

Tinkering Together



2022: Proceedings
of an Early Childhood
Ideas Festival

Edited by Mike Petrich, Claudia Caro,
Elizabeth Rood, & Natalie Nielsen

Tinkering Together 2022

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CONTENTS

Note from the editors	viii
About the Event	2
Tinkering Together Proceedings	3
The Power of Tinkering	4
Tinkering and Child Development	5
COVID-19 and Early Learning	7
COVID Breaking Points: Inequities and Unsustainability of the Early Learning Field	8
Structure for Tinkering Together	12
Program Detail for Tinkering Together	16
Tinkering Together Podcast	16
Episode 1: The Tinkering Cycle	17
Episode 2: Tinkering and STEAM Learning	19
Episode 3: Tinkering and Equity	21
Tinkering Together Visual Stories	29
Tinkering Together Resources & Reflections	32
Stories of Practice: Tinkering Together Workshops	33
Spinning Tops Workshop	34
Balance Workshop	35

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Designing for Equitable Collaboration	36
Phase 1	37
Phase 2	38
Phase 3	39
Collaborations	39
Appendix A	40
Tinkering and Elementary School Learners	40
References	41
The Tinkering Studio	46
Early Childhood Tinkering	46
Funding	47
Contributors	47
About the Publisher	48



National Science Foundation



Note from the editors

Welcome to the *Tinkering Together 2022: Proceedings of an Early Childhood Ideas Festival* funded by the National Science Foundation (NSF) and brought to you by the Tinkering Studio at the Exploratorium, a museum of science, art, and human perception in San Francisco, California.

The design of *Tinkering Together* emerged in response to the disruption of the COVID-19 pandemic. The original intent was to offer a traditional in-person event at the Exploratorium. However, the pandemic propelled us to pivot and reimagine a novel digital approach that places equity at its conceptual foundation. The proceedings of the event aim to amplify the many voices in the early learning community involved in the online festival

Tinkering Together is the result of collaboration among many dedicated people. First and foremost, our thanks to all the educators who shared their work in the podcasts, videos, and written material. The Tinkering Together advisors have been most gracious and instructive in supporting the redesign of the event. Lastly, thanks to all of you for being part of the *Tinkering Together* community. We hope we can continue to advance the conversation around early learning, making, and STEAM in ways that authentically benefit learning for all educators, families, and children.

On behalf of the *Tinkering Together* team,
Claudia Caro and Mike Petrich



About the Event

The Tinkering Studio at the Exploratorium organized *Tinkering Together*, a conference bringing together stakeholders exploring applications of making and tinkering to support STEAM learning in informal early childhood environments.

Tinkering Together was designed to broaden participation in informal STEAM learning by furthering exploration of tinkering in the early learning and care community. The Tinkering Studio collaborated with early childhood educators to develop programming with practitioners for practitioners—the outcome is a multimedia online festival that serves as an introduction to tinkering through the perspective of real-world individuals. These early learning educators act as STEAM ambassadors to the field and the general public by illustrating how the tinkering practice is relatable and within reach.

Tinkering Together reimagines the typical conference program by offering on-demand content in the form of podcast and video series, recordings of a live fireside chat and interactive workshops, and compiled resources. Each of these content strands is described in detail in these proceedings.



Tinkering Together Proceedings

Proceedings typically document what happened during an in-person event. Because this event was experimental in nature, the proceedings outlined here include both the end product as well as the process and decision-making of our design. As such, this document has the following key components:

The Power of Tinkering

Tinkering Together 2022: Proceedings of an Early Childhood Ideas Festival begin by defining the tinkering approach and explain why it is a personally-meaningful, play-based approach that aligns with the developmental needs of early learners.

COVID19 and Early Learning

Discussion of the impacts of COVID-19 on the early learning and care community as a way of acknowledging the vulnerability of the field and the impact for everyday children, families, and educators as well as the design of the event.

Structure for Tinkering Together

Explanation of the structure of the program and how these content strands work to activate and broaden participation in informal science through a variety of entry points.

Program Detail for Tinkering Together

In-depth summary of the *Tinkering Together* festival programming.

Designing for Equitable Collaboration

Design process of the *Tinkering Together* website prototype to illustrate how online spaces developed around ideas of justice may be valuable in building meaningful civic online hubs that promote and build confidence in informal science learning.

Many obstacles exist to building collaborative, meaningful learning opportunities for adults working in early education and care.

Tinkering Together represents an experiment in collaboration, a fresh approach to engaging adult learners with asset-based, representative multimedia available on demand. *Tinkering Together* was designed to meet adult learners where they are, in terms of time and place and in terms of knowledge. The intent is to welcome people to an ongoing collaborative movement that brings STEAM-based playful learning to young children.





The Power of Tinkering

Tinkering is an open-ended approach to STEAM learning that offers children opportunities to identify problems and work on solving them in playful, creative ways. It involves using tools, playing with materials, and collaborating with others to build, test, and develop new understanding about the world. Tinkering investigations involve Science, Technology, Engineering, Arts, and Math (STEAM) learning and rely on direct experiences with real phenomena. Playful exploration brings joy and empowers children to pursue investigations that interest them, and the collaborative nature of tinkering supports children to work with and learn from peers and adults. Tinkering leads to deepened knowledge, stronger skills, and increased agency and confidence for all learners.



The tinkering approach can open up new possibilities for children *and* adults. It empowers educators to shift their practice in ways they hadn't imagined or thought possible, all without expecting them to change themselves or their educational programming. Small shifts in how adults support children's play and learning, a focus on process, iteration, and reflection, and a growing community of practice are part of what makes this transition possible and easy.

The tinkering approach works well in a range of settings. Educators and providers working both in home-based settings and more traditional preschool centers

can integrate tinkering into their work with children. Additionally, informal environments including libraries, after-school activities, and family learning are well suited to tinkering.

Tinkering and Child Development
Tinkering Together seeks to build on theoretical foundations by making connections between well-established child development theories and their relationship with early childhood learning.

Tinkering is grounded in *constructivism*, an educational psychology theory that conceives of learning as a process of taking in information, as we interact with the world, and then

assimilating newly acquired knowledge into what we already understand. Rooted in the seminal work of developmentalist Jean Piaget, constructivism is widely influential in early childhood settings because of its focus on how knowledge builds over time and with age (Piaget, 1968). Constructivist teaching looks different than traditional models of education, where an instructor provides students information or teaches to particular outcomes. Instead, constructivist educators act as facilitators of learning, paying attention to what learners know and how their cognition is progressing. Constructivist learning experiences are intentionally designed to build

upon schema, the ideas and understanding a learner has already assimilated.

While constructivism focuses on the way an individual makes meaning from experience, social constructivist theory emphasizes how our understanding is built through shared learning and interaction (Vygotsky, 1978). Vygotsky's notion of the "zone of proximal development" is particularly important to the tinkering approach, as it highlights the role of thoughtfully guided, socially-mediated experiences in learner's development of understanding. Tinkering is strongly grounded in this conception of learning as both socially and cognitively constructed. Additionally, tinkering draws from *constructionism*, a

constructivist learning theory articulated by Seymour Papert, that posits that our strongest understanding results from problem-based learning through the creation of tangible products.

Tinkering has deep potential to support children in developing their growing understanding of the world by building on prior knowledge; engaging with real-world phenomena, tools, and materials; reflecting on their learning with the support of adult engagement; and, practicing learning in a collaborative, social environment (Gutwill et al., 2015; Bevan et al., 2018). While the impacts of tinkering experiences on learners have been well-documented, work-to-date has focused on elementary through adult-aged learners (see Appendix

A). Integrating tinkering into the learning experiences of young children (ages three to five), as supported by families, educators, and care providers, represents a new and emerging area of research-based practice.

Tinkering is a natural fit for informal learning environments due to its playful nature and because it is driven by the learners' questions. Research demonstrates children's natural inquisitiveness and their tendency to approach the world like a scientist (Gopnik, Meltzoff, & Kuhl, 1999), and tinkering capitalizes on these innate tendencies. Tinkering as a practice offers a compelling entry point to STEM learning, interest, and identity development (Vossoughi & Bevan, 2014; Bevan et. al., 2015) for young children, as it aligns with play-to-learn methodologies, the effectiveness of which are well-established (Zosh, Hopkins, Jensen, Liu, Neale, Hirsch-Pasek, Solis, & Whitebread, 2017; Lillard, et al., 2013). The nascent understanding of the impacts tinkering could have on early learners made it compelling to convene the field to consider how to shape future research and learning.

Tinkering Together offers discussions, visual case studies, and resources that illustrate informal science learning in early childhood through the tinkering approach.



Covid-19 & Early Learning

The original intent of the *Tinkering Together* conference was to offer seventy-five stakeholders (speakers, advisors, participants), an opportunity to meet in person at the Exploratorium in San Francisco to share knowledge and open communication channels regarding potential future work at the intersection of tinkering, making¹, STEAM, and early learning. The COVID-19 pandemic precluded this type of in-person engagement, but it offered instead an important opportunity to evaluate our thinking against the critical real-world challenge of broadening participation to include diverse early learning providers in a meaningful yet accessible way.

The crisis of the COVID-19 pandemic deteriorated an already fragile education service and care system for young children, families, and providers. It escalated risks to the community of early educators and care providers, who represent some of our nation's most marginalized intersecting groups— low-income, under-employed, women, BIPOC, immigrant, and English learning communities. The U.S. Department of the Treasury found marginalization of early educators—rooted in race, class, and gender—that is reflected in their wages and in the level of public investment

(2021). According to scholar Elliot Haspel, author of *Crawling Behind: America's Childcare Crisis and How to Fix It*, “Women of color have been subsidizing the entire system by taking very low wages. We’ve long exploited their labor” (as reported in Carr, 2021). In the same reporting, Maurice Sykes of the Early Childhood Leadership Institute notes that, “K-12 is seen as part of the public good whereas child care is seen as part of the service industry.” COVID-19 precipitated a real-world reckoning of a vulnerable field and offered a glimpse of potential long-lasting systemic repercussions.

While challenges to the early learning and care field are clearly much broader in scope than could be addressed within the programmatic goals of the event, the significance of the cultural moment is profound and needs to be taken into consideration in the context of the conceptualization, design, and execution of *Tinkering Together*. It is for this reason that we provide a brief overview of the effects of the pandemic vis-à-vis the early care and learning ecosystem.

¹Making and tinkering are related but separate practices (Brahms & Wardrip, 2014.) The conference intentionally included practitioners and researchers with experience and interest in both.

Covid Breaking Points

Inequities and Unsustainability of the Early Learning Field

The global COVID pandemic illuminated and intensified chronic structural problems in early care and education.



Poverty Level Wages

According to the *Early Childhood Workforce Index 2020*, published by the Center for the Study of Child Care Employment, economic insecurity was widespread among the early learning workforce even before the COVID-19 pandemic struck because jobs in the field consistently failed “to generate sufficient wages that would allow early educators to meet their basic needs” (McLean et al., 2021). This report compared state-level wage data, and found that early care workers are in economic distress and continue to be the lowest-paid occupation nationwide—child care workers make an average of \$11.65 per hour and preschool teachers (in centers or schools) about \$14.67 (McLean et al., 2021). Even before the pandemic, fifty-three percent of child-care workers received public assistance, compared with twenty-one percent of the U.S. workforce as a whole (Whitebook et al., 2018). Depressed wages have been a long-standing trend in the United States. Longitudinal, comparative analyses of data drawn between 1988 and 1992 and data drawn in 1997 show a decade-long stagnation in wages for most child care teaching staff (Whitebrook et al, 2014).

Definitions of Public Good

In the *Early Care and Education Programs During COVID-19: Persistent Inequities and Emerging Challenges* report, researchers from the Center for the Study of Child Employment explain that the business model of the childcare field, which is typically subsidized by a combination of funding streams from the federal, state, and local levels, creates disparities and economic challenges because it places the burden on parents to fund the type of care they can afford (Kim et al., 2022). According to a recent U.S. Department of the Treasury report, *The Economics of Childcare Supply in The United States*, the lack of public investment in the early care and education system contributes to an unsustainable funding model for parents and the early learning and care field (2021). This report also explains that public investment in care before children enter school is significantly less than in other developed countries stating that “France invests \$7,400 per infant to 5-year-old child, the average country in the European Union invests \$4,700, and the United States invests only \$2,400” (2021). Other experts agree that the early childhood education and care system in the United States has long been dysfunctional. Treasury Secretary Janet Yellen has characterized it as a “textbook example of a broken market” (Miller, 2021). Maurice Sykes, a senior associate at the Early Childhood Leadership Institute in Washington, D.C supports this

by saying that “every ‘civilized’ country has some system of early care and education regardless of [family] income, we do not have that commitment” (Carr, 2021).

Closures

Even before the pandemic, childcare services were not able to provide care for everyone who needed them (U.S. Department of Treasury, 2021). According to reporting from *The New York Times*, the pandemic was a tipping point that ended up “increasing the cost of childcare by half” in part due to regulations related to testing and implementation of safety protocols (Miller, 2021). For these and other reasons, children’s play spaces and early care centers experienced widespread closures during the initial stages of the pandemic. As reported in the *The Hechinger Report*, one estimate is that about 20,000 programs—roughly 10 percent of the nation’s total—closed permanently (Carr, 2021). In a recent article published in *The Atlantic*, early childhood policy expert and author Elliot Haspell explains that the impact of the closures have continued well into 2022 with families reporting ongoing challenges finding childcare due to low availability despite high demand (2022). *The New York Times* reporting supports this notion, claiming that “child care—for children too young for school, and for the hours before and after school—is operating at 88 percent of its pre-pandemic capacity” (Miller, 2021).

Personal Cost

The National Association for the Education of Young Children (NAEYC) conducted a national survey across thousands of early childcare programs in November 2020 to assess the impacts of the COVID-19 pandemic on their operations (2020). The study found that ninety-three percent of respondents that had managed to stay open during the pandemic did so at great personal and professional cost, including losing money, and resorting to desperate measures such as using personal credit cards or dipping into personal savings accounts.

Emotional Labor

In addition to the financial strain caused by the pandemic, care providers were also under emotional duress from the added demands of supporting children and families in a time of crisis. Scholars explain that “the need for early educators to engage in emotional labor² is significant as they provide supervision and care, respond to behavioral challenges, resolve conflict, and work in tandem with other professionals and parents” (Purper, et al., 2022). According to an article by *New America*, children and parents alike exhibited behavioral challenges rooted in the pressures of the pandemic (Sproul, 2022). Across the country, more than 175,000 children have recently experienced an adverse childhood experience associated with losing a parent, grandparent, or caretaker to the pandemic. For

those who work with children, additional training is required to respond to any childhood trauma, including those associated with the pandemic.

Not only are early childhood educators dealing with the emotional wellbeing of children and parents, they also have to manage the impact of the pandemic on their own emotional lives. According to scholars, research conducted since the start of the pandemic suggests that the work of early educators has become more challenging and is taking a greater emotional toll on early educators (Purper et. al., 2022). Although there is a lot more research needed to understand the impact of the pandemic on early childhood educators emotional wellbeing, recent studies seem to indicate a concern for early childhood educators mental health. A report on the impact of the pandemic in Massachusetts included personal wellbeing measures—defined as overall mental and physical health—in their survey of early learning educators across the state. This survey found that early learning educators “were more likely to report that the pandemic had adverse impacts on their mental health than on their physical health” and that the pandemic had caused moderate

levels of stress (Hanno et al., 2020). Another nationwide survey asked early educators about the impact of COVID-19 and ninety one percent of early childhood educators indicated that they were “somewhat to very concerned” about the increase in their overall stress levels (Jones, 2020).

Workforce Development

Recovery in the early learning and care field continues to be challenging given the lack of opportunities to make a living wage. In terms of staffing shortages, sixty-nine percent of providers surveyed in November of 2020 by the National Association for the Education of Young Children (NAEYC) reported that recruitment and retention of staff was harder than before the pandemic (2020). Another survey conducted by NAEYC in July, 2021 completed by more than 7,500 early learning educators found that “four out of every five child care centers said that they had a staffing shortage, and seventy eight percent of respondents identified low wages as the main obstacle to recruitment of educators”. Not surprisingly, low wages are cited by eighty one percent of respondents in this survey as the reason they leave the profession (2021). *The New York Times* reports that low pay and lack of job stability, a

challenge faced by many in other service sectors, also affects child care providers (Miller, 2021). This reporting points out that unlike restaurants or stores that pay more and have minimum conditions for employment, the early learning field requires that workers have more qualifications that can include background checks, certifications and even college degrees (Miller, 2021). *The New York Times* forecasts that staffing shortages are likely to continue for the foreseeable future, as workers migrate to other sectors of the economy offering more competitive wages (Miller, 2021).

Given the strain on the early care and learning ecosystem and our commitment to reach diverse providers working in varied settings, the format of an on-demand multimedia online event was both pragmatic and rooted in our commitment to racial, gender, and economic justice. We also understood that, particularly in this time of challenge, many of the people who work with young children see the world as discounting and undervaluing them and their work. Seeing themselves reflected back in the programming became an anchoring feature of design. Representation would communicate welcome, respect, and a seat at the table.

²According to Purper et al. 2022, “The term emotional labor was coined by Hochschild (1983) and is defined as work that “requires one to induce or suppress feeling in order to sustain the outward countenance that produces the proper state of mind of others” (2012, p. 7). Engagement in emotional labor is often required from service employees like nurses and teachers, who need to restrict or limit their emotional displays in order to provide an expected high level of customer service.”



Structure for *Tinkering Together*



WHILE WE CONSIDERED THE EFFECTS OF THE PANDEMIC

on the early learning field, we also valued and sought to uplift the many ways in which the early care and learning community demonstrates resilience and resourcefulness. The Tinkering Studio made a commitment to support practitioners to tell stories of STEAM and tinkering practice in their own words as a way of connecting to the diversity, resilience, and inherent strengths of the early childhood field.

Tinkering Together was designed as a flexible, multimedia event hosted on a website. The design employs an asset-based, grassroots perspective by elevating the experiences of early care educators and providers as the primary source of insight. The website provides a prototype of how technology can invite broad participation in STEAM learning.

The event is organized around three content strands, curated to address specific outcomes and audiences. Each of the strands is centered around a guiding question. In addition, the multimedia offerings are designed to function as case studies of practice. These include edited video and audio stories as well as recorded (unedited) panel discussions and workshops. As such, the work is not scripted and educators' responses and viewpoints are representative of their personal perspective and experiences.

THE THREE CONTENT STRANDS

work to activate and broaden participation in informal science through a variety of entry points.

STRAND 1

Key Voices

How might we introduce the key ideas of tinkering and explore how the approach supports STEAM thinking, positive mindsets, and equitable learning through conversations with diverse providers?

PURPOSE

To introduce key goals of the tinkering approach and bring them to life through audio stories.

AUDIENCE

Intended for broadest distribution and designed to be accessible to those new to tinkering.

STRAND 2

Stories of Practice

How might we showcase tinkering in a wide array of real-world settings?

PURPOSE

To illustrate the relevance of tinkering in different settings (home providers, center-based, informal learning) with different ages of children, and with varied culture and language groups.

AUDIENCE

Adults who are part of the early learning and care ecosystem.

STRAND 3

Community Resources

How might we share practical knowledge with participants?

PURPOSE

Offer a compendium of resources from workshops to books that can be shared widely.

AUDIENCE

Practitioners looking for free tinkering and making resources to support their work.

MULTIMEDIA APPROACH

A three-part audio journalism series (*Tinkering Together Podcast*) hosted by author and NPR education correspondent Anya Kamenetz. Each episode focuses on a different core idea and incorporates the voices and perspectives of individuals working with young children.

BROADENS PARTICIPATION

These edited audio stories introduce tinkering and link the approach to key ideas in early childhood, such as equity, social-emotional development, and exploration, in order to support practitioners who are new to tinkering. Care is taken to highlight peers in the field reflecting on what they have learned about tinkering in their settings.

MULTIMEDIA APPROACH

A four-part video miniseries (*Tinkering Together Visual Stories*) each set in a different type of learning environment.

BROADENS PARTICIPATION

By showing educators and children engaging in tinkering in a wide variety of settings, these videos communicate that science learning opportunities surround us and are accessible to all. The videos demonstrate that early educators and providers, as they are, where they work, and with the materials they have, can competently engage in science phenomena exploration with children.

MULTIMEDIA APPROACH

Online library of resources and blogs related to making, tinkering, and STEAM in early childhood practice.

BROADENS PARTICIPATION

The resources and reflections of practice feature profiles of educators, connections to children's books, STEAM, and tinkering projects. The aim is to signal the richness of topics related to STEAM that can be explored in the early childhood field.

Program Detail for *Tinkering Together*

An in-depth summary of programming is outlined in this section.



Tinkering Together Podcast

THE *TINKERING TOGETHER* PODCAST is a three-part audio series that defines the tinkering approach and brings it to life by having early childhood educators describe their experiences with tinkering and STEAM learning. The podcasts and accompanying livestream fireside chat are hosted by National Public Radio education correspondent Anya Kamenetz.



EPISODE 1: THE TINKERING CYCLE



**ERNESTO
RODRIGUEZ**

Early childhood educator



**RYAN
KURADA**

Transitional Kindergarten
Coordinator at the Sonoma
County Office of Education



**ANYA
KAMENETZ**

National Public Radio
education correspondent

In the first of three podcasts

exploring tinkering in early childhood settings, NPR education correspondent Anya Kamenetz introduces tinkering as an approach that is aimed at people of all ages. She describes a project called STEAM Starters, which both Rodriguez and Kurada were part of. This project invited early learning experts to partner with the Tinkering Studio to develop new tinkering activities that would be age-appropriate for young learners. As the podcast describes, projects highlighted the key elements of tinkering:

- **purposeful play**
- **learner choice**
- **collaboration**

Rodriguez describes in the podcast how his classroom began their tinkering by reading the book *Balancing the Birds*, which introduced mathematical concepts such as counting, balancing weights and measures, addition and subtraction. The children already had some familiarity with these concepts and naturally began applying what was happening in the book to real life. As they began asking questions, teachers brought out materials to start the purposeful play that would support their explorations.

As Rodriguez reflects, educators can use everyday materials that could be relevant to *Balancing the Birds*, such as paper towel tubes,

boxes, cones, blocks, balls, bowls, plastic flower vases, cylinders, and tape. As Rodriguez says, “One of the things that really, really amazed me is that...you are just giving them materials, and they start using it and they come up with more ideas.”

Although every aspect of tinkering appears to be spontaneous, Kamenetz explains that it requires considerable planning. Adult facilitators must think about how to scaffold children’s exploration and then assemble materials that children might use. The podcast describes the Tinkering Cycle, as a systematic yet flexible way to implement the tinkering approach by going through iterations of

Tinkering is how you make children think and solve problems.

ERNESTO RODRIQUEZ



planning an activity, facilitating it for learners, observing and documenting the learning that happens, and reflecting on it in order to relaunch the activity in new and rich directions.

As the podcast describes, tinkering is more structured than it first appears. Adults use words and objects to help children explore their curiosity about scientific, engineering, or mathematics principles such as balancing objects. As Rodriguez describes, “We just put the materials on the table, and just let them see what they do. We just support them...We ask questions... What do you think about these? What are you doing next? We just ask them open-ended questions and see how their creativity goes. I think that was the most fun part.”

In the podcast, Rodriguez reflects on how the tinkering approach aligns to how he runs his program. He reflects, “We really respect the kids, we respect their ideas. Our philosophy as a program is to let them be, you know, if a kid wants to build a castle, okay, let’s build a castle. If a kid wants to make a meal for everybody, let’s go, let’s

go. So we just let them explore whatever interests they have.” But with tinkering, Rodriguez observes, adults must walk a fine line between giving children space to explore and providing structure to guide their scientific discovery. He offers some guidance for facilitators, “So adults, you know, it’s fine to give words of encouragement. Definitely ask them questions. Make sure everybody stays safe, of course. And step in when you see those opportunities to take things a little bit further, pursue a child’s question that comes up naturally, maybe offering a new material to try.”

Rodriguez and Ryan Kurada, a teacher and STEAM instructional coach with the Sonoma County Office of Education, reflect in the podcast on some of the benefits of tinkering for children. Tinkering, they say, gives children opportunities to think like scientists and learn how to solve problems. Tinkering also has an important social component: as children generate their own questions, they talk to each other and share their ideas about what is happening. Rodriguez finds this dialogue helpful for

language development, especially for students in his program who speak English and Spanish. Kurada observes that the open-ended nature of tinkering “leads to true engagement and true understanding of science concepts.” Rodriguez agrees, remarking how his students experienced the staying power of big ideas learned during STEAM Starters: “They really, really embraced the concept. And they were using it in everything...they couldn’t stop talking about it. They were talking about balance for months.”

Tinkering also benefits the adults who facilitate it, as these educators demonstrate in their reflections. They discuss how they delight in children’s problem-solving abilities and imagination and how they have gained new insights into how and why they are teaching in certain ways. Kurada also describes that a benefit of tinkering is to reduce the intimidation of teaching science that many early childhood educators experience. As Kurada explains, “[I]t makes it a little less scary [when] we’re learning together with our students.”



EPISODE 2: TINKERING & STEAM LEARNING



**IHUOMA
IHUEKWUMERE**

Site Director of
the Transbay
Child Development
Center in
San Francisco

Ihuoma Ihuekwumere is a site director of the Transbay Child Development Center in San Francisco, which serves children 18 months to pre-kindergarten age. Her school collaborated with the Exploratorium's Tinkering Studio to develop the STEAM Starters project. This project invited early learning experts to partner with the Tinkering Studio to develop new tinkering activities



**PAULA
HOOPER**

Assistant
Professor
of Instruction,
Northwestern
University

that would be age-appropriate for young learners.

Early learning educators at Ihuoma's center were invited to learn how to engage children in tinkering activities. They learned about the tinkering cycle which involves teachers planning, reflecting and relaunching activities that explore phenomena related to balance, light and shadow and



**ANYA
KAMENETZ**

National Public
Radio education
correspondent

motion. A popular starting point to kick off the tinkering investigation was to read a story book related to a particular phenomenon. Then, the teachers and children use a wide variety of carefully chosen materials to explore questions that came up as they read the book. These materials are everyday household items such as cardboard tubes, hair dryers, balls, pieces of cardboard, or an orange.

If there's one rule of tinkering in early childhood classrooms, it's that tears are going to happen.

ANYA KAMANETZ



As Ihuekwumere shares in the podcast, the teaching philosophy at their school fits well with the tinkering approach. She explains, "We see the image of the child as strong, capable, and resilient. And we strive to support children in their interests to just learn deeper and wider as much as they can."

Also, since tinkering is open-ended, children are in charge of the exploration process. This self-direction includes the opportunity to make mistakes, and those mistakes happen often. Ihuekwumere describes the emotional ups and downs children experience during tinkering: "At first they start off, very joyful. And then when they make mistakes, they fall apart. And they regroup and they know that 'If I don't try more, I may not get what I imagined.'" She finds it amazing when children learn to accept failure as part of their tinkering process.

Ihuekwumere explains that tinkering activities help children develop social-emotional skills such as resilience in the face of failure. She describes tinkering activities as "frustration-rich," and explains that tinkering is "chock

full of frustration. It is. And in my experience, whenever you offer tinkering activities to children, there's this very rough spot where it's all tears, because things don't work the way they're supposed to." As Ihuekwumere points out, however, children are resilient, and with skillful adult guidance they can persevere through their feelings of disappointment. That guidance involves supportive helpers who make it clear that it's fine for things to not work out perfectly, and who gently direct children to try to solve the problem in a different way.

Tinkering "takes patience from the adults, and also the child. Adults have to observe children and...really listen to what they're saying to you," says Ihuekwumere. Paula Hooper, assistant professor of instruction at Northwestern University, agrees. Hooper helps teachers think about, "how pedagogically can I make this situation, a place where kids are sharing their ideas... not afraid to grapple with their ideas, being excited about sharing their ideas." Much of her work focuses on making the classroom a safe place to experiment, to work out students' ideas out in public, and sometimes even to fail.

Hooper and Ihuekwumere discuss some of the social and emotional growth that happens when children tinker. After initially working alone, many children naturally begin to collaborate and share their ideas with each other. They often experience "a-ha" moments when they appreciate what someone else has done. Ihuekwumere says, "For kids at that age to be able to see multiple perspectives of others, to create their own understanding, is... it's really rich." She realizes it might be hard to believe, "but this is actually real and this is something that... it just happens naturally through their play."

The podcast explores how repeated failures and trying again that happens in tinkering also helps children approach conflict in relationships. Ihuekwumere has seen the problem solving skills children use during tinkering extend to other situations in their lives. She notes, "And so you find that it kind of spreads around is just... it pays, it pays forward. It pays forward into other areas of their lives, which is just pretty amazing."



EPISODE 3: TINKERING & EQUITY



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IHUEKWUMERE**

Site Director
of the Transbay
Child Development
Center in
San Francisco



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**RYAN
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Transitional
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County Office
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**ANYA
KAMENETZ**

National Public
Radio education
correspondent

In the final episode of the podcast series, NPR education correspondent Anya Kamenetz speaks with the participants from the previous two episodes, along with early childhood educator Melissa McCloud, about how tinkering connects to issues of equity, empowerment, and social justice.

Kamenetz’s dialogue with the speakers highlights how tinkering projects are designed to make science feel accessible, particularly to people who might not match the stereotype of a scientist or engineer. This accessibility, they said, often begins with the selection of materials and tools that allow for

the exploration of phenomena like momentum or balance. They often repurpose everyday objects such as paper towel rolls or Amazon boxes.

Preschool teacher and STEAM instructional coach Ryan Kurada says everyday materials are essential because teachers

often feel that they don't have the resources to incorporate hands-on science activities in the classroom. But using materials that are on hand, such as the flashlight on a cell phone, shifts the focus away from science as "a grandiose, expensive experiment."

For Melissa McCloud, who lives on the Quartz Valley Indian Reservation in far Northern California, using everyday materials is practical and ties to Native American traditions. She says, "[W]e're natural gatherers, we look around to see what we have in our environment, or what is around us to use...we use what is there." For example, when her students were exploring lights and shadows, McCloud says, "We didn't think of lights and flashlights and stuff. We thought of the moonlight, the sunlight. That's what came into our mind at first."

Tinkering also reduces some of the gender barriers associated with science and mathematics. Before students at Ihuoma Ihuekwumere's early education center began tinkering, she had

to get creative to interest her girl students in activities like blocks. With tinkering, however, the girls "took over the classroom" because of the staff's excitement and all the experimenting, laughter, and "aha" moments that were happening.

Early educator Ernesto Rodriguez has a bilingual classroom where students speak English and Spanish. His students range from two-and-a-half to five-and-a-half years old, which means there is a big range in terms of their language development and social skills. Rodriguez has observed that tinkering promotes vocabulary and language development. He also notices sharing and interactions among students of different ages during tinkering. As he says, "the young ones learn from the old ones, and the old ones learn from the young ones."

For the speakers, another important benefit of tinkering is that it reduces the hierarchy that is common in the formal education system. Tinkering is inclusive. In a tinkering classroom or tinkering

activity, everyone is invited, everyone is a collaborator, and there is no single, right answer. In these ways, professor of teacher preparation Paula Hooper sees tinkering as a vehicle to help children and teachers learn to value differences and understand their unique strengths.

Educators explain how the tinkering approach invited them to learn and discover alongside their students. Rodriguez has learned to navigate the new dynamics that come with tinkering. For McCloud, "It's exciting too, when the kids discover something that we weren't even thinking about." Tinkering also makes McCloud feel valuable as an educator even though she has not been formally certified. Describing her experience with the Exploratorium's Tinkering Studio, she says, "I didn't feel like I was right or wrong. I felt like if I tried, it was, it was good enough. So it really made me feel good and really made me... actually helped uplift myself to feeling like... just because I wasn't a certified teacher, that I wasn't... I wasn't any good."



We're in an interesting moment right now, where there's been a lot of work on multicultural education and white privilege and all these kinds of things that raise up the need for equity.

PAULA HOOPER

Tinkering Together

Fireside Chat

The Fireside Chat was a live online event that featured Anya Kamenetz, in conversation with Ihuoma Iheukwumere, early childhood educator with the Transbay Child Development Center, South of Market Childcare in San Francisco, California; Raemona Little-Taylor, Deputy Director of County Library

Services at the Marin County Free Library; and Mike Petrich, Director, Informal Learning Center, Exploratorium, San Francisco California; as they discuss current making and tinkering practices in early childhood settings, and the implications and future of tinkering.

The fireside chat was developed as a stand-alone event and a companion to the Tinkering Together Podcast Series to engage the community in discussions about the tinkering in practice.

WHAT IS THE TINKERING APPROACH?

To start, speakers share their non-negotiable elements of the tinkering approach.

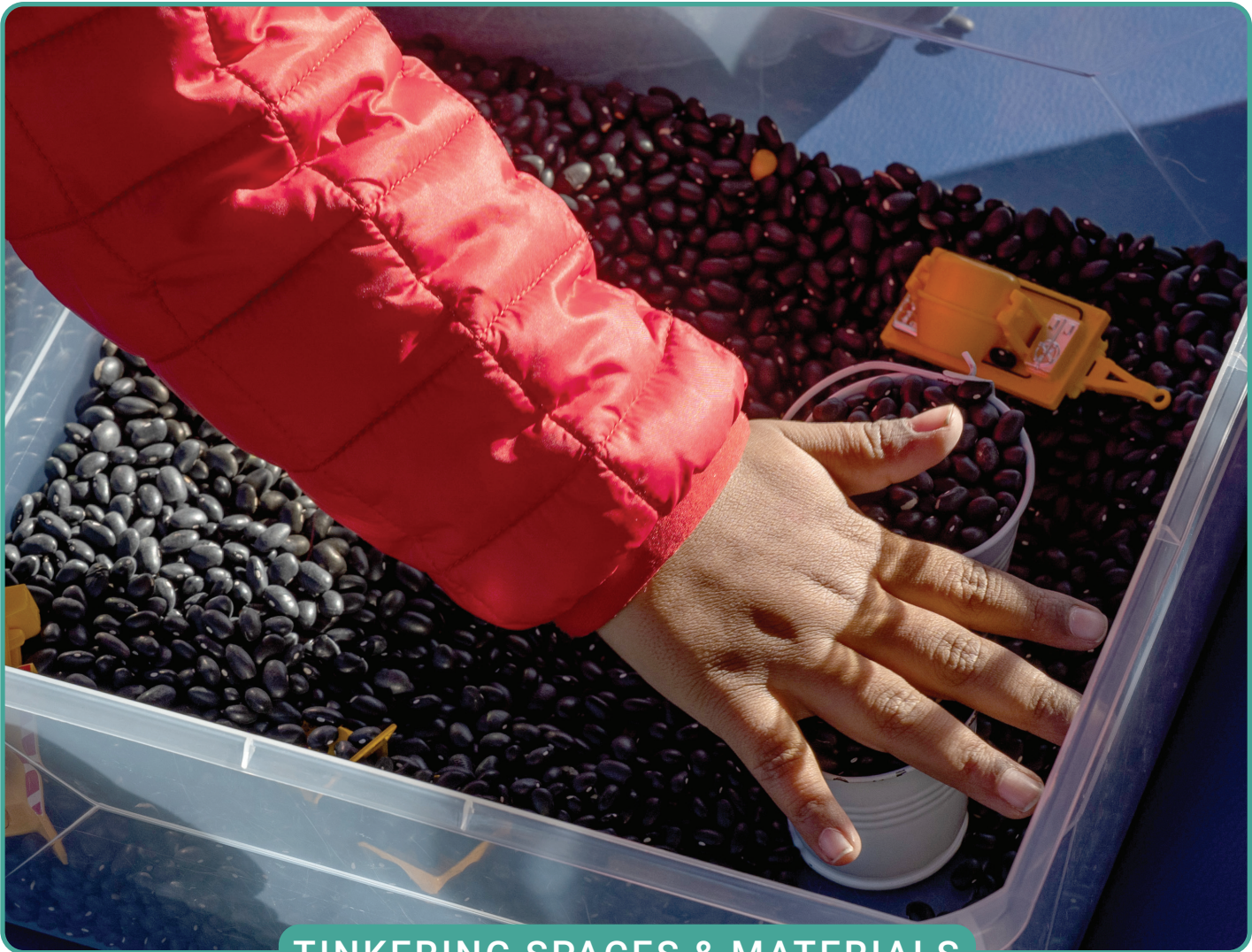
For **Iheukwumere**, **curiosity-driven play** is at the center of tinkering. She explains that tinkering looks like: “playful experimentation” where the **engagement is iterative** and constantly changing as children observe and reflect on the things that they’ve done. Through this experimentation, **children construct understandings** of the topics that naturally interest them. Tinkering, says Iheukwumere, **“looks like it’s not purposeful, but it is**, and the more they do it, and they revisit, they get even deeper and they create this understanding of what they’ve been able to.” Another important aspect of tinkering for Iheukwumere is that **failure is part of the learning process**.

Iheukwumere finds it rewarding to see children persevere through these inevitable failures.

Play is also a central element of tinkering for **Little-Taylor**. On the Learning Bus, a mobile learning vehicle operated by the Marin County Free Library, play is considered to be the child’s work. Little-Taylor and her staff also see **children as experts**. As she explains, “our staff and team we learn from the children every day in our spaces, and they teach us so much about how to engage with the world and how to see it.” The Learning Bus team also takes the stance that **tinkering is the child’s experience** as opposed to

what parents or other adults think children should be doing, and how. For Little-Taylor, “There’s no prescriptive way. It is however the child wants to enter that space.”

Petrich also emphasizes the key role of **play**. He describes tinkering as a **purposeful focus for exploration** that is **driven and directed by the child**. Tinkering for Petrich also involves **collaboration between the adult and the child**. This collaboration goes beyond children building something together or building something side by side and learning from each other. Instead, says Petrich, tinkering allows adults to learn both from and about children.



TINKERING SPACES & MATERIALS

DISCUSSING THE ROLE OF MATERIALS IN TINKERING, Iheukwumere notes that “the environment is a third teacher.” The speakers agree that intentionally setting up the environment as a provocation allows children to express their creative genius. Having a variety of carefully chosen materials is central to this exploration, and the speakers discuss whether children can experience the same level of knowledge-building through virtual tinkering. Petrich raises the possibility of exploring digital tools such as coding or animation programs that children can use with a tablet.

The speakers discuss the affordances of their different tinkering settings:

The Learning Bus, a mobile vehicle that brings preschool experiences to historically underserved communities in Marin County, California. Little-Taylor explains that the Learning Bus is an extension of the county's public libraries and is seeking in part to overcome the historical legacy libraries have of systemic racism and gatekeeping. Because it is mobile, the Learning Bus can reach even the remote corners of the county. Another advantage is that the Learning Bus is designed to serve families, and often sees the same families week after week, from when their children are born until they go to school. The staff puts the child-caregiver relationship at the center of its activities. The Learning Bus makes 11 stops every week and each stop lasts 45-60 minutes. It is designed as a supplement rather than a full preschool experience, especially for families that do not have access to preschool programs.

Transbay Child Development Center, a preschool in San Francisco that serves children from a range of racial/ethnic and socioeconomic backgrounds. The center has a dedicated maker space and structured time for children to explore their curiosity. Iheukwumere explains that the center's teachers understand that every child "comes to school with something more than their backpack—they come with their stories, their experiences, their cultures." Teachers at the center use children's diverse experiences and knowledge to support their tinkering work. Iheukwumere and her staff take extensive notes, pictures, and videos of tinkering activities. They use that documentation to reflect on their roles as facilitators and on how children engage in the activities to continually improve the tinkering experience.

The Exploratorium's Tinkering Studio, is a drop-in setting for families to play and explore together. The Tinkering Studio designs interesting experiences for and with children, with the goal of supporting the relationship between the caregiver and the child as they learn together. Materials are a key element of the Tinkering Studio. The materials are recycled materials and everyday objects that the staff repurposes in unusual and playful ways. Petrich believes that "it's important that we're doing it with materials that don't feel like they're built by experts." The Exploratorium also uses the interactions that happen between children and caregivers during tinkering as a professional development model for its community partners.



Kamenetz asks the speakers

to reflect on how tinkering as an approach can be inclusive, empowering, and give children a sense of agency. Petrich explains that equity is at the forefront of the Exploratorium's Tinkering Studio and notes that "if this work is not culturally relevant, if it's not linguistically accessible, and if it doesn't...reflect the values of those in the communities that want to support this type of learning then we're not doing our job well." He points out that although there is no single approach to equitable teaching, it is inherently equitable for educators to believe that all children are capable of exploring and complexifying many types of problems, and to provide opportunities that support children's thinking. Petrich believes that tinkering can be especially valuable for learners who experience fewer successes in the education system because they can engage with concepts in ways that are more tactile, more meaningful, and more expressive.

Iheukwumere agrees with Petrich that "equity is...in the eyes of the beholder, because it looks different for every different child." She emphasizes the role of the teacher in validating every child's curiosity. Teachers in her center build strong relationships with each family and each child to learn about their stories and experiences, so that they can use those stories and experiences to support each child's learning. Staff members also have conversations

amongst themselves and with families about what inequities look like for people from different races, different genders, and different socioeconomic levels. They ask families about their expectations and their values to help their work with the children in their center. Program staff make concerted efforts to help children understand that they are relevant and that their ideas are important. They also celebrate children's successes during tinkering to help them persevere through the frustrating times.

Little-Taylor also believes that equity and empowerment must be intentionally cultivated. The success of the Learning Bus depends on trusting relationships with families and the community. The staff thinks about equity in every aspect of their work, beginning with where the bus goes. Says Little-Taylor, "We focus on the communities that have been most impacted by the systemic inequities in being excluded from participation and having access to many things. And that's where we root ourselves and root the work, because those are the communities where we see we can make the greatest impact..." They also hand select every book with specific families in mind and the graphics on the outside of the bus depict children who have been in the program.

Iheukwumere and Petrich also discuss gender equity in tinkering. They agree that the

facilitators play a significant role in engaging both boys and girls. In Iheukwumere's center, they have found that when teachers approach activities with joy and curiosity, the children want to participate because they want to be with their favorite person. She points out that, "the girls are actually elbowing the boys out to participate..." Petrich explains that the Tinkering Studio staff is a mix of males and females, and they strive to design tinkering experiences that are relevant and interesting to everyone. He believes that by "paying attention to what our own instincts are about what we love, and what we're interested in" it is easier to create gender neutral experiences and honor diversity.

Little-Taylor adds that the Learning Bus staff is conscious of the language they use around gender because "we want the child...to identify themselves, as opposed to staff." Instead of referring to boys, girls, men, women, or men, they use general neutral terms such as "friends," or "co-conspirators."

Kamenetz praises the speakers for their efforts to offer activities that aren't sorted or pre-labeled by gender and that allow young children to explore different phenomena in ways that are natural to them. Petrich believes those designs result from the general stance of not presuming to know what is good for the other person, and from being open to learning from colleagues and collaborators.



I USED TO THINK *THIS* ABOUT TINKERING, NOW I THINK *THIS*

Kamenetz asks the speakers

to reflect on how their thinking about tinkering has changed as they have gotten more involved with the approach. She prompts them to frame their reflections by saying, "I used to think this, and now I think this."

Iheukwumere: "I used to think that tinkering was very frustrating for young children. But now I think that frustration is actually valuable."

Little-Taylor: "I used to think that tinkering required a lot of technical skill and expertise. And now, I think that anyone can tinker and it's happening all the time, even if it's not described as tinkering."

Petrich: "I used to think that tinkering was about experiences for children, teens and adults that could communicate to each other

clearly about how their ideas are immediately changing and build out and explore and experiment. And it was required that you actually had that discourse ... to really deeply understand the change in [someone's] understanding... And now I realize that tinkering as an early childhood experience, it is at its core, the way that children come to understand the world in natural and important ways."



I used to think tinkering was an activity. And now I think it's a worldview, I think it's a way of being. And it's not just a way of being for children, it's a way of approaching the whole world.

ANYA KAMANETZ

AUDIENCE Q&A

The fireside chat closes with a few questions from the audience.

Q: How do you support adults in their evolution and in being co-learners with the children?

A: Iheukwumere responds, “Sometimes it just takes just diving right in. If you’ve never tried something, try it.” She notes that it is important to provide support and prompts to let adults know there is no perfect approach or answer. When this happens, Iheukwumere says, “[Adults] let go of all the fears and all the stresses and actually start enjoying themselves and enjoy being silly and goofy and discovering something new with a child.”

Little-Taylor adds that it is important to have materials that inspire adults to engage as learners alongside their children.

Q: What is the difference between how children and adults engage in tinkering?

A: Petrich observes that it is more likely for a young child who is pre-verbal or developing their language ability to express their ideas through actions. For example, they will reach for objects or make a shadow on the wall. Older children and teens, he says, are “really good at playing right at school. So they’ll tell you what they think you want to hear from them.” For both children and adults, though, the “aha moments” show in their eyes.

Iheukwumere adds that “for the child, [tinkering] is mostly about the process. And for the adults it is the product.”

Q: What feedback do you get from the people who show up? And what changes have you made as a result?

A: In the Tinkering Studio, says Petrich, “there is no tinkering development without the direct and immediate feedback from all users.” The staff is always facilitating and observing how adults and children use the materials, what questions they ask, and what suggestions they have, and using that feedback to improve the experience.

Little-Taylor says that the Learning Bus experience is similar, and explains that “staff are so embedded in the community and with the families that they have an ongoing feedback loop.” They invite and engage the families in designing the programs with them on the bus.

For Iheukwumere, the most rewarding feedback comes from parents who say, ‘This is the most fun I’ve had with my child while learning.’ She explains that parents are often grateful for the opportunity to see their children as experts, and pleasantly surprised by the children’s knowledge.



Tinkering Together *Visual Stories*

Tinkering Together Visual Stories is a four-part miniseries showcasing tinkering in action by real-world early learning practitioners. The series highlights family child care providers, informal care providers, libraries, and museums.





Julie and Maggie use a play-based curriculum to implement tinkering for early learners in their family child care program. As Julie notes, “I guess I had been using tinkering without knowing I was using tinkering. I didn’t know tinkering existed. It’s hands-on, it’s learning through fun, it’s learning through exploration.” They use common household items such as paper clips and balls to support children’s tinkering, and they encourage families to do the same because children are surprisingly creative with those items. Julie and Maggie believe that tinkering benefits children and the adults who facilitate it. Maggie explains that helping children tinker is a learning experience for her as an educator. She explains that, “It’s important for me to learn what

they’re telling me... I’m reflecting on what they’re saying to one another when they’re learning together. They’re teaching me every day as I’m guiding them in life.” Julie adds that tinkering is similar to the scientific method, and she sees value in children learning how to accept the inevitable failures that happen during tinkering. When children persist through the failures, she explains, they have a “huge sense of accomplishment” when they ultimately succeed.

Melissa and Jeanne child care providers in the Quartz Valley Indian Reservation, integrate tinkering into existing cultural practices. Melissa has always been a hands-on learner, and believes that “when we make

something fun, it interests [children] more. Play helps kids discover for themselves.” Tinkering has helped Melissa and Jeanne realize that they have been doing math and science all along with children in their center. For example, inspired by *The Hungry Caterpillar* they observed the growth of a worm they found when they were shucking corn together. Melissa and Jeanne use their propensity as “natural gatherers” and their connection to the natural world to support children’s tinkering with the materials that are around them, such as rocks, streams, the sun, and the moon. When children brought a pretty rock to Melissa, she shined a light through it and invited them to find other rocks and objects that would reflect



light. She says, “It’s exciting when the kids discover something that we weren’t even thinking about. It’s really exciting because they’re excited. They’ll talk about it to each other.” Jeanne appreciates that tinkering broadens children’s horizons and provides experiences that will put them on an equal footing when they start school. She explains that these experiences are especially important because of the remote location of the reservation. For this reason, Jeanne says, “[Tinkering] is everything to me. It’s a big ball of fun. Let’s do this!”

Raemona, Alejandra, and Mirabel share the philosophy of the Learning Bus, a play-based learning center on wheels from the Marin County Free Library. The Learning

Bus is addressing the county’s disparities in access to enriching early learning opportunities by inviting young children and caregivers to read, build, and tinker together. By encouraging play and experimentation, the Learning Bus also is helping to build a growth mindset in young children. As Raemona explains, “Children are natural tinkerers. If you give them materials they will start to create.” A key element of the Learning Bus is to help adults see how children are learning through play and think about how to provide those experiences in their own homes. For Mirabel, “One of my favorite things about the Learning Bus is seeing how the parents interact with their child.” Books are central to the Learning Bus experience. Having books plus an activity combines hands-on learning with the joy of learning how to read. Because Learning Bus staff members recognize that all children bring unique strengths, they intentionally design the activities to help each child to reach their full potential and find joy in learning. Alejandra approaches her work with the belief that, “We are here to spark their interest and follow that interest.”

Delia and Samantha, museum educators at the New York Hall of Science, implement bilingual, multi-generational approaches for making and learning with early learners and their families.

These programs are based on the philosophy that “play is how children make sense of the world” and that hands-on learning experiences “allow people to feel like they are smart and that they are capable of doing really cool things.” Delia and Sam honor the diversity and strengths of the families who tinker in their space: the workshops are conducted in Spanish, parents are co-owners, and they use everyday materials. Delia explains, “Where I thought that bringing in 3-D printers or laser cutters would be a good idea, what resonated was using simpler materials and simpler tools.” For example, one workshop used a tortilla maker in the traditional way to make tortillas and then to make artistic prints. Sam agrees that it is important “to use tools and materials that are familiar to people, especially things that have associations with them already, like woodworking.” She uses woodworking to “flip the narrative” about gender and power tools, noting that, “Anyone can use woodworking equipment, not just boys.” Through these experiences, the museum is trying to build parents’ confidence to help children explore their curiosity and express their creativity as they learn science at home. They also emphasize the idea that knowledge is shared among all participants. As Delia explains, “The learning journey belongs to the child, it doesn’t belong to the educator.”

Tinkering Together

Resources & Reflections

Tinkering Together Reflections offers community resources and insights related to making, tinkering, and STEAM in early childhood practice. This component is designed to build on and extend the diverse voices that were showcased in the other content strands of *Tinkering Together*.

Stories from early childhood educators that feature the power of children's ideas.

Joanne Lee-Yuen, a lead teacher at Wu Yee Head Start in San Francisco, California, speaks about growing up in a family of educators and her approach to tinkering and making in the classroom.

Jonshā Harris, a preschool teacher at Pacific Primary in San Francisco describes making and tinkering in her classroom. Native educators **Dr. Danielle Lansing (Diné)**, a faculty member at the Southwestern Indian Polytechnic Institute in Albuquerque, New Mexico, and **Dr. Sharon S. Nelson-Barber**, a sociolinguist in WestEd's Science and Engineering Division share insights about connecting culture to STEM education and ways to enhance students' love of learning.

Book selections to pair with hands-on projects.

Tinkering Studio staff have selected these books with an eye toward playful learning, inclusion, and creating space for a variety of author, illustrator, and protagonist voices across a set of themes such as identity building, balance, structures and construction, and light, color, and shadow.

Resources to support hands-on and playful engagement for young learners.

These resources include two investigations – Ramps and Rollers and Light and Shadow – that are part of the STEAM Starters project to co-create versions of tinkering activities with preschool teachers and their classes.

A report on the Tinkering Studio's Tinkering@Home initiative.

When the COVID pandemic was at its height in summer 2020, the Tinkering Studio experimented with new tools and resources to help parents support young children's engagement in tinkering at home. This report documents those efforts.

This feature of the website invites new contributions and diverse perspectives to enrich and continue the conversations that began during *Tinkering Together*.

Stories of Practice

Tinkering Together Workshops

To support adults learning how to incorporate tinkering into their education practice, the Tinkering Studio has long offered in-person workshops and professional development events. Due to the pandemic, the team pivoted to offering tinkering experiences online. Given the museum’s nascent engagement with early childhood educators, these professional development events were experimental in multiple ways: they were virtual with a relatively new audience.

For *Tinkering Together*, the team used the opportunity to better understand how to make virtual, synchronous workshops positive and effective learning environments when the participants were participating over Zoom and with people they had not previously met or worked with.

In particular, the following questions were explored to inform future work:

How might distinct communities of educators be brought together online and be introduced to tinkering through a hands-on experience?

How can language and cultural differences of adult learners be supported in online, synchronous professional development?

The team organized two workshops—one with spinning tops and one with balance—and invited a total of four distinct groups to participate, with two in each. The workshops were hosted via Zoom. The groups included a school-based team of teachers, an already established Portuguese speaking group of early educators interested in creativity and based in Brazil, and a bilingual Cantonese-English professional development cohort based in San Francisco.

In addition, *Tinkering Together* participants were invited to view the live (or recorded) workshops. While the primary focus remained the groups participating synchronously over Zoom, the livestream and the recording allowed for a broader audience than could be accommodated in the Zoom sessions.



SPINNING TOPS WORKSHOP

The Spinning Tops workshop engaged early childhood educators from the Transbay Child Development Center in San Francisco with a mixed-aged group of educators from the Brazilian Learning Network to use common household materials to make spinning tops. In order to prepare for the workshop participants were given a description of the activity and a list of materials to collect prior to the activity. This information was also made available to the general public through the festival website.

This workshop was both bi-cultural and bilingual. A globally common toy was selected as the focus, and the workshop was conducted in English with

simultaneous Portuguese translation. A primary focus for the Tinkering Studio team was to explore how a group of early learning educators who work together (but do not regularly participate in online professional development) would interact with an already established online learning cohort from another country (Brazilian Creative Learning Network, Brazil). With these divergent groups, the Tinkering Studio considered how to support them to come together to tinker as adult learners online. The team observed that the educators grappled with phenomena of spinning tops in similar ways: initial attempts with materials led to experimentation, theory testing, and insights into process. After a period of time

making tops, the educators debriefed the experience, shared reflections on both their successes and failures, and considered implications for their work with children. The Tinkering Studio's most significant insight from the workshop centered around the complexity of facilitating the Portuguese-only speaking group through a translator during the live Zoom session. In particular, the selection of an appropriate translator is critical: someone who is at least somewhat familiar with the practice of making and tinkering can be beneficial to the Portuguese participants, while not hindering any learning opportunities for the English-speaking educators.

BALANCE WORKSHOP

The Balance workshop involved early childhood educators from an established online, bilingual Cantonese-English community of practice in San Francisco. The workshop invited participants to tinker with balance by arranging everyday objects and ordinary materials to create structures that balanced on a point and moved when poked. In order to prepare for the workshop participants were given a description of the activity and a list of materials to collect prior to the activity in both English and Cantonese. This information was also made available to the general public through the festival website.

For the Tinkering Studio facilitators, this online workshop provided an opportunity to consider how best to engage an already established online community of practice accustomed to their own facilitators and types of activities.

As with the Spinning Tops workshop, the Tinkering Studio team saw evidence of workshop participants engaging with phenomena in predictable ways: by formulating a plan, testing different types of materials, developing hypotheses, and

considering questions to build their balance sculptures.

Like the Spinning Top workshop, the Balance workshop was translated to allow participants to engage with the language they were most comfortable using for thinking and discussion. In contrast, however, this workshop made use of consecutive (rather than simultaneous) translation so that the audience watching the livestream online could hear participants speaking in their own voices and participate whether they spoke English or Cantonese. The team postulated that, even though consecutive translation took time, it would signal valuing of participants' ideas and encourage greater sharing across languages. The additional time also gave participants greater opportunity to look closely at examples and consider material choices as different elements were pointed out in both English and Cantonese.

Through this workshop, the Tinkering Studio facilitators observed participants share ideas, take creative risks, and incorporate materials in unfamiliar ways. There were some moments of challenge. One moment, in particular, stood out when a facilitator who did

not have a prior relationship with participants noticed that one person was engaging in a craft activity that did not explore the phenomenon of balance. The facilitator gently redirected the participant's making so that they would consider how to turn their creation into a balancing sculpture.

Participants experienced a range of emotions throughout the workshops. They voiced moments of frustration with their explorations, indicating a level of comfort, in addition to expressing enthusiasm and demonstrating discovery. The ending debrief led naturally into a conversation of how educators could apply this activity and mindset to their own settings, indicating that this already formed group is accustomed to applying learning to their practice as teachers. The Tinkering Studio facilitator who led the activity but did not have prior relationship with the participants reflected on the value of including two additional facilitators who were familiar with the group, one of whom was a skilled translator. The familiarity and technical skill of this facilitator helped to achieve a conversational, low-stakes environment for exploration across language differences.

Designing for Equitable Collaboration



The Tinkering Studio views equity as a practice of examining assumptions and takes an iterative approach to development and design. Reflecting on the historical trends and the impact of the pandemic on the early learning field, the Tinkering Studio also needed to consider the ways in which the digital design of the *Tinkering Together* event could further exacerbate inequalities in the community. In order to design the event with equity as the guiding element *Tinkering Together* was conceptualized and developed in three iterative, equity-centered phases:

Phase 1

Reflection on definitions of justice and exploration of compatible online learning approaches.

Phase 2

Development of a conference model based on sound theoretical principles that align with the tinkering approach and the goals for the project.

Phase 3

Translation of the concept of the event from an idea to a digital product.

PHASE 1

The challenge in designing

online experiences centered around equity is that there are no theoretical models or approaches that fit neatly into real-world scenarios. Phase 1 of this nuanced iterative process involves intentional steps to develop clear definitions of values and examining how these values play out in the design of the event. Developing foundational definitions furthered our aim to integrate educational approaches with sound theory to reimagine the work and to incorporate learning models reflective of the latest in online learning and engagement. Different philosophical and learning approaches were used as guideposts to facilitate design innovation and were not intended to provide a prescriptive formula for development.

Given the cultural moment, a critical step in the process was to question assumptions about the values held around “typical” conference programs that tend to elevate voices in the early childhood field that already hold power and status and who have

the flexibility to leave their work sites to attend professional development opportunities. It became essential to engage in an exploration of the definition of “equity” in order to position these values as the driving element in the conference design. Of particular concern was the digital format of the event and ways in which we could wield technology to advance our stance on equity, rather than ignore its lack of neutrality.

In the beginning stages of crafting the concept for the *Tinkering Together* festival, leading voices such as Sasha Constanza-Chock and Nishant Shah inspired the Tinkering Studio team to challenge and refine philosophical stances related to ideas and definitions of justice.

Shah’s Future Justice is an emerging approach that helps to reexamine the relationship between crisis and justice by asserting that crisis can’t be the only compass by which we define the future (2022). Future Justice provides a paradigm that “aims at unfolding alternative

ideas of justice, which are informed by ideas of collectivity, care, restoration, non-violence and compassion”. Making this theoretical pivot, Shah explains, empowers us to make space for the invention of different ideas, narratives and media that are essential for those that have been historically marginalized. Future Justice helped to shape the philosophical stance from which to begin to prioritize the voices we were committed to elevating and the space to be bold to do away with a traditional keynote and breakout session conference model in favor of showcasing a community of practitioner voices.

Costanza-Chock describes the ways design and designers perpetuate structural inequality and oppression in online spaces (2018). His work influenced the development of core commitments related to anti-racist practices that became integral to the the iterative process of designing the event architecture and the curatorial choices made for speakers, technology, and schedule.

The Tinkering Studio team further reflected on the relationship between justice and pedagogy by examining core commitments and praxis in order to explore alignments between the tinkering approach and compatible online learning approaches. The Connected Learning approach which “advocates for broadened access to learning that is socially embedded, interest-driven, and oriented toward educational, economic, or political

opportunity” (Ito et al., 2013) provided another starting point from which to begin to grapple with the complexity of the informal learning ecosystem and systemic educational inequality. Connected Learning’s stance on progressive education helped us to explore the interconnection between digital and in-person spaces and the impact of digital experiences and environments on learners of all ages. This model defines learning as an

“ongoing process, connected to a diverse and evolving ecosystem of learning resources, institutions, communities, and outcomes” (Freire, 1970, as cited in Ito et al., 2013). Importantly, Connected Learning embraces the opportunities in digital media environments (Ito, et al., 2013) and has provided practical principles for program design for groups of practitioners such as educators and librarians.

PHASE 2

Once we developed guiding ideas related to justice, we moved on to shaping the content strands by exploring alignments between the values-stance, online learning approaches, and the overarching goals of the event.

Tinkering Together was designed to convene stakeholders from the tinkering and early childhood ecosystems and further the exploration and evolution of practitioner and researcher knowledge about tinkering in the early childhood context. The ultimate long-term goal of the project included having more young children introduced to STEM learning through tinkering’s personally-meaningful, play-based approaches that align with the developmental needs of early learners.

The core content strands of *Tinkering Together* are designed to holistically address and examine the needs of both adults and children in early childhood learning contexts, the ways these contexts can be made more equitable through culturally sustaining pedagogies; and the influence of tinkering-based learning experiences on very young learners. Also, the event facilitates the sharing of promising practices that use tinkering to support the STEM learning of young children, as well as surface challenges and questions facing this emergent field.

The three main content strands Key Voices, Stories of Practice, and Community Resources, act as interlocking elements complementing one another to:

- **Analyze and document the state of the field of STEM-rich tinkering in informal early childhood contexts.**

- **Provide tangible resources to the field highlighting current promising practices and future opportunities for development to advance research and support practitioners in deepening their impact.**

- **Further the understanding of how tinkering interventions may contribute to the development of STEM interest, identity and learning amongst early childhood audiences.**

Tinkering Together featured podcasts, videos, and resources reimagine the traditional conference genre to support broader field building and engagement.

PHASE 3

The *Tinkering Together* website is the result of an intentional approach to the design of online civic and learning spaces. The production of the website in Phase 3 is the culmination of a design trajectory that builds on the values mapping and understandings related to online learning approaches from Phase 1 and the development of the content strands as related to the overall

goals of the project in Phase 2. Together, the three Phases follow an interdependent arc of design blending values, theory, and practice.

Tinkering Together was designed as a mobile-first multimedia experience enabling participants to access on-demand conference programming and resources. The user-friendly interface offers

intuitive side bar navigation and a visually compelling and elevated visual art direction to optimize uptake and engagement of the content. *Tinkering Together* is also a hub for resources and is the main channel for participant recruitment, dissemination, sharing conference insights in real-time, and distributing post-conference materials and publications.

COLLABORATIONS

In 2018, with support from the Early Learning and Care Division of the California Department of Education, the Tinkering Studio launched STEAM Starters, a two-year pilot project bringing tinkering into child development centers in San Francisco. This project included direct work in classrooms, the development of age-appropriate adaptations of tinkering phenomena and experiences for young children, and the training of early childhood educators to become tinkering facilitators.

Based on the success of this effort, the Tinkering Studio developed a set of online tinkering modules for early childhood educators in California. The STEAM Starters online professional development modules are intended to engage early childhood teachers and caregivers in tinkering-based learning explorations rich with science practices.

Tinkering Together has been primarily co-created with the early learning educators that collaborated with us in the STEAM Starters project. The innovative vision for the event was possible because the Tinkering Studio has developed close working relationships with the early learning community. This work, rooted in justice and professional respect, has allowed us all to grow and to continue asking questions about the ways children, educators, and communities might engage in tinkering to enhance their learning of STEAM and their comfort with science, but also support the development of children and educators who are confident and capable learners.

Appendix A

Tinkering and Elementary School Learners

The impacts of tinkering interventions on learners ranging from elementary-aged students through adulthood are increasingly well-documented. We now know that learning through well-facilitated tinkering activities can help:

- 1 | learners develop confidence in their ability to use insights gained through their direct experience of iterating on a problem to enhance the design/outcome of a given project (Kali, 2018; Martin, 2015);
- 2 | learners develop a growth mindset as they understand that 'failure' or encountering an obstacle or challenge is part of the process, rather than an undesirable final outcome of it (Martin, 2015; Martinez & Stager, 2013; Dougherty, 2016);
- 3 | learners begin to see themselves as people who are interested in and capable of understanding and solving STEM problems, and in doing so start to develop STEM identity (Martinez & Stager, 2013; Ryan et al., 2016; Clapp et al., 2017);
- 4 | educators support an equitable learning environment by offering an alternative to didactic teaching (which privileges a certain type of learning style), and instead invite diverse learners to harness their direct experience and particular point of view (Vossoughi et al., 2013; Barton et al., 2017; Moll et al., 1992; Ryoo et al., 2016); and
- 5 | facilitators develop new dispositions as science educators engaging in scientific practices and concepts in ways that are inspiring, personally meaningful, and constructivist in nature (Gutwill et al., 2015; Bevan et al., 2018; Brahms & Wardrip, 2014).

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The Tinkering Studio

The Tinkering Studio is a learning laboratory, supporting learners of all ages to explore playful ideas with science, art, and technology, and to think with their hands by actively constructing and exploring with tools, materials, and STEAM phenomena.

The Tinkering Studio is physically located at the Exploratorium, a museum of science, art, and human perception in San Francisco CA, and also exists online as a community of artists, scientists, developers, educators, and facilitators who explore and share the tinkering approach through a broad collection of tools, materials, and technologies.

tinkering.exploratorium.edu

EARLY CHILDHOOD TINKERING

Tinkering Studio educators and designers are exploring ways in which tinkering can open new possibilities and pedagogical alignments with the

early childhood field. Tinkering and making harmonize with developmentally appropriate, early childhood teaching and learning. The tinkering approach

emphasizes the importance of the child's play and exploration, which is at the center of early childhood learning experiences.

TINKERING TOGETHER

Tinkering Together has been created by The Tinkering Studio at the Exploratorium, in close collaboration with early childhood learning experts from around the country. Project advisors and contributors representing a broad

spectrum of informal learning environments and early childhood settings have contributed to the media and materials that we are sharing here. This project was made possible through the generous support of the National

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