HANDS ON!

A magazine for mathematics
and science educators

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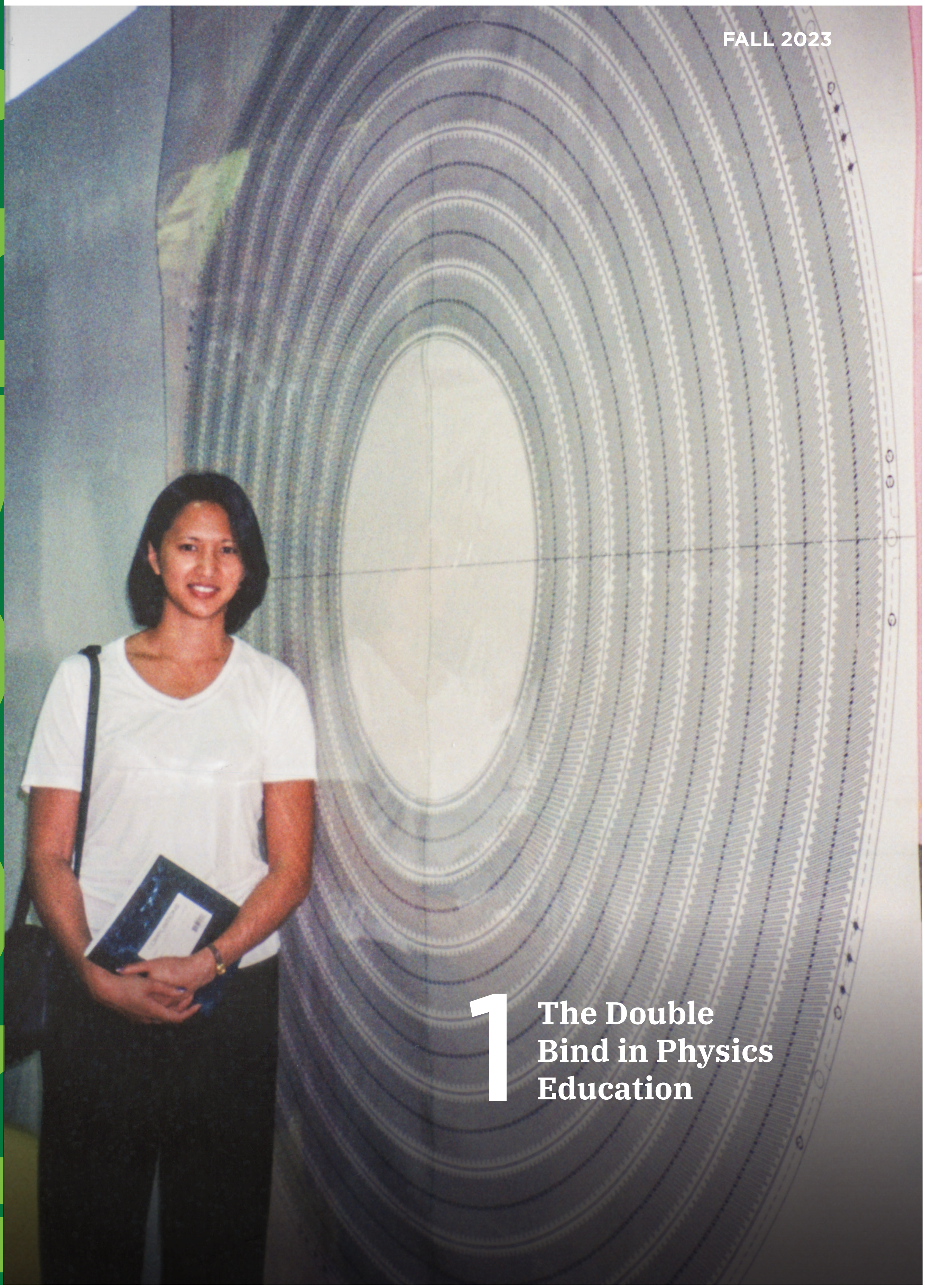

FALL 2023

1 The Double Bind in Physics Education

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Letter from the President

Welcome to the Fall 2023 *Hands On!* magazine. In this issue, we're celebrating the publication of a new book by Dr. Maria (Mia) Ong and exploring STEM through design challenges, offering valuable resources and tools to support young learners in formal and informal education spaces.

Our feature article is an interview with Dr. Mia Ong, inspired by her book 'The Double Bind in Physics Education.' The book chronicles 25 years of ten women's experiences from entrance into undergraduate physics programs to their educational and career paths. It highlights Mia's dedication to researching the underlying systemic inequities and barriers that hinder women's success in physics, along with her commitment to utilizing her research and voice to enact systemic change.

'Playful Engineering: Discovering the Unique Potential of Engineering with Young Children and Their Families' explores how young minds can derive meaning from engagement with their family, teachers, and caregivers in engineering design challenges. The TERC-led research team created home-based engineering activity kits for 15 English and Spanish-speaking family partners — meeting them where they were, using storybooks, songs, toys, and imagination as the foundation of the engineering design process.

In 'Making an Impact with TERC's Open-Access MPACT Curriculum' young learners collaborate to develop math skills, computational thinking, and spatial reasoning concepts through 3-D modeling and printing activities, designed for grades 4-7. These free and adaptable resources have boosted student math content knowledge and allowed teachers to cover multiple standards, including computer science and twenty-first century skills.

Laurie

Laurie Brennan, President

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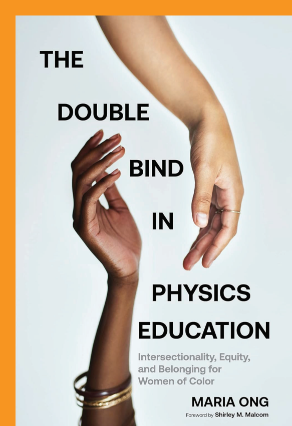
Hands On! is published semi-annually by TERC, a non-profit education research and development organization dedicated to building futures for all learners through STEM education and teaching.

THE DOUBLE BIND IN PHYSICS EDUCATION

An Exploration of Inclusion in Physics



Maria (Mia) Ong's groundbreaking book, *The Double Bind in Physics Education*, presents a compelling case for far-reaching higher education reform. Her extensive 25 years of research sheds light on the challenges faced by women of color in STEM fields, documenting 10 women's experiences from entrance into undergraduate physics programs to their educational and career journeys.

To gain further insights into her work, we had the opportunity to sit down with Maria Ong for an interview. In this conversation, she discusses the challenges these women face, the intersectionality of race and gender discrimination, and how it influences academic opportunities and career choices.

CAN YOU SHARE THE STORY BEHIND WHY YOU FELT COMPELLED TO WRITE THIS BOOK?

The short answer is that I wanted to write a book that addressed the question: *Why haven't diversity efforts from the past 2+ decades worked?* Millions of dollars have been spent on efforts such as summer STEM camps for middle and high school students or teaching undergraduate students' self-confidence or behaviors rooted in grit. These efforts are admirable and well-intended, but they're insufficient in scale and band-aids to a much bigger problem. It became clear to me that the practices and culture within STEM institutions were the underlying issues.

Dr. Mia Ong is a Senior Research Scientist at TERC and leads the Institute for Meta-Synthesis. She is also the Founder and Director of Project SEED (Science and Engineering Equity and Diversity), a social justice collaborative affiliated with The Civil Rights Project/*Proyecto Derechos Civiles* at UCLA. For over 20 years, Dr. Ong has conducted qualitative and mixed-methods research, including three NSF-sponsored literature synthesis projects, focused on equity in STEM. Her publications include synthesis articles on women of color in STEM in *Harvard Educational Review* and *Journal of Engineering Education*. She has extensive experience teaching qualitative research methods and equity in education at schools such as Harvard, Vanderbilt, MIT, Boston University, and Swarthmore College. Dr. Ong holds a doctorate in Social and Cultural Studies in Education from the University of California at Berkeley.

IF THERE'S A SHORT ANSWER, IS THERE ALSO A LONG ANSWER?

When I was a graduate student in the mid 90s, I became interested in the experiences of intersectionality, specifically the experiences of women of color, in spaces that were not traditionally built for them. By "women of color" I mean women who identify as Black, African American, Latinx or Latine, Chicana, Native American, Indigenous, Asian American, mixed race or ethnicity.

As an Asian American woman and a former chemistry major, I was drawn to the sciences and attracted to physics as a context to study. Prior to doing my study, I had a brief role as a coordinator of a physics undergraduate program. I noticed many women of color had similar stories and experiences, yet they were not communicating with each other about them. I started searching for existing research that could shed light on what I was observing. Surprisingly, I discovered that there was very little research available on the topic.

At that point, a colleague suggested I take the initiative and conduct the research myself. I made the decision to leave my position and embark on this research journey that ultimately culminated in this book.

COULD YOU SHARE THE BEGINNINGS OF YOUR RESEARCH PROCESS AND HOW IT EVOLVED?

The research began with a simple set of questions: *What is it like to be a woman of color in physics or physics-related fields? What drove women of color to pursue degrees in these fields? What were the barriers? What supported them along the way?*

I began to follow a small group of women of color, as well as other nontraditional students. They generously allowed me to study them over the years, observing them in classrooms, homes, and eventually, in workspaces. Along the way, I conducted numerous interviews to delve deeper into their experiences. Their stories over the past 25 years, I thought, gave deep insight into why the representation of women of color in physics hasn't significantly changed in the past few decades.

Mia Ong visited a simulated surface of Mars at the Jet Propulsion Laboratory during a data collection trip (February 1997).

HOW DID YOU ARRIVE AT THE TITLE FOR YOUR BOOK?

When I started the research for this book the concept of intersectionality was not very well studied or very well understood, especially within STEM education contexts. Dr. Shirley Malcolm and her colleagues Paula Hall and Janet Brown had written a very important report called, "The Double Bind: The Price of Being a Minority Woman in Science." It was published by the American Association for the Advancement of Science in 1976 and addressed the experience of being a woman of color in science, but the phenomenon of intersectionality in STEM wasn't well publicized beyond this report. Of course, their report had a tremendous impact on all my research, and the title of my book honors their report.

WHO DO YOU ANTICIPATE WILL BE THE IDEAL AUDIENCE FOR THIS BOOK?

I wrote this book for young women of color and individuals belonging to other marginalized groups who are pursuing careers in physics and other STEM fields. I hope it also engages faculty and leaders at both local and national levels, as well as researchers.

CAN YOU ELABORATE ON THE IMPACT YOU ENVISION FOR EACH OF THE THREE AUDIENCES THIS BOOK SPEAKS TO?

My ideal outcome is that this book provides support and validation to women of color who may have felt alone or doubted their experiences. I want them to know that they belong, that what they are going through is real, and that they are not alone. I hope discussions of this book create spaces where people can openly share their experiences and find inspiration in knowing that others have succeeded despite the odds.

I envision this book reaching people in positions of power who are looking for guidance on creating change for inclusive excellence. In the book I present a framework that offers a variety of options, ranging from small adjustments to syllabi to more substantial interventions, all of which can profoundly impact individuals' sense of belonging. For other educators and administrators, I hope that it opens their eyes to the stories and challenges highlighted. Ideally, I hope it will encourage them to recognize that these experiences are not limited to specific classrooms or universities, and that they can make meaningful changes in their own environments.

Lastly, it would be wonderful if this book sparks further research. There are still many unanswered questions and gaps in our understanding. By presenting these unanswered questions, I hope to inspire other researchers to delve into these areas and gather the necessary data to find answers. There is much work to be done, and I believe that this book can motivate researchers to explore and address these important issues.

ARE THERE ANY SPECIFIC CHAPTERS/ PASSAGES THAT YOU THINK ARE PARTICULARLY COMPELLING TO SHARE, AS AN ENTRY-POINT TO READING THE ENTIRE BOOK?

I used mainly storytelling in this book because stories are accessible. They reach peoples' hearts to create change in a way that intellectual arguments can't always do. I also used theory to frame the stories, to give readers a shared vocabulary and theoretical basis, and to demonstrate that these concepts have been studied in the past, though not necessarily with women of color or in the field of physics.

Irene's story reveals how her classmates overlook her expertise when they go to the man she's tutoring for answers rather than her, demonstrating concepts of invisibility and lack of recognition. Kendra encounters discrimination when her access to a science building is questioned by a security guard even though she had a key, which illustrates acts of low expectations and stereotyping on the part of the guard. And Elena faces accusations of cheating after doing well on an exam because she was given more time due to a learning difference, which is an example of identity-based harassment.

These individual stories collectively contribute to a deeper understanding of the experiences and challenges faced by women of color in physics and related fields.

WHAT IS YOUR IDEAL OUTCOME WITH THE RELEASE OF THIS BOOK?

I have a few ideal outcomes: an increase in women of color and other members of minoritized groups in physics and related fields, a greater sense of belonging for them, an awareness by leaders, faculty, and students alike of intersectionality and how it plays out in physics and other STEM spaces, and systemic change resulting in greater inclusion overall.

WHAT'S NEXT, IF ANYTHING, IN THIS LINE OF RESEARCH?

It can be challenging to secure funding for this type of work, but I would love to continue this line of research. Over the past 25 years, I have been a constant presence in the lives of the women featured in this book. They have shared their milestones and personal achievements with me, whether it's getting promoted, graduating, starting a family, or even celebrating their children's successes in a soccer game. I don't take this lightly and I'm honored to be this person in their lives.

It's incredibly inspiring to witness many of these women now holding positions of power and influence. They are actively contemplating and implementing changes to ensure that the next generation does not have to face the same obstacles they encountered. They are invested in grooming future leaders who can drive even more significant transformations in our field. So, yes, there is a desire to carry forward this research and explore the continued growth and impact of these women in shaping the future.

CREDITS

The Double Bind: The Problem of Being a Minority Woman in Science: The Problem of Being a Minority Woman in Science is published by Harvard Educational Press and avaialble for purchase at https://qr.page/g/DMqS1jCdq8

The book draws its title from the American Association for the Advancement of Science (AAAS) publication, *The Double Bind: The Problem of Being a Minority Woman in Science* [authored by Shirley M. Malcom, Paula Q. Hall, and Janet W. Brown], in which the status and experiences of women of color in STEM was first raised. The "double bind" referred to the unique challenges minority women faced as they simultaneously experienced sexism and racism in the STEM careers.

Photos courtesy of M. Ong.

Playful Engineering

Discovering the Unique Potential of Engineering with Young Children and Their Families

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Families engage in many aspects of the engineering design process as they play and build together.

Educators and researchers have long recognized the importance of math and science for young children. Even before they enter the K–12 school system, children are often celebrated as "young scientists" with an intrinsic curiosity and motivation for exploring the world around them (McClure et al., 2017; NRC, 2007). Similarly, researchers have documented the ways that young children begin to develop an understanding of mathematical quantities and relationships from a very early age and how these early experiences with math provide an important foundation for children's long-term learning and development (NCSM &NCTM, 2018; NCTM, 2000).

As the topic of engineering has gained prominence in education, scholars are also beginning to explore what engineering learning might look like for preschool-age children (Ata-Aktürk & Demircan, 2021; Cardella et al., 2021; English & Moore, 2018; Gold et al., 2021; Svarovsky, Cardella, et al., 2017). As a discipline, engineering is related to but distinct from math and science (NASEM, 2020; NAE & NRC, 2009). Both topics are essential to the practice of professional engineering. However, engineering always focuses on developing a design solution to a problem or challenge, usually with the needs of specific communities and the context of a specific project serving as constraints. Professional engineers often use the *engineering design process* (see example in Figure 1) to guide their work and inform the development, testing, and revision of design solutions (Cunningham, 2018; NAE & NRC, 2009).

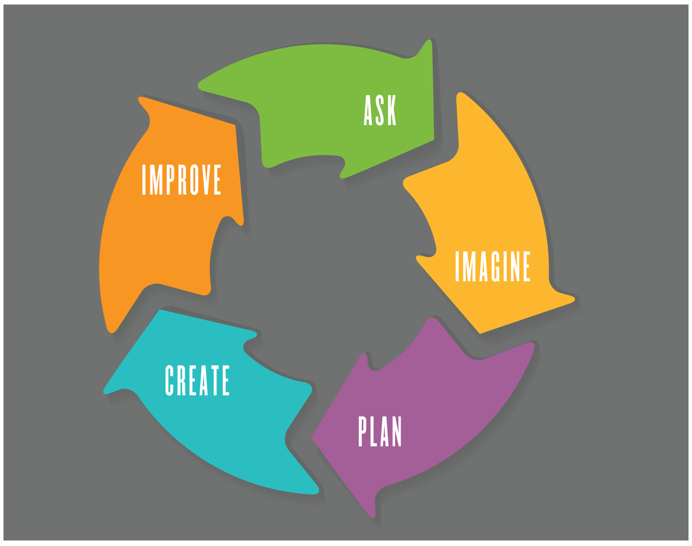

Figure 1. Example representation of the engineering design process (Cunningham, 2018).

Our work with families and young children over the last 10 years has confirmed the rich ways these children, with the support of parents, teachers, and other caring adults, can engage with engineering and create solutions to design challenges that are meaningful to them (Pattison et al., 2020; Pattison, Ramos Montañez, & Svarovsky, 2022; Pattison et al., 2016; Pattison, Ramos Montañez, López Burgos, et al., 2023; Svarovsky, Pattison, et al., 2017). Like the interaction featured at the beginning of this article, our research has also revealed the unique ways that these young children engage in engineering, which is in turn expanding our ideas about what engineering education can look like at this age (Pattison, Ramos Montañez, Svarovsky, et al., 2022; Pattison, Svarovsky, et al., 2022; Wagner et al., 2023). In this article, we share findings from our work to inspire others to incorporate engineering into early childhood learning experiences inside and outside of school.

Studying Early Childhood Engineering

MFS
READY, SET, GO!
Engineering

Since 2019, we have collaborated with English- and Spanish-speaking families from our local community in Portland, OR, through the *Ready, Set, Go! Engineering* program to develop and test activities and resources for supporting engineering engagement for preschool-aged children (3 to 5 years) and their families (Pattison, Ramos Montañez, Svarovsky, et al., 2023; Wagner et al., 2023). The program is part of a National Science Foundation-funded design-based research project lead by the University of Notre Dame in partnership with TERC and Metropolitan Family Service (MFS). MFS is a not-for-profit organization that provides a range of family services for low-income, racially, and ethnically diverse communities across the metropolitan region. In partnership with MFS educators and leaders, the project leveraged the deep relationships the organization has built with families to support collaborations with caregivers and children throughout the research process.

During the 2019-20 and 2020-21 school years, we partnered with 15 English- and Spanish-speaking families from MFS's early childhood program to iteratively test and refine a set of three home-based engineering activity kits for families. Each kit included a bilingual storybook, which served as the inspiration for the design challenge, as well as a bilingual activity guide for parents and materials for families to explore and develop design solutions. For example, the *Pollitos* activity

Figure 2. Photo of the *Pollitos* family engineering activity from the *Ready, Set, Go! Engineering* project.

challenged families to use colorful wooden blocks to build a structure that would keep a hen and her family of baby chicks safe and cozy (Figure 2). In this case, the activity was inspired by a traditional children's song, *Los Pollitos Dicen*, which is popular in many Spanish-speaking countries.

What We Learned

"Hay un dicho que se dice en México: Tu eres ingeniero en tu propia vida. Mucha gente lo dice... Pero ahora digo, 'Oh, es verdad.' Ingeniería es estable diario con nosotros... ya cuando empezamos haciendo las actividades de los programas, decíamos que ingeniería está aquí y lo vemos, pero no sabemos." [There's a saying in Mexico: You're the engineer in your own life. A lot of people say it.... But now, I say, 'Oh, it's true.' Engineering is a daily constant for us. When we started the program activities, we said that engineering is here and we see it, but we didn't realize it before.]

The collaborative research with families not only helped us develop an engaging set of engineering activities, but it also revealed deep insights about the unique ways that young children and their families engage with engineering.

1. Young children with the support of their families are capable of rich engagement with engineering design practices.

The study added to the growing evidence that preschool-age children are capable of engaging deeply with engineering and practicing all aspects of the engineering design process (Cardella et al., 2021; NASEM, 2021). We observed children and families thinking deeply about the nature of the design challenge, exploring the constraints and affordances of the materials, brainstorming and planning their designs, building and testing solutions, and making revisions based on what they learned. We observed the important ways that parents and other family members supported children's engagement, including helping to frame the challenge, adapting the activity to the specific needs and abilities of their children, and collaborating in the design and testing process. From families, we also learned about the many ways these engineering experiences can support other family goals, such as helping children practice multiple languages, managing frustration, or creating opportunities for families to spend quality time together.

2. Young children and families use story, narrative, and imagination to bring their engineering experiences to life.

All the engineering activities in the project were based on stories and included materials to help enrich the narrative context, such as stuffed animals. What we learned from the study is that these narratives, combined with children's natural imagination, were essential to how families engaged with the engineering. The books were treasured elements of the activity kits, creating a launching point as families used the narratives, characters, and materials to set the context for the design challenges. For example, with the *Pollitos* activity, many families spent time playfully engaging with the baby chickens and singing the song before building. Families also used the stories and narratives to motivate user-centered design, such as thinking about how to build a structure to keep the baby chickens safe and adding other design elements (windows, kitchen, bed) that the babies needed to be cozy. Stretching the boundaries of traditional engineering education, children and families also used their stories and imagination to creatively modify the original design challenges—like deciding that the chickens were really princes and princesses and what they needed was a towering castle to protect them from monsters. This not only helped connect the activities to children's existing interests but often motivated ongoing design and revision well beyond the original challenges.

3. Young children and families are flexible in how they use engineering.

The engineering design process is often portrayed as linear and rigid. But professional engineers do not follow the same steps or use those steps in the same order every time (NAE & NRC, 2009). And the same is true for families. Sometimes families began by talking about the design challenge and brainstorming possible solutions. But just as often, they would jump right into building and testing, fleshing out the challenge as they went. In many cases, thinking about the engineering problem and planning their design was interwoven throughout their process of exploring, building, and testing. Sometimes families only engaged in a few aspects of the engineering design process during a particular interaction, like focusing on materials exploration or testing different structures without talking about the original challenge. Similarly, families naturally blended science inquiry and engineering design during the activities. For example, families often spent time exploring the properties of the materials, like how the blocks stacked together, before they got deeper into the design challenge. In almost every case, this flexibility seemed to be an important and natural way for young children and their families to engage with engineering.

Recommendations for Educators

We know that young children are capable of engaging deeply with engineering from an early age. Not only that, but the ways they engage with engineering design activities are often unique, surprising, and inspiring. Given what we've learned from families during this project, here are some ideas for educators to keep in mind when integrating engineering into their work with young children and families:

- ***Start with a book, story, or song.*** These are great sources of inspiration for engineering design challenges and great ways to set the context for an engineering activity.
- ***Add a design challenge to an inquiry activity.*** If there is a science inquiry activity that children and families already enjoy, try adding an engineering design challenge to build on children's natural inclination to both explore

and create. This might be as simple as a question: "Can you build a home with these blocks to keep the animals safe and cozy?" or "Plan a taco party for your friends and family. How will you arrange the plates and food for your guests?"

- ***Use stuffed animals and other characters.*** Young children love stuffed animals and other character toys, like dolls or wind-up figurines. We've found these can be powerful motivators for user-centered design and help children and families use their imagination to continuously expand on their original creations.
- ***Carefully choose materials.*** It's important to think about how materials will work with young fingers and how those materials align with the engineering design challenge so that children can take the lead in building and testing and families can find many different solutions to the same challenge.
- ***Follow the lead of children and families.*** As you try out new engineering activities, see what children and families are interested in and let this be your primary guide to creating rich, rewarding engineering learning experiences.
- ***Don't feel pressure to do it all.*** Start by trying a small engineering addition to an activity or focusing on one or two aspects of the engineering design process.

Most importantly, enjoy learning about engineering with families!

Additional Resources

Ready, Set, Go! Engineering project website (https://www.terc.edu/familystem/ready-set-go-engineering/)

Head Start on Engineering project website (https://www.terc.edu/hse/)

More ideas for incorporating engineering into early childhood programs (https://shorturl.at/bcqyA)

The way families naturally use materials can provide inspiration for new engineering design activities.

Acknowledgements

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Making an Impact

with TERC's Open-Access MPACT (Math and Computational Thinking Through 3D Making) **Curriculum**

ELISE LEVIN-GÜRACAR
JENNIFER KNUDSEN

"MPACT [Math and Computational Thinking Through 3D Making] prepares kids for the future in every way because they're working with each other, learning how to work as a team, talking through their reasoning," *explains Krysta Bradley, a co-design teacher on MPACT, about the curriculum she helped create.*

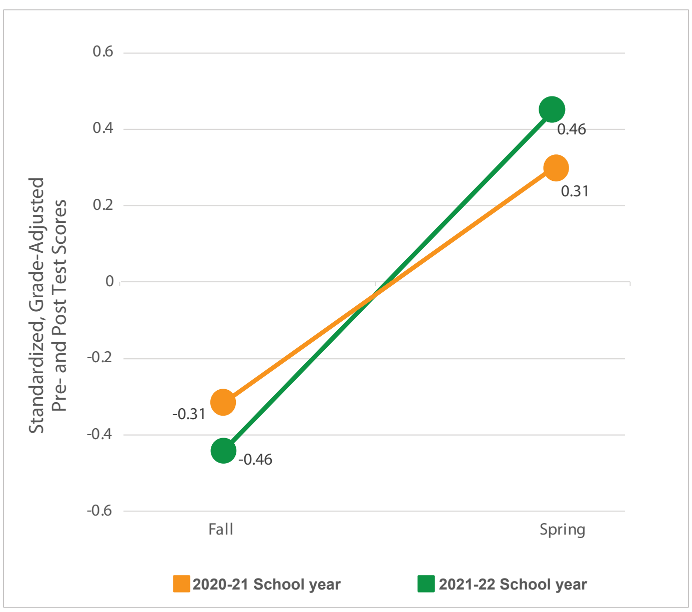
MPACT

Math and Computational Thinking Through 3D Making

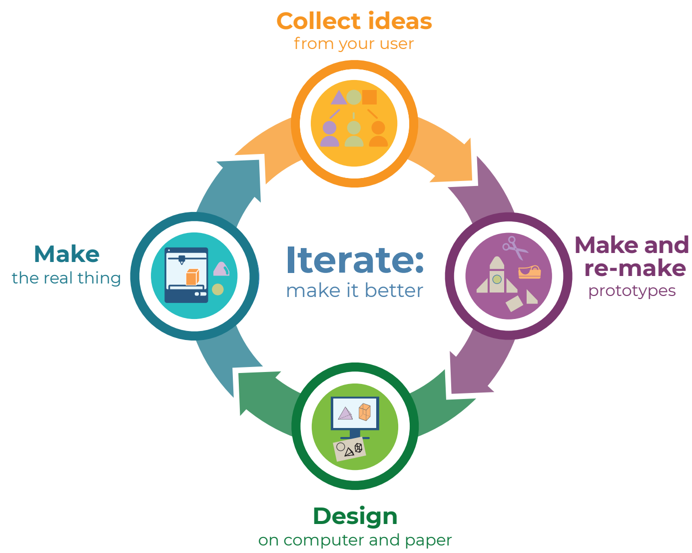
Developed at TERC through an Education Innovation and Research program grant from the U.S. Department of Education, MPACT offers a hands-on, engaging, and fun way for students to learn math, computational thinking, and spatial reasoning concepts, coupled with maker skills. TERC team members recognized the potential for learning mathematics in students' drawing, modeling, and making real 3D objects—particularly 3D geometry and measurement. They saw that computational thinking and spatial reasoning have many overlaps with mathematics, with opportunities for learning through 3D modeling, especially for 3D printing.

MPACT's Units

MPACT's resulting four design-and-making units for Grades 4–7 were independently evaluated by SRI International. An assessment of content knowledge demonstrated statistically significant gains for students (Gagnon et al., 2023), as shown in the figure below.



Each grade level includes three modules, with mini-maker experiences in Modules 1 and 2 to prepare students for a unique culminating project in Module 3.



Students move through the design cycle (shown above) in each of the modules. For example, in Module 3 of the Grade 5 curriculum, students make a toy with wheels for a younger child. In doing so, they:

1. Learn about the needs of their user
2. Create prototypes with scrap paper and tape
3. Design wheels in Tinkercad™ (3D modeling program) and 3D print them
4. Make the rest of the toy with inexpensive or upcycled materials

Then they give the toy to the younger child and see if it's a fun toy to play with!

MPACT's Audience

Co-designed by elementary and middle school teachers, and piloted and refined with their feedback, MPACT has been used by general classroom teachers, math teachers, and STEM/STEAM (Science, Technology, Engineering, [Arts], and Math) teachers. While most teachers have used the curriculum during the school day, it has also been implemented in afterschool programming. One teacher, who used MPACT for an afterschool 3D-printing club for 4th through 6th graders, reported that it was "very successful." MPACT units can be used as challenge problems outside of the grade level for which they were designed or as a way to reinforce concepts students may have learned previously.

	4TH GRADE	5TH GRADE	6TH GRADE	7TH GRADE
Math Content	Symmetry and angle measurement	Volume and linear measurement	Volume, surface area, and linear measurement	Probability and scale drawings
Module 1	Make a Bookmark	Make a Bookmark	Make a Bookmark	Make a Bookmark
Module 2	Make a Kite from a Single Piece of Paper	Make a Soma Cube Puzzle	Make a Soma Cube Puzzle and a Box to Keep It In	Make Dice for the Sighted and the Blind
Module 3	Make a Stamp to Print With	Make a Toy on Wheels for a Younger Child	Make a Mobile for a Community Center	Modify a Game to be Played by the Sighted and the Blind

MPACT's progression of lessons by grade level.

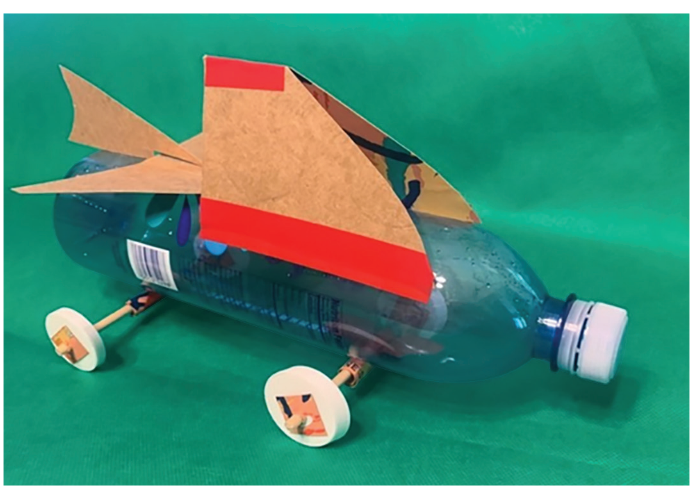
What Makes MPACT Distinctive

"I find that [MPACT] helps me incorporate the computer science standards and the twenty-first century skills that we're trying to teach our students—you know, the 4 'C's' (collaborating, creating, critical thinking, and creativity)—all those things that we want our students doing. I'm all about integrating as much as I can into my units. And this program does that. They are talking, they are listening, they are speaking, they are reading. So it's a unit where you can hit multiple standards. ***And the kids love it."***

–MPACT TEACHER

MPACT units offer a great deal of flexibility in terms of how much time they might require, whether they are high- or low-tech, and the concepts on which a teacher might want to focus. The projects also incorporate social–emotional principles, including empathy, in designing for particular populations (such as a younger child when making a toy, or the visually impaired when designing dice). Importantly, MPACT's focus on spatial reasoning supports students in learning a skill not often taught. Krysta Bradley notes, "I learned through MPACT that it [spatial reasoning] is something that can be taught. And my students come to me struggling with it. So, it was one way for me to help them overcome that barrier in mathematics."

Student projects for Grade 5 Module 3: Make a toy on wheels for a younger child.



Students working on Grade 7 Module 3: Modify a Game to be Played by the Sighted and the Blind.

Research shows that the ability to reason spatially is not a fixed characteristic of individuals: spatial skills can be learned (Uttal & Cohen, 2012). MPACT supports development of spatial reasoning throughout the modules, by presenting students with spatial-reasoning problems. For example, in the Grade 5 unit on making a cube puzzle with seven unique pieces (Soma cube puzzle), students are challenged to put together a prototype of the puzzle using linking cubes, and then to design the pieces in a student-friendly 3D digital design tool (Tinkercad), in order to 3D print them. In doing so, students transition from *physically* rotating the pieces to using *mental* rotation—one of the key skills needed for success in many STEM fields.

Spatial reasoning is also key in the learning progression that MPACT uses to help students develop a rich understanding of measurement of 3D space—volume. Students' first understandings about volume typically develop in early childhood (Piaget & Inhelder, 1974). By 4th grade, they are typically measuring volume with units such as cups, pints, and liters—units they can count (or consider fractions of). Then, often in 5th grade, they are asked to measure the volume of rectangular prisms based on three linear measures—height, width, and length.

MPACT follows a well-researched learning progression for developing a deeper understanding of the formula for volume in terms of those three measures (Battista, 2007). But MPACT adds to that learning progression with guidance for using the 3D digital modeling tool to create and manipulate shapes composed of configurations of unit cubes, complementing the traditional learning progression, which uses physical blocks alone.

MPACT Materials Available Now

MPACT materials launched August 10, 2023, at a release party. (Watch clips here.)

All units—including teacher notes, student work pages, and presentation slides—are now available for download and adaptation, with a Creative Commons license. This open license means anyone is free to share, improve, and build upon the lessons. MPACT developers would love to hear how users make these lessons their own. Feel free to share your experiences or edited lessons with them at mpact_info@terc.edu.

The MPACT website (https://www.terc.edu/mpact3d/) also contains resources for teaching the units, including 3D making tutorials and activities, and low-tech modules that do not require use of a 3D printer.

The MPACT team can provide professional learning experiences remotely or in person. For further details, contact the team at mpact_info@terc.edu.

Authors

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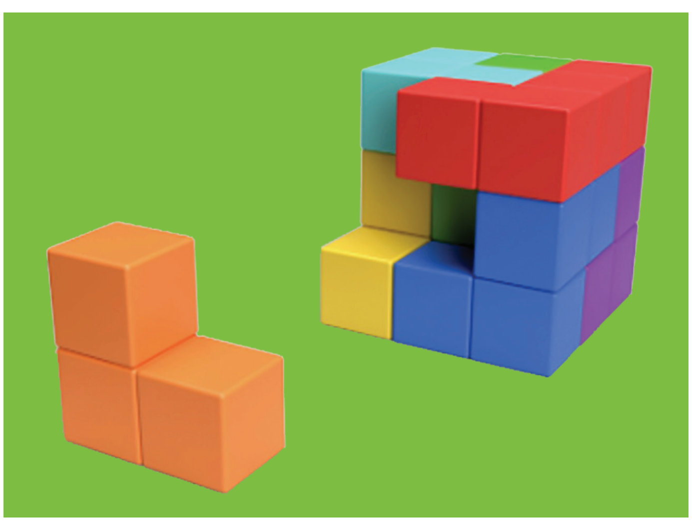
Elise Levin-Güracar is a math educator and researcher at TERC. She is MPACT's teacher liaison and social media lead. She studied education, public policy, and sociology at the University of California at Berkeley, and received her secondary math teaching credential after student teaching with a 7th-grade class. She continues to teach math to third- through eleventh-graders. As a maker, she enjoys gardening, playing with acrylic paint, and learning new crafts (most recently ceramics and water marbling).



This cube puzzle can help students gain spatial reasoning skills.

Jennifer Knudsen (Ms./she/her)
TERC MPACT director Jennifer Knudsen is an educator whose experience is at the intersection of research and design. She has led the development of ground-breaking project- and problem-based middle-school mathematics and interdisciplinary curricula, often with integrated technology. As the principal investigator of a series of design-and-research projects with innovative professional learning models, she has experimented with improvisational games for setting mathematical norms. As a mathematics and computer-science teacher in New York City Public Schools, she brought activities from gifted-and-talented programs to students in "remedial" classes and wrote a problem-solving curriculum for aspiring engineers. Each of these projects focused on educational equity for youth from marginalized communities. Knudsen learned to love mathematics at Evergreen State College, where she received an interdisciplinary BA degree. Her focus as a maker is on arts and crafts—watercolor, collage, and, recently, slow stitching.

The contents of the MPACT curriculum were developed under a grant from the Department of Education. However, those contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

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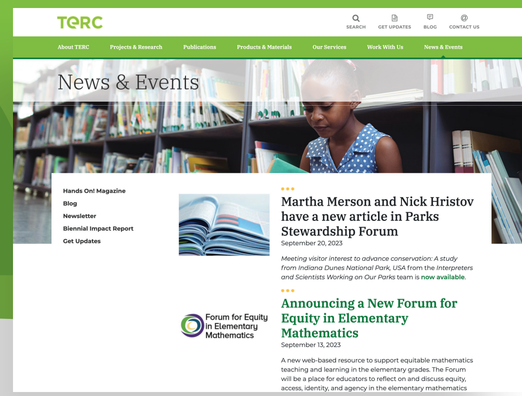
What's New at TERC.edu?



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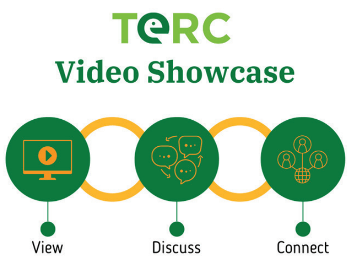
terc.edu/news-events

TERC Interactive Video Showcase



The TERC Video Showcase is an 8-day interactive event for visitors and TERC staff to engage with each other around the innovative ideas presented in project-produced short videos aimed at enhancing science, technology, engineering, mathematics, and CS education for all learners.

Taking place November 14-21, 2023, educators, researchers, parents, and funders are invited to view the video presentations and interact with the presenters and other visitors by posting comments, queries, and ideas.

This collection of video narratives will become a part of the TERC Video Library which will be publicly available year-round.

Open Innovation Challenge to Mitigate Global Warming

Gillian M. Puttick, Brian Drayton, and Santiago Gasca, *Connected Science Learning, 5*(5). September–October 2023

https://tinyurl.com/2tj3r6zp.

Read the *Innovate to Mitigate* team's newest article in which the challenge environment's novel features are expanded with findings from interviews of students and teachers in Florida, Maryland, and Ohio.

EarthMovieTheater.org release Windows on Earth the Movie

https://tinyurl.com/2p8e37v9

The Association of Space Explorers (ASE) and TERC present "Windows on Earth – the Movie" on EarthMovieTheater.org. This 48-minute film features stunning astronaut photography of Earth accompanied by the ethereal music of Steve Thomas. It offers a unique perspective of our planet through the astronaut's lens and the musician's ear.

Michael Cassidy, Senior Researcher at TERC, recently enlightened PBS Kids about the significance of computational thinking

Michael Cassidy, Senior Researcher, *8 Fun Ways to Help Kids Learn Patterns*, PBS Kids Newsletter. June 2023.

https://tinyurl.com/3zxc4rpu

Computational thinking problem-solving skills include breaking down big problems into small parts that are easier to solve, paying attention to important details, designing solutions to problems, and working with patterns. Cassidy describes how these skills can be adapted and applied to learning and activities.

Martha Merson and Nick Hristov have a new article in Parks Stewardship Forum

Martha Merson, Leila Valoura, Brian E. Forist, Nickolay I. Hristov, Louise C. Allen. Meeting visitor interest to advance conservation: A study from Indiana Dunes National Park, USA. *Parks Stewardship Forum 39* (3). Sept. 2023

https://tinyurl.com/uk4uf356

Though interpretive rangers plan programs and talking points with care, they have few opportunities to learn which messages stay with their audience as detailed memories.

Open-ended telephone interviews conducted months after a ranger-led hike to a prominent dune in Indiana Dunes National Park illustrate the extent to which visitors' recollections show continuity with their reasons for attending the ranger-led hike and their uptake of resource message.

Listen to the episode of the Assembling Inclusion Podcast where they chat with Jodi Asbell-Clarke of TERC about her groundbreaking INFACT project.

https://tinyurl.com/4twcs23z

In this episode of *Assembling Inclusion*, Katie Nieves Licwinko talks to Jodi Asbell-Clarke from TERC about the INFACT project, which has developed an inclusive program to teach computational thinking skills in grades 3-8 by embedding supports and multiple modalities, so all students can find success. They also talk about neurodiversity in STEM and education.

CALM: The Way Math Should Be, the new article from Heidi Schuler-Jones, Adult Numeracy Center Director

Heidi Schuler-Jones, *Progresso Vol 33*, No. 2. (2023)

https://tinyurl.com/32ve5e8r

Many adult education teachers learn quickly that they don't choose our environment. They teach whatever is needed to whomever shows up at whatever level they are that day using whatever patchwork of materials are available in the shared classroom space. *CALM: The Way Math Should Be* discusses the challenges of adult mathematics education and offers a comprehensive math curriculum that can help.

Family Voices: Learning from Families with Preschool-Age Children from Historically Marginalized Communities to Expand our Vision of Engineering

Scott Pattison, Smirla Ramos-Montañez, Gina Svarovsky, 2023 American Society for Engineering Education Annual Conference. Baltimore, MD

https://tinyurl.com/4a4s36wd

As part of the ongoing Head Start on Engineering project, the team developed and analyzed case studies of seven families who had participated in the family-based engineering program during the 2020–21 school year. Their analysis highlighted several themes related to the ways families came to understand engineering through the program and how they connected this understanding to their own interests, beliefs, and values: (a) everyday problem solving, (b) family relationship building, (c) child skill development, and (d) pathways to equity.

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Announcing a New Forum for Equity in Elementary Mathematics

Forum for Equity in Elementary Mathematics

- **A new web-based resource to support equitable mathematics teaching and learning in the elementary grades.**
- **A place for educators to reflect on and discuss equity, access, identity, and agency in the elementary mathematics classroom.**

terc.edu/mathequityforum

Find equity-related resources, publications, and professional learning opportunities to broaden and deepen perspectives and to open up discussions among educators as they seriously and passionately pursue equity in mathematics learning for elementary students.

Use *A Framework for Reflecting about Equity in the Elementary Mathematics Classroom* to help structure discussions about factors that either support students to develop strong mathematics identities or perpetuate assumptions about who can and can't do mathematics.