TERC
Because math and science build futures

Engineering for Equity

Exploring the intersection of engineering education, family learning, early childhood, and equity

Scott Pattison & Smirla Ramos Montañez
With contributions from Gina Svarovsky & Shauna Tominey

BOOK

The *Engineering for Equity* eBook is based on a blog series developed by Scott Pattison and Smirla Ramos Montañez.

Read more at https://blog.terc.edu/engineering-for-equity

Photos on pages 6, 9, 10, 21, 33 © Emily Maletz 2017

This material is based upon work supported by the National Science Foundation under Grant Numbers 1906409, 1930848, and 2115463. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Recommended citation: Pattison, S., Ramos Montañez, S., Svarovsky, G., & Tominey, S. (2022). *Engineering for equity: Exploring the intersection of engineering education, family learning, early childhood, and equity*. https://blog.terc.edu/engineering-for-equity

Because Math and Science Build Futures

TERC is a Cambridge, MA based nonprofit made up of teams of forward-thinking STEM experts dedicated to innovation and creative problem solving. TERC believes great futures are built through math and science.

For more than 50 years, TERC has taken a learner-centered approach to education in both formal and informal settings. At the frontier of theory and practice, TERC's work encompasses research, content and curriculum development, technology innovation, professional development, and program evaluation. Through TERC's curricula and programs, students develop the knowledge and skills needed to ask questions, solve problems, and expand their opportunities. TERC's professional development helps teachers and facilitators utilize new tools, materials, and inquiry-based strategies to enrich the learners' experience.

With a passion for social justice, TERC strives to create level playing fields for all learners, reaching more than three million students each year. TERC imagines a future where teachers and students are members of vibrant communities engaged in creative, rigorous, and reflective inquiry.

To learn more, please visit www.terc.edu.

Table of Contents

Introduction

Scott Pattison, Smirla Ramos Montañez

> ***Re-imagining engineering education from an asset-based approach has a strong propensity to develop a knowledgeable citizenry who understands the importance and value of our human constructed world, while validating and acknowledging the contributions of people of color and minoritized groups to engineering. As a field dominated by hegemonic practices and norms, engineering is a field that greatly needs critical perspectives that could help deconstruct dominant discourses.***
> ***(Mejia et al., 2018, p. 9).***

For decades, scholars across a variety of fields have been calling for a re-examination of the ways that we address inequities in science, technology, engineering, and mathematics (STEM) education (Ladson-Billings & Tate, 1995; National Research Council, 2009; Schenkel & Calabrese Barton, 2020; Varelas et al., 2015; Vossoughi et al., 2016). With the explosion of the #BLM movement in the US, the stark realities of American politics and culture wars, the challenges faced by children and families during the COVID-19 pandemic, and other events of the last several years, these ideas about equity are starting to receive the attention they deserve. They are not new ideas. Many researchers and educators, and especially scholars of color, have been highlighting systems of inequity and championing alternative approaches for decades. But at last there seems to be some traction, with more individuals in positions of power and privilege taking notice.

Like many researchers in the field of STEM education, we have worked with so-called "undeserved" and "underrepresented" communities for many years. In our case, primarily low-income and Latinx families through our partnerships with Head Start and other community organizations. And like many researchers, we have used what we now acknowledge are relatively superficial approaches to addressing issues of inequity in STEM education— "targeting" marginalized communities, identifying problems of representation, attempting to increase access,

making our research "culturally relevant." In retrospect, much of this work likely sustained the systems of inequity that we hoped to address. And by in large, the outcomes and findings benefited us as researchers and academics, rather than the communities we intended to serve.

Thanks to funding and support from TERC and the National Science Foundation, over the last year we have been able to take a few hours each week to step back from our current work, reflect on our assumptions, learn from others, and explore new ways that our research could both uncover and help dismantle inequities and racism in the STEM education system. We spent this time talking to families and leaders in our community, interviewing experts on the intersection of equity and STEM education across the country, and reading reports and literature. Throughout the process, we received guidance and feedback from a group of scholars who were generous enough to serve as critical friends: Christopher Wright, Drexel University; Nelda Reyes, AB Cultural Drivers; Maria Olivares, Boston University; and Christine Cunningham, Penn State University. In addition, our longtime collaborator from the University of Notre Dame, Gina Svarovsky, served dual roles both as critical friend and project thought partner.

This eBook, and the series of blog posts on which it is based, is the result of these conversations and this reflective process. Our goal is to explore the themes and ideas that emerged from the year and how these might fundamentally change the way we think about STEM, work with families and children, and conduct research. We also hope this resource will serve as a catalyst for ongoing discussions within and beyond the STEM education research community.

Our work is situated at the intersection of engineering education, family learning, early childhood, and equity. As informal STEM learning researchers, we focus on studying and supporting ways that young children and their families engage with and develop long-term interests in engineering and other STEM topics through everyday learning experiences outside of school, including how these experiences are connected across contexts and over time (Cardella, 2020; Pattison, Callanan, et al., 2020; Pattison, Gontan, et al., 2020; Pattison, Svarovsky, et al., 2020; Pattison & Svarovsky, 2021). As our ideas about equity have evolved, we have increasingly focused on centering families within our work, developing long-term,

reciprocal relationships with communities and organizations, building on family assets rather than focusing on deficits and challenges, and moving beyond the traditional ideas of access to instead focus on understanding and helping disrupt the deeper systems of inequity within our society (Bang et al., 2016; Bevan et al., 2018; Calabrese Barton & Tan, 2020; Ladson-Billings, 2006; Tolbert et al., 2018; Yosso, 2005).

While our reflections focus on engineering education and our work with families, we believe the themes that emerged for us over the last year have implications across STEM domains and learning contexts. In the following chapters of this eBook, we reflect on a variety of topics, including approaches to collaborating with families, asset-based perspectives on STEM education, and equity-based strategies for engaging families with engineering. We hope that these reflections provide useful insights for other teams and help raise the visibility of these larger conversations about equity across the field of STEM education.

Family Collaboration

Scott Pattison, Smirla Ramos Montañez

> ***Nosotros venimos de muchos lugares diferentes y siempre logramos adaptarnos. No nos limitamos, siempre pensamos en lo que podemos hacer. Aunque tengamos poco, siempre lo compartimos y envolvemos y ayudamos a otras personas. Relacionado al aprendizaje, los padres latinos valoran el aprendizaje y le gusta que sus niños aprendan más de lo que ellos han aprendido—que lleguen mas lejos que lo que hemos podido hacer.*** [We come from many different places, and we always manage to adapt. We don't limit ourselves. We always think about what we can do. Although we might not have much, we share what we have, involve ourselves, and help others. Related to learning, Latino parents value learning and want their children to learn more than they have—to go farther than we have been able to go.]
>
> ***— program participant***

Rethinking Our Approach to Collaborating with Families to Study and Support Engineering Learning

To begin, we reflect on how our conversations and readings have made us rethink assumptions about families, our approaches to family research, and the ways we support engineering learning for both children and parents. As we have discussed elsewhere, this focus is particularly relevant during the global health pandemic, when educators have been forced to seriously consider the important role of family learning at home.

Reviewing the literature on family learning and equity is a stark reminder of how plagued the STEM education field is by outdated models, perspectives, and assumptions about family learning and parent engagement. It's also a reminder of how personal these topics are—how our own cultural experiences related to families and child development are deeply imbedded in our assumptions and perspectives as researchers and educators. Perhaps it's precisely because of the deeply personal nature of these experiences and perspectives that it's harder for us to challenge traditional approaches and ways of thinking.

With the history of STEM education research primarily conducted through the lens of schooling, families have often been seen an afterthought—or worse, an impediment to children's education. Learning and education are assumed to primarily occur at school, with family interactions and goals seen as secondary or irrelevant. Parents,

and especially those from traditionally marginalized communities like the Latinx and Hispanic families we work with, are often assumed to be disengaged from the children's education or ineffective in supporting learning (Ladson-Billings, 2007; McWayne et al., 2013). This is especially true for so called "parent engagement" efforts, which often focuses on meetings scheduled at the school without regard to barriers families face to attending these events (Ladson-Billings, 2021; McWayne et al., 2021; Quintos et al., 2019). Parents that don't attend are assumed to not care deeply enough or to be "uninvolved" in their children's education (Coba-Rodriguez et al., 2020; Huguley et al., 2021). Similarly, in research studies, parents are usually positioned as informants for understanding children's learning, rather than collaborators, learners, and educators in their own right (Civil et al., 2005; Quintos et al., 2019). Even the idea of the family is often defined narrowly, with a primary focus on the biological parents or the mother-child dyad, disregarding the diversity of family configurations and the variety of adults, siblings, relatives, and friends that play a fundamental role in children's lives (NASEM, 2016).

Perhaps even more pernicious are the assumptions about the "right way" to be a parent (Callanan et al., 2020; Wang et al., 2021). In early childhood research and education especially, there is an assumption

that all learning needs to be child led, guided by open-ended questions, and focused on skills and knowledge valued within a school setting. This is especially true in the preschool years, when so many efforts are dedicated to "kindergarten readiness." And since much of education and child development research has been conducted with White, middle- or upper-class children where these ideas are part of the cultural paradigm of child rearing, this focus has been largely affirmed. And yet, broader developmental and cross-cultural studies have repeatedly shown that there are many effective approaches to parenting and supporting child development across cultures and around the world (Alcalá et al., 2018; Arauz et al., 2019; Cho et al., 2021; Gaskins, 2008; McWayne, Foster, et al., 2018; Rogoff, 2003, 2014). For example, while White middle-class parents from Western countries often focus on child-centered or didactic approaches to teaching and learning, other cultures create opportunities for children to be authentically

engaged in adult-oriented activities as they develop their skills and a sense of their place in the community (Arauz et al., 2019; Rogoff, 2014; Rogoff et al., 2003).

In our experience, parents and primary caregivers, and especially those from traditionally marginalized communities, face the consequences of these stereotypes and assumptions every day. In a recent interview with a parent participating in one of our studies on family engagement with engineering activities, the mother, who identifies as African American, admitted that as a parent she "feels so judged." Despite her deep commitment to her child's learning and development, she lives under the constant burden of others assuming she is a bad parent, doesn't facilitate her child's learning in the right way, or is not as involved as she should be with her children. In another interview with a Spanish-speaking mother, the woman shared her experiences picking up her child from kindergarten for his therapy appointments. She said she was repeatedly questioned about taking her child out of school, with the implication that she was making poor decisions as a parent or didn't care enough about his education to understand what was good for him. For her, school was a place of hostile judgment and criticism. Added to this were the language and cultural barriers, since her primary language is Spanish and none of the front-desk staff members were bilingual (see also Ansari et al., 2020).

Although it was sobering to reflect on how widespread these ideas about families and parents continue to be, we were encouraged in our conversations and readings by the more expansive views that exist or are emerging. A growing body of research is highlighting family-based experiences outside of school as not just important but as a primary learning context for young children (Dou et al., 2019; NASEM, 2016; NRC, 2009). Many researchers and educators are beginning to adopt a broader perspective on who counts as family, parent, or caregiver (Herron & Jamieson, 2020; Walsh, 2003). Others are exploring new ways to collaborate with parents and other family members in research and education projects, such as positioning parents as primary stakeholders or working to balance the power hierarchies between school and home (Ladson-Billings, 2021; McWayne et al., 2021; Quintos et al., 2019). And a few scholars are beginning to question the cultural assumptions

about parenting and child rearing underlying the vast majority of education and child development research (Alcalá et al., 2018; Solis & Callanan, 2016; Wang et al., 2021).

Implications for Engineering Education

Although these ideas about families are not specific to engineering or STEM, we believe they have profound implications for how we think about and conduct our work as engineering educators and researchers. And this in turn is critical for supporting a more equitable vision of engineering education. These ideas have received new attention recently in scholarship connecting engineering and equity (Ata-Aktürk & Demircan, 2020; McWayne et al., 2018; Pattison et al., 2020). To organize our own thinking, we have begun to consider how these new perspectives on families impact the way we think about three aspects of our work:

(a) Where engineering learning and engagement happen,

(b) What we mean by engineering, and

(c) How we work with families to support this learning and engagement.

Where do engineering learning and engagement happen?

Once we take seriously the role of families in children's education and learning, it quickly becomes clear that engineering and STEM learning more broadly are already happening every day in children's homes and in their interactions with parents and other family members. Instead of asking "how we can get families engaged with STEM," we begin with the question: "How are families already engaged?" (See Mejia et al., 2018; Vossoughi et al., 2016.)

> *With my other children, I would just let them play. But these activities let me participate. Playing with him, I can see the strategies he's using, his strengths and weaknesses. The activities also bring out his imagination … I've learned to participate with him, and to see his strengths and weaknesses.*
>
> *— program participant*

Decades of research have documented the rich ways that families engage with science and mathematics at home and in other informal learning settings (Callanan et al., 2013; Marin & Bang, 2018; NRC, 2009; Pattison et al., 2017; Silander et al., 2018; Strickler-Eppard et al., 2019). Emerging research is also describing how families engage with engineering in a variety of ways. For example, researchers have documented how young children's play with simple materials like blocks creates opportunities for engaging with

the engineering design process and using engineering thinking skills (Gold et al., 2020; Schmitt et al., 2018). In our work, we have seen that as families develop a broader sense of what engineering is—more than building bridges but a process for solving problems—they begin to connect it with many of the things they are doing every day, from fixing a broken piece of furniture to planning the morning routine for getting their children to school (Pattison et al., 2020). For example, one parent shared this in a recent conversation::

> *I never thought about it, being an engineer, solving little problems like that. That's just what you do every day. Just what you have to do to solve the problem. But I guess that's engineering.*
>
> *— program participant*

Not only are children and their families engaging with engineering at home, but they have a wealth of existing knowledge and expertise to bring to these experiences (Calabrese Barton et al., 2021; Mejia et al., 2018; Rosebery et al., 2016; Wilson-Lopez et al., 2016; Yosso, 2005). As we discuss more in our future reflections on asset-based perspectives on engineering learning, this may be especially true for low-income families and the Latinx and Hispanic communities we work with through the *Head Start on Engineering* project. For these families, resourcefulness and everyday problem-solving are an essential part of life and a valued skill they hope to share with their children.

What do we mean by engineering?

Acknowledging that families already engage in engineering at home using their own engineering-related knowledge and experience forces us to rethink what we mean by engineering—and perhaps more importantly, who decides what counts as engineering and what does not (Mejia et al., 2018; Philip et al., 2018, p. 2018; Tan et al., 2018). As many scholars have argued, although the process of engineering is deeply rooted in the resourceful creativity, problem-solving, and inventiveness practiced by humans across time and cultures, the modern concept of engineering has largely been co-opted as the field became codified through professional organizations and university training programs (McGowan & Bell, 2020). This modern conceptualization has propagated a relatively narrow understanding of engineering and its role in society, ignoring the existing engineering knowledge and skills within communities outside the academic sphere and whitewashing the troubled history of the field in supporting the exploitation and repression of marginalized communities (Holly, 2020; Mejia et al., 2018; Vossoughi et al., 2016). And although calls have been made to shift how engineering is described (e.g., NAE,

2008), the fundamental ideas of the discipline have been transferred with very little critique to the broader K-12 education system (Cunningham & Lachapelle, 2014; McGowan & Bell, 2020).

If these ideas are problematic yet so pervasive, what are alternative approaches to defining engineering? This is a challenging topic that we will take up in more detail in a later chapter. But our recognition that families already practice engineering in their daily lives provides some insights. For most families that we have worked with, parents and caregivers begin with a relatively narrow definition of the word "engineering," often focusing on the physical creations that some engineers build (e.g., bridges) or the skills that they see as being required to become an engineer (e.g., math). However, after learning more about the engineering design process and seeing a variety of examples of engineering in different contexts, many families come to develop a broad and empowering understanding of engineering—a problem-solving process that we all use every day to overcome challenges, big or small. Many parents and caregivers also come to identify engineering as synonymous with the problem-solving skills they are helping their children develop and that they see as critical for their children's success.

How do we work with families to support engineering learning and engagement?

Recognizing that families already practice engineering and that these everyday engineering processes provide new insights into how we conceptualize the discipline leads us finally to think about the ways we work with families through our engineering education studies and programs. Again, the history of this relationship in engineering and STEM education research is fraught (Bevan et al., 2018; McGowan & Bell, 2020; Vossoughi et al., 2016). Even efforts that are ostensibly aimed at supporting equity often focus on surface-level goals, such as providing more access to existing programs and resources, rather than fundamentally rethinking the roles and relationships within the STEM education systems (Bevan et al., 2018; McGowan & Bell, 2020; Mejia et al., 2018; Philip et al., 2018).

One of the hardest truths for us as researchers to accept, we believe, is the immense amount of power and privilege many of us carry relative to the communities and families we work with (Garibay et al., 2017; Ladson-Billings & Tate, 1995; Tolbert et al., 2018). But if we acknowledge the ways that families are already engaging in STEM at home and the deep expertise and knowledge families bring to these experiences, then we must also accept that families are experts in their own right in the study of engineering education and learning. This acceptance leads us to a new vision in which researchers position themselves as learners and collaborators with parents (Civil et al., 2005), building long-term and reciprocal relationships with families (Tolbert et al., 2018) and using community-based and participatory approaches to research (Bang et al., 2016; Curry-Stevens et al., 2014; Holly, 2020; Meyer et al., 2021; Tolbert et al., 2018; Weiner & McDonald, 2013). As challenging as it is, we must find ways to share power when deciding what counts as engineering, what the goals of engineering education are, what the best approaches are to supporting engineering learning for families and children, and how success is measured. This also requires us to think critically about how we support the multiple roles that parents and other significant adults play in the family as learners, teachers, and advocates (Civil et al., 2005; Quintos et al., 2019) and an integral part

of the broader family system (Broderick, 1993; Pattison et al., 2020)

One inspiring example of this type of work comes from Christine McWayne at Tufts University (McWayne et al., 2013, 2018, 2020, 2021). McWayne and her colleagues argue forcefully that we must move beyond traditional assumptions about "family engagement" with schools and develop models that equalize the power dynamics between parents and teachers and acknowledge the multiple ways that parents support their children's learning (McWayne et al., 2021; McWayne et al., 2018). Through their work in partnership with Head Start, they explored opportunities such as collaborative development teams with both teachers and parents, multiple methods for parents and families to share their knowledge and experience with teachers that do not require English fluency or attending school-

based events, and opportunities for parents to connect with each other to develop community. The group argued that these strategies not only helped redefine parent engagement and school-family relationships but also supported teachers in "building culturally relevant curriculum grounded in children's everyday lives." We agree that these strategies are promising, and we see more opportunities to develop family-school partnerships that not only inform classroom curriculum but also highlight the importance of family-based learning and the critical role of parents as their children's first teacher (Bang et al., 2016).

Rethinking how we work with families has also motivated us to reflect on an even more fundamental question: Who benefits from our work? As we noted in the introduction, we believe that although our work over the last decade has been with low-income English- and Spanish-speaking communities, who have long been underrepresented in STEM education and fields, much of the direct benefits of our projects have flowed back to us as researchers—including the money we receive from our grants, the recognition that comes from publishing and dissemination, and the social and political capital we accrue through our work as professionals. Several engineering education scholars recently reflected on a similar tension after attending a professional conference where workers at the conference center were on strike (Major, 2020; Riley et al., 2020): What are "ways we, as a community, can begin to 'show up' to address systematic inequalities in our engineering education practices and participation" (Major, 2020, p. 166). We don't have a simple answer to this question, but it's an issue that we plan to center in our future work moving forward—thinking about the ways that we leverage our engineering education research to support the goals of the families we work with, elevate and empower the voices of family members, and help address fundamental systems of inequity in STEM education.

Applying Asset-based Approaches

Smirla Ramos Montañez, Scott Pattison

> ***One of the most prevalent forms of contemporary racism in US schools is deficit thinking. Deficit thinking takes the position that minority students and families are at fault for poor academic performance because: (a) students enter school without the normative cultural knowledge and skills; and (b) parents neither value nor support their child's education. (Yosso, 2005 p.75)***

Reflecting on our collaborations with families has also led us to consider the importance of rejecting deficit-based views and narratives, which permeate the US educational system, and instead embracing asset-based perspectives that value the strengths, cultures, and diversity of families. For us as engineering education researchers, we believe incorporating asset-based perspectives is critical for not only supporting the development of engineering knowledge and skills for families but ultimately working with them to expand and redefine engineering.

Recognizing and Valuing Strengths

Early in our reflective process, the use of asset-based perspectives emerged as an important and promising approach to shift diversity, equity, and inclusion efforts in STEM education (Denton et al., 2020). Asset-based approaches focus on recognizing and valuing the strengths of individuals and communities, rather than emphasizing the challenges and disadvantages that communities face engaging in White-dominant systems (Ladson-Billings, 2007). These challenges can often be so great that they make us lose sight of the resilience, strength, and resourcefulness that is present in each community. It can also lead researchers and practitioners to focus on "solutions" or ways to remediate the perceived problems rather than acknowledging and working to disrupt power structures or oppressive systems that are in place. We have been guilty of this in our work in the past and are working to shift our perspectives. For example, in the proposal development process, we often

spend considerable energy articulating the "perceived problems" (e.g., need for career pipelines and diversifying the workforce) we want to solve "for" communities through our work rather than collaborating with community members to understand their broader goals and priorities.

In our work with families in the *Head Start on Engineering* project, we have seen many examples of the assets that families bring to their engagement with engineering. For example, when we checked-in with Daniela, a parent that participated in the program a year prior to our conversation, she spoke about what they had been doing at home related to engineering. Daniela and her son wanted to create a picture board for decoration. In the middle of the project, they ran out of glue. Daniela said:

> ***Cuando se acabó el pegamento utilizamos la harina como pegamento. Me recordé cuando era niña y le enseñé como buscar opciones.*** [When we ran out of glue, I used flour to make glue. It reminded me of when I was a child, so I taught (my son) how to find other solutions.]

Rather than let this barrier or other circumstances stop them, Daniela drew from her own childhood experiences and used materials in the house to engineer a solution to the problem. Reflecting on her broader experience after the program, she added:

> ***La verdad es que no he tenido apoyo. Una vez se acabó el programa no he tenido oportunidades. Económicamente no se nos hace fáciles para hacer proyectos. Como le dije tuvimos que utilizar la harina por que no podía comprar pegamento. No quería que se me escapara ese momento y decidí hacerlo. Estoy motivada para buscar recursos y oportunidades.*** [The truth is that I haven't had much support. I haven't had many opportunities after the program ended. Things aren't easy economically, especially for doing projects like this. Like I mentioned, we had to use flour as glue because I couldn't purchase glue. I didn't want to let the moment pass, so I just decided to use the flour. I am motivated to look for new resources and opportunities.]

Throughout our conversation, Daniela seemed empowered by the recognition that she had engaged in the engineering design process. And we can only imagine how powerful this experience was for her child, who was able to experience first-hand the resiliency and ingenuity of his mother. This along with many other experiences have expanded our views of what it means for families to engage with engineering and is helping us think more deeply about how we design programs and learning experiences in collaboration with communities.

Talk the Talk and Walk the Walk

While many researchers and educators explicitly oppose deficit-based approaches and recognize the value of asset-based perspectives, one challenge is that only a few studies detail what an asset-based approach looks like, especially when we consider engagement with engineering. While there is some consensus that asset-based practices involve the value and incorporation of individuals' cultural practices (Aronson & Laughter, 2016; Darling-Hammond et al., 2020), the concept still remains abstract. For some educators and researchers, the goal of employing asset-based pedagogies might be tied to disrupting unjust educational systems while for others it is more about increasing knowledge or skills of underrepresented individuals so they can "fit better" or "assimilate" within certain disciplines. A promising tool to help us untangle these ideas is the development and application of asset-based frameworks. Many of these frameworks are grounded in Critical Race Theory (CRT) and encourage researchers and educators to recognize and value assets without judging communities against White normative standards (Ladson-Billings & Tate, 1995).

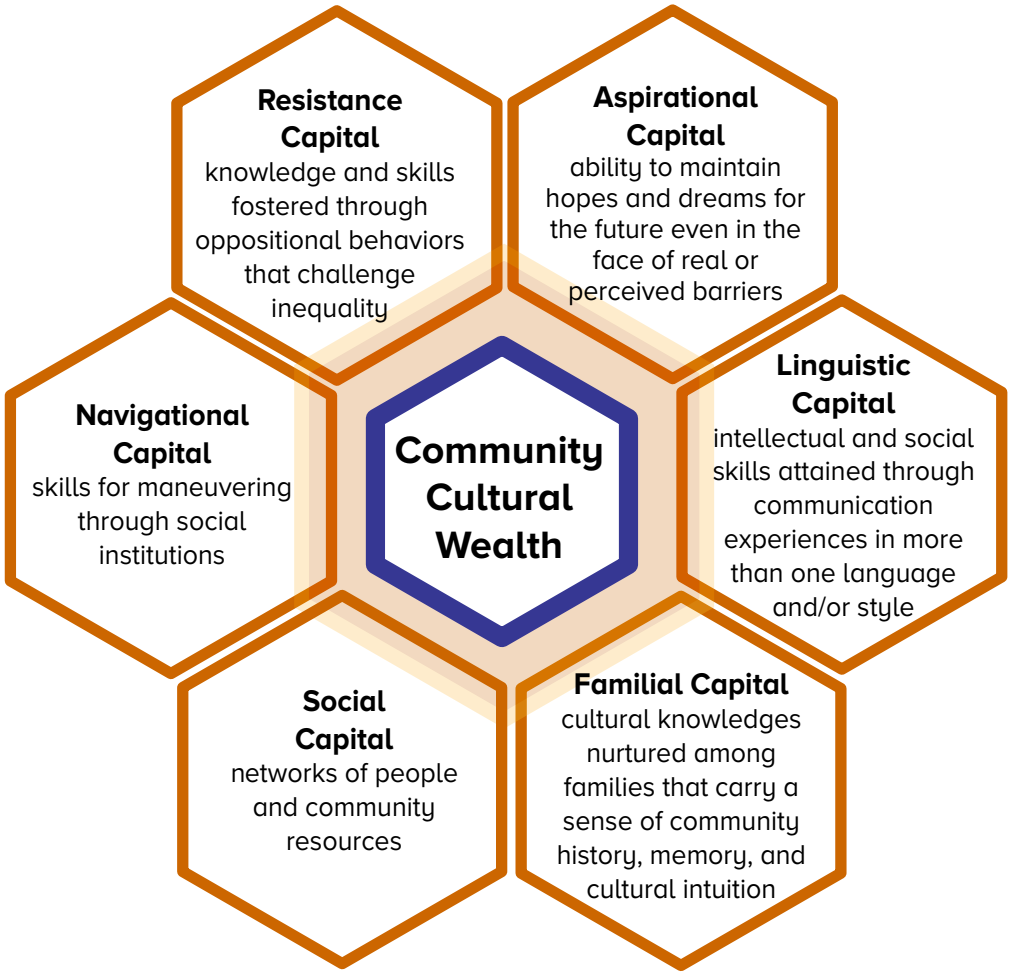
In our exploration, we came across a subset of asset-based frameworks that have been applied when exploring engagement with STEM. Among these were Funds of Knowledge (González et al., 2005), Third Space (Soja, 1996, Moje et al., 2004), Community Cultural Wealth (CCW) (Yosso, 2005), and the Family Resilience Framework (FRF) (Walsh, 2003). These frameworks have helped researchers better understand and build on participants' assets. However, many of them remain in the context of formal education, focusing primarily on developing curriculum and inclusive teaching practices.

Two Promising Frameworks for Guiding Equity Work with Families

While there is much we can learn about asset-based frameworks from formal education settings, it was important for us to consider what these frameworks and practices look like when working with families with young children in informal education spaces like the home. Two asset-based frameworks, CWW and FRF, were of particular interest to our work because they have been applied more broadly to understand family assets and how those influence STEM engagement. Furthermore, we were inspired by the goals

expressed by the scholars that developed the frameworks of "transforming education" and "empowering people of color to utilize assets abundant in their communities" (Walsh, 2003; Yosso, 2005). In other words, these types of frameworks can help us as researchers disrupt the systems that we have often inadvertently supported.

The Community Cultural Wealth (CCW) framework was developed by Yosso (2005) using Critical Race Theory to challenge traditional interpretations of cultural capital. Yosso describes CCW as "an array of knowledge, skills, abilities and contacts possessed by Communities of Color to survive and resist macro and micro-forms of oppression" (p. 77). She describes six forms of capital that are part of CCW and are often unacknowledged or unrecognized within communities of color: aspirational, linguistic, familial, social, navigational, and resistance (see image below).



The Family Resilience Framework (FRF) was developed by Walsh (2003) initially to guide clinical interventions for families. The framework is grounded in family systems theory (Bowen, 1978; Broderick, 1993; Cox & Paley, 1997) and describes the components that contribute to building family resilience, which is defined by Walsh as "the ability to struggle well with a focus on the future" (p.132). This framework has recently been applied to challenge deficit perspectives and describe the experiences of Latinx families during the transition from preschool to kindergarten (Coba-Rodriguez et al., 2020). In this study, the authors found that Latina mothers are resilient and resourceful in the face of challenges like poverty and that they engage their preschoolers in varied learning activities that prepare them for kindergarten.

As outlined by Walsh, some of the key processes that support family resilience include:

- **Belief system**—shared beliefs that help families make meaning of hard situations and facilitate a positive outlook
- **Organizational patterns**—patterns like flexibility, shared leadership, mutual support, and connection that help build resilience
- **Communication processes**—the ability to communicate openly, share emotions, and engage in collaborative problem solving

Implications for Our Work

While the use of asset-based frameworks has been shown to be a powerful approach and important step in the journey towards equity, we want to reflect on and think critically about how the frameworks ground our work and what they look like in practice. Here are some of the questions we are currently asking ourselves.

What is the goal of engaging families with engineering?

As we develop programs or research studies, one of the first things we often do as researchers is craft an argument that explains a perceived problem. Then we articulate goals for the project, strategies, and outcomes. While there may not appear to be anything inherently wrong with this process, one of the things we are currently trying to do is work with communities and families to better understand what they think are meaningful questions, goals, and outcomes while articulating how the project can authentically contribute to these. We aspire to develop goals

that are not geared towards remediating or fixing individuals or communities but rather fixing or reshaping systems—like education research or family engagement programs. For example, our work with families with young children has shifted over the years to better understand the way that families already use engineering design skills in their lives to solve everyday problems. Through this understanding, we hope to empower families and work alongside them to disrupt an educational system that often fails to value their knowledge and experiences.

How are families participating in the research?

We have been thinking deeply about the ways we engage families through our research. As discussed in the previous chapter, we aspire for our work to be relational and reciprocal, with the researcher giving as much as they are asking from participants. As we noted, the work of Christine McWayne with Head Start families provides an example of family-school partnerships that contribute to creating culturally inclusive environments for all families (McWayne et al., 2021). We also want to involve families across all levels of the work, helping co-develop and co-construct knowledge. In the next chapter, we will share more about a newly NSF-funded project in which we hope to advance this goal by engaging Latinx parents as researchers to explore how home-based engineering activities can support the development of executive function skills.

What strategies will help ensure the work is truly-asset based?

While we are embracing the application of asset-based frameworks, we are also concerned that without constant reflection and accountability the work won't be truly asset based. In the systematic literature review conducted by Denton, Borrego, and Boklage (2020) to explore the application of Yosso's CCW framework in STEM education, the authors identified multiple instances where CCW was used in deficit-based statements and contributed to damaging stereotypes about communities. The authors encouraged practitioners to be careful of how they adopt the framework and reflect on the original intentions of the authors. Without additional strategies, constant reflection, and input, we run the risk of doing more harm than good to the communities we work with. One promising strategy we have been employing is working with an equity coach. In a recent

project, for example, the equity coach is a part of the project team and provides mentoring and evaluation of our equity strategies and approaches. They conduct observations of project activities, meet with project team members to discuss strategies, and regularly share their reflections. We have found this collaboration to be rewarding for both researchers and families and an essential mechanism for accountability to our long-term equity goals.

Engineering and Executive Function Skills

Scott Pattison. Shauna Tominey, Smirla Ramos Montañez

> ***Family research and practice must be rebalanced from a focus on how families fail to how families, when challenged, can succeed. (Walsh, 2003, p. 16)***

In this chapter, we reflect with our colleague, Dr. Shauna Tominey, on how these discussions over the last year shed light on a more recent strand of our work: investigating the intersection of engineering and executive function skills. Through our conversations with community partners and families, it has become clear that there is rich potential for engineering education efforts to support executive function and other fundamental aspects of development in early childhood. These connections may be a powerful way that engineering education research can address equity in STEM—by connecting with broader learning goals valued by families and communities.

However, much of the existing work on executive function is fraught with many of the equity issues we have noted previously, including deficit perspectives and lack of authentic collaboration with parents and families. In this chapter, we explore some of these challenges and possible ways forward as we prepare to launch a new NSF-funded initiative designed to engage parents as research partners in understanding how we can leverage informal family engineering activities to support the development of executive function skills for preschool-age children from Latinx families.

Supporting Executive Function Skills through Engineering Activities

If you ask the parent of a preschooler to tell you about their child's executive function skills, you might be met with a look of confusion. But ask that same parent what their child does well and what they are working on, and you will have a very different conversation. Many parents are eager to share how much their child has grown, how quickly they are learning, the struggles they have following directions at certain places or certain times of day, as well as the ups and downs of managing big feelings. At face value, there is no mention of the term "executive function" anywhere in this response—but evidence of executive function is everywhere. Over the past few decades, executive function has been a hot topic in the research world. And yet, a critical voice is still missing from these

conversations: the voice of families. Even the way executive function is defined is heavy with jargon and the specific constructs are steeped in academic theory.

In research terms, executive function is defined as a broad set of interrelated cognitive skills required for organizing and carrying out purposeful, goal-directed activities, such as focus and self-control, working memory, and flexible thinking (Diamond, 2013; Meltzer, 2018; NRC, 2000). Decades of research suggest that these skills are critical for children's development and long-term success inside and outside school (Blair, 2016; Immordino-Yang et al., 2018; Jones et al., 2016; NRC, 2000). Research also suggests that early childhood is an important stage for the development of these skills and other related aspects of self-regulation (Blair, 2016; Jones et al., 2016; NRC, 2000). For example, preschool-age children are developing their abilities to inhibit and control their behavior, focus and sustain their attention, flexibly shift their thinking and strategies, and understand and manage their emotions (Ackerman & Friedman-Krauss, 2017; Jones et al., 2016).

Educators and researchers are increasingly recognizing that executive function skills are central to engagement with STEM (Gropen et al., 2011; NVF, 2020). Inspired by discussions with our project partners and families, we believe early engineering design activities, such as those we have been developing through *Head Start on Engineering*, offer a promising approach to supporting executive function skills in a way that is engaging, contextualized, and strength based (Bustamante et al., 2018; Gold, 2017). For example, executive function skills provide a critical foundation for children to persevere, manage frustration, and problem-solve as they engage in meaningful engineering learning activities (Gold et al., 2021). Since parents and other significant adults play a central role in supporting learning at this age (NASEM, 2016), we also must partner with parents to help them understand and scaffold their children's executive function development, both in specific situations and over time.

Although promising, the connection between executive function and engineering in early childhood has not been extensively studied. From an equity lens, there are many challenges to studying executive function and its connection with STEM. First and foremost,

the overwhelming majority of research studies on executive function in early childhood take a deficit-based approach, focusing on the "problems" within communities rather than strengths and assets (NVF, 2020). Similarly, much of the work in education on this topic has focused primarily on compliance as an outcome, rather than the ways that executive function skills support children's ability to grow and thrive throughout their lives. Currently, there is little understanding of the ways that families perceive and value executive function, the strengths and assets they bring to supporting their children's development, and the different culturally relevant approaches that families might use to support executive function for their children. Shifting this lens in both research and practice can only happen when children and families are centered in this work in a meaningful way.

Introducing the *Diálogos* Project

With the support of the National Science Foundation, we now have the opportunity to explore some of the challenges and help co-construct a more holistic, family-centered approach to engineering and executive function skills in collaboration with Latinx families in our community.

Diálogos is a pilot project that will engage parents as research partners to explore how we can leverage informal family engineering activities to support the development of executive function skills for preschool-age children from Latinx families. Led by TERC, the project is a collaboration with Oregon State University and community partners at Metropolitan Family Service and Mt. Hood Community College Head Start. The full project name (*Diálogos: Harnessing Latinx Community Cultural Wealth to Support Executive Function in Early Childhood through Family Engineering Experiences*) reflects our commitment to not only identifying ways that engineering activities support executive function skill development for young children and their families but also to collaborate with Latinx families to explore the deeper questions of how families think about executive function skills, what knowledge and practices families already possess related to executive function skill development, and the ways that engineering activities can build on and amplify these existing practices.

Using asset-based approaches, the two-year exploratory project will develop and test a participatory, dialogic method in which parents are central collaborators, sharing their in-depth perspectives and partnering with researchers to develop conceptual frameworks and new approaches. The parent dialogue series will be supported by a systematic literature review examining the intersections between engineering design, executive function, and the strengths and assets within Latinx families.

Anticipating Our Equity Challenges

Although we are excited about this new opportunity, we are keenly aware of the challenges and pitfalls that lay ahead. Given our reflections over the last year, we already anticipate a number of areas where we will need to think carefully about how the project will help disrupt rather than perpetuate systematic inequities in education. To begin, here we share an initial set of principles that we hope will help us avoid these pitfalls.

Families are already thinking about and supporting executive function development

In our experience, many efforts related to executive function development are situated in a basic formula: "children from poor communities and communities of color have problems with executive function that make them behave and perform poorly in school. In order to achieve equity in education, we need to fix these children and their families by improving their executive function skills."

In the previous chapter, we talked in detail about the problems inherent in this type of deficit-based approach, even when educators or researchers claim to be using equity-oriented or culturally responsive approaches to address the so-called problems. So, what is the alternative? To begin, we reject the notion that children and families from Latinx communities in our region are "impoverished" in terms of their executive function development or the strategies for supporting this development. Executive function is a skill that all children are developing and benefit from developing, rather than a capacity that is lacking in certain communities or a marker of children that are "at risk" or "deficient." As we know from other research fields, these perceptions have important implications. For example, researchers have highlighted how perceptions of children's behavior related to race or gender are connected with higher suspension and

Similar to our approach with engineering, we are interested in building meaningful relationships with families and hearing from them about where and how children and their families are thriving and how can we amplify and support these strengths.

In recent conversations we've had with English- and Spanish-speaking parents of preschool-age children, we learned a tremendous amount about parents' awareness of the multiple aspects of their children's development and the many strategies they use to support them. Even though families didn't explicitly use the term executive function, many parents talked about related areas of development or situations where executive function is at play, such as helping their children deal with frustration or becoming more flexible thinkers. For example, one mother shared strategies for how she helps her child understand and manage his emotions:

> *"It helps trying to figure out what we were feeling and getting familiar with self-awareness. We were doing children's yoga, volcano breaths, and other movements that we can do to take the moment to reflect. I have been working with him to verbalize and get him to express himself. We all have emotions!*

Families should decide what makes sense for them and their children

Just as many efforts to support executive function and STEM learning for children and families are rooted in a deficit perspective, many programs and studies begin with the implicit assumption that researchers and educators know what is best for families and their communities.

Underlying this approach is the assumption that we have highlighted before: that there is one "right way" to be a parent and support children's development, related to executive function or otherwise. Although we don't often admit it, this assumption is equivalent to the idea that if families from institutionally marginalized communities could just be taught to think, act, and learn like White, middle- and upper-class families, the problems within the education system would be solved (Gutiérrez,

2013; Philip et al., 2018; Yosso, 2005). Instead, we begin with the assumption that there are multiple approaches to supporting children's development based in the knowledge, practices, and values of different cultural communities (e.g., Wang et al., 2020). Our hope is that by collaborating closely with Latinx parents and caregivers, we can learn from and with families about approaches for supporting executive function skills that align with their values, support their broader goals for their children, and affirm their cultural knowledge and traditions. In other words, this project is more about co-developing goals and strategies *with* rather than *for* families.

Beyond programming, we also believe it's important for us as education researchers to rethink the relationship we have with families throughout the research process. In the field of community health research, scholars have highlighted how research must be grounded in the needs and goals identified by the community, not by outside "experts" (Israel, 2013). So, as we embark on this new project, we need to ask ourselves the following:

- **Who should determine the direction and focus** for the next decade of research on the intersection of executive function and engineering?
- **Are the priorities we as academics have identified** the most important for the Latinx families we hope to serve?

- **Will our iterative and dialogic approach to collaboration with families help** shift this balance or simply justify the preservation of existing systems and structures?
- **Can we let go of our "epistemic arrogance,"** as a colleague so aptly described it in a recent conversation?
- **Can we inspire and create pathways for the next generation** of researchers and scholars from linguistically and culturally diverse backgrounds and lived experiences who will reflect their communities and carry on this work in ways that increasingly center family voice?

Our thinking and exploration in this area has been ongoing and filled with missteps. In past work, we've explored culturally responsive approaches to research in an effort to better connect with families from different cultural backgrounds. More recently, we've been inspired by calls to elevate the voice and power of community members within the education

system (Curry-Stevens et al., 2014; Garibay & Teasdale, 2019; Levitan, 2019; Tolbert et al., 2018)—to let the research be a conduit of family perspectives, rather than a translation or a distortion. For the *Diálogos* project, we looked to community-based participatory research approaches (Israel, 2013; Minkler & Wallerstein, 2008), including working with a group of parent leaders in the Latinx community to help guide the focus of the proposal and designing the research methods using participatory, dialogic approaches (Civil et al., 2005; Quintos et al., 2019). But we know it's not enough. The challenge remains of how to conduct research and develop knowledge that truly reflects, serves, and is motivated by the communities within which the research takes place.

Executive function is a small part of supporting children's learning and development

In embarking on this most recent project, we have joined the growing chorus of those emphasizing the importance of executive function for STEM learning and child development (Gropen et al., 2011; NVF, 2020). From families' perspectives, we understand that this academic and arguably reductive concept is only a small part of the goals they have for their children. The term executive function originates from the cognitive neuroscience field and is often defined as "a set of mental processes, located in the pre-frontal cortex region of the brain, that are used to carry out goal-directed behavior" (Jones et al., 2016, p. 8). But families don't experience life as a set of "mental processes." Instead, they help their children navigate daily challenges that involve all aspects of mind and body—like getting ready for school in the morning, making friends, or helping out with household chores.

This point was driven home in our recent conversations with parents about how they support their children's executive function development and the skills they think are important for their children to succeed in school and life. The stories families shared were about broad development domains and concrete daily situations—many of which involve but are not limited to executive function. For example, one mother shared how she has been working to help her daughter

deal with frustration when something doesn't turn out like she wants:

> ***La frustración. Si está haciendo algo y no le sale como ella quería se pone así. Se pone insoportable. Cuando se molesta sí sabe que se puede sentar en su silla o agarrar uno de sus peluches. Pero cuando se frustra pierde todo. [Cuando esto pasa] le doy su espacio un rato y luego la abrazo. Le digo: "Sé que esto es difícil, vamos a intentarlo más tarde." Y la conforto.*** [Frustration. If she is doing something and it doesn't turn out the way she wants, she gets frustrated. She can be unbearable. When she gets mad, she knows that she can sit in her chair, or she can grab her stuffed animal, but when she gets frustrated, she loses everything. (When that happens) I give her space, and I tell her, "I know this was hard, so let's try it again later." And I try to comfort her.]

For our new project, we anticipate this will be a tension as we try to connect with and inform the literature on executive function and STEM while also acknowledging and supporting the whole child and whole family in ways that align with their daily experiences. To this end, we hope to work towards an inclusive and pragmatic conceptualization of executive function, recognizing the multiple aspects of development that it relates to and connects with. Similarly, we hope to help families recognize and practice the executive function-related skills required for preschool-age children to accomplish complex tasks involved in collaborative STEM learning.

In our proposal, we defined executive function as the set of self-regulation skills that allow young children, with the support of their parents, to engage effectively in STEM learning activities by focusing attention and ignoring distractions, retaining new information in their minds long enough to follow through with directions, demonstrating self-control/inhibitory control, and managing their emotions. But we acknowledge that this definition is limiting. It is framed primarily from a research perspective rather than representing the ways that families with preschool-age children experience executive function in their daily lives, the terms that they use to think about these experiences, and the goals and values they have related to their children's development and learning. Through the *Diálogos* project, we hope to revise and expand this definition as part of the development of a new vision for how family-based STEM learning experiences can support not only executive function skills but the range of goals that families value for their children.

Re-envisioning Engineering Education

Scott Pattison, Gina Svarovsky, Smirla Ramos Montañez

> ***Do we approach community engagement in ways that protect our own power and privilege, because we don't want to lose them, or are we willing to figure out ways to share authority and open up space in ways that allow for something richer, more equitable, and meaningful? (Garibay et al., 2017)***

In this chapter, we reflect with our colleague, Dr. Gina Svarovsky, on how our work over the last year has motivated us to think differently about not only how we engage families with engineering but also how we conceptualize the discipline.

Understanding the History of Engineering Education

As Bang and colleagues have argued (Bang et al., 2016), equity in education cannot be achieved without a deep understanding of the historical processes that shaped where we are today. With this in mind, it's important to briefly consider the history of engineering education in the United States.

Broad engagement with the field of engineering education is relatively new, especially compared to similar efforts within mathematics and science. Although the American Society for Engineering Education (ASEE) was founded in 1893, the first department of engineering education was not established until 2004 at Purdue University—not even two decades ago. During the early years of the field, the majority of work in engineering education focused on the undergraduate level. Towards the end of the 2000s, engineering-focused standards for K–12 education were beginning to be included at the state level. These became much more prominently articulated in 2013 as part of the Next Generation Science Standards (Moore et al., 2015; NGSS Lead States, 2013). As such, it has been less than 10 years at the time of this eBook that engineering education in pre-college settings has been a major focus of research and education efforts.

During this time, the historical roots of engineering education in universities has shaped the discourse around what counts as engineering and how it should be defined (e.g., Bix, 2002; Pawley, 2009). Even while researchers and educators increasingly focused on engaging younger learners, there was an ongoing undercurrent of skepticism about the "legitimacy" of engineering for these audiences. Questions would arise, such as: Does it count as engineering if the students

aren't using calculus or differential equations, higher level understandings of statics and kinematics, or advanced software programs such as CAD? Engineering also continues to be a field dominated by White males (NCSES, 2021), which further shapes the conversation about what is and is not considered engineering.

Pre-college engineering educators and researchers (e.g., Cunningham, 2018; Moore et al., 2014) have addressed these questions in a number of ways, including the incorporation of engineering tools to support young learners and, perhaps most importantly, the centering of the engineering design process (EDP)—a defining hallmark of the discipline. By emphasizing the engineering design process and arguing that children could engage in the EDP even without traditional tools and concepts of formal engineering, Engineering is Elementary and other curriculum packages brought engineering ideas to younger students across the country (NASEM, 2021).

Taking a Critical Look at Where We Are

While this expansion throughout the school system has been an exciting time for engineering education, it has also highlighted fundamental challenges in the field (McGowan & Bell, 2020; Mejia et al., 2018; Pawley, 2012). Many educators and researchers are now exploring ways of supporting youth and communities that have traditionally been disenfranchised by this history. However, the field has been slower to critically examine the discipline itself and how our definitions and frameworks for engineering also contribute to systems of inequity and injustice (Mejia et al., 2018). Martin and Wendell aptly summarize this "flawed narrative" that "assumes that, even though the technical frontiers of the discipline are constantly evolving, the fundamentals of what engineering is and what it means to be an engineer are settled" (Martin & Wendell, 2021, pp. 42–43).

Many equity scholars have argued forcefully for why simply introducing traditional conceptualizations of engineering is inherently flawed. The way engineering and other disciplines are defined and practiced is not benign, neutral, or apolitical (McGowan & Bell, 2020; Philip et al., 2018; Tan et al., 2018; Vossoughi et al., 2016). Instead, decisions about what counts as engineering and who decides have deep implications for equity in STEM education. They position some individuals and

communities as possessing knowledge and others as needing teaching and remediation. They label some practices as valued and some as invisible or irrelevant (Pawley, 2012). These ideas become baked into institutions, policies, and evaluation systems to the extent that they are taken for granted and assumed to be free of value, bias, or judgement. Yet a critical look at their history reveals the ways they represent very specific world views and cultural perspectives and privilege the experiences and knowledge of some individuals and communities over others.

Reflecting on Our Own Assumptions

If we truly seek to broaden our understanding of engineering in education, then we believe we must recognize that individuals and communities possess deep skills, knowledge, and experiences related to engineering beyond what we as academics have delineated in our frameworks and curricula. We must also shift away from the view that there is a single "right way" to do engineering and begin to explore how engineering knowledge and practices are unique and variable across individuals, contexts, communities, cultures, and time periods (Philip et al., 2018). We also must reflect deeply on the troubled history of engineering and engineering education and leverage our work to help address these injustices and elevate those voices that have been traditionally marginalized (Bang et al., 2016; Major, 2020; McGowan & Bell, 2020; Vossoughi et al., 2016).

In our own work, these realizations have been a long time in coming. For years we have sought to bring high-quality engineering learning experiences to low-income communities, Latinx families, and other groups that are currently underrepresented in engineering and other STEM fields. And yet, even as we have worked to carefully design our studies and programs to be accessible and have tried to understand and incorporate existing knowledge, practices, and assets from families, we have only recently begun to intentionally interrogate our own core understandings of the discipline, the ways in which we frame it for the families we work with, and how this connects with existing knowledge and practices within communities.

Learning and education have traditionally been spaces where inequities are reified and reinforced. But they can also be powerful opportunities for contesting power and injustice and re-imagining a more equitable

vision for education (Calabrese Barton et al., 2021; Philip et al., 2018). The evolution in our own thinking around engineering and engineering education has been productively and generously catalyzed by listening to families and observing them engaging in engineering practices within natural environments such as their homes. As highlighted in the quotes below, our study participants have graciously shared their interactions and their reflections around engineering with us over the years. In so doing, they have both directly and indirectly challenged us as engineering education researchers to push back on the traditional boundaries of what counts as engineering.

> *When I thought of engineering, I didn't think of solving problems. I thought of a technical person, like a space engineer—something that I wasn't. At the end of the day, I learned that we are all engineers.*
>
> *— program participant*

> ***La principal sorpresa que me lleve era que no sabía, creí que ingeniería significaba que era un hombre construyendo unas casas es ingeniería, pero ahora pienso más sencillo. Utilizamos la ingeniería todo el tiempo hasta en pequeños proyectos que hacemos en la casa. Por ejemplo, hace poco hicimos una tabla para pegar fotos y se me acabó la pega. Pensamos en otras cosas que podíamos utilizar.*** [The biggest surprise is that I thought engineering was when a man builds houses, but now I think it's simpler. We use engineering all the time, even in small projects that we do at home. For example, when we were making a picture board and I ran out of glue. Then we had to think about what else we could use.]
>
> *— program participant*

As we discussed in our previous chapters, we believe an asset-based perspective is essential to shaping a more equitable vision for engineering education and research (Martin & Wendell, 2021; Mejia et al., 2018). This perspective positions educators and researchers as learners in a process of understanding the existing knowledge and practices of families and allowing these to drive education and learning (Vossoughi et al., 2016). A variety of scholars are actively working towards identifying and supporting children and families' engineering-related

assets. For example, Amy Wilson-Lopez and her colleagues have described the powerful ways that Latinx youth bring their everyday funds of knowledge related to engineering to address community challenges or contribute to more human working environments (Wilson-Lopez et al., 2016; Wilson-Lopez & Acosta-Feliz, 2021).

Similarly, the families and community members we work with are helping us co-create a more expansive definition of engineering that we then are iterating on and sharing back with new families as a way of creating a learning space that recognizes multiple ways of knowing and doing. We agree with Yosso and others that the ultimate goal of this work is not to simply document assets and funds of knowledge but to collaborate with families and communities to leverage these assets to reshape education systems (Yosso, 2005). Similarly, in her work on "rehumanizing" mathematics education, Gutiérrez challenges us to think about how we can both honor existing knowledge and help support and expand ongoing learning for children and families. This is akin to the notion of "third space" (Soja, 1996), which describes a learning environment in which families' experiences and ways of knowing are valued and incorporated alongside other types of knowledge, such as the disciplinary practices of working engineers (see also Calabrese Barton & Tan, 2009; Moje et al., 2004; Verdín et al., 2021; Wilson-Lopez et al., 2016). In this way, we create a dialogue between multiple perspectives and experiences that contributes to a broader, more inclusive understanding of engineering education.

Moving Forward

> *Diversifying participation in engineering means that we need to not just bring learners into existing engineering practices, structures, and ways of knowing, but that we take a critical look at the field of engineering education and challenge researchers and educators to create learning opportunities that build on diverse ways of knowing about engineering and being engineers in the world. (McGowan & Bell, 2020, p. 981)*

Our reflections over the last year have challenged our own thinking about how we define engineering and the ways this influences our approaches to supporting engineering learning for families with young children. These reflections have also catalyzed a new depth to our collaborative research—pushing us to learn from families and expand our own definitions and assumptions. Next, we outline three areas that have emerged in our recent studies: (1) appreciating that the engineering process is not always linear or complete, (2) acknowledging the productive connections between engineering and everyday problem-solving, and (3) seeing children's imaginative play as a space for supporting a rich and more expansive view of engineering learning.

Engagement in the engineering process is not always linear or complete

In K-12 settings, engaging in engineering often involves learning about a multi-step engineering design process (EDP), which always begins with an exploratory phase of identifying and further defining the problem. Learners then typically move through the entire design process, building, testing, and revising. Although there are many of ways to represent this process and the nuanced ways that professional engineers commonly engage in it, there are now several well-known versions for young students, including the five-step EDP developed for the Engineering is Elementary curriculum: Ask-Imagine-Plan-Create-Improve (Cunningham, 2018).

However, this often may not be the approach taken by children and families with engineering activities outside the classroom or in their everyday design and problem solving. For example, during an interview with one mother about her experience as a parent in the *Head Start on Engineering* program, she talked about how the engineering design process is relevant to many of the things she does with her child. She also noted that her family often paid less attention to the planning step and instead just started to create, which would often "lead to more questions and talking more together." Like when they recently worked to rearrange her daughter's room, she said they had "eliminated the planning part because we just jump right in there."

In truth, this more complex, organic depiction of the engineering process may be more accurate to the work of professional engineers. Our studies have shown that within family-focused informal learning environments, the EDP does not tend to unfold in a linear manner. Instead, different aspects of the EDP can be more emphasized than others, and there is often movement back and forth and around the different steps as families seek to better understand the design challenges they are solving, the materials they are working with, and the constraints they are facing. For example, families may "skip" the problem-scoping phase and instead incorporate goal discussion and materials exploration as an ongoing part of their design and building.

Letting go of a more rigid and narrow definition of the engineering design process is promising in a variety of ways. First, it allows us as educators and researchers to fully acknowledge and appreciate the diverse design and problem-solving strategies that families use in their daily lives, whether or not

these adhere to our own frameworks. Second, going beyond the typical engineering design process allows us to appreciate the value of experiences or resources that highlight one or two aspects of engineering design but don't take families through an entire design cycle. Finally, broadening our ideas about the process suggests approaches for connecting with how families and young children naturally learn and developing engineering experiences that are tailored to the abilities of young learners.

Everyday problem-solving is a rich connection point for families

In our collaborations with families, we have seen over and over the important connections that families make between the engineering ideas as we present them and the problem solving that they do every day at home and at work. For example, one mother shared these reflections during a recent conversation:

> *It's just extra activities to have you and your child come together. It's so important to watch and allow their minds to work on how to solve a problem. That's the main thing in life. That's the main skill in life, problem solving. Life always has problems. How do you go about fixing problems. That's what the engineering process is about. Making things work. That's so important. When I thought about engineering before, I thought, oh whatever. But we are all engineers. It was enlightening for me.*
>
> *— program participant*

For this mother and many other families, the connection between engineering and everyday problem solving seems to be a primary driver for ongoing engineering engagement and learning (Pattison et al., 2020). The connection creates a strong value for the topic, since problem solving is often a primary skill families hope to develop in their children. It also highlights the way they are already using engineering skills and helps them bring their own knowledge and expertise to the program experience, including the resourcefulness and inventiveness that is often a way of life with the low-income and immigrant communities we work with. One mother described it this way when reflecting on her program experience::

> ***Siempre estamos haciendo ingeniería, siempre. Eso se me ha quedado en la mente siempre y podemos lograr hacer ingeniería.***
> [We are always doing engineering. This has always stuck in my mind, and that we can do engineering ourselves.]

These connections also create a powerful motivation for ongoing engagement and interest development. For example, families find ways to incorporate the engineering design process into their learning interactions with their children or they seek out new opportunities to practice engineering design and problem solving as a family (Pattison et al., 2021).

We believe that supporting these connections with everyday engineering can help make the engineering content of our programs relevant and engaging for families. More importantly, however, it is an opportunity for us to learn from families and expand our own ideas about the discipline. How engineering is defined is often based not just on the content or practices but also on where it happens and who is doing it (Pawley, 2009). These perspectives have led to historical biases in what is and isn't considered engineering (McGowan & Bell, 2020; Mejia et al., 2018; Pawley, 2012). One family from our program shared the conversations they themselves had been having about what counts as engineering after playing with an activity connecting taco making with process engineering:

> *Well, when you think about engineering you think about building things and with the tacos you built things, but you built food. Did that count as engineering? Does that mean chefs are food engineers? Those are the kind of conversations we had in our home. Like the other night, my daughter asked my husband, 'Daddy, are you engineering some food?'*
>
> *— program participant*

In our work, we have increasingly tried to learn from families about their everyday problem-solving practices and then use these examples to inform ongoing changes to the way we frame engineering for other participants. For example, one common scenario we present to families as engineering is trying to figure out the most effective and efficient morning routine for a busy household, with multiple people needing to get ready, eat breakfast, and head out the door to different locations at different times. Thinking through this process, understanding the many constraints, complexities, and interdependencies, developing a plan, iterating on it, and optimizing it over time can certainly be considered engaging in an engineering design process. But all too often, this work is not legitimized by traditional engineers or those who hold narrow definitions of engineering. In our work, we have tried to better highlight these examples, and

invite project team members and families to share their stories as a central part of our collaborative programs.

Children's imaginative play creates opportunities for rich, expansive engineering

As a final example, our recent work with families and their preschool-age children has opened our eyes to the rich engineering that can happen during children's playful, imagination-driven learning experiences—and how these moments can again help broaden our ideas about engineering as researchers and educators.

Take for example the video that a family recently sent to us of the mother and four-year-old daughter playing at home with a "Pollitos Dicen" activity that we had shared. The stated goal of the activity, based on the popular Spanish children's song, Pollitos Dicen, was for families to work together to build a structure to protect a group of small chicks from the sun, rain, and hungry foxes. The families were provided with a one-page bilingual activity guide, a set of wooden blocks and stiff boards, and small wind-up chicks.

In the video, the mother began by reading through the guide and then singing the song with her child while the daughter played excitedly with the chicks. The pair then talked about the activity goal and what the chicks might need to feel safe and protected. The daughter started to build, while the mother watched and offered encouragement. As they worked, the daughter continued to play with the chicks and to bring more imaginative elements into the design. First the structure was a chicken coop, but then it became a castle with all the chicks as princes and princesses. When they had a few levels built, they talked about rain, and the daughter decided they needed a roof for the top level. She also wanted a place for the chicks to sleep when they were tired and experimented with how much room they would need to fit on each level. To the mom's apparent surprise, the daughter then started talking about the monsters that were coming to get the chicks and thinking about the walls and traps that they would need for protection. She asked the mom if monsters could climb and started adding different blocks and boards to make the structure safer.

On the surface, this interaction challenges many of our ideas about engineering. It was certainly not a linear or complete engineering design process, as traditionally depicted. On the other hand, the interaction also highlighted the deep engagement and rich engineering design practices that are possible in these types of playful, family-based learning moments. Throughout the building process, the daughter and mother were continuously engaging in conversation and reflective decision making (Wendell et al., 2017). And perhaps more importantly, they were doing this using a user-centered lens, motivated by their focus on the needs of the "cute" chicks

that were both pre-defined by the activity and emergent as part of the family's imaginative play (e.g., monsters). The daughter was also empowered to take charge of the design, using her imagination to have ownership over all aspects of the design process. Without being constrained by pre-determined design goals or physical design constraints, which can sometimes be a barrier for young children that are still developing their fine motor skills, she was able to engage deeply in many aspects of the engineering design process, including problem scoping, building, evaluation, and revision.

Addressing a Critical Question

The ideas above represent just a few of the many ways that our collaborations with families have helped us expand and enrich our understanding of what counts as engineering, where, and for whom. However, all these reflections raise a critical question: If we work with families to create a broader vision of engineering, do we do them a disservice when then encounter traditional perspectives in school? This we believe is a challenging issue, especially since it is impossible to expect that educational systems and institutions will change overnight. As Megan Bang and colleagues noted in regards to their collaboration with Native communities, "our work did not proceed from a romanticized view that ignored the demands for Native children to achieve in school/Western forms of knowing" (Bang et al., 2016, p. 4).

Our current thinking is that this tension raises a new challenge for us as educators and researchers—we cannot be content to merely study and support families and children. Instead, our efforts must simultaneously be aimed at dismantling and reshaping education systems. As Gutiérrez wrote, we must collaborate with families to both "play the game and change the game" (Gutiérrez, 2009). In this way, we distance ourselves from the traditional notion of education research as separate, objective, and aloof and instead take full responsibility for our roles in shaping both the equities and inequities in our education systems (Aguirre et al., 2017; Philip et al., 2018; Vossoughi et al., 2016).

We also acknowledge that through engaging families in engineering, our highest aim is not necessarily to build deep fluency with engineering design practices, but rather, to cultivate a sense of empowerment and agency within young children and their families. While yes, we believe that early engineering activities can plant the seeds of early interest in and understanding of engineering practices, we also strongly believe that engineering activities provide meaningful opportunities for families to develop their skills and identities as creative problem solvers who can be innovative and responsive—which may ultimately help young people and their families engage as changemakers in their everyday lives and communities.

Final Thoughts

Scott Pattison, Smirla Ramos Montañez

> ***In addition to asking such questions throughout the process of research, we need to consider the actions and activities we can do to engage in genuine equity work. Learning to engage in genuine equity work is not an end goal; it must be seen as an ongoing process and something we can always improve upon. (Aguirre et al., 2017, p. 136)***

In our field of informal STEM learning, like other fields, there has been a growing interest in deepening relationships with and broadening participation for groups that have been traditionally underrepresented and marginalized in STEM. For example, many of the presentations and discussions during the recent National Science Foundation Advancing Informal STEM Learning Awardee Meeting focused on these topics and provided an opportunity to engage colleagues in conversation about disrupting systems of privilege and oppression.

Still, there is a tremendous amount of work ahead. As we close the eBook, we acknowledge that this is just the beginning of an ongoing learning process for us, our partners, and the families we work with. Engaging in equity work requires constant reflection about our intentions and our actions. Looking back at our writings, approaches, and assumptions from even a few years ago, it's easy to be critical. And we are sure that in the future, the chapters in this eBook will also feel stale and outdated, revealing biases and assumptions that we have yet to unearth and grapple with. Just as our research knowledge about education and learning continues to evolve, so too must our perspectives, approaches, and methods.

As a final call to action for ourselves and others, we highlight just a few of the outstanding questions that we hope to focus on in the coming years.

How do we bring these ideas into practice?

All these equity-focused reflections and ideas are compelling, but they can also feel abstract and removed from everyday practice. The real challenge is to find ways of reshaping our language, tools, and methods to align with these equity perspectives—and most importantly, to put in place systems that will hold us accountable to our goals and the communities we serve.

How do we shift power dynamics to elevate the knowledge and experiences of families?

Even as researchers and educators focus more efforts on issues of diversity, equity, and inclusion, many of the power dynamics and hierarchies between institutions, families, and communities are unchanged—thus preserving the fundamental structure of who decides and who benefits from this work. How do we shift these dynamics? How do we move away from the paradigm of "fixing" community "problems" that pervades every aspect of the current funding and education system? How do we reposition our roles as researchers and educators in order to create space for families and community members to shape a new vision for equitable STEM education?

What broader system-level changes are necessary to move these ideas forward?

For all the topics we have taken up here, we can think of practical steps for ourselves and within our individual projects and studies. But addressing systemic inequities requires system change. At what level of these systems do we choose to work? How do we stay connected to our communities and still advocate for system-level changes? What is our role as researchers and educators in changing these broader systems, including the ones that help preserve our jobs and positions of authority?

In closing, we want to express our gratitude to the many individuals that have shared their time, perspectives, and knowledge to inform this work. This includes the members of the Engineering for Equity advisory committee, Christopher Wright, Nelda Reyes, Maria Olivares, and Christine Cunningham; our partners at Mt. Hood Community College Head Start, Metropolitan Family Service, Oregon Museum of Science and Industry, and University of Notre Dame; and the many parents and families that have collaborated with us over the years.

We also want to thank the group of equity scholars that have inspired us with their research and writings, including Megan Bang, Angela Calabrese Barton, Monica Cardella, Marta Civil, Cecilia Garibay, Gloria Ladson-Billings, Andres Lopez, Christine McWayne, Joel Alejandro Mejia, Gigliana Melzi, Mira Mohsini, María Quijano, Vitzah Santilli, Lori Takeuchi, Edna Tan, Idalis Villanueva, Shirin Vossoughi, Amy Wilson-Lopez, Tara Yosso,

and many more. We encourage others to read, cite, and engage with their work as another important way to elevate these conversations in the research and education communities in which we work.

Finally, thank you to all those who have taken the time to read through this collection of reflections. We welcome your feedback, ideas, insights, and stories. It is through this process, we believe, of continuously examining, questioning, and rethinking the assumptions and practices within each of our professional communities that we can move towards a more equitable vision of STEM education.

About the Authors

Scott Pattison, PhD, is a Research Scientist at TERC. He has been studying and supporting STEM education and learning since 2003, as an educator, program and exhibit developer, evaluator, and researcher. His current work focuses on engagement, learning, and interest and identity development in free-choice and out-of-school environments, including museums, community-based organizations, and everyday settings. He has led numerous informal STEM education research projects and initiatives, including *Head Start on Engineering*, *Storybook STEM*, *Math in Making*, and *REVEAL*.

Smirla Ramos Montañez, PhD, is a bilingual (Spanish/English) and bicultural (Puerto Rican/American) Family STEM Learning Researcher at TERC. She has led and supported a variety of projects, including program and exhibit evaluation as well as STEM education research designed to provide accessible, culturally relevant, and engaging experiences for diverse audiences. Currently, she is the PI of the NSF-funded *Diálogos* project, which will engage parents as research partners to explore how informal family engineering activities can be leveraged to support the development of executive function skills for preschool-age children from Latinx families.

Gina Svarovsky, PhD, is an Associate Professor of the Practice at the University of Notre Dame Center for STEM Education. For nearly two decades, she has been interested in how young people learn science and engineering in both formal and informal learning environments. Specifically, her research interests are focused on exploring how youth from traditionally minoritized and non-dominant populations in engineering are able to develop engineering skills, knowledge, and ways of thinking as a result of participating in a variety of learning experiences. In addition to helping to collaborate with the other authors on the leadership of *Head Start on Engineering* and *Storybook STEM*, she currently leads the *REACH-ECE* project, which focuses on exploring how the different elements of engineering activity kits can catalyze engineering engagement for young children and their families.

Shauna Tominey, PhD, is an Associate Professor of Practice & Parenting Education Specialist at Oregon State University. As a former early childhood teacher and parenting educator, Shauna blends practical experience with research to develop programs aimed at promoting social-emotional skills for children and the adults in their lives and is co-developer of the Red Light, Purple Light self-regulation intervention. She also serves as the Principal Investigator for the Oregon Parenting Education Collaborative, a statewide initiative providing high-quality parenting education to families with children of all ages. With specific interest in trauma-informed and anti-racist approaches to social and emotional learning, she is a member of the LiberatED collaborative. Dr. Tominey is the author of “Creating Compassionate Kids: Essential Conversations to Have With Young Children” and a regular contributor for PBS Parents.

Resources

Here are a few resources that we have found helpful for going deeper into the topics introduced in this eBook. Although we provide the official publisher link in most cases, many of these resources are available for free on other websites. Chapters and articles can also be requested directly from authors through websites like ResearchGate (https://www.researchgate.net/).

Equity and Asset-Based Frameworks

- Critical Race Theory in education (https://journals.sagepub.com/doi/10.1177/016146819509700104)
- Community Cultural Wealth (https://www.tandfonline.com/doi/abs/10.1080/13613320520003 41006)
- Funds of Knowledge (https://www.routledge.com/Funds-of-Knowledge-Theorizing-Practices-in-Households-Communities-and/Gonzalez-Moll-Amanti/p/book/9780805849189)
- Family Resilience Framework (https://onlinelibrary.wiley.com/doi/10.1111/j.1545-5300.2003.00001.x)
- Third Space (https://ila.onlinelibrary.wiley.com/doi/abs/10.1598/RRQ.39.1.4)
- Rehumanizing Mathematics (https://www.nctm.org/Store/Products/Annual-Perspectives-in-Math-Ed-2018-(Download)/)

Family Learning Resources

- Parenting Matters (https://nap.nationalacademies.org/catalog/21868/parenting-matters-supporting-parents-of-children-ages-0-8)
- Embracing a New Normal: Toward a More Liberatory Approach to Family Engagement (https://www.issuelab.org/permalink/download/38504)
- Learning Science in Informal Environments (https://nap.nationalacademies.org/catalog/12190/learning-science-in-informal-environments-people-places-and-pursuits)
- Learning Across Boundaries: How Parents and Teachers Are Bridging Children's Interests (https://joanganzcooneycenter.org/publication/learning-across-boundaries/)
- Principles for Supporting Informal Family STEM Learning (https://www.informalscience.org/news-views/four-principles-supporting-family-learning-during-global-health-crisis-research-based-reflections)

Engineering and Equity Resources

- Critical Theoretical Frameworks in Engineering Education: An Anti-deficit and Liberative Approach (https://www.mdpi.com/2227-7102/8/4/158)
- Reflections on Asset-based Pre-college Engineering Education to Promote Equity: An Introduction to the Special Issue (https://docs.lib.purdue.edu/jpeer/vol11/iss1/3/)
- What Counts as "Engineering": Toward a Redefinition (https://www.researchgate.net/publication/232728530_What_counts_as_engineering_Toward_a_redefinition)
- Engineering Education as the Development of Critical Sociotechnical Literacy (https://link.springer.com/article/10.1007/s11191-020-00151-5)

Head Start on Engineering Project

- Project website (https://www.terc.edu/hse/)
- Bilingual engineering activities for families (https://www.terc.edu/hse/resources-for-families/)
- Publications for researchers and educators (https://www.terc.edu/hse/publications/)

References

Aguirre, J., Herbel-Eisenmann, B., & Celedón-Pattichis, S. (2017). Equity within mathematics education research as a political act: Moving from choice to intentional collective professional responsibility. *Journal for Research in Mathematics Education*, 48(2), 24.

Alcalá, L., Rogoff, B., & López Fraire, A. (2018). Sophisticated collaboration is common among Mexican-heritage US children. *Proceedings of the National Academy of Sciences, 115*(45), 11377–11384. https://doi.org/10.1073/pnas.1805707115

Ansari, A., Pivnick, L. K., Gershoff, E. T., Crosnoe, R., & Orozco-Lapray, D. (2020). What do parents want from preschool? Perspectives of low-income Latino/a immigrant families. *Early Childhood Research Quarterly, 52*, 38–48. https://doi.org/10.1016/j.ecresq.2018.08.007

Arauz, R. M., Dexter, A. L., Rogoff, B., & Aceves-Azuara, I. (2019). Children's management of attention as cultural practice. In T. Tulviste, D. L. Best, & J. L. Gibbons (Eds.), *Children's Social Worlds in Cultural Context* (pp. 23–39). Springer International Publishing. https://doi.org/10.1007/978-3-030-27033-9_3

Aronson, B., & Laughter, J. (2016). The Theory and Practice of Culturally Relevant Education: A Synthesis of Research Across Content Areas. *Review of Educational Research, 86*(1), 163–206.

Ata-Aktürk, A., & Demircan, H. Ö. (2020). Supporting preschool children's STEM learning with parent-involved early engineering education. *Early Childhood Education Journal*. https://doi.org/10.1007/s10643-020-01100-1

Bang, M., Faber, L., Gurneau, J., Marin, A., & Soto, C. (2016). Community-based design research: Learning across generations and strategic transformations of institutional relations toward axiological innovations. *Mind, Culture, and Activity, 23*(1), 28–41. https://doi.org/10.1080/10749039.2015.1087572

Bevan, B., Calabrese Barton, A., & Garibay, C. (2018). *Broadening perspectives on broadening participation in STEM: Critical perspectives on the role of science engagement*. Center for Advancement of Informal Science Education. https://www.informalscience.org/sites/default/files/BP-Report.pdf

Bix, A. S. (2002). Equipped for life: Gendered technical training and consumerism in home economics, 1920-1980. *Technology and Culture, 43*(4), 728–754.

Blair, C. (2016). Executive function and early childhood education. *Current Opinion in Behavioral Sciences, 10*, 102–107. https://doi.org/10.1016/j.cobeha.2016.05.009

Bowen, M. (1978). *Family therapy in clinical practice*. Aronson.

Broderick, C. B. (1993). *Understanding family process: Basics of family systems theory*. Sage Publications.

Burke Harris, N. (2019). *The deepest well: Healing the long-term effects of childhood adversity*. Mariner Books. http://www.vlebooks.com/vleweb/product/openreader?id=none&isbn=9780544828728

Bustamante, A., Greenfield, D., & Nayfeld, I. (2018). Early childhood science and engineering: Engaging platforms for fostering domain-general learning skills. *Education Sciences, 8*(3), 144. https://doi.org/10.3390/educsci8030144

Calabrese Barton, A., Greenberg, D., Kim, W. J., Brien, S., Roby, R., Balzer, M., Turner, C., & Archer, L. (2021). Disruptive moments as opportunities towards justice-oriented pedagogical practice in Informal Science Learning. *Science Education*, sce.21682. https://doi.org/10.1002/sce.21682

Calabrese Barton, A. M., Schenkel, K., & Tan, E. (2021). The ingenuity of everyday practice: A framework for justice-centered identity work in engineering in the middle grades. *Journal of Pre-College Engineering Education Research (J-PEER), 11*(1). https://doi.org/10.7771/2157-9288.1278

Calabrese Barton, A., & Tan, E. (2009). Funds of knowledge and discourses and hybrid space. *Journal of Research in Science Teaching, 46*(1), 50–73. https://doi.org/10.1002/tea.20269

Calabrese Barton, A., & Tan, E. (2020). Beyond equity as inclusion: A framework of "rightful presence" for guiding justice-oriented studies in teaching and learning. *Educational Researcher*. https://doi.org/10.3102/0013189X20927363

Callanan, M. A., Luce, M. R., Triona, L., Rigney, J. C., Siegel, D. R., & Jipson, J. L. (2013). What counts as science in everyday and family interactions. In B. Bevan, P. Bell, R. Stevens, & A. Razfar (Eds.), *LOST opportunities: Learning in out-of-school time* (pp. 29–49). Springer.

Callanan, M. A., Solis, G., Castañeda, C., & Jipson, J. (2020). Children's question-asking across cultural communities. In L. P. Butler, S. Ronfard, & K. H. Corriveau (Eds.), *The Questioning Child* (1st ed., pp. 73–88). Cambridge University Press. https://doi.org/10.1017/9781108553803.005

Cardella, M. E. (2020, March). *Early childhood engineering: Supporting engineering design practices with young children and their families*. NARST 2020 Annual International Conference, Portland, OR. https://www.researchgate.net/publication/340234317_Early_Childhood_Engineering_Supporting_Engineering_Design_Practices_with_Young_Children_and_Their_Families

Cho, H. S., Cheah, C. S. L., Vu, K. T. T., Selçuk, B., Yavuz, H. M., Şen, H. H., & Park, S.-Y. (2021). Culturally shared and unique meanings and expressions of maternal control across four cultures. *Developmental Psychology, 57*(2), 284–301. https://doi.org/10.1037/dev0001136

Civil, M., Bratton, J., & Quintos, B. (2005). Parents and mathematics education in a Latino community: Redefining parental participation. *Multicultural Education, 13*(2), 60–64.

Coba-Rodriguez, S., Cambray-Engstrom, E., & Jarrett, R. L. (2020). The home-based involvement experiences of low-income Latino families with preschoolers transitioning to kindergarten: Qualitative findings. *Journal of Child and Family Studies, 29*(10), 2678–2696. https://doi.org/10.1007/s10826-020-01781-7

Cox, M. J., & Paley, B. (1997). Families as systems. *Annual Review of Psychology, 48*(1), 243–267. https://doi.org/10.1146/annurev.psych.48.1.243

Cunningham, C. M. (2018). *Engineering in elementary STEM education: Curriculum design, instruction, learning, and assessment*. Teachers College Press.

Cunningham, C. M., & Lachapelle, C. P. (2014). Designing engineering experiences for all students. In Ş. Purzer, J. Strobel, & M. E. Cardella (Eds.), *Engineering in pre-college settings: Synthesizing research, policy, and practices* (pp. 117–140). Purdue University Press. https://doi.org/10.2307/j.ctt6wq7bh

Curry-Stevens, A., Reyes, M.-E., & Coalition of Communities of Color. (2014). *Protocol for culturally responsive organizations*. Center to Advance Racial Equity, Portland State University. https://www.oregon.gov/ohcs/OSHC/docs/HSC-2016/030416_HSC_LIFT_CARE-report.pdf

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Denton, M., Borrego, M., & Boklage, A. (2020). Community cultural wealth in science, technology, engineering, and mathematics education: A systematic review. *Journal of Engineering Education, 109*(3), 556–580. https://doi.org/10.1002/jee.20322

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education, 103*(3), 623–637. https://doi.org/10.1002/sce.21499

Garibay, C., Lannes, P., & González, J. (2017). *Latino audiences: Embracing complexity*. https://www.informalscience.org/latino-audiences-embracing-complexity

Garibay, C., & Teasdale, R. M. (2019). Equity and evaluation in informal STEM education. *New Directions for Evaluation, 2019*(161), 87–106. https://doi.org/10.1002/ev.20352

Gaskins, S. (2008). The cultural meaning of play and learning in children's museums. *Hand to Hand, 22*(4), 1–2, 8–11.

Gilliam, W. S., Maupin, A. N., Reyes, C. R., Accavitti, M., & Shic, F. (2016). Do early educators' implicit biases regarding sex and race relate to behavior expectations and recommendations of preschool expulsions and suspensions. *Yale University Child Study Center, 9*(28), 1–16.

Gold, Z. S. (2017). *Engineering play: Exploring associations with executive function, mathematical ability, and spatial ability in preschool* [Doctoral dissertation, Purdue University]. https://docs.lib.purdue.edu/dissertations/AAI10682945/

Gold, Z. S., Elicker, J., Evich, C. D., Mishra, A. A., Howe, N., & Weil, A. E. (2021). Engineering play with blocks as an informal learning context for executive function and planning. *Journal of Engineering Education*, jee.20421. https://doi.org/10.1002/jee.20421

Gold, Z. S., Elicker, J., Kellerman, A. M., Christ, S., Mishra, A. A., & Howe, N. (2020). Engineering play, mathematics, and spatial skills in children with and without Disabilities. *Early Education and Development*, 1–17. https://doi.org/10.1080/10409289.2019.1709382

González, N., Moll, L. C., & Amanti, C. (2005). *Funds of knowledge: Theorizing practice in households, communities, and classrooms*. Erlbaum.

Gropen, J., Clark-Chiarelli, N., Hoisington, C., & Ehrlich, S. B. (2011). The Importance of executive function in early science education. *Child Development Perspectives, 5*(4), 298–304. https://doi.org/10.1111/j.1750-8606.2011.00201.x

Gutiérrez, R. (2009). Framing equity: Helping students "play the game" and "change the game." *Teaching for Excellence and Equity in Mathematics, 1*(1), 4–8.

Gutiérrez, R. (2013). The sociopolitical turn in mathematics education. *Journal for Research in Mathematics Education, 44*(1), 37–68. https://doi.org/10.5951/jresematheduc.44.1.0037

Herron, A., & Jamieson, A. (2020). Grandfathers at Melbourne Museum: Shining a spotlight on overlooked museum visitors. *Visitor Studies, 23*(2), 101–119. https://doi.org/10.1080/10645578.2020.1772616

Holly, J. (2020). Disentangling engineering education research's anti-Blackness. *Journal of Engineering Education, 109*(4), 629–635. https://doi.org/10.1002/jee.20364

Huguley, J. P., Delale-O'Connor, L., Wang, M.-T., & Parr, A. K. (2021). African American parents' educational involvement in urban schools: Contextualized strategies for student success in adolescence. *Educational Researcher, 50*(1), 6–16. https://doi.org/10.3102/0013189X20943199

Immordino-Yang, M. H., Darling-Hammond, L., & Krone, C. (2018). *The brain basis for integrated social, emotional, and academic development*. The Aspen Institute. https://www.aspeninstitute.org/publications/the-brain-basis-for-integrated-social-emotional-and-academic-development/

Israel, B. A. (Ed.). (2013). *Methods for community-based participatory research for health* (2nd ed.). Jossey-Bass.

Jones, S., Bailey, R., Barnes, S., & Partee, A. (2016). *Executive function mapping project: Untangling the terms and skills related to executive function and self-regulation in early childhood* (OPRE Report # 2016-88; p. 68). Office of Planning, Research and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in U.S. schools. *Educational Researcher, 35*(7), 3–12. https://doi.org/10.3102/0013189X035007003

Ladson-Billings, G. (2007). Pushing past the achievement gap: An essay on the language of deficit. *The Journal of Negro Education, 76*(3), 316–323.

Ladson-Billings, G. (2021). I'm here for the hard re-set: Post pandemic pedagogy to preserve our culture. *Equity & Excellence in Education, 54*(1), 68–78. https://doi.org/10.1080/10665684.2020.1863883

Ladson-Billings, G., & Tate, W. F. (1995). Toward a critical race theory of education. *Teachers College Record, 97*(1), 47–68. https://doi.org/10.1080/10282580701850413

Levitan, J. (2019). Incorporating participant voice in culturally responsive leadership: A case study. *Leadership and Policy in Schools, 19*(3), 390–406. https://doi.org/10.1080/15700763.2019.1585546

Major, J. C. (2020). To cross the picket line or join it: Facing engineering education's role in the socioeconomic exploitation of marginalized peoples to further a discipline. *Journal of Engineering Education, 109*(2), 164–169. https://doi.org/10.1002/jee.20313

Marin, A., & Bang, M. (2018). "Look it, this is how you know:" Family forest walks as a context for knowledge-building about the natural world. *Cognition and Instruction, 36*(2), 89–118. https://doi.org/10.1080/07370008.2018.1429443

Martin, L., & Wendell, K. B. (2021). Reflections on asset-based pre-college engineering education to promote equity: An introduction to the special issue. *Journal of Pre-College Engineering Education Research (J-PEER), 11*(1). https://doi.org/10.7771/2157-9288.1325

McGowan, V. C., & Bell, P. (2020). Engineering education as the development of critical sociotechnical literacy.

Science & Education, 29(4), 981–1005. https://doi.org/10.1007/s11191-020-00151-5

McWayne, C., Hyun, S., Diez, V., & Mistry, J. (2021). "We Feel Connected… and Like We Belong": A Parent-Led, Staff-Supported Model of Family Engagement in Early Childhood. *Early Childhood Education Journal*. https://doi.org/10.1007/s10643-021-01160-x

McWayne, C. M., Foster, B., & Melzi, G. (2018). Culturally embedded measurement of Latino caregivers' engagement in Head Start: A tale of two forms of engagement. *Early Education and Development, 29*(4), 540–562. https://doi.org/10.1080/10409289.2018.1442094

McWayne, C. M., Hyun, S., Diez, V., & Mistry, J. (2021). "We feel connected… and like we belong": A parent-led, staff-supported model of family engagement in early childhood. *Early Childhood Education Journal*. https://doi.org/10.1007/s10643-021-01160-x

McWayne, C. M., Melzi, G., Schick, A. R., Kennedy, J. L., & Mundt, K. (2013). Defining family engagement among Latino Head Start parents: A mixed-methods measurement development study. *Early Childhood Research Quarterly, 28*(3), 593–607. https://doi.org/10.1016/j.ecresq.2013.03.008

McWayne, C. M., Mistry, J., Brenneman, K., Greenfield, D., & Zan, B. (2018). Supporting family engagement in science, technology, and engineering (STE) curriculum among low-income immigrant families with preschool children. In M. Caspe, T. A. Woods, & J. L. Kennedy (Eds.), *Promising practices for engaging families in STEM learning* (pp. 79–95). Information Age Publishing, Inc.

McWayne, C. M., Mistry, J., Brenneman, K., Zan, B., & Greenfield, D. (2020). A model of co-construction for curriculum and professional development in Head Start: The readiness through integrative science and engineering (RISE) approach. *Teachers College Record, 122*(11), 1–46.

Meek, S. E., & Gilliam, W. S. (2016). Explusion and suspension in early education as matters of social justice and health equity. *NAM Perspectives, 6*(10). https://doi.org/10.31478/201610e

Mejia, J., Revelo, R., Villanueva, I., & Mejia, J. (2018). Critical theoretical frameworks in engineering education: An anti-deficit and liberative approach. *Education Sciences, 8*(4), 158. https://doi.org/10.3390/educsci8040158

Meltzer, L. (Ed.). (2018). *Executive function in education: From theory to practice* (2nd ed.). The Guilford Press.

Meyer, M. L., Louder, C. N., & Nicolas, G. (2021). Creating with, not for people: Theory of change and logic models for culturally responsive community-based intervention. *American Journal of Evaluation*, 109821402110160. https://doi.org/10.1177/10982140211016059

Minkler, M., & Wallerstein, N. (Eds.). (2008). *Community-based participatory research for health: From process to outcomes* (2nd ed). Jossey-Bass.

Moje, E. B., Ciechanowski, K. M., Kramer, K., Ellis, L., Carrillo, R., & Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and Discourse. *Reading Research Quarterly, 39*(1), 38–70. https://doi.org/10.1598/RRQ.39.1.4

Moore, T. J., Glancy, A. W., Tank, K. M., Kersten, J. A., Smith, K. A., & Stohlmann, M. S. (2014). A framework for quality K-12 engineering education: Research and development. *Journal of Pre-College Engineering Education Research (J-PEER), 4*(1). https://doi.org/10.7771/2157-9288.1069

Moore, T. J., Tank, K. M., Glancy, A. W., & Kersten, J. A. (2015). NGSS and the landscape of engineering in K-12 state science standards. *Journal of Research in Science Teaching, 52*(3), 296–318. https://doi.org/10.1002/tea.21199

National Academies of Sciences, Engineering, and Medicine. (2016). *Parenting matters: Supporting parents of children ages 0-8*. National Academies Press.

National Academies of Sciences, Engineering, and Medicine. (2021). *Science and engineering in preschool through elementary grades: The brilliance of children and the strengths of educators* (E. A. Davis & A. Stephens, Eds.; p. 26215). National Academies Press. https://doi.org/10.17226/26215

National Academy of Engineering. (2008). *Changing the conversation: Messages for improving public understanding of engineering*. National Academies Press.

National Center for Science and Engineering Statistics (NCSES). (2021). *Women, minorities, and persons with disabilities in science and engineering*. National Science Foundation. https://ncses.nsf.gov/pubs/nsf21321/report

National Research Council. (2000). *From neurons to neighborhoods: The science of early child development*. National Academy Press.

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits.* National Academies Press.

NewSchools Venture Fund. (2020). *EF+MATH program: Executive functions, mathematics, and equity: A primer*. NewSchools Venture Fund. https://www.efmathprogram.org/resources

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press.

Pattison, S. A., Callanan, M., Katz, P., Huerta Migus, L., Ramos Montañez, S., Svarovsky, G., & Takeuchi, L. (2020, April 22). *Four principles for supporting family learning during the global health crisis: Research-based reflections for teachers and educators*. https://www.informalscience.org/news-views/four-principles-supporting-family-learning-during-global-health-crisis-research-based-reflections

Pattison, S. A., Gontan, I., Ramos Montañez, S., Shagott, T., Francisco, M., & Dierking, L. D. (2020). The Identity-Frame Model: A framework to describe situated identity negotiation for adolescent girls participating in an informal engineering education program. *Journal of the Learning Sciences, 29*(4–5), 550–597. https://doi.org/10.1080/10508406.2020.1770762

Pattison, S. A., Ramos Montañez, S., & Svarovsky, G. N. (2021). *Family values, parent roles, and life challenges: Parent reflections on the factors shaping long-term interest development for young children and their families participating in an early childhood engineering program* [Manuscript in review].

Pattison, S. A., Rubin, A., & Wright, T. (2017). *Mathematics in informal learning environments: A summary of the literature (updated)*. http://www.informalscience.org/mathematics-informal-learning-environments-summary-literature

Pattison, S. A., & Svarovsky, G. N. (2021, January 15). *Sharpening our focus on equity: Reflections from the Storybook STEM project*. https://www.informalscience.org/news-views/sharpening-our-focus-equity-reflections-storybook-stem-project

Pattison, S. A., Svarovsky, G., Ramos Montañez, S., Gontan, I., Weiss, S., Núñez, V., Corrie, P., Smith, C., & Benne, M. (2020). Understanding early childhood engineering interest development as a family-level systems phenomenon: Findings from the Head Start on Engineering project. *Journal of Pre-College Engineering Education Research (J-PEER), 10*(1), 72–89. https://doi.org/10.7771/2157-9288.1234

Pawley, A. L. (2009). Universalized narratives: Patterns in how faculty members define "engineering." *Journal of Engineering Education, 98*(4), 309–319. https://doi.org/10.1002/j.2168-9830.2009.tb01029.x

Pawley, A. L. (2012). What counts as "engineering": Toward a redefinition. In C. Baillie, A. L. Pawley, & D. Riley (Eds.), *Engineering and social justice: In the university and beyond*. Purdue University Press.

Philip, T. M., Bang, M., & Jackson, K. (2018). Articulating the "how," the "for what," the "for whom," and the "with whom" in concert: A call to broaden the benchmarks of our scholarship. *Cognition and Instruction, 36*(2), 83–88. https://doi.org/10.1080/07370008.2018.1413530

Quintos, B., Civil, M., & Bratton, J. (2019). Promoting change through a formative intervention: Contradictions in mathematics education parental engagement. *Mind, Culture, and Activity, 26*(2), 171–186. https://doi.org/10.1080/10749039.2019.1602656

Ready, D. D., & Reid, J. L. (2019). Children's executive function development and school socio-economic and racial/ethnic composition. *Early Childhood Research Quarterly, 47*, 457–471. https://doi.org/10.1016/j.ecresq.2018.08.002

Riley, D., Foster, E. K., & Karlin, J. (2020). Show up and disrupt. *Journal of Engineering Education, 109*(1), 7–10. https://doi.org/10.1002/jee.20305

Rogoff, B. (2003). *The cultural nature of human development*. Oxford University Press.

Rogoff, B. (2014). Learning by observing and pitching in to family and community endeavors: An orientation. *Human Development, 57*(2–3), 69–81. https://doi.org/10.1159/000356757

Rogoff, B., Paradise, R., Arauz, R. M., Correa-Chávez, M., & Angelillo, C. (2003). Firsthand learning through intent participation. *Annual Review of Psychology, 54*(1), 175–203. https://doi.org/10.1146/annurev.psych.54.101601.145118

Rosebery, A. S., Warren, B., & Tucker-Raymond, E. (2016). Developing interpretive power in science teaching. *Journal of Research in Science Teaching, 53*(10), 1571–1600. https://doi.org/10.1002/tea.21267

Schenkel, K., & Calabrese Barton, A. (2020). Critical science agency and power hierarchies: Restructuring power within groups to address injustice beyond them. *Science Education, 104*(3), 500–529. https://doi.org/10.1002/sce.21564

Schmitt, S. A., Korucu, I., Napoli, A. R., Bryant, L. M., & Purpura, D. J. (2018). Using block play to enhance preschool children's mathematics and executive functioning: A randomized controlled trial. *Early Childhood Research Quarterly, 44*, 181–191. https://doi.org/10.1016/j.ecresq.2018.04.006

Silander, M., Grindal, T., Hupert, N., Garcia, E., Anderson, K., Vahey, P., & Pasnik, S. (2018). *What parents talk about when they talk about learning: A national survey about young children and science.* Education Development Center, Inc., & SRI International. http://www.edc.org/sites/default/files/uploads/EDC_SRI_What_Parents_Talk_About.pdf

Soja, E. W. (1996). *Thirdspace: Journeys to Los Angeles and other real-and-imagined places*. Blackwell.

Solis, G., & Callanan, M. A. (2016). Evidence against deficit accounts: Conversations about science in Mexican heritage families living in the United States. *Mind, Culture, and Activity, 23*(3), 212–224. https://doi.org/10.1080/10749039.2016.1196493

Strickler-Eppard, L., Czerniak, C. M., & Kaderavek, J. (2019). Families' capacity to engage in science inquiry at home through structured activities. *Early Childhood Education Journal, 47*, 653–664. https://doi.org/10.1007/s10643-019-00958-0

Tan, E., Calabrese Barton, A., & Schenkel, K. (2018). Methods and strategies: Equity and the maker movement. *Science and Children, 55*(7). https://doi.org/10.2505/4/sc18_055_07_76

Tolbert, S., Schindel, A., & Rodriguez, A. J. (2018). Relevance and relational responsibility in justice-oriented science education research. *Science Education, 102*(4), 796–819. https://doi.org/10.1002/sce.21446

Varelas, M., Settlage, J., & Mensah, F. M. (2015). Explorations of the structure-agency dialectic as a tool for framing equity in science education. *Journal of Research in Science Teaching, 52*(4), 439–447. https://doi.org/10.1002/tea.21230

Verdín, D., Smith, J. M., & Lucena, J. (2021). Funds of knowledge as pre-college experiences that promote minoritized students' interest, self-efficacy beliefs, and choice of majoring in engineering. *Journal of Pre-College Engineering Education Research (J-PEER), 11*(1). https://doi.org/10.7771/2157-9288.1281

Vossoughi, S., Hooper, P. K., & Escudé, M. (2016). Making through the lens of culture and power: Toward transformative visions for educational equity. *Harvard Educational Review, 86*(2), 206–232. https://doi.org/10.17763/0017-8055.86.2.206

Walsh, F. (2003). Family resilience: A framework for clinical practice. *Family Process, 42*(1), 1–18. https://doi.org/10.1111/j.1545-5300.2003.00001.x

Wang, S., Lang, N., Bunch, G. C., Basch, S., McHugh, S. R., Huitzilopochtli, S., & Callanan, M. (2021). Dismantling persistent deficit narratives about the language and literacy of culturally and linguistically minoritized children and youth: Counter-possibilities. *Frontiers in Education, 6*, 641796. https://doi.org/10.3389/feduc.2021.641796

Wang, W., Vallotton, C. D., & Bowles, R. P. (2020). Ethnic variances in socializing young children's mastery motivation among White, African American, and Hispanic low-income families. *Early Childhood Research Quarterly, 51*, 329–337. https://doi.org/10.1016/j.ecresq.2019.12.012

Weiner, J., & McDonald, J. A. (2013). Three models of community-based participatory research. *LDI Issue Brief, 18*(5), 1–7.

Wendell, K. B., Wright, C. G., & Paugh, P. (2017). Reflective decision-making in elementary students' engineering design. *Journal of Engineering Education, 106*(3), 356–397. https://doi.org/10.1002/jee.20173

Wilson-Lopez, A., & Acosta-Feliz, J. (2021). Transnational Latinx youths' workplace funds of knowledge and implications for assets-based, equity-oriented engineering education. *Journal of Pre-College Engineering Education Research (J-PEER), 11*(1). https://doi.org/10.7771/2157-9288.1289

Wilson-Lopez, A., Mejia, J. A., Hasbún, I. M., & Kasun, G. S. (2016). Latina/o adolescents' funds of knowledge related to engineering. *Journal of Engineering Education, 105*(2), 278–311. https://doi.org/10.1002/jee.20117

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education, 8*(1), 69–91. https://doi.org/10.1080/1361332052000341006