boring, rote type of learning and towards more productive understandings of math. More specifically, it positions math as a subject ripe for hands-on, experiential learning, and a critical part of young children's overall development. Finally, the metaphor supports the idea that math can become "second nature," but only if introduced early enough in children's lives.

How to use the recommendation:

Communicators can consider the following guidelines when applying the metaphor:

- **Emphasize the role of communication in learning math:** People understand that learning a language gives people the ability to communicate with each other. Use this common understanding to underscore for people why communication—speaking about math and "speaking in Math"—is an essential part of early math learning.
- **Show the relationship of early math skills to critical thinking and other types of learning:** Learning a language enables people to make sense of the world around them, work in teams, and make connections between ideas. Tap into this understanding of language's many purposes to help audiences connect early math learning to a broader set of skills.
- **Expand people's perception of what math is:** Learning a language is more than just memorizing vocabulary; it's about understanding general principles and knowing which concepts to apply when and how. Use examples of the complexity of learning a language to help people get past the idea that math is only about numbers.

Even in short communications like a tweet, using the metaphor can move people's understanding of early math in the right direction. For example:

> Do you #speakMath? Young children learn language through immersion, so the more we #speakMath to them, the quicker they'll pick it up! Details at MathFromBirth.org

Recommendation 5: Use the *Math Lens* metaphor to broaden the parameters of early math learning and to increase understanding of how to help young children learn math.

The *Math Lens* metaphor is also an effective tool for deepening people's understanding of early math learning. The metaphor works especially well to help adults think productively about how to support young children's early math skills development. Here's the idea:

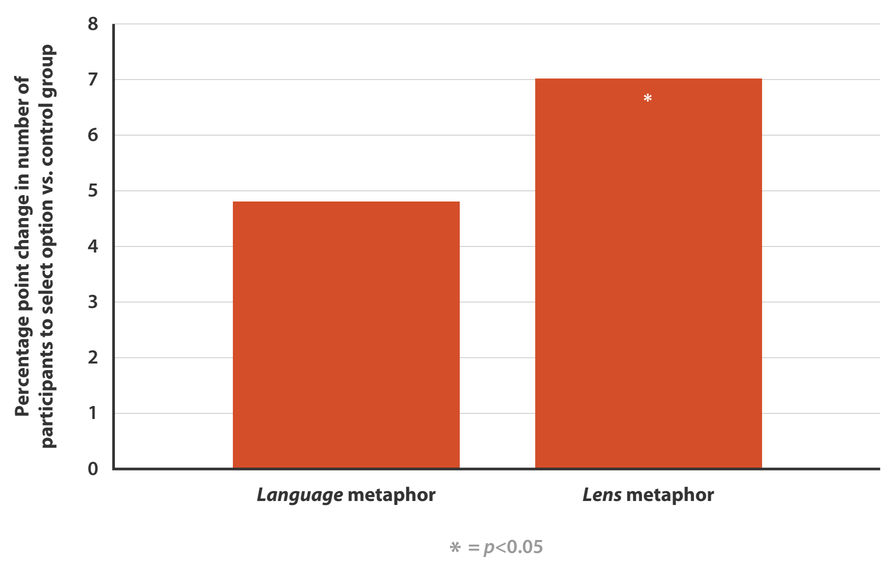
> *Learning math is like learning to use a special lens that allows people to see and understand the world in a new and different way. Just like adjusting to a new set of eyeglasses or using a telescope, the less often children view things through a math lens, the more challenging it is for them to see the world through it. That's why it's so important for kids to begin learning math from birth. Adults can help children see the world through a math lens by showing them how to use math to interpret everyday life, for example, by comparing the sizes of pebbles at the park, measuring ingredients in the kitchen, or identifying shapes like triangles, squares, and circles in buildings.*

Similar to the *Math Language* metaphor, talking about math as a lens increased people's understanding of the importance of young children's access to math learning opportunities before beginning school. Additionally, the *Lens* metaphor is particularly well suited to expand people's grasp of math's pervasiveness and role in everyday life, which in turn improves their support for making sure children have early math learning opportunities.

One important finding from the peer discourse sessions is that the *Lens* metaphor effectively enabled people to explain why and how mathematizing everyday activities (for example, helping children to find the math in everyday objects and play) is essential to helping children learn math. In other words, the *Lens* metaphor led people to think of their own examples of how to support children's early math learning in daily life—it made people smarter about identifying practical solutions.

The metaphor also led people to talk about math in terms other than simply numbers, productively complicating their conception of what math *is*. It was especially successful in facilitating participants' recognition that math is everywhere and in everything, which raised math's salience as knowledge that everyone needs and uses. By expanding the role and value of math in everyday life, the *Lens* metaphor increases support for early math learning opportunities.

Figure 5: Effect of Metaphors on People's Belief That The Best Time to Learn Math Is Before Age 5



Though members of the field thought that the metaphor may be too abstract for some audiences, participants' easy use of the metaphor contradicted this concern, an indication that the metaphor works precisely because the concept of visual technology—from eyewear to microscopes to telescopes to 3D glasses—is so pervasive in our everyday lives and speech. The physicality of the *Lens* metaphor may also help to counter people's belief that math is dry, rote, or boring by cuing up the public's productive ideas about hands-on learning and helping people to create an association between hands-on learning and math.

Figure 5 above shows that respondents in an experimental survey who were exposed to the *Lens* metaphor were more likely than the control group to believe that the best time to begin learning math was before age 5. In the same experiment, these respondents were also more likely to believe that the opportunity to learn math at an earlier age is a better explanation than natural ability for why some people have better math learning outcomes than others (see Figure 4 above).

How to use this recommendation:

Communicators can consider the following guidelines when applying this metaphor:

- **Focus on how viewing the world through the lens of math helps children to learn math:** Use the metaphor of the lens to explain *both* that math is a way of seeing the world *and* that using a math lens is an important tool for teaching children math skills.
- **Extend the metaphor by illustrating the use of a math lens:** Metaphors work especially well when they are reinforced or given "room to breathe" in a communication. Make the metaphor more concrete by offering examples of what it looks like to use a math lens, for example: "A math lens can be used anywhere, even in simple play like collecting leaves at a park. Adults can ask children to describe the sizes of different leaves and which are bigger, or to group leaves in different ways, such as by size, color, or shape, then talk about how many there are in different groups."

Explanatory metaphors are adaptable by design, so communicators can and should use *Lens* creatively, according to their messaging needs. For example:

In a speech:

We use lenses all the time to help us see differently: to improve our vision, to shade our eyes from the sun, to magnify microscopic organisms, and to bring the night sky closer. In the same way, we can use a math lens to help our children see the world differently. By helping them to see the ways math is present everywhere we look and in everything we do—from playing to building to cooking to just observing—we can develop their math skills early on and make seeing the world mathematically a regular part of their lives.

In a grant proposal:

The purpose of this initiative is to build the capacity of the early learning workforce to design curricula for children ages 0 to 3 that apply a math lens to a wide range of play activities, in order to develop children's ability to see mathematically from a very early age. Research shows that early exposure to math-related concepts, language, and activities improves children's long-term academic outcomes.

FOREGROUND EQUITY ISSUES TO GENERATE CONCERN ABOUT EARLY MATH AND BUILD PUBLIC WILL FOR IMPLEMENTING SOLUTIONS.

The public's thin understanding of early math learning—its importance to children's overall learning and development, its limited accessibility for many children, and the long-term consequences of that limited access—make it hard for people to understand early math learning as an equity issue. That challenge is compounded by widely shared cultural narratives that complicate how the public sees, or doesn't see, how inequities shape people's lives.

Chief among these narratives is the American mythology of the self-made individual, capable of overcoming any hardship through grit and ingenuity, that is tightly woven into the fabric of US popular discourse on virtually every social issue. One consequence of this dominant narrative is that our prevailing cultural default for explaining disparities in outcomes is to attribute them to differences among individuals (e.g., some children are just better at math or care more about school) rather than to structural conditions (e.g., some children don't have access to quality early math learning opportunities). It also makes people less likely to see how systems-level interventions can help or why they are appropriate. This widespread tendency to turn to the individual to explain the causes and effects of a social problem is common across social issues. It shuts down conversations about collective change and the role of public policy in shaping the contexts that shape our lives.

FrameWorks tested a number of framing strategies to see which could improve people's ability to reason about early math from an equity and systems-based perspective. Several proved to be effective.

Recommendation 6: Appeal to place-based arguments about fairness to build support for equitable solutions.

One way to engage bystander publics in an issue is to connect the issue to their values, that is, to their deeply held core beliefs or principles. Appealing to a widely shared value helps to reach people on an emotional level in order to establish why an issue or problem matters, even to those not directly affected by it, and what's at stake in addressing it.

In previous framing research on how to communicate about informal STEM learning opportunities, FrameWorks researchers found that appealing to the value of *Fairness Across Places*—the idea that all people deserve to have the resources they need to thrive, regardless of where they live or come from—moved people's support for policies and programs designed to rectify the inequitable distribution of educational or other resources in underserved communities, including communities of color. This framing strategy works by tapping into a fundamentally American value, fairness, but with a twist:

By framing educational resources in terms of geographic or community distribution, it focuses attention on systems and policies, rather than on people—on a faulty distribution system rather than on perceived differences among groups that people might otherwise use to rationalize disparities. Appealing to *Fairness Across Places* steers audiences away from their default tendency to assume that the problem and its solution exist at the level of the individual and instead pushes them to ask, "Why *don't* all children have what they need to learn well?" or "Why *is* the system so unfair?" Tapping into people's sense of fairness primes them for a productive conversation about disparities and how they can be prevented or repaired through collective action and policy change.

Findings from both the peer discourse sessions and quantitative experiments in this project support extending the use of place-focused framing such as the *Fairness Across Places* value to messages about early math learning. For example, in peer discourse sessions, conversations that included discussions of place tended to be the most productive and led participants to think more expansively about structural solutions, e.g., how the presence of well-funded libraries or other early learning environments in a community can provide opportunities for more young children to develop strong math skills.

Likewise, a message contextualizing racial disparities in early math learning within the broader history of racial and ethnic discrimination and segregation (discussed in more detail in Recommendation #7) also introduced the idea of place as a determining factor in children's early math learning opportunities, yielding strong results among participants of color across a number of policy measures. The findings indicate that drawing attention to the importance of place in shaping children's and families' opportunities to engage in early math learning improves not only people's support for increased access to early math learning opportunities but also their ability to imagine what kinds of structural solutions can improve conditions (e.g., devoting more resources to libraries in underserved communities for early math learning opportunities).

Advocates who want to communicate about disparities in early math learning can effectively begin the conversation with an appeal to the fundamental fairness of expecting that all children, no matter where they live, should have what they need to learn and develop well, and that communities that are under-resourced deserve to be prioritized.

How to use this recommendation:

Communicators should keep these notes in mind when **appealing to *Fairness Across Places***:

- **Use this value early in a message:** Values function as priming agents in a message, guiding people to view an issue in a certain way, and for that reason, values appeals work especially well at the start of a communication, where they have the best chance to steer the conversation in a productive direction.

- **Be sure to emphasize place:** The key to this strategy's effectiveness lies in focusing on *distribution of resources* as a root cause of the problem. Without that emphasis on place, appeals to fairness can backfire by reinforcing biased thinking about why some people have more than others.
- **Use inclusive language:** Appealing to a value in stories about policy change engages people's civic-mindedness by tapping into their sense of belonging to a community. Strengthen the effects of *Fairness Across Places* with cues that bolster audiences' sense of collectivity: "*Our* children," "no matter where *we* live," "*all of us* deserve," etc.

For example, a short vision statement on the website of an early math learning organization might use the *Fairness Across Places* value like this:

> *We envision a [place name, e.g., Virginia] in which all babies and toddlers, regardless of county, town, or neighborhood, have access to early math learning opportunities from birth that enable them to begin kindergarten with strong math skills already in place.*

Recommendation 7: Put racial disparities in early math learning into historical context to mobilize people of color.

In recent research on communicating about socioeconomic integration and affordable housing,[4] FrameWorks researchers found that explaining the ways in which structural racism (such as redlining or the disproportionate sale of expensive subprime mortgage loans to African American home-buyers) has historically contributed to concentrated poverty in communities of color increases people's support for housing policies designed to address racial inequities. FrameWorks researchers hypothesized that a similar explanatory strategy might work to move people's support for addressing racial inequities in early math learning.

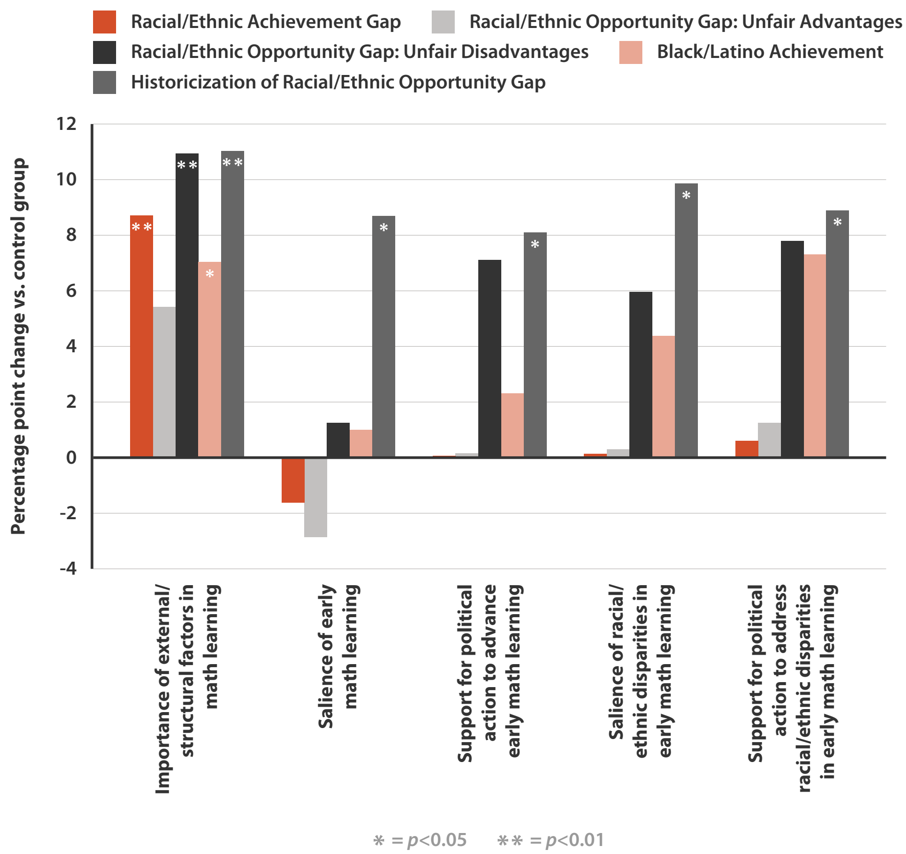
The hypothesis proved partially correct. The researchers conducted an experiment testing people's response to framing strategies focused on explaining racial disparities in early math learning. Since the tested messages focused on racial disparities, the researchers analyzed the data for variances in response by racial subgroup in order to measure how respondents' reception of such messages might be influenced by their racial identity. They found that participants of color who received a message contextualizing early math disparities within the broader history of racial and ethnic segregation, discrimination, and exclusion were more likely than participants of color in the control group (who received no message) to:

- believe that learning math at a younger age is a better explanation for disparate outcomes than natural ability
- attribute greater importance to structural influences on math learning outcomes
- recognize the importance of early math as a social issue

- express concern about racial/ethnic disparities in early math
- support political action both to advance early math learning and to address racial-ethnic disparities in early math learning.

As Figure 6 shows, no other messages about racial and ethnic disparities exhibited effects across this full range of outcomes among participants of color. None of the messages significantly affected white participants' knowledge, attitudes, or beliefs, either negatively or positively. These findings indicate an important opportunity to engage and mobilize communities directly affected by racial and ethnic inequities without eliciting a backfire effect among white people.

Figure 6: Effects of Racial and Ethnic Disparities Frames on Attitudes and Political Support for Early Math Learning among People of Color



Situating early math disparities within the shared historical experience of racial and ethnic marginalization gives the issue of early math learning more traction by heightening a sense of linked fate among audiences of color. This contextualization more strongly leads people to think of early math learning as a racial and ethnic issue, not simply a socioeconomic one, and with consequences for Black and Latino people, as a whole. It also moves people away from thinking that parents are primarily responsible for their children's early math outcomes. Instead, it invites consideration of why and how race and ethnicity matter for early math learning, and the need for "big picture" and racially equitable solutions to address disparities. It also activates and strengthens the extant-but-weak connection people see between math skills and the social progress of our nation by linking early math learning opportunities to efforts to right historical wrongs. Explicitly drawing a link between early math disparities and the history of racial and ethnic inequities in the US can help to put early math on the public's radar as a social—not individual—concern, particularly among audiences of color.

How to use this recommendation:

This framing strategy derives its effects from the power of explanation. This means both establishing that the connection exists, and detailing step-by-step how, exactly, a history of racial and ethnic inequities and discrimination relates to contemporary disparities in early math learning. The explanation should be clear but does not need to be exhaustive, so advocates can incorporate the strategy into a wide range of communications formats, even short ones. For example:

> *All young children need access to early math learning opportunities so they can begin developing math skills from birth. Unfortunately, our country's history of racial discrimination, segregation, and exclusion in areas like education and housing means that young children of color have less access to early math learning opportunities than their white peers. This puts them at a disadvantage in school, because children who don't develop math skills before starting kindergarten have a difficult time catching up. The sooner we make early math inequities a priority, the sooner we can eliminate racial disparities in our children's educational outcomes.*

Recommendation 8: Foreground socioeconomic disparities to build support for collective action on early math.

A message highlighting the relationship of household income and related disparities to early math learning outcomes can build public will for broad structural action to correct these disparities.

Both peer discourse sessions and a survey experiment demonstrated the value of this framing strategy. Most participants in peer discourse sessions already understood—and objected to—the fact that socioeconomic status is a strong determinant of early math learning outcomes. Many participants named specific ways in which lower socioeconomic status (SES) affects children's learning. For example, families with a lower SES have less time and less money to allocate to children's early math learning resources, such as technology or preschool education, and are more likely to live in areas with fewer informal learning environments such as libraries. Participants overall expressed concern about these limitations, based on their belief that the "playing field should be level," at least when kids start school.

In the survey experiment, participants were asked to read one of four short articles about socioeconomic disparities in early math learning. One article discussed how increasing early math learning opportunities for lower-income children can improve their later math outcomes and overall academic achievement, thereby reducing disparities in academic outcomes between lower-income and higher-income students. The second explained how children from higher-income families have an unfair advantage because they have more access to early math learning opportunities. The third article offered an inverse of the second, explaining how children from lower-income families are at a disadvantage because their access to early math learning opportunities is more limited than that of their higher-income peers. The fourth provided statistics about significantly weaker math skills of kindergarten-aged children from lower-income households compared to their wealthier peers.

Figure 7: Effects of Socioeconomic Disparity Frames on Attitudes, Understanding, and Political Support for Early Math Learning

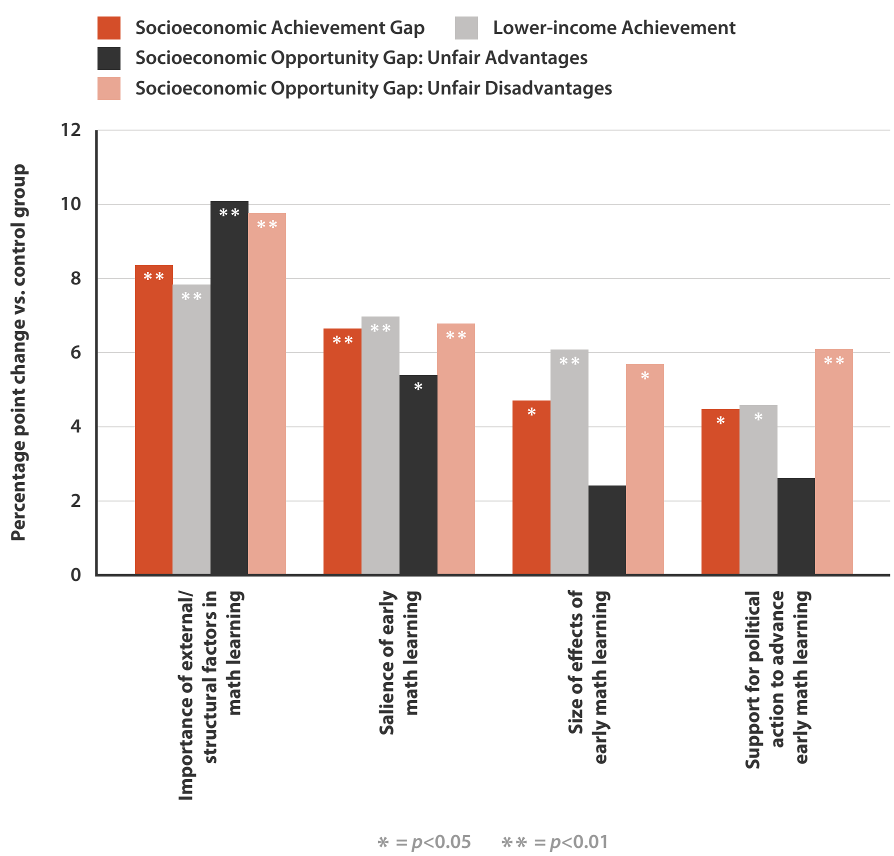


Figure 7 shows that compared to the control group (who read nothing at all) in an experimental survey, people who received a message characterizing socioeconomic disparities in early math learning as a problem and calling for solutions were more likely to believe that learning math earlier is a better explanation of disparate outcomes than natural ability, to believe that early math learning is an important issue that affects not only children but our society as a whole, and to support political action to advance early math learning.

Messages about the relationship of socioeconomic status to early math learning outcomes successfully moved people's thinking about the need for collective action and structural solutions, especially the need for more free and accessible early math resources and learning opportunities for children in lower SES households and communities. This ready connection between SES and early math outcomes may be partly due to people's existing association of math with economics, in which strong math skills are presumed to lead to higher-paying workforce opportunities.

Another reason this strategy works well may be due to the way in which the tested messages frame opportunity. In US public discourse, opportunity tends to be characterized as an intangible yet ubiquitous presence in society, there to be exploited by any individual with enough luck or ambition. Our language is full of clichés that support this characterization: "opportunity is what you make it," "look for opportunities and you'll find them," "opportunity favors the bold." When opportunity is imagined so abstractly but democratically—as something anyone can have if they want it—an individual's inability to find it is easily read as a personal failure.

In contrast, all four of the messages tested in the experiment focused on the unequal distribution of opportunity on the basis of wealth, and three of the four cast "opportunity" as tangible, quantifiable resources (e.g., qualified teachers, high-quality and well-funded public preschools, parents with higher educational attainment) and their unequal distribution as the all-too-common byproduct of wealth disparities. Intentionally framing opportunity as a resource whose manufacture and distribution are determined by our economic and social policies counters the entrenched, pernicious cultural narratives that blame and shame lower-income communities for their impoverished circumstances.

How to use this recommendation:

The key to using this recommendation is to connect lower socioeconomic status to diminished opportunities. Be sure to offer examples of how one leads to the other, in order to guide people to a systems-perspective and prevent them from defaulting to harmful biases or assumptions about lower-income parents. For example:

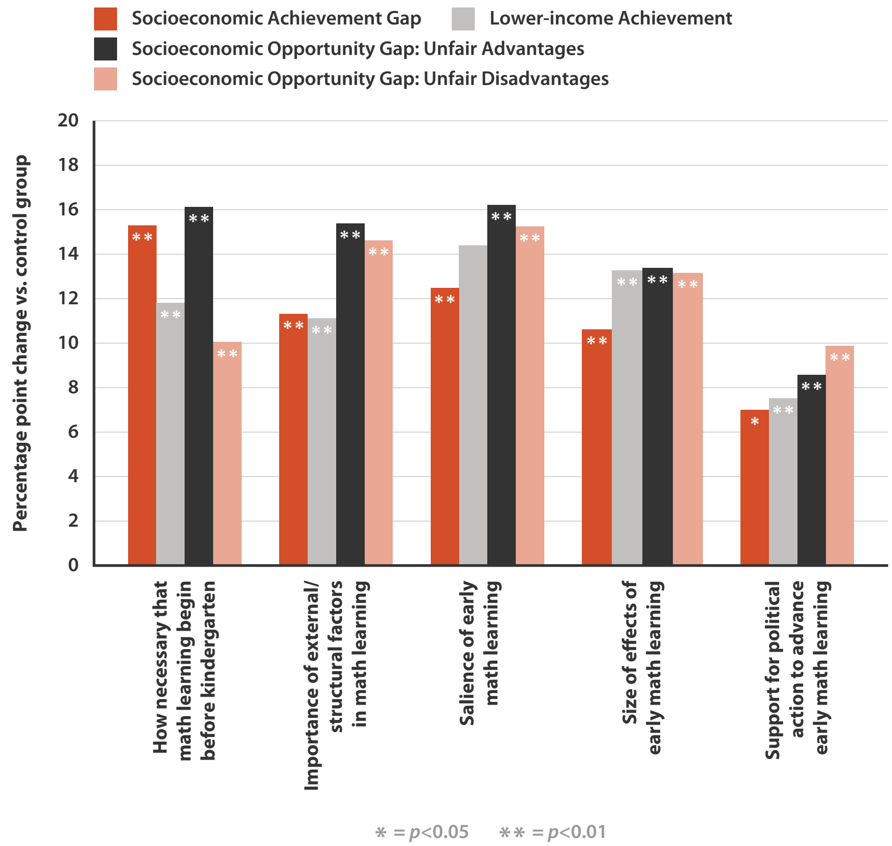
Children from lower-income families are unfairly disadvantaged by having fewer good opportunities to learn math before they start kindergarten. That's because lower-income parents are more likely to live in communities with fewer public resources like libraries or early learning programs and, compared to wealthier parents, are less likely to have time and money to spend on early math learning resources. Children who lack opportunities to learn math early begin kindergarten with weaker math skills. They do less well than their wealthier peers later on, too—in both math learning and overall academic achievement. As a country, we need to ensure all kids have plenty of good opportunities to learn math early on in life and start kindergarten with solid math skills.

Recommendation 9: Mobilize lower-income people by explaining opportunity as a structural issue.

Another key finding emerged from the socioeconomic framing experiment: Explaining how early opportunity, or its absence, can set in motion a lifetime of compounding advantages or disadvantages can increase the salience of early math for lower-income audiences and galvanize their support for collective or political remedies to unequal math learning opportunities. FrameWorks researchers hypothesized that, as with the experimental messages focused on racial disparities (detailed earlier in this report), participants' responses to messages about socioeconomic disparities might be related to their own identity or status. Accordingly, the researchers analyzed the data from this experiment for variance in response by socioeconomic subgroups and found a correlation between participants' SES and their responses to framing strategies that situate early math outcomes as a matter of socioeconomic disparities. Participants who identified as lower-income responded strongly and positively to messages about the relationship between socioeconomic status and access to early learning opportunities.

Figure 8 shows that lower-income participants who received these messages were significantly more likely than their peers in the control group to understand and support a broad range of early math policy measures and principles. They were more likely to recognize the importance of early math learning, attribute math success to early learning opportunities rather than to natural aptitude, support broader access to early math learning opportunities, believe developing children's early math skills is important to society as a whole, and express political will to address early math disparities.

Figure 8: Effects of Socioeconomic Disparity Frames on Attitudes, Understanding, and Political Support for Early Math Learning among People with Lower Incomes



It is perhaps not surprising that this strategy works well to mobilize lower-income people's will for changing the status quo on early math. We suspect two related factors may be contributing to this effect:

- First, as described in Recommendation 8, this reframing strategy may garner especially strong results among lower-income participants because it voices what socioeconomically disadvantaged communities know from experience, namely, that opportunity in America is a tangible resource whose inequitable distribution is the result of policies that deliberately limit supply.
- Second, messages that focus attention on structural inequities such as a lack of preschools with qualified teachers may be a welcome relief to lower-income adults who are all too used to bearing society's scorn for failing their children. FrameWorks' previous research has consistently documented the public's overwhelming tendency to blame parents for their children's negative outcomes without considering the role of social determinants—such as a lack of economic or community resources—in shaping those outcomes. Respondents who participated in cognitive interviews for this project similarly expressed

the belief that parents are responsible for children's early math outcomes, overlooking any role for social investment or public policy. Such beliefs de facto target lower-income communities, whose families simply have fewer resources to put towards ensuring their children's successful development. One possible explanation for our findings, therefore, may be the power of tacitly supporting lower-income parents through messages that explicitly acknowledge the role of structural inequities in their children's early math learning outcomes.

Note that the socioeconomic framing strategies tested also move support among higher-income participants but to a lesser degree. The real strength in this framing strategy is in the mobilizing effects it can have on lower-income audiences whose communities stand to benefit from policy action on early math and whose engaged support could help to advance the issue more quickly.

How to use this recommendation:

The guidelines below can help communicators use this strategy with fidelity:

- **Focus on socioeconomic status as an unfair advantage/disadvantage:** Doing so can tap into lower-income audiences' political will for redressing unequal opportunity.
- **Make "opportunity" concrete:** Help audiences understand that "opportunity" means "resources" by providing tangible, easy-to-visualize examples of what sorts of resources are missing from lower-income communities that can remediate the disparities in educational outcomes between lower- and higher-income families.

This framing strategy can be incorporated into messages alongside other framing strategies detailed in this report or used as a standalone strategy in communications directed at lower-income audiences. For example:

In a presentation to elected officials at a budget hearing:

> *Early math learning is a critical component of children's overall healthy development. It helps young children develop critical reasoning and problem-solving skills, trains their brains to think creatively, and gives them a leg up when they start school. Early math makes children more likely to succeed academically. Yet our district's youngest children are entering kindergarten already behind their wealthier peers one town over because our district isn't providing them with the opportunity—with the resources—to learn math skills early. The socioeconomic status of children's families should not be a disadvantage in their education. We need more and better qualified early educators, we need more and higher quality public preschool options, and we need more and better-funded public libraries. Let's not stunt our children's education before it starts by robbing them of the opportunities wealthier children have just because they live in a different zip code.*

In a message about early math learning opportunities directed to lower-income families:

> *It's a fact: Kids from wealthier families on average start kindergarten with stronger math skills than lower-income kids simply because they have more opportunities to learn math earlier, like quality preschools in their community and more qualified teachers. It's a learning gap that's hard to close once children start school and it gets worse over time.*
>
> *Children shouldn't be at a disadvantage just because of their families' income—and they don't have to be. Kids from lower-income households can do just as well if they have the same opportunities to learn math early. That's why we are working to make good early math learning resources available to ALL kids, so they all start kindergarten ready for success—because the most important numbers in a child's life shouldn't be their parents' W-2 or zip code.*

Moving Forward

In fighting for more and better early math learning opportunities for children under the age of 5, early math advocates enter a lively public square: Many advocates, organizations, and policymakers are debating which of many possible paths will lead us most expeditiously to a workforce and citizenry prepared to face the challenges of the future. Being heard is harder when so many others are speaking for their cause, too.

As if that were not enough, the public's lack of knowledge about early math—why it matters, what it is, how we can help children get more of it—presents additional challenges. For most people, the role of math in young children's lives is minimal; children need to learn to count, they think, and the rest will come later once they start school. They assume when kids are good at math, it's because they have a knack for it, and not because they have been exposed to it continually from an early age. They have a limited understanding of how critical early math skills are to the entire enterprise of raising children ready for school and life, and they do not see early math's absence in children's lives before kindergarten as a direct consequence of racial and socioeconomic inequities.

The research recommendations shared in this report, however, offer hope: Strategies exist that can guide the public's thinking about early math in new directions. Intentionally building a link in people's minds between early math learning and early childhood development can raise math's salience as an issue. Using metaphors to translate the process of early math learning into something more familiar and easy to imagine can help audiences reconsider what they thought they knew about math as a subject. Taking steps to show how math is connected to larger systems of inequity can foster the public's sense of collective responsibility and their will for political action to change the status quo. We offer these recommendations with optimism that early math advocates will use them to replace the public's outdated perceptions of math with a new and powerful story about early math learning that can ensure all children have access to the early math learning opportunities that are fundamental to the promise of equitable education for everyone.

Appendix A: Research Methods

Several types of research inform the strategies and recommendations in this report. Each of these methods is described in more detail below.

EXPERT INTERVIEWS

To explore experts' knowledge about the core principles of early math, FrameWorks conducted 10 one-on-one, one-hour phone interviews with participants whose expertise included research, practice, and policy. Interviews were conducted in May and June of 2017 and, with participants' permission, were recorded and transcribed for analysis. FrameWorks compiled the list of interviewees, who reflected a diversity of perspectives and areas of expertise, in collaboration with the Heising-Simons Foundation.

Expert interviews consisted of a series of probing questions designed to capture expert understandings about what early math is, what facilitates early math learning and what challenges exist, and what needs to happen for early math learning to improve. In each conversation, the researcher used a series of prompts and hypothetical scenarios to challenge experts to explain their research, experience, and perspectives; break down complicated relationships; and simplify complex concepts. Interviews were semi-structured in the sense that, in addition to pre-set questions, researchers repeatedly asked for elaboration and clarification and encouraged experts to expand upon concepts they identified as particularly important.

Analysis employed a basic grounded theory approach. Researchers categorized common themes from each interview. They also incorporated negative cases into the overall findings within each category. This procedure resulted in a refined set of themes, which researchers supplemented with a review of materials from relevant literature.

CULTURAL MODELS INTERVIEWS

The cultural models findings presented in this report are based on a set of interviews with members of the public, supplemented by a review of FrameWorks' past work on informal STEM learning. To understand the public's current thinking, FrameWorks conducted 10 in-person, in-depth interviews with members of the public in July 2017 in Atlanta, Georgia and Chicago, Illinois.

Cultural models interviews—one-on-one, semi-structured interviews lasting approximately two hours—allow researchers to capture the broad sets of assumptions, or cultural models, which participants use to make sense of a concept or topic area. These interviews are designed to elicit ways of thinking and talking about issues—in this case, issues related to early math. Interviews covered thinking about math and early childhood in broad terms before turning to a discussion of learning math during early childhood specifically. The interviews touched on the process, causes, and effects; responsibility; and solutions to improve early math learning.

The goal of these interviews was to examine the cultural models that participants use to make sense of early math. Therefore, researchers gave participants the freedom to follow topics in the directions they deemed relevant. Researchers approached each interview with a set of topics to cover but left the order in which these topics were addressed largely to participants. All interviews were recorded and transcribed with participants' written consent.

By including a range of people, researchers could identify cultural models that represent shared patterns of thinking among members of the public. These participants were recruited by a professional marketing firm and were selected to represent variation along the domains of ethnicity, gender, age, residential location, educational background (as a proxy for socioeconomic status), political views (as self-reported during the screening process), religious involvement, and family situation (e.g., married, single, with children, without children, age of children).

Findings are based on an analysis of these 10 interviews and of relevant excerpts from interviews FrameWorks has conducted on related topics in the past, focusing especially on excerpts from interviews on informal STEM learning. To analyze the interviews, researchers used analytical techniques from cognitive and linguistic anthropology to examine how participants understood issues related to mental health. First, researchers identified common ways of talking across the sample to reveal assumptions, relationships, logical steps, and connections that were commonly made, but taken for granted, throughout an individual's talk and across the set of interviews. In short, the analysis involved patterns discerned from both what was said (i.e., how things were related, explained, and understood) and what was not said (i.e., assumptions and implied relationships). In many cases, analysis revealed conflicting models that people brought to bear on the same issue. In such cases, one of the conflicting ways of understanding was typically found to be dominant over the other, in the sense that it more consistently and deeply shaped participants' thinking. In our analysis, researchers prioritized the new, early math-specific interviews; older interview excerpts were used primarily to confirm or contextualize findings.

Analysis centered on ways of understanding that were shared across participants. Cultural models research is designed to identify common ways of thinking that can be identified across a sample. It is not designed to identify differences in the understandings of various demographic, ideological, or regional groups (which would be an inappropriate use of this method and its sampling frame).

ON-THE-STREET INTERVIEWS

FrameWorks researchers conducted 54 on-the-street interviews in Nashville, Tennessee and Houston, Texas in April 2018. In these one-on-one interviews, we tested six explanatory metaphors (*Language*, *Reading*, *Team Sport*, *Music*, *Art*, and *Cooking*) about how children can learn math before they start kindergarten. Researchers were attentive to recruiting participants from different demographic groups, although, due to the mode of recruitment, were unable to use specific demographic quotas. These interviews were video recorded from start to finish with written consent from all participants.

In the interviews, researchers began by asking participants a short series of open-ended questions designed to gather information about people's top-of-mind thinking about early math. Participants were then orally presented with one of the metaphors and were then asked a series of follow-up questions to ascertain whether and how their thinking shifted as a result of exposure to the metaphor.

Researchers analyzed the resulting video data, looking for patterned ways in which each metaphor affected thinking and talking about early math. The analysis also focused on isolating the reasons why each metaphor had its respective effects. Based on the results of this analysis, four metaphors were brought (*Language*, *Reading*, *Team Sport*, and *Music*) forward for further investigation in a controlled survey experiment. The results also led us to further test one metaphor (*Language*), and to develop and bring forward one new metaphor for qualitative and experimental testing, a *Lens* metaphor.

PEER DISCOURSE SESSIONS

We conducted six 90-minute peer discourse sessions in Denver, Colorado and Baltimore, Maryland in May and June 2019. Each session included nine participants and a moderator. Participants were recruited by a professional marketing firm and were selected to ensure variation across various demographic categories (e.g., gender, age, race/ethnicity, income, location of residence). People of color and low-income people were oversampled to ensure their views were reflected in the findings.

Sessions were designed to accomplish four goals:

1. Gather information on the cultural models—shared, implicit assumptions and understandings—that shape the public's thinking about math and early math learning;
2. Determine how the public interprets and responds to facts about early math learning;
3. Determine how people interpret and respond to framing early math learning as an issue of early childhood development, collective economic wellbeing, socioeconomic and racial equity, and democracy; and
4. Determine how people understand and apply a lens and language metaphor to early math learning.

In these sessions, participants began by discussing a series of open-ended questions about early math learning (e.g., "When do you think is a good time for children to start learning math?" and "How do you think children can best learn math before they start kindergarten?") Following this, participants engaged in several activities in which they were divided into smaller groups and provided with different information and messages about early math learning that they were asked to elaborate on and integrate into presentations and discussion with the broader group.

ONLINE SURVEY EXPERIMENTS

FrameWorks researchers conducted two online survey experiments with a common design in April and August 2019, including a total of 6,311 respondents. Respondents were adults (over 18) matched to national demographic benchmarks for gender, race/ethnicity, income, age, and political party.

In each experiment, respondents were randomly assigned to a message "treatment" or to a null control. The first experiment tested ten message treatments to understand how exposure to these frames affects public opinion. This included five values-based messages (*Children's Future Success*, *Collective Economic Well Being—Labor Market Needs*, *Collective Economic Well Being—Financial Decision-Making*, *Democracy*, and *Social Progress*) and four explanatory metaphors (*Language*, *Reading*, *Team Sport*, and *Music*). The second experiment tested two explanatory metaphors (*Language* and *Lens*), five messenger or source cue treatments (a base message that explained the importance of early math learning for childhood development with *No Messenger*, and four treatments framing the same message with support for early math learning expressed by four types of messengers or sources: *Pediatricians*, *Early Childhood Educators*, *Members of the Public*, and *Bipartisan Majorities of Members of the Public*), five messages about racial and ethnic disparities in early math learning (*Achievement Gap*, *Opportunity Gap as Unfair Disadvantage*, *Opportunity Gap as Unfair Advantage*, *Opportunity Gap in Historical Context*, and *Black and Latino Achievement in Math*), and four messages about socioeconomic disparities in early math learning (*Achievement Gap*, *Opportunity Gap as Unfair Disadvantage*, *Opportunity Gap as Unfair Advantage*, and *Lower-Income Achievement in Math*).

After reading the message (or, in the null control group, no message), respondents were asked a series of questions designed to measure understanding and attitudes about early math learning, understandings of how it works, and support for political action to support it. Questions were either Likert-type items with seven-point scales or multiple-choice questions. Questions were randomized, or sets of questions related to a common idea, and the order of the first five batteries was randomized, with two additional batteries (on policy support and program funding) presented in consistent order afterward.

Multiple regression analysis (OLS and ordered logit regression) was used to determine whether there were differences between treatment groups and the control group. Regressions controlled for demographic variables and determined statistical significance of differences between the treatment and control groups. A threshold of $p<0.05$ was used to determine significance. Significant differences between the treatment and control groups indicated that the messages affected people's opinions.

A third, question-wording experiment tested the effects of different names for early math learning on people's attitudes and understandings of it. The survey was administered using Amazon's Mechanical Turk and was completed by 1,249 respondents. In the survey, respondents were randomly assigned to receive one of 12 sets of questions. Each set of questions was identical, except in how it described early math. Respondents received questions that asked about early math in one of 12 ways (*Early math*, *Early mathematical reasoning*, *Early mathematical thinking*, *Early mathematical understanding*, *Early childhood math*, *Early childhood mathematical reasoning*, *Early childhood mathematical thinking*, *Early childhood mathematical understanding*, *Birth to pre-K math*, *Birth to pre-K mathematical reasoning*, *Birth to pre-K mathematical thinking*, or *Birth to pre-K mathematical understanding*). In each experimental condition, respondents received a series of closed-ended questions using the designated terminology. For example, some respondents were asked "At what age would you say children begin to learn early math", while others were asked "At what age would you say children begin to learn early childhood mathematical thinking?"

Appendix B: Nationally Representative Experimental Survey Samples

Table A1: Sample Demographics of Wave 1 Survey Experiment

Demographic	% of experimental sample (total N=2,511)	% of US population
Age (mean=48.2)		
18–29	20.3	21.0
30–44	22.7	26.0
45–59	28.6	27.0
60+	28.4	26.0
Sex		
Female	53.6	49.2
Male	46.4	50.8
Annual Household Income		
$0–$24,999	23.4	23.2
$25,000–$49,999	23.9	23.7
$50,000–$99,999	30.5	30.0
$100,000–$149,999	13.9	13.0
$150,000 and above	8.4	10.0
Education		
Less than high school diploma	11.2	13.6
High school diploma	25.7	28.1
Some college, or associate's degree	28.7	29.1
Bachelor's degree	21.5	18.3
Graduate or professional degree	12.9	11.0

Demographic	% of experimental sample (total N=2,511)	% of US population
Race and ethnicity		
American Indian or Alaska Native	0.7	0.8
Asian	3.7	4.0
Black or African-American	11.1	10.6
Hawaiian or Pacific Islander	0.2	0.1
Hispanic or Latinx	16.3	16.3
White, non-Hispanic or Latinx	66.4	60.6
Other race or ethnicity	1.7	7.6
Political party identification		
Democrat	46.3	46.0
Republican	37.4	37.7
Independent, or other party	16.4	16.3
Parental or primary caregiver status		
Parent or primary caregiver of any children under 18	23.0	30.0
Not a parent or primary caregiver of any children under 18	77.0	70.0

Table A2: Sample Demographics of Wave 2 Survey Experiment

Demographic	% of experimental sample (total N=2,703)	% of US population
Age (mean=48.2)		
18–29	19.2	21.0
30–44	24.0	26.0
45–59	29.8	27.0
60+	26.9	26.0
Sex		
Female	52.9	49.2
Male	47.1	50.8
Annual Household Income		
$0–$24,999	22.4	23.2
$25,000–$49,999	26.7	23.7
$50,000–$99,999	31.4	30.0
$100,000–$149,999	12.7	13.0
$150,000 and above	6.8	10.0
Education		
Less than high school diploma	3.9	13.6
High school diploma	30.8	28.1
Some college, or associate's degree	34.7	29.1
Bachelor's degree	19.1	18.3
Graduate or professional degree	11.6	11.0

Demographic	% of experimental sample (total N=2,703)	% of US population
Race and ethnicity		
American Indian or Alaska Native	0.8	0.8
Asian	4.5	4.0
Black or African-American	11.8	10.6
Hawaiian or Pacific Islander	0.1	0.1
Hispanic or Latinx	11.7	16.3
White, non-Hispanic or Latinx	68.4	60.6
Other race or ethnicity	2.6	7.6
Political party identification		
Democrat	47.0	46.0
Republican	38.0	37.7
Independent, or other party	14.9	16.3
Parental or primary caregiver status		
Parent or primary caregiver of any children under 18	29.6	30.0
Not a parent or primary caregiver of any children under 18	70.4	70.0

Endnotes

1. This experiment used a sample from Mechanical Turk (MTurk) that, unlike the samples of the first two experiments, was not nationally representative. Although samples drawn from Mechanical Turk are not nationally representative of the US population, academic research strongly suggests that experimental effects are replicated with MTurk samples. See Mullinix, K. J., Leeper, T. J., Druckman, J. N., & Freese, J. (2015). "The generalizability of survey experiments." *Journal of Experimental Political Science* 2, 109–138.

2. First Five Years Fund. "Early Childhood Education: The Public Is Ready for Action." (Undated). www.ffyf.org/why-it-matters/voter-demand

3. Nall Bales, S., Volmert, A., & Kendall Taylor, N. (2015). *The Power of Explanation: Reframing Informal STEM Learning*. Washington, DC: FrameWorks Institute.

4. Ibid.

5. O'Neil, M. & Sweetland, J. (2018). *Piecing It Together: A framing playbook for affordable housing advocates*. Washington, DC: FrameWorks Institute.

ABOUT FRAMEWORKS

The FrameWorks Institute is a nonprofit think tank that advances the mission-driven sector's capacity to frame the public discourse about social and scientific issues. The organization's signature approach, Strategic Frame Analysis®, offers empirical guidance on what to say, how to say it, and what to leave unsaid. FrameWorks designs, conducts, and publishes multi-method, multi-disciplinary framing research to prepare experts and advocates to expand their constituencies, to build public will, and to further public understanding. To make sure this research drives social change, FrameWorks supports partners in reframing, through strategic consultation, campaign design, FrameChecks®, toolkits, online courses, and in-depth learning engagements known as FrameLabs. In 2015, FrameWorks was named one of nine organizations worldwide to receive the MacArthur Award for Creative and Effective Institutions.

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