HANDS ON

A magazine for mathematics and science educators

TERC

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12 Storybook STEM

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Letter from the President

Lifelong STEM learning pathways can be developed for children when we build on their natural curiosity and interest in storybooks. Engaging them in learning as early as possible and throughout adulthood, encourages individual thinking processes and strategies. But it's not only the learner who benefits. It's also those with whom they engage, whether responding to a question or solving a problem. Did I pique your interest?

I think around the box is a glimpse into how a student from a group seriously underrepresented in STEM programs, Natives—and even more rare, two-spirit—changed minds and created opportunities. While pursuing an undergraduate degree in computer science, Tokala approached tasks in a more creative way than his peers, using this difference as an asset. When faced with blatant and aggressive discrimination, Tokala chose to help people through their prejudices against Natives by remaining calm and sharing his way of thinking. He changed lives and perceptions of Natives further opening the door for other Natives to pursue an education in computer science.

We often don't see open-ended questions and math teaching and learning paired together. In *If You Know the Answer, Don't Ask the Question*, the authors discuss how open-ended questions help improve our understanding of what a young learner knows and how to better engage with them. When asked "How can you tell that this is a triangle?" as opposed to "What shape is this?", the child is able to reveal what she understands and how she is thinking. This sparks conversation and curiosity, aiding in children's longer-term mathematical understanding, critical for later school success.

Storybook STEM studies the varied and rich research of using children's storybooks to explore STEM learning opportunities for young children and their families. The process started with a national survey followed by a conference hosted at TERC for early childhood reading, family learning, and informal STEM education experts, researchers and educators. The group shared how they currently use storybooks, with a common goal to catalyze cross-disciplinary thinking and partnerships. The resulting recommendations focus on the need to rethink and address issues of diversity, equity, and inclusion when integrating storybooks, STEM, and family learning.

Laurie

Laurie Brennan, *President*

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"I think around the box"

Experiences of a Native Two-spirit Undergraduate Student in Computing

Christina B. Silva
Nuria Jaumot-Pascual
Maria Ong
Kathy DeerInWater

Diversity is necessary for the creative and critical problem solving of 21st century STEM fields; yet many groups remain severely underrepresented in STEM higher education. Studies exploring the representation and experiences of minoritized groups in STEM contexts can provide insight into factors that support students' persistence and into how institutions can increase recruitment and retention. However, some underrepresented groups comprise such small percentages in STEM education studies that they are rendered not statistically significant and are thus omitted from report results. This is known as the "small numbers" problem (Pawley, 2019), and it particularly impacts Native groups—especially Native two-spirit individuals who are severely underrepresented in STEM programs, and thus nearly invisible in studies.

To help address this research deficiency, in 2019, the Double Bind team at TERC partnered with the American Indian Science and Engineering Society (AISES) on *Native Women and Two-Spirit Individuals in Computing Higher Education* (NAWC2), a research project funded by the Women of Color in Computing Collaborative. The project examined factors that influence and support Native women and two-spirit individuals' persistence in computer science (CS) undergraduate education. Our team utilized photo elicitation, a methodology that collects data by asking participants to take photographs in response to research prompts, and then uses these photos to guide participants' interviews. Photo elicitation evokes a deeper meaning to participants' experiences, as the combination of photos and words expresses more than what words alone can. Given the method's empowering potential for participants, we implemented it with a decolonizing intent, meaning the intent to center Indigenous experiences and ways of thinking (Smith et al., 2018). We also conducted a focus group in which participants responded to the study's preliminary findings.

With such a scarcity of research on two-spirit individuals in STEM, in this article we bring forward findings from NAWC2 about a participant who called himself Tokala and identified as two-spirit, and shared how his identity as a two-spirit Native man influenced his journey as an undergraduate in CS.

According to Jacobs et al. (1997), the term "two-spirit" is relatively new in both literature and common use. "Two-spirit" originated in 1990 as a term for contemporary Native LGBTQ+ individuals and has come to refer to Native roles and identities around gender/sexual orientation categories that emphasize the spiritual aspect of one's life. However, there is no consensus around the meaning of the term, as it varies by individual and culture. Our research team chose not to define the term for our project, but rather followed participants' self-identification. Tokala clearly identified as a two-spirit individual, and here we share what we learned from his contributions to the NAWC2 study.

Creative: ***"I'm creative, and I'll do things with style and everything ... I think more than just outside the box. I think around the box. Being a two-spirit individual at the same time kind of makes everything somehow work together, and then makes everything you do inspiration to other people."***

"I think *around* the box"

Tokala often reflected on how being two-spirit aided him in his CS classes because he approached tasks in a more creative way than his peers. He acknowledged that he was different from those learning alongside him and chose to view this difference as an asset. He reflected:

> *I feel like I approach [things] in a very different [and] creative way at the same time. It's obvious I'm different in class too. But it gives me a challenge ... Being creative, you create different situations or scenarios on what to do or how to do it ... Being a two-spirit in [CS] and [in] college ... it kind of made everything I do in the class different than all the kids, and then they want to learn off of me too.*

Tokala further explained his perspective when relating a time he and his peers were tasked to dismantle machinery. He could see different ways to take it apart, while his peers saw only one approach, until they witnessed his way of working. Tokala commented:

> *They only see the outside or the inside, or they see one way. And then [there's] me. I see different ways of how to take this apart. Or I could see different ways to help to reset it and make it new … So when they see that I'm actually … beyond this typical one-track mind, that's when they start to change, and that's when they start to actually do things differently along with me too.*

Tokala actively acknowledged how he is different and saw these differences as an advantage in his CS major. He saw various ways to approach a situation and in doing so, helped others think and create differently as well. In describing one of his photos, entitled "Creative," which featured a structure he created only using binder clips, he described himself as "think[ing] *around* the box."

"I changed their perspectives"

As Tokala pursued his undergraduate degree in CS, he also had a job assisting mostly non-Native people to use computers, write resumes, and apply for jobs. He kept a cactus at that job, which he photographed and shared with us. He told us he felt that the plant was "applauding" him and helping him feel "peace of mind" when he interacted kindly with clients who were prejudiced against him. He shared:

> *I consider I broke a lot of barriers in that area because, well, you know how people are towards Natives, and they think that we can't do much in [the CS] area. But here comes me, all happy and bright, and they said a lot of [negative] words, but I just kept my cool. I smiled, and I helped them out even though they smash a computer or a keyboard or something … So whenever I helped out prejudiced people, their perspectives on Natives changed a lot, because I wasn't angry or rude or anything. I just helped them through it, and I was the nicest person in that area … And that's why I feel like working there was a great opportunity, because I changed a lot of people's lives, and I changed their perspectives.*

By demonstrating computing competence and cheerful patience, Tokala combatted stereotypes and actively challenged the prejudices he faced. As in his classroom experiences, Tokala changed how people saw things; in this case, how people perceived him and by extension other Native people.

School Work: ***"[I]f you think about plants, they're rooted, and they breathe, just like how we are. And no matter what, they're always silent, but yet whenever you're near them, you feel sincerity, or you feel like peace of mind."***

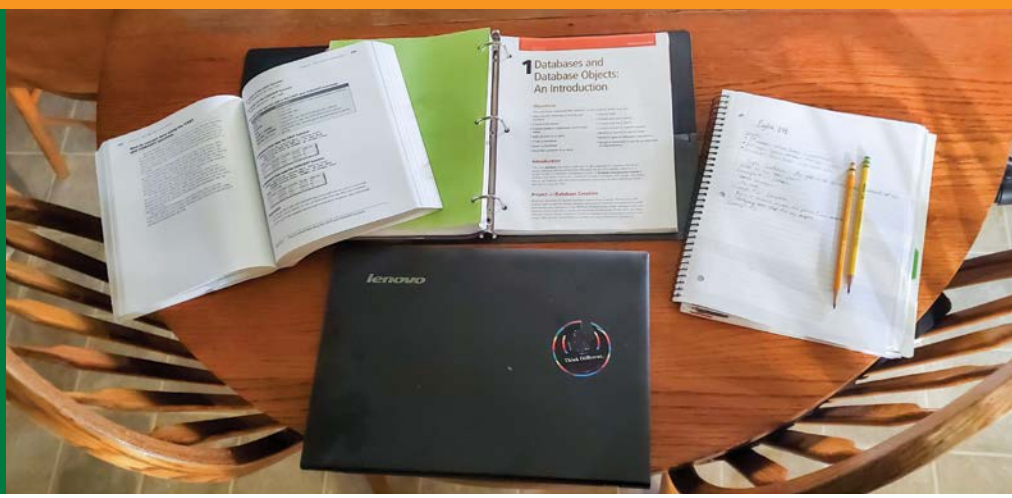
"I need to go beyond"

As noted earlier, Native people are underrepresented in CS, especially those who identify as two-spirit. Referring to a photo of his laptop, school textbooks, and notebooks, Tokala said he felt a responsibility to succeed and serve as a role model to inspire other Native and two-spirit individuals to pursue CS.

> *Having a Native in [CS] is very essential, because you can help out in different ways and in different things … [T]here are some downfalls in being alone sometimes. But having the notion that you're paving the way for others after you gives you peace of mind … Paving and making your own path sometimes it gets lonely and kind of gets hard, but it's worth it when you see people doing more [of] what you're doing, and seeing them get inspired, and seeing them find their own true passion and actually dreaming again. That's something I want to keep doing.*

Here we see how Tokala wanted to give back to his community by paving a way for others to have the courage to pursue their own dreams and passion. Although being different

Hard Working: ***"I don't know any other Native in my area that's actually in [STEM], or doing something in it, because it's very rare. Whatever I do, I affect the people after me, and that's why I need to go beyond, and beyond more than other people especially being a Native two-spirit individual in [STEM]."***



from his peers as a Native and two-spirit individual made him feel alone, he expressed that he found peace with this reality knowing that others like him would follow. This quote highlights again how Tokala perceives his pursuit of a CS degree as benefitting not just himself but others as well; his peers who follow his lead on seeing creative solutions; his clients whose minds are changed about what Native people can accomplish; and here, future CS and STEM students who will come after him because he helped inspire them and create a path to succeed.

Conclusions, Recommendations, and Next Steps

Tokala embraced being Native and two-spirit as he pursued his undergraduate CS degree. He saw these two intersecting identities as an advantage for persistence and innovative problem solving, and acknowledged how being two-spirit helped him be more creative in the classroom. Tokala also described how he overcame barriers when he was confronted with individuals who had prejudices against him because he was Native. Rather than feel discouraged, he challenged their perceptions and ultimately changed their perspectives about him. Finally, Tokala discussed how being the only two-spirit student in his CS program served as a motivator to keep going, because he was paving the way for others like him. Although he acknowledged a sense of loneliness, Tokala was looking to complete his degree not just for himself, but for the Native and two-spirit CS and STEM majors who would come after him.

Learning from the experiences that Tokala shared, we offer the following recommendations to institutions and departments, faculty and staff, and other practitioners seeking to help other Native and two-spirit students in CS persist as Tokala has:

- Hire and retain Native faculty, particularly those who identify as two-spirit, so that students see themselves represented.
- Increase numbers and reduce isolation for Native and two-spirit student cohorts through active recruitment.
- Reform curriculum and pedagogy to welcome multiple ways to solve a problem.
- Invest in programming that dismantles stereotypes about Native and two-spirit people and aids in the acknowledgement of prejudices and biases.
- Support affinity groups for Native and two-spirit students, such as AISES and the Society for Advancement of Chicanos/Hispanics and the Native Americans in Science (SACNAS) chapters and LGBTQIA2 organizations, that aid in creating a sense of community and belonging.

Additionally, the team is currently working on a full-length article, based on NAWC2 findings, to be published in a peer-reviewed journal on the centrality of giving back for Native undergraduate students in CS. We also have a short dissemination article coming up in *Winds of Change*, AISES' quarterly publication.

Additional Research & Resources

To expand on what we learned from the NAWC2 project, in 2020 TERC and AISES began a partnership with the University of Georgia to conduct a project called *Native STEM Portraits: A Longitudinal Mixed-Methods Study of the Intersectional Experiences of Native Learners and Professionals in STEM* (NSF/HRD-2000619) (NSP). NSP is

a broader, four-year, mixed-methods project that addresses factors that support or hinder the persistence of Native individuals, with a particular focus on women and two-spirit individuals, in multiple STEM fields across higher education and the professions. To learn more about the NSP goals and project team, please visit: www.terc.edu/projects/native-stem-portraits/.

For more information about the NAWC2 project, our partners, and our funders, please visit:

- AISES: www.aises.org/
- NAWC2 at TERC: www.terc.edu/projects/nawc2/
- Women of Color in Computing: www.wocincomputing.org/native-american-women-and-two-spirit-individuals-in-computing-higher-education/

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If You Know the Answer, Don't Ask the Question

Open-ended questions and math conversation

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Triangles, triangles, triangles … big ones, small ones, fat ones, thin ones. It's triangle month at El Gato Early Reading Readiness (ELR) program, a pop-up preschool that caregivers attend alongside their children.[1] All month long, children find triangular objects, move their bodies to form triangles, and sing songs about triangles. Today, as children use foam stickers in geometric shapes to make collages, Jasmine, the program facilitator, circulates to show caregivers how to support children's math learning.

First, Jasmine approaches 4-year-old Ana and her grandmother, who are choosing stickers. Jasmine points to a scalene triangle (with each side a different length), and asks Ana, "How can you tell this is a triangle?" (Figure 1). Ana picks up the triangle and looks closely. Slowly, she traces each edge with her index finger and says, "Because … three straight sides," and then she touches each vertex and says, "three corners."

Figure 1. It's a triangle because it has three straight sides and three corners.

Ana's grandmother takes Jasmine aside and asks, "Why did you tell her it's a triangle? You gave away the answer!" Jasmine explains that the "answer" to her question is about properties of triangles; Ana's answer shows that she recognizes that a solid figure with three straight sides and three angles is a triangle, even if it doesn't look like a "typical" triangle.

Next, Jasmine approaches Marco, also 4, and his father. She points to a scalene triangle and poses the same question, "How can you tell this is a triangle?" Marco replies with a confident grin, "You're tricking me. That's not a triangle!" When Jasmine asks him to explain, he tells her it's pointed the wrong way and it's too long. He finds an equilateral triangle among his foam stickers, lays it point-upward and announces, "*This* is a triangle!" (Figure 2). Seizing a learning moment, Jasmine asks, "How are those two shapes the same?" Marco notes that both have three sides and three corners, "but, it doesn't *look* like a triangle … maybe if I turn it like the other one … ."

Figure 2. How are these triangles alike? How are they different?

As Marco continues to mull over the two shapes, Jasmine recognizes that Marco's ideas of what constitutes a triangle are developing; he understands that they have three sides and three angles, but his conception is not sufficiently robust to consistently encompass triangles with unfamiliar proportions or orientations.

[1]El Gato is a pseudonym.

MAKE CONNECTIONS
You and Me and Math

This article is based on our *Make Connections* project, a collaborative, multi-year effort to develop, evaluate, and nationally disseminate an English/Spanish math program for young children and their caregivers. The program includes interdisciplinary adult-child math units for ages 0-2 and ages 3-5, story time connections, professional development materials, and information for caregivers on ways to promote young children's mathematical development through everyday conversation and open-ended questions.

Make Connections materials convey math concepts and activity steps visually, in order to be inviting and accessible to adults with math anxiety and with low literacy. Activities rely upon inexpensive or recycled materials (e.g., toilet paper tubes, plastic bottle caps). The program is available for free access at: https://makemathconnections.org

TERC and YMCA of Silicon Valley spent several years developing *Make Connections* in partnership with YMCA Early Learning Readiness (ELR) sites, which simultaneously engage children and their family, friend, and neighbor caregivers in a preschool setting. Programs are led by community-based facilitators. Development partners include ELR sites serving low-income and immigrant families in CA (San Jose and Los Angeles), MA (Methuen/Lawrence), NJ (Ellizabeth/Rahway), and ME (Portland). YMCA of Silicon Valley disseminated the program throughout and beyond the YMCA network.

Open-ended questions spark math conversations

Educators, researchers, and policymakers underscore the value of engaging in conversation with young children to uncover their mathematical thinking and to foster their mathematical learning, curiosity, and confidence (Ginsburg, 2019; NAEYC and NCTM, 2010; NCTM, 2019; Woods, 2017). Open-ended questions can spark conversations and help children gain the deep mathematical understanding they need for later school success: as children explain their thinking, they learn to verify their ideas for themselves, rather than rely on adults to tell them if they are correct; they come to explore inconsistencies and contradictions in their thinking, as Marco did; and, they learn that their math thinking matters. Open-ended questions can also help adults get a sense of what children understand. If, instead of asking open-ended questions, Jasmine had held up a triangle and asked, "what shape is this?" or requested that children identify a triangle from a group of shapes, she wouldn't have gathered as rich a picture of children's understandings. A correct answer could even be a lucky guess, rather than a reflection of what children know.

Yet, coming up with open-ended math questions is often a challenge. Most adults learned math in a format that centers on closed questions, whether finding the answer to an arithmetic problem, determining which of two amounts is larger, or identifying a shape correctly. In this traditional approach, math answers consist of a number or word, rather than an explanation.

"I've definitely grown by asking [the questions in the activities] to make sure the kids are getting the concepts. The questions showed me that 'good' math questions can be about thinking, rather than about finding the answer."

—ELR FACILITATOR ON CHANGES IN HER OWN LEARNING

Three steps to open-ended math questions

In our work creating math curriculum and professional development for ELR programs, we help facilitators and caregivers come to see math as a subject in which answers can be about how you know or what you notice. Open-ended math questions are at the core of our approach.

Below, we share three strategies that we've found particularly successful for helping adults (including the many with a history of math anxiety) become more comfortable and confident with open-ended math questions.

Plan activity-specific open-ended questions in advance.

For adults just learning to pose open-ended math questions, a concrete starting point can be invaluable. We provide activity pages with open-ended questions (shown with speech bubbles) for adults to ask children, as a way to prompt mathematical thinking and discussion. For instance:

> Discussion questions for the activity, *Hands Together*, (Figure 3) engage children in comparing hands with an adult caregiver. As they explore and talk over similarities and differences, they naturally discuss amounts, shapes, and sizes.

Figure 3. How are our hands the same? How are they different?

> When prompted to compare hands, Lucas, age 5 explained, "We both have five fingers. Yours are longer and wider than mine."

> Discussion questions for the activity, *Mix and Matchup* (Figure 4) engage children in finding and explaining meaningful ways of comparing amounts.

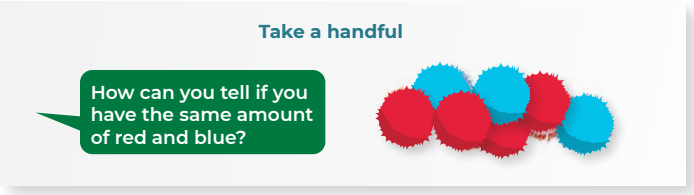

Figure 4. How can you tell if you have the same amount?

To compare amounts, Sofia, age 3, paired up her three blue and four red pompoms and noted that one red didn't have a partner (Figure 5, left). When prompted to show a second way, she distributed her pompoms on the corners of a piece of paper, and explained that there were more red because one corner had a red pompom but not a blue one (Figure 5, below).

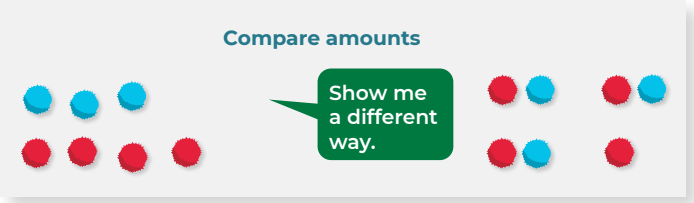

Figure 5. Left: this red doesn't have a partner. Right: this corner doesn't have a blue pompom.

Use open-ended question-starters.

Many math learning opportunities happen in the moment. To help adults build their repertoire of open-ended math questions so they can better seize those math moments, we encourage them to focus on one question-starter each week.

How do you know … For instance, "How do you know 3 + 2 is 5?", "How do you know this one is longer?", "How do you know this is a square?". To answer, children must show or explain their thinking.

How are they the same? How are they different? Look for opportunities for children to compare two things: two patterns, two shapes, or two sets. You'll engage them in looking closely, noticing, and describing.

How did you … "How did you make this pattern?" "How did you make your block tower?" "How did you make sure both paper dolls are the same size?" Even if children are not able to fully articulate their problem-solving processes, they'll still learn that their problem-solving approaches matter.

"Using the questions, I saw for myself how much they help children learn. [Misha] placed something wrong in a sorting activity. My first thought was to ask her to check if that was correct—basically, I'd be telling her she's wrong. Instead, I asked her how the groups were the same and different, like it said on the sheet, and she self-corrected. If I had stepped in quickly to evaluate her, she would not have had the opportunity to learn from her own mistakes."

—ELR FACILITATOR ON USING OPEN-ENDED QUESTIONS WITH CHILDREN

Ask yourself these two questions.

As facilitators and caregivers develop their own open-ended math questions, we encourage them to consider two things:

Does this question engage children in explaining their thinking? To respond to your question, children should have to explain or demonstrate their ideas.

Do *I* already know the answer to this question? If you know the answer, find a way to turn the question around, so you're asking children to explain *how they know* what the answer is.

If you don't already know the answer, you'll learn something new!

Open-ended questions make math with young children a learning experience for everyone. They can spark children's thinking, curiosity, and reflection; they also offer adults a window into children's thinking. If *you* don't already know the answer, you'll learn something new—about how children think, about ways that children see the world, or about something else entirely unexpected.

For more information and to download the *Make Connections* materials, visit https://makemathconnections.org/

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We are grateful to the Heising-Simons Foundation for supporting this work, to the many YMCA staff and families who participated in co-development with us, and to Valerie Martin of TERC for her mathematical graphics that engage even the most math-avoidant.

This anecdote is drawn from our observations at YMCA Early Learning Readiness (ELR) programs, pop-up preschools in low-income communities across the U.S. ELR goals are twofold: to promote children's healthy development and learning and to help the adults in their lives support their development and learning. Programs are led by community-based facilitators.

Authors

In over 25 years at TERC, ***Marlene Kliman*** has led national-scale research and development projects involving mathematics learning in public libraries, after-school programs, community-based childcare settings, family homes, and other informal learning environments. Her projects have been funded by public and private agencies including the National Science Foundation, the Heising-Simons Foundation, and the IBM Work/Life Fund. Marlene and Mary Hoshiko Haughey of YMCA of Silicon Valley have collaborated on math-out-of-school projects for many years. On *Make Connections*, the project on which this article is based, Marlene led math materials development, initial phases of professional development, and research on impact, along with Valerie Martin and Audrey Martinez-Gudapakkam.

Mary Hoshiko Haughey is currently the Chief Operating Officer with the YMCA of Silicon Valley. In this role, Mary provides leadership and support to early learning, after school education and enrichment, and day camp programs as well as YMCA health and wellness operations. Mary is passionate about education and uses innovative YMCA programming to help close the opportunity gap. As part of this work, Mary and her team integrated an early math emphasis in YMCA early learning programs designed for caregivers and the children they care for as they learn and grow together. This work was made possible in partnership with TERC and the Heising-Simons Foundation. Mary earned her M.A. in Education and M.A in Human Services at Concordia University in St. Paul, Minnesota. Mary is also Faculty at Gavilan College in the child development department.

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Audrey Martinez-Gudapakkam is a qualitative researcher at TERC with over ten years of experience in STEM education research and evaluation in public schools, community-based organizations, and universities in Massachusetts, Texas, and Mexico. Audrey draws on her prior teaching experience in her work on evaluation projects, which primarily involve STEM-related teacher professional development. Audrey's other work combines her interests in early childhood education, minorities, and immigrants, including an investigation she is conducting on how to engage Latino families with young children by building on daily activities to teach math and science concepts.

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STORYBOOK **STEM**

Children's Literature as a Tool for Supporting Equitable STEM Learning for Families

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There is growing interest in supporting opportunities for STEM learning for families before children enter kindergarten. Such early learning experiences play an important role in preparing children for school and building lifelong STEM learning pathways (McClure et al., 2017; Shwe Hadani & Rood, 2018). In the preschool years, children's storybooks are a common learning resource with huge potential to support STEM learning. They are also a primary way that many children learn about the world and engage in conversations with family members and other significant adults, even as the use of other media and technology increases (Common Sense Media, 2013; Geerdts et al., 2016).

Storybooks can be a powerful way of introducing or framing a STEM activity for young children and families.

Although the idea of combining storybooks and STEM education is not new, recently there has been a renewed and expanded interest in this area—especially as an approach to STEM access and learning in early childhood (Popov et al., 2017). A variety of projects across the country are now using fiction books and reading activities as avenues for STEM engagement with young children and families. However, there has been almost no coordination across these projects to ensure that their efforts build on prior work, align research questions, or share and synthesize results.

Storybook STEM was a National Science Foundation-funded conference grant led by TERC, in partnership with the University of Notre Dame, designed to foster this much needed collaboration and to better understand and advance research and education efforts. The project engaged school teachers, informal STEM educators, and researchers who work with or study family learning for preschool-age children (three to five years) and use early childhood fiction books as a tool to engage these families in STEM topics and skills. In this article, we share more about the project, recommendations that emerged through the discussions, and implications for how we support equitable learning for families.

Gathering Perspectives

Over two years, the *Storybook STEM* project team coordinated a series of activities to engage researchers and educators across the country and to gather information about current work. We collected feedback from 231 researchers, educators, and other professionals through a national survey, and we connected with 156 participants in an online forum. Such outreach allowed us to document how storybooks are currently being used (especially outside of school), the research base supporting this work, and outstanding questions that researchers and educators are grappling with.

Building on this foundation, in December 2019 our project team convened a group of 21 early childhood reading, family learning, and informal STEM education experts at TERC. Over two days together, we explored more deeply the role of children's fiction books in supporting STEM learning with young children and their families and sought to catalyze cross-disciplinary thinking and partnerships. Participants came from across the country, representing a broad range of learning contexts, professional roles, audience focus areas, and STEM discipline expertise.

What Did We Learn?

Through our discussions, the group developed a series of recommendations for researchers and educators, with a particular focus on the need to rethink and directly address issues of diversity, equity, and inclusion when integrating storybooks, STEM, and family learning.

Convening participants challenged researchers and educators to rethink:

- How stories are developed
- What we mean by stories
- Our relationships with families
- How we measure success
- Connections between research and practice

1. RETHINK AND RECONFIGURE HOW STORYBOOKS ARE DEVELOPED

As several convening participants noted, the vast majority of children's storybooks, whether they are explicitly related to STEM or not, are written and illustrated by White individuals and arguably represent White, middle-class values and cultural perspectives. Furthermore, the children's publishing field is predominantly White, limiting the cultural perspectives shaping the development and selection of books (Kelly, 2018; Kliman, 2019).

In order to realize the potential of storybooks to broaden STEM access and engagement for families with young children, it is critical to increase the diversity represented in children's books, as well as the teams that develop and study them. This means:

- increasing the diversity of the individuals and contexts represented in these books so that children and families from all communities can see themselves in the stories;
- ensuring that professionals of color are involved at every stage of story development, selection, distribution, and research; and
- supporting senior professionals of color, including writers, illustrators, and researchers, to lead and bring their perspectives to the process.

This shift invites educators and researchers to reflect on the underlying issues power and privilege related to who selects and tells stories and who decides how these stories are integrated with STEM for families.

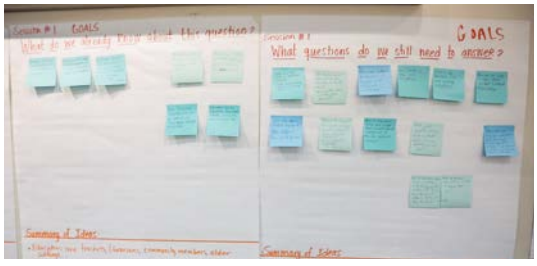
2. RETHINK AND BROADEN WHAT WE MEAN BY STORIES

From the outset, convening participants questioned the exclusive focus on storybooks rather than other forms of narrative and storytelling. Again, children's storybooks are a common resource and component of home learning for White, middle-class families that may not be as common or as familiar for families from other communities. As convening participants discussed, a focus on storybooks must be balanced with supporting other family storytelling practices and finding creative ways to integrate these practices with STEM learning.

This broader approach includes empowering families to share and tell their own stories as part of STEM programs, which promises to:

- create a deeper sense of relevance to the STEM topics for learners from many communities; and
- put families in a central role for shaping the way story and STEM are integrated.

In general, convening participants stressed that we should not assume the same approaches, outcomes, and practices are appropriate for all communities. Ideally, educators, researchers, and families work together to understand and support the storytelling practices within each community and leverage these to create relevant and accessible entry points to STEM.



In December 2019, 21 experts were invited to TERC to explore the role of storybooks in supporting early childhood STEM learning.

3. RETHINK AND EXTEND OUR RELATIONSHIPS WITH FAMILIES

Participants also stressed the importance of moving beyond thinking about families as solely the *audience* for programs that integrate children's storybooks. Rather families should be invited in as collaborators at every step of the process, including:

- identifying education and research goals;
- prioritizing outcomes and measures;
- creating or selecting stories to ensure representation of all storytelling traditions within different communities; and
- implementing and studying programs.

This approach will not only help ensure that programs and research studies are relevant and accessible but will also put families in control of how stories become a resource for their children.

The re-orientation also implies embracing a different perspective on intergenerational learning and the multiple roles of parents. As emphasized by convening participants, parents are not just contextual factors in their children's development but are educators and learners themselves. Programs for families that connect storybooks with STEM learning should therefore both support meaningful, enriching interactions between parents and children and further parents' own learning about storybooks and STEM. Both research and educator efforts should also acknowledge the diverse approaches to parenting and family learning across cultures that influence how families engage with books and stories more broadly.

4. RETHINK AND EXPAND HOW WE MEASURE SUCCESS

Definitions of success guide our work as researchers and educators, and also reveal our biases and assumptions about storybooks, STEM, and education. Applying a diversity and equity lens to ideas about measuring success, the convening group explored ways that our outcome measures should be broadened and expanded. Different perspectives suggest a variety of approaches to this challenge.

- From a *disciplinary perspective*, this might include emphasizing STEM practices just as much as content knowledge and vocabulary.

Convening participants challenged the field to address issues of diversity, equity, and inclusion when integrating storybooks, STEM, and family learning.

- From a *family learning and child development perspective*, this requires thinking about ways that storybooks not only focus on STEM learning but also support and honor other family goals, such as early literacy development, cultural values, and spending time together.
- From an *equity perspective*, educators and researchers should work closely with families and community stakeholders to decide what outcomes are of the highest priority and how existing family assets and strengths are highlighted and supported.

Participants acknowledged that this balancing act between different goals and perspectives is challenging but also critical to ensure that these efforts are successful for all communities.

5. RETHINK AND REINFORCE THE CONNECTION BETWEEN RESEARCH AND PRACTICE

Finally, convening participants agreed that more work needs to be done to connect researchers and practitioners at all stages of the process. This includes sharing the research that does exist with teachers, educators, and other professionals working directly with families and providing training and professional development opportunities on current questions, issues, and approaches related to using storybooks in STEM education. Similarly, practitioners can be engaged in the earliest stages of research and development to ensure that efforts are aligned with the needs of different professional audiences and incorporate insights from both research and direct experience with families. Overall, the participants felt that the cross-disciplinary nature of the convening should serve as a model for future efforts—catalyzing collaboration and communication across sectors, disciplines, and professional roles.

A Timely Call to Action

The *Storybook STEM* project brought experts together across disciplines, fields, and professional roles to better understand the work that has been done related to the integration of storybooks and STEM for young children and their families and to provide guidance for future research and educational efforts. What emerged from the convening is, we believe, something even more profound: a call to action for researchers and educators to think more critically about this integration and how it supports a vision of equity in STEM education for all communities.

This call to action is timely. It aligns with a growing movement across education and the STEM fields to move beyond superficial notions of access or representation and more fundamentally address the systems of oppression, inequity, and injustice that are ingrained within our society (Brown et al., 2019; Calabrese Barton & Tan, 2020; Garibay & Teasdale, 2019; Hall, 2020). We hope this convening and the recommendations that have emerged serve as one small contribution to these efforts.

Additional Resources

We invite you to explore project findings and resources in more detail on the project website, https://www.terc.edu/storybookstem

- Full project report https://www.terc.edu/storybookstem/wp-content/uploads/sites/5/2020/09/Storybook-STEM-Convening-Report-Final.pdf
- Bios and resources from convening participants https://www.terc.edu/storybookstem/convening/convening-participants
- List of resources compiled from the national survey and online forum https://www.terc.edu/storybookstem/resources

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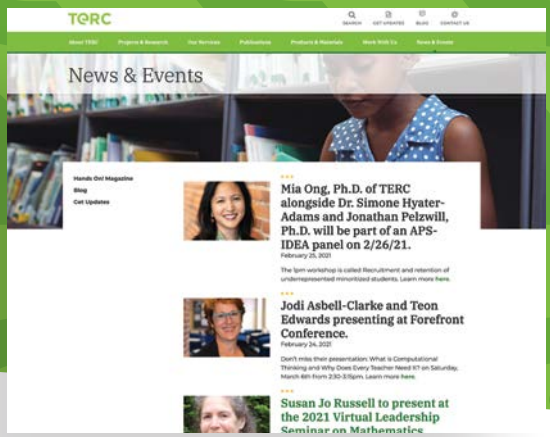

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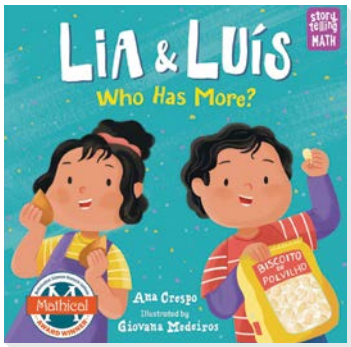
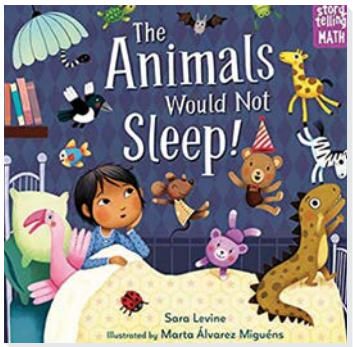
Congratulations to *Lia & Luis* and *The Animals Would Not Sleep!*, winners of the 2021 Mathical Awards!





Two books from the Storytelling Math project are winners of the 2021 Mathical Awards announced today by the Mathematical Sciences Research Institute (MSRI) in partnership with the National Council of Teachers of English (NCTE) and the National Council of Teachers of Mathematics (NCTM), and in coordination with the Children's Book Council (CBC).

The Mathical Book Prize recognizes outstanding fiction and literary nonfiction for youth ages 2-18.

- For **Pre-Kindergarten**, the Mathical Award Winner is ***Lia & Luís: Who Has More?***, by Ana Crespo (Charlesbridge).
- For **Grades K-2**, the Mathical Award Winner is ***The Animals Would Not Sleep!***, by Sara Levine (Charlesbridge).

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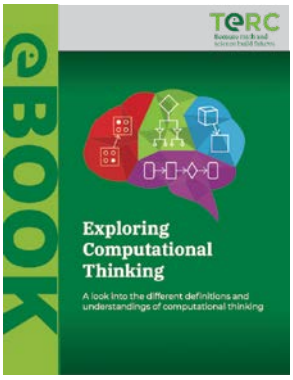
Our Computational Thinking blog series has become an eBook!



Developed from a five part blog post series, you'll read about the findings of Mike Cassidy and Teon Edwards as they explored different definitions and various peoples' understandings of computational thinking.

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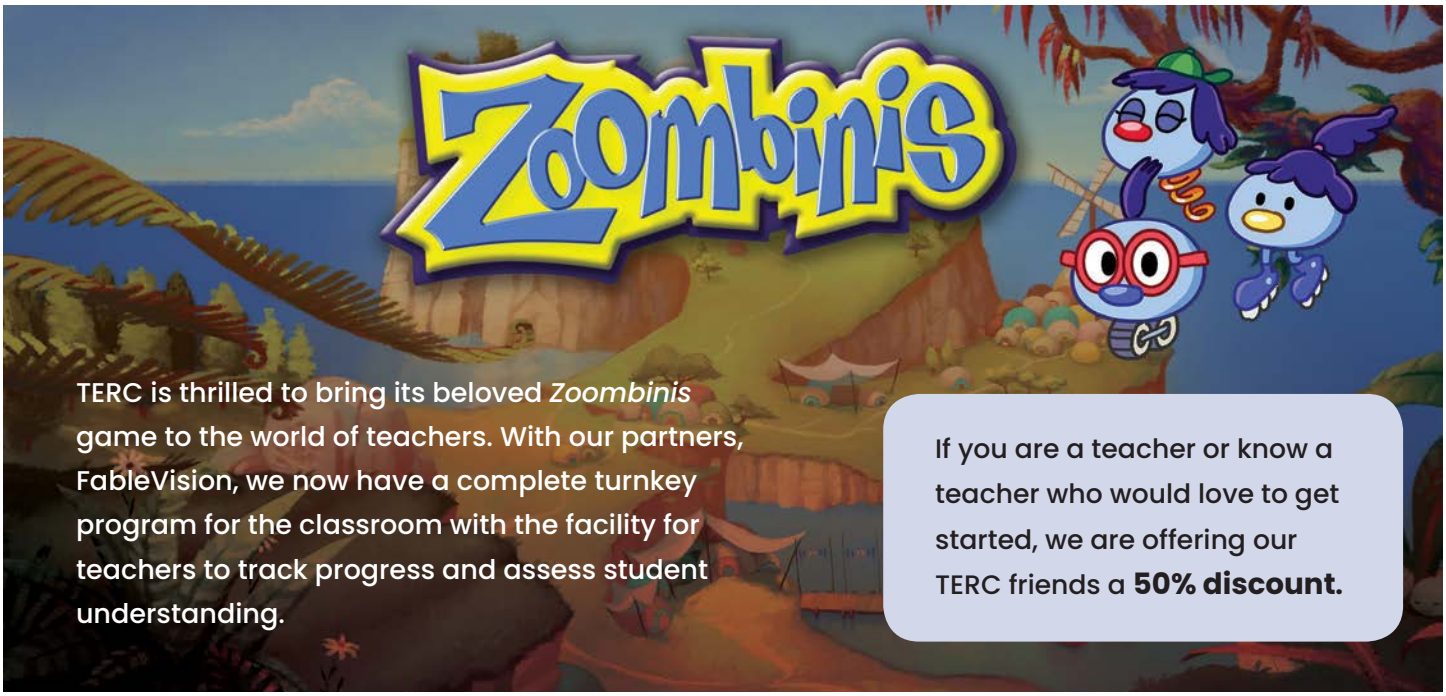

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