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Supporting Latine Children's Informal Engineering Learning Through Tinkering and Oral Storytelling

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Providing equitable informal science, technology, engineering, and mathematics (STEM) learning opportunities to young children from diverse backgrounds may be a way to increase access and interest in STEM and can help to address the broader goal of increasing representation. Importantly, these learning experiences must be meaningful and engage everyday cultural practices. Guided by a strengths-based approach, the current study examines how oral stories as a cultural resource can be harnessed to support Latine children's engagement in a tinkering activity. The project explores whether and how setting an at-home tinkering activity within a story context engenders rich parent–child conversations that provide engineering learning opportunities for young children. Fifty-two Latine parents and children (M_{age} = 7.69 years; 23 girls; 90.4% Mexican heritage) were randomly assigned to either hear a story as a frame for a hands-on tinkering activity or to engage in the same tinkering activity without the story. After families finished tinkering, a researcher elicited the children's reflections about their tinkering experience. Approximately 2 weeks after the activity, children were asked to share their tinkering reflections with a second researcher. Parents and children in the story condition talked more about engineering during tinkering, and these children also talked more about engineering during both reflections than did children in the no-story condition. These findings suggest that integrating oral storytelling into tinkering activities is a promising future direction for the creation of more equitable informal engineering learning opportunities for Latine children and families.

Public Significance Statement
This study suggests that integrating the everyday cultural practice of oral storytelling into a tinkering activity can advance informal engineering learning opportunities for Latine children. Tinkering with oral storytelling has the potential to increase families' engagement in and learning of engineering as well as to make engineering more accessible and equitable for Latine parents and children.

Keywords: Latine children and families, informal engineering learning, oral stories and storytelling, strengths-based approach, parent–child conversations

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Stories are ubiquitous in the lives of children, providing them with opportunities to make sense of their world, develop self-identities, share personal experiences with others, build community and family bonds, and understand cultural values (Delgado-Gaitan, 1994; Espinoza-Herold, 2007; Heath, 1983; Miller et al., 2005; Reese, 2012; Rogoff, 2003). Cultural communities with rich oral traditions, such as those from Latin American heritage, rely frequently on oral storytelling to convey knowledge to children (McDowell et al., 1993; Reese, 2012; Sánchez, 2009). Considering growing recognition of the need for more research on the everyday practices and

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strengths of children from many communities within the United States (e.g., Melzi & McWayne, 2023), we studied whether and how the oral storytelling practices of Latine[1] families can be harnessed to support Latine children's informal engineering learning.

We focused on Latine families, a large and growing segment of the U.S. population. Latine populations currently represent 19% of the total U.S. population, with projections estimating that they will account for 28% in the year 2060 (U.S. Census Bureau, 2017). Yet, even with increasing numbers, Latine individuals are still underrepresented in science, technology, engineering, and mathematics (STEM) fields and careers (National Research Council [NRC], 2009). Moreover, few studies center on ways to support STEM skills among Latine children. This study addresses this need by examining conversations Latine children have with their caregivers that provide STEM learning opportunities at home. Importantly, our work takes a strengths-based approach, considering how everyday experiences, specifically oral stories, are cultural resources for Latine families (e.g., Espinoza-Herold, 2007). We concentrate only on Latine families, avoiding a more typical deficit approach comparing Latine children to white middle-class children and focusing on gaps (see Gutiérrez & Rogoff, 2003; Medin et al., 2010). The children studied were 4–10 years old, given research suggesting that interest in science begins to decrease after the elementary school years (NRC, 2009). Grounded in sociocultural theories of development (e.g., Bruner, 1996; Rogoff, 2003; Vygotsky, 1978), our work asks how encouraging parent–child oral storytelling among Latine families can support children's engagement in engineering-rich conversations and advance engineering learning opportunities during tinkering at home activities.

Tinkering is a hands-on, playful, open-ended form of problem-solving, often involving everyday and recycled materials. Work on tinkering in the context of engineering largely focuses on three major components of engineering design outlined in the *Next Generation Science Standards* (NGSS Lead States, 2013) and *A Framework for K-12 Science Education* (NRC, 2012): (a) defining a problem, (b) developing solutions, and (c) testing and optimizing the solution (Bevan et al., 2015; Honey & Kanter, 2013). Engineering-rich tinkering is characterized by engagement in these engineering design practices, including iterative cycles of trying out designs to solve problems, making adjustments based on the results of a test, and then testing again (Resnick & Rosenbaum, 2013). Just like professional engineers, learners engaged in tinkering may move back and forth between making, testing, and fixing to create and try out multiple solutions that are refined based on the criteria and constraints of the problem.

Researchers and educators point to the potential benefits of tinkering experiences to promote access and equity in engineering education (e.g., Vossoughi et al., 2013). To realize these benefits, however, we need to design opportunities that connect with everyday talk and practices among children from diverse cultural backgrounds. Furthermore, just as oral storytelling and other conversations during events can help support children's initial understanding and encoding of experiences, oral reflection afterward can play an important role in further learning processes of consolidation and retrieval (Acosta et al., 2021; Haden et al., 2021; Pagano et al., 2019). Therefore, we invited children to provide oral reflections about their tinkering experiences immediately after the activity and weeks later. We asked whether storytelling during tinkering might enhance the amount of engineering information children were able to subsequently report about their experiences.

Stories to Support Children's Engineering Learning

Several early childhood curricula and resources for teachers in schools combine stories with hands-on activities in engineering (e.g., Aguirre-Muñoz & Pantoya, 2016; Tank et al., 2013). For example, the *Novel Engineering* curriculum incorporates engineering activities into the narrative texts that are already part of teachers' lesson plans in the classroom (McCormick & Hammer, 2016; McCormick & Hynes, 2012). Students identify problems faced by the characters, or clients, in the literature and they engineer a solution that considers the fictional clients' needs and the situational constraints (McCormick & Hammer, 2016). As another example, *Engineering is Elementary* (EiE) school curriculum units begin with storybooks in which the elementary school-aged protagonist solves problems with the help of adult engineers (Cunningham & Lachapelle, 2014). Solving the story problem then becomes a launch point for the hands-on activities. Pre- to post-program gains are evident from the EiE curriculum, both in terms of understanding of engineering and confidence and attitudes toward future STEM education and career choices. However, for the most part, the assessments of the effectiveness of the school-based programs do not offer clear conclusions about whether it is the hands-on activities themselves that are benefiting engineering understanding or the storybooks. Nonetheless, Casey et al. (2008) compared two intervention conditions to a control condition to answer whether block-building activities themselves benefit spatial skills among kindergartners, and to what extent a story context further advanced learning. They found that whereas the block-building activities led to increases in children's posttest spatial visualization and block-building skills, storytelling with the specially crafted math books had added benefits for children's block-building. Taken together, the findings of these studies support the idea that storytelling can be an effective context for teaching engineering and other STEM-related skills.

Other work highlights the growing interest in how stories can impact informal STEM learning outside of schools and formal curriculum (e.g., Haden et al., 2023; D. Siegel, 2019; Zimmerman et al., 2018). For example, Bennett et al. (2019) created engineering experiences in a museum that invited 7- to 14-year-old girls to create inventions that would help a story character (e.g., a grandma who kept losing her glasses). They found that adding some narrative elements to an activity, such as a character or setting, increased girls' engagement in engineering compared to when versions of the same activity were presented without narrative elements. Furthermore, Haden et al. (2018) found differences among engineering experts in the extent to which they told engineering-rich oral narratives to introduce hands-on activities for families during museum and library programs. Programs with the most engineering-rich oral narratives told by the experts engendered the most engineering talk and engagement in engineering practices by families during the activities, and the most engineering talk by children when reflecting on their experiences immediately afterward. This work is encouraging given that informal engineering activities that include stories can provide opportunities for engineering learning.

In this study, we focused on oral storytelling and encouraging families to tell their own stories because of research suggesting that in some U.S. Latine households, oral storytelling may be a

[1] We use the gender-inclusive Spanish term *Latine* to refer to individuals whose cultural background originated in Latin America.

more frequent practice for supporting children's learning than book reading (Billings, 2009; Melzi et al., 2019). In Latine homes, oral narratives emerge organically during daily activities and are often about past family experiences, traditional or personal stories containing *dichos* or *consejos*, as well as children's stories and legends (Delgado-Gaitan, 1994; Espinoza-Herold, 2007; Melzi et al., 2019; Reese, 2012). Latine parents use oral stories centered on family experiences to help their children learn cultural values and to support their children's critical thinking. For instance, Delgado-Gaitan (1994) described how a working-class, Mexican immigrant family living in California used *consejos*, a cultural narrative consisting of nurturing advice, to teach their children about the value of education. The *consejos* given to the children were often accompanied by stories of the parents' personal experiences. Similarly, Espinoza-Herold (2007) demonstrated how a mother's use of *dichos*, which are oral sayings or proverbs, helped a Mexican immigrant daughter pursue her educational aspirations when she faced major obstacles. The *consejos* and *dichos* shared by these parents reflected their life experiences. Moreover, because parents used these stories to guide their children in challenging situations which required some form of problem-solving, they relate conceptually to the stories used in the engineering programs and curriculums previously reviewed. Overall, sharing oral stories, in particular stories of personal experience, is an existing home practice that from our perspective represents a strength of Latine families (see also Haden et al., 2023).

Parent–Child Conversations and Children's STEM Learning

Integrating stories into tinkering activities can be beneficial for children's engineering learning because stories may engender engineering-rich family conversations. There is a large body of research considering how the conversations parents and children have during hands-on, informal STEM learning opportunities at home or in a museum can facilitate children's STEM understanding (Callanan et al., 2017, 2020; Crowley et al., 2001; Haden, 2010; Haden et al., 2014; Solis & Callanan, 2016; Tenenbaum & Callanan, 2008). For instance, while exploring museum exhibits together, parents support their children's sense-making with explanations, by asking *wh-* open-ended questions (e.g., "what" and "why"), and by connecting the museum experience to their children's prior experiences (Benjamin et al., 2010; Callanan & Jipson, 2001; Crowley et al., 2001; Jant et al., 2014). Research also shows that parents' STEM talk in museums is positively related to the STEM content their children talk about during the experience, and what they report afterward (Acosta et al., 2021; Haden et al., 2014).

Other work with Mexican heritage families suggests that conversational interactions between parents and children during STEM learning opportunities can promote children's learning of science (D. R. Siegel et al., 2007; Solis & Callanan, 2016; Tenenbaum & Callanan, 2008; Tenenbaum et al., 2002). Tenenbaum and Callanan (2008) found that Mexican-descent parents used scientific talk (e.g., causal explanations, predictions) with their children while exploring museum exhibits and when completing science activities at home. Solis and Callanan (2021) observed Mexican heritage families as they engaged in a sink-or-float task at home, and found that parents' approach to the task corresponded with differences in their children's scientific learning opportunities. In their work, Solis and Callanan (2021) focused on the strengths of Mexican heritage parents, in particular those with lower levels of schooling. Their findings revealed the distinct, but highly supportive, ways that parents with lower schooling facilitated their children's science understanding. Amid recent calls for more research that identifies the strengths of cultural communities by valuing their practices and lived experiences (Rogoff et al., 2017, 2018), in the current study we integrated oral storytelling into the tinkering activity.

Postevent Reflections Reveal Children's Learning and Remembering

Our measure of children's learning stems from the literature on children's memory development for personally experienced events (e.g., Haden et al., 2001; Tessler & Nelson, 1994), which suggests that parent–child conversations as events unfold can support children's recall of the experience afterward. Research in a children's museum provides further evidence that conversational reflections following experiences in STEM exhibits can help build a richer understanding of the experience, as well as reveal what children and families learned (Benjamin et al., 2010; Jant et al., 2014; see Haden et al., 2021, for a review). Most of this prior work has focused on parent–child reminiscing conversations after museum experiences (e.g., Haden et al., 2014; Pagano et al., 2019), although by age 4 or 5, children are able to provide independent reflections to unfamiliar individuals who did not experience the event with them (Acosta et al., 2021; Acosta & Haden, 2022). For example, in Acosta and Haden (2022), researchers used open-ended prompts to elicit the posttinkering reflections of 5- to 11-year-old Latine children after engaging in a tinkering challenge. The children's reflections revealed within-group variation in Latine families' engineering learning opportunities, as well as differences based on receiving engineering information from museum staff prior to tinkering.

The reflections children share shortly after an experience can be considered an outcome of learning, but they are also important in the learning process as these conversations can help with the consolidation of the experience, creating a more long-lasting representation in memory (McGaugh, 2000; Pagano et al., 2019). In several studies, Haden and colleagues (Benjamin et al., 2010; Jant et al., 2014; Marcus et al., 2017) have considered families' memory conversations at home following a museum visit, to understand what children remember from their experiences. Jant et al. (2014) examined the memory conversations of families who explored two exhibits in a natural history museum. They found that over time children reported less information about their experience except that children who received conversation instructions about the objects in one of the exhibits remembered more about their museum experience two weeks after the visit than at the 1-day delay. The findings from Jant and colleagues suggest that postevent reflections helped with consolidation of the experience with children showing better recall over time. However, their conclusions are limited by the high attrition rate in the memory follow-ups. The current study addresses this shortcoming as both the tinkering observations and the children's reflections were conducted online, setting the stage for a more comprehensive examination of informal learning and remembering over time.

Current Study

This study is a part of a larger research project designed to serve informal educational practice. In light of the pandemic, we worked with our museum partners to develop an at-home tinkering activity with an engineering design challenge: *Make a Hat*. The criteria for success was the hat had to fit the child's head. The constraints included the materials families had available at home for building and a 30-min time limit. Some families watched a video invitation to tinker that featured a story to frame the activity and invited them to create their own story for their party hat, whereas others watched a video that invited them to make a hat with no story frame. We used video conferencing technology (i.e., Zoom) to observe and record families' interactions while they built their hat, and to record the children's reflections immediately posttinkering and weeks later. We examined the tinkering observations and posttinkering reflections for families' talk about engagement in engineering practices during problem-solving. Engineering practice talk included talk about planning, testing, and improving their design (NGSS Lead States, 2013; Quinn & Bell, 2013). A focus on engineering practices acknowledges that families engage in engineering in their everyday lives and helps contribute to a broader and more inclusive definition of engineering (National Academy of Engineering, 2008; Pattison et al., 2022).

The work was guided by a primary research question: *How is using a story to frame the tinkering activity related to the parent–child engineering conversations during tinkering, and the children's engineering reflections elicited immediately after tinkering and several weeks later?* We predicted that families who received the story frame as part of the tinkering activity would produce more engineering talk during their parent–child conversations and would have children who talked more about engineering in their posttinkering reflections at both time points compared to families who did not receive the story frame.

Method

Participants

A total of 52 Latine parents and children between the ages of 4–10 ($M = 7.69$ years, $SD = 2.05$; 23 girls, 29 boys) participated in the study. The sample size was based on a power analysis using G*Power 3.1 (Faul et al., 2007) for analysis of variance (ANOVA) with main effects and interactions, $\alpha = .05$, power = .80, and a large effect size ($f = .40$), which indicated that 52 families were needed. Families who self-identified as Latino/e/x (both the parent and child) were recruited with the help of the Chicago Children's Museum, who provided flyers to their community partners that serve various Latine communities in the Chicagoland area. Most of the families were recruited through postings on social media and by word of mouth. Eleven (21.2%) of the 52 families had previously participated in a separate study in the museum's Tinkering Lab exhibit when the programming involved making rolling creations, such as cars and skateboards, or building playground equipment for a finger toy puppet.

Table 1 displays the family demographics and background characteristics of the study sample based on parent (50 mothers and two fathers) report. As shown in the table, the majority of parents reported that they and their children were of Mexican heritage, 92.3% and 90.4%, respectively. Half of the sample reported a family income of <\$50,000 annually. More than half reported speaking only Spanish or more Spanish than English with their child.

Table 1
Family Demographics and Background Characteristics Based on Parent Report

Characteristic	Number (percent) of sample $N = 52$
Child ethnicity	
Mexican	15 (28.8%)
Mexican American	24 (46.2%)
Mexican and other (e.g., Salvadoran, German)	8 (15.4%)
Guatemalan	1 (1.9%)
Puerto Rican and Afro-Latina	1 (1.9%)
Afro-Latina	1 (1.9%)
Venezuelan	2 (3.8%)
Parent ethnicity	
Mexican	42 (80.8%)
Mexican American	3 (5.8%)
Mexican and other (e.g., Spanish, German)	3 (5.8%)
Guatemalan	1 (1.9%)
Puerto Rican and Afro-Latina	1 (1.9%)
Venezuelan	2 (3.8%)
Parent schooling	
Outside the United States (e.g., Mexico, Venezuela)	20 (38.5%)
In the United States	23 (44.2%)
Both in and outside the United States	9 (17.3%)
Born outside the United States (e.g., Mexico, Venezuela)	
Children	5 (9.6%)
Parents	35 (67.3%)
Family income	
Less than \$25,000	12 (23.1%)
\$25,000–\$49,999	14 (26.9%)
\$50,000–\$74,999	9 (17.3%)
\$75,000–\$99,999	10 (19.2%)
\$100,000 or more	7 (13.5%)
Language(s) spoken with child	
Spanish only	17 (32.7%)
More English than Spanish	14 (26.9%)
More Spanish than English	11 (21.2%)
Both languages equally	7 (13.5%)
English only	3 (5.8%)

Furthermore, on average, parents reported completing 14.57 years of education ($SD = 4.66$), ranging from 6 to 24 years. Parents reported a variety of occupations, including stay-at-home parent (48.1%), teacher (9.6%), and factory worker (3.8%). Twenty-two families (42.3%) had previously visited Tinkering Lab at Chicago Children's Museum.

Procedure

The study procedure was approved under Loyola University Chicago Institutional Review Board Protocol 2992, *Tinkering with Digital Storytelling*. Once families consented to participate, a date and time was set for the Zoom videocall based on their availability. Families were also given a list of suggested materials to collect for the day of the activity, which included paper, cardboard, plastic, tape, string, scissors, a measuring tape, and a small mirror. All Zoom videocalls were recorded. A bilingual, native Spanish speaker conducted all calls, and all study protocols and materials, including the video invitations shown to families prior to tinkering, were available in Spanish and English. Families received e-gift cards for their participation.

Tinkering Activity

Families were randomly assigned to one of two conditions—a story condition or a no-story condition (control group)—and at the outset watched via Zoom a short video introduction to the activity corresponding to their condition. For families in the *story condition*, the narrator invited the parents and children to make a hat for a party and it was up to them to decide what type of party it was for. The narrator in the video then proceeded to share a personal story about a time when they had to make a hat to take to their cousin's birthday party. To make the hat, the narrator had to engineer at home and followed three steps: make it, try it, and fix it. After sharing their story, the narrator reminded the family that the hat they made had to fit on the child's head. The video ended with the narrator presenting several prompts to help families think about and create their own story for their party hat (e.g., What kind of party is it? Who will be there?). Before the family began tinkering, the researcher asked the parent and child to continue thinking and talking about their story as they made their hat. For families in the *no-story condition*, the narrator in the video invited the family to make a hat, which had to fit on the child's head, with no mention of a party, and no sharing of a personal story about a birthday party.

After watching their respective video, all families were given 30 min to complete the activity with the materials they had collected. The researcher muted their audio and video to avoid distracting the family during tinkering. The researcher introduced a secondary engineering challenge, or criteria, to both groups at the 20-min mark to encourage testing and redesign. Specifically, all families were told that the hat needed to be secured on the child's head so it would not fall off when the child jumped up and down; for those in the story condition, the researcher added the story element that there would be a trampoline at the party. All families received a 5-min warning before their 30 min were up. When their time had expired, they were asked if they would like an additional 5 min to put the final touches on their hat. Therefore, the maximum amount of time that families spent tinkering was 35 min.

Reflections Immediately After Tinkering and Background Questionnaire

Children's reflections were elicited by the researcher immediately after tinkering. All reflections began with a general open-ended prompt: "Tell me [the story about your party hat/about your hat]! I want to hear all about it!" followed by general prompts and questions (e.g., "Tell me more." "Anything else you would like to tell me?"). Then, the researcher asked all children a series of more specific questions to elicit information not provided in response to the more general probe: (a) How did you make your hat? (b) Did you try it on? What happened when you tried it on the first time? (c) Did it fit your head? Can you tell me more about that? (d) Did you have to change or fix anything about your hat? What changes did you have to make? (e) Did your hat stay securely on your head as you jumped up and down? Can you tell me more about that? (f) Did you have fun? and (g) Is there anything else you would like to share?

Parents then completed the background questionnaire with the researcher who screen shared and read aloud all the questions and recorded parents' responses on the form. As part of the background questionnaire, we asked parents to indicate how often they shared oral stories (e.g., childhood experiences and family stories) with their child, and how often their child shared oral stories (e.g., childhood or daily experiences and made-up stories) with them and others on a scale of 1 (*almost never*) to 7 (*daily*).

Reflections Weeks Later

All children who completed the tinkering activity and reflection immediately after the activity also completed the reflection weeks later. In a reminder email/text/phone call, the parent was asked to not speak to their child about their tinkering experience right before the call and to not have the hat with them during the call. These reflections were also recorded via Zoom.

A second bilingual researcher, who was not present for the tinkering activity and first reflection, elicited the children's weeks-later reflection. The researcher began the reflection with all children using a general open-ended prompt: "When you tinkered at home, you met with (researcher's name), and they showed me a picture of the amazing hat you made! I am really interested in hearing all about it. Can you please tell me all about your hat?" The initial prompt was followed by other general questions to elicit additional information (e.g., "Tell me more about that." "What else do you remember?") and then the same follow-up questions used in the initial reflections.

Coding

Engineering Talk

The tinkering conversations and reflections at both time points were transcribed from the Zoom recordings in their original language by bilingual researchers. Transcripts were coded for frequency of engineering talk by parents and children using a system adapted from prior work (Acosta & Haden, 2022; Acosta et al., 2021; Haden et al., 2014). We chose to analyze frequency of engineering talk, which is consistent with other work in the informal learning literature that has also examined frequencies of STEM-related talk (e.g., Acosta & Haden, 2022; Callanan et al., 2017; Marcus, Tõugu, et al., 2021). The unit of analysis in our coding scheme was instance of occurrence where any word or group of words that expressed the engineering content were coded, except for repetitions. For example, in the statement, "I don't think your hat is going to fall off, but try it on," it received one code for *predictions* ("I don't think your hat is going to fall off") and one code for *testing* ("try it on"). In describing the coding schemes, we present the code, its definition, and examples in the language used by the speaker (English or Spanish).

Engineering Talk During Tinkering. Parents' and children's engineering talk during the tinkering activity included talk about *planning*—open-ended questions and responses about what to do next and their ideas (e.g., "So what are you gonna do?" "¿Cómo lo haríamos?"), *predictions*—stating or eliciting an inference about the functionality of their hat before a test has occurred (e.g., "Would this fit your head though?" "¡Pero si brinco se me va a caer!"), *testing*—stating or eliciting a test of the hat by either putting it on their head or jumping up and down (e.g., "Let's try this again." "A ver ahora póntelo."), *redesigning*—eliciting or stating changes that will help the functionality of their hat (e.g., "What can we do to make sure it stays on your head?" "¿Qué te parece si lo amarramos?"), *associations*—connections between the activity and families' knowledge and experiences in the past or in the future (e.g., "We can grab string and tie it here, kinda like that Mary Poppins hat almost?" "¿Te acuerdas de los [sombreros] que yo me pongo cuando voy a cortar el zacate afuera?"), and *engineering concepts and constraints*—talk about balance and stability related to the hat, measurement, and issues around how well the hat fits (e.g., "It's too big!" "¿Me traes la cinta para medir tu cabeza?").

Two bilingual, native Spanish speakers independently coded 25% of the data for reliability. Cohen's κ averaged .88 for parents' and .84 for children's engineering talk. The two coders resolved any disagreements through discussion.

Engineering Talk in the Reflections. Children's engineering talk in their reflections immediately after tinkering and weeks later included *planning*—talking about their or their parent's ideas during tinkering (e.g., "But then I got the idea of making a top hat." "Yo tuve la idea de hacer un sombrero para la lluvia."), *predictions and causal explanations*—offering predictions or explaining a reason for an event or action (e.g., "I put tape so it can stay better on me." "Le pusimos pinzas para que no se caiga."), *testing*—talking about a test of the hat on their or their parent's head or jumping to see if it stayed on (e.g., "So at first when we put it on, we thought it looked good." "La primera vez cuando yo brincaba, el sombrero se iba para atrás."), *redesigning*—talking about changes they made to their hat or how they fixed it (e.g., "It was still a bit small for my head so then we just loosened it a little bit." "Con tape lo pegamos aquí más junto para que quede así perfecto."), *associations*—connections between the tinkering activity and the family's knowledge and experiences in the past or in the future (e.g., "I've heard that making anything into a cone structure it'll be the best." "Mi primera idea, [yo] quería hacer un sombrero de México."), and *engineering concepts and constraints*—talk about measurement, the balance and stability of their hat, and issues related to the making of their hat (e.g., "It was too small for my head." "Estaba un poquito flojo.").

Two bilingual, native Spanish speakers coded 20% of the data for reliability. Cohen's κ averaged .89 for the children's reflections immediately after tinkering, and .90 for the children's reflections weeks later. Disagreements were resolved through discussion.

Families' Tinkering Stories

We created a coding scheme that captured whether and how parents and children talked about a story for their hats as they tinkered. After reading through the transcripts, three holistic categories emerged from the data that reflected the variation in tinkering stories: (a) *party script*—families talked about some story elements that were typical of parties (e.g., selecting a theme for the party, having balloons, cutting a cake) but these did not connect to any personal experiences, or they included fantastical party elements (e.g., having a party with animals in the North Pole), (b) *personal experiences*—families talked about some story elements and connected these to something that was personally meaningful (e.g., inviting their friends or family, having the party at the child's grandmother's house) or invited the use of their prior experiences to build their story (e.g., picking specific games to play at the party because those were the ones the child played at a birthday party they had previously attended), and (c) *no narrative*—families did not talk about any story elements during tinkering.

Cohen's κ on 20% of the data by two bilingual, native Spanish speakers was 1.0.

Data Availability and Preregistration

The data, analytic method, and coding schemes from this study will be made available via an open-source repository at the conclusion of the larger project of which this study is a part. This study was not preregistered.

Results

Initial analyses of family demographic and background characteristics are followed by statistical tests of the research question about the effects of story-based tinkering. There were three outliers (defined as equal to or greater than three standard deviations above the mean), one each for parents' and children's engineering talk during tinkering and children's reflections immediately posttinkering; therefore, at the outset, all main analyses were run with and without outliers. Because the pattern of significant results did not change except in one instance (noted below), we report the analyses with the outliers removed due to their undue influence on the group means (Osborne & Overbay, 2004). Table 2 displays the means and standard deviations for the engineering talk outcome variables for the sample with the outliers removed.

Family Demographic and Background Characteristics

Initial analyses regarding family demographic and background characteristics were aimed at (a) understanding the variability within our sample and (b) identifying demographic and background characteristics associated with the engineering talk dependent variables that would then be included as covariates in the main analyses. All significant ANOVA tests were followed with Bonferroni post hoc tests.

Language Use

During tinkering, we observed 18 families (34.6%) speaking only in English, 21 families (40.4%) speaking only in Spanish, and 13 families (25%) speaking both languages. Parents' years of education differed according to language spoken during tinkering, $F(2, 49) = 17.19$, $p < .001$, $\eta_p^2 = .41$, with English-only families having more years of education ($M = 18.61$, $SD = 3.18$) than Spanish-only families ($M = 12.10$, $SD = 4.28$), and families who used both languages ($M = 12.96$, $SD = 3.06$), and no differences between the latter two groups. The same pattern was observed with regard to income, $F(2, 49) = 12.90$, $p < .001$, $\eta_p^2 = .35$, with families who only

Table 2
Means and Standard Deviations for Parents' and Children's Engineering Talk With Outliers Removed

Engineering talk	*N*	Minimum	Maximum	*M* (*SD*)
Parents' engineering talk during tinkering	51	3	37	15.90 (8.40)
Children's engineering talk during tinkering	51	0	20	7.55 (5.05)
Children's engineering talk in reflections immediately after tinkering	51	0	24	8.59 (5.44)
Children's engineering talk in reflections weeks later	52	0	19	7.94 (4.20)

spoke English during tinkering reporting higher incomes ($M = 3.94$, $SD = 1.47$) compared to families who only spoke in Spanish ($M = 1.95$, $SD = 1.07$), or used both languages ($M = 2.54$, $SD = 1.13$), and no differences between the latter two groups. The three language groups did not differ on parents' and children's engineering talk during tinkering, $F\text{s} \leq 2.55$, $p\text{s} \geq .09$, $\eta_p^2 \leq .10$.

For the children's reflections immediately posttinkering, 32 children (61.5%) spoke in English, 15 (28.8%) spoke in Spanish, and five (9.6%) used both languages. There were no differences between the three groups for their engineering talk in their reflections immediately after tinkering, $F(2, 48) = 1.99$, $p = .15$, $\eta_p^2 = .08$. For the children's reflections weeks later, 37 children (71.2%) spoke in English and 15 (28.8%) spoke in Spanish. There were no differences between the language groups for children's engineering talk in their reflections weeks later, $F(1, 50) = 1.40$, $p = .24$, $\eta_p^2 = .03$.

Parents' Years of Education

With regard to parents' schooling, an ANOVA indicated a significant difference in years of schooling based on where the education was obtained, $F(2, 49) = 15.96$, $p < .001$, $\eta_p^2 = .40$, with parents who received their education outside the United States having fewer years of schooling ($M = 10.95$, $SD = 3.47$) than parents who received their education in the United States ($M = 16.46$, $SD = 3.46$), and parents who completed their schooling both in the United States and in another country ($M = 17.78$, $SD = 4.71$); the latter two groups were not different. Parents' total years of schooling were positively related to parents' and children's engineering talk during the activity, $r\text{s} \geq .37$, $p\text{s} \leq .008$, and the children's reflections weeks later, $r = .33$, $p = .019$, but not their reflections immediately posttinkering.

Associations Between Other Background Characteristics and Engineering Talk

Further descriptive analyses examined whether and how all families' demographic and background characteristics were related to all the engineering talk outcome variables. Child age was significantly correlated with children's engineering talk in their reflections immediately after and weeks later, $r\text{s} \geq .37$, $p\text{s} \leq .007$, but not with parents' nor children's engineering talk during tinkering. How much time families spent tinkering did not correlate with parents' or children's engineering talk during tinkering, $r\text{s} \leq .19$, $p\text{s} \geq .19$, nor children's engineering talk in their reflections, $r\text{s} \leq .21$, $p\text{s} \geq .14$. There were no significant differences between boys and girls in parents' and children's engineering talk during tinkering, nor children's engineering talk in their reflections immediately after or weeks later, $F\text{s} \leq 0.62$, $p\text{s} \geq .44$, $\eta_p^2 \leq .01$. Similarly, there were no significant differences in engineering talk as a function of where the child was born, or whether families had visited Tinkering Lab before. There was a significant difference in parents' engineering talk during tinkering between parents born outside the United States and U.S.-born parents, with the former using less engineering talk ($M = 13.65$, $SD = 6.30$) than the latter ($M = 20.41$, $SD = 10.31$), $F(1, 49) = 8.44$, $p = .005$, $\eta_p^2 = .15$. For repeat participants, children who had participated in prior tinkering studies talked more about engineering in their reflections immediately after ($M = 12.30$, $SD = 6.93$) than children who were participating for the first time ($M = 7.68$, $SD = 4.68$), $F(1, 49) = 6.42$, $p = .015$, $\eta_p^2 = .12$.

Describing Families' Oral Story-Sharing Practices

As part of the background questionnaire, parents reported how often they and their children shared oral stories on a scale from 1 (*almost never*) to 7 (*daily*). Parents indicated an average rating of 5.90 ($SD = 0.93$; range = 4–7) for sharing stories with their child, and 6.37 ($SD = 1.04$; range = 3–7) for children's sharing of stories. The frequency with which parents shared oral stories with their child was not associated with parents' years of education nor their family income, $r\text{s} \leq .20$, $p\text{s} \geq .15$. Furthermore, there were no differences in how often parents shared oral stories as a function of where they were born, with parents born outside the United States reporting sharing oral stories at a similar frequency as parents born in the United States, $F(1, 50) = 0.69$, $p = .41$, $\eta_p^2 = .01$. There were also no significant differences in parents' frequency of sharing oral stories based on their child's gender, $F(1, 50) = 0.00$, $p = .95$, $\eta_p^2 = .00$, nor any associations with their child's age, $r = -.03$, $p = .85$. Finally, how often parents and children reported sharing oral stories was not related to families' engineering talk during or after tinkering, $r\text{s} \leq .23$, $p\text{s} \geq .10$.

Effects of Story-Based Tinkering

Next, we turned to hypothesis testing, which considered the effects of story-based tinkering for parents' and children's talk during the activities, and children's subsequent reflections. We first determined that random assignment resulted in the groups being equal on all demographic and family characteristics reported by parents, as well as on the amount of time families spent tinkering (see Table S1 in the online supplemental materials). Moreover, the online supplemental materials provide analyses in which we examined families' engineering talk during the primary and secondary challenge (as opposed to a total composite score). The results of these analyses support our decision to analyze parents' and children's engineering talk during the activity as a total composite score across the primary and secondary challenges. In testing the effects of story-based tinkering, any demographic or background characteristic that was related to an outcome variable was included and retained in the main analysis as a covariate if it was significant at $p < .05$.

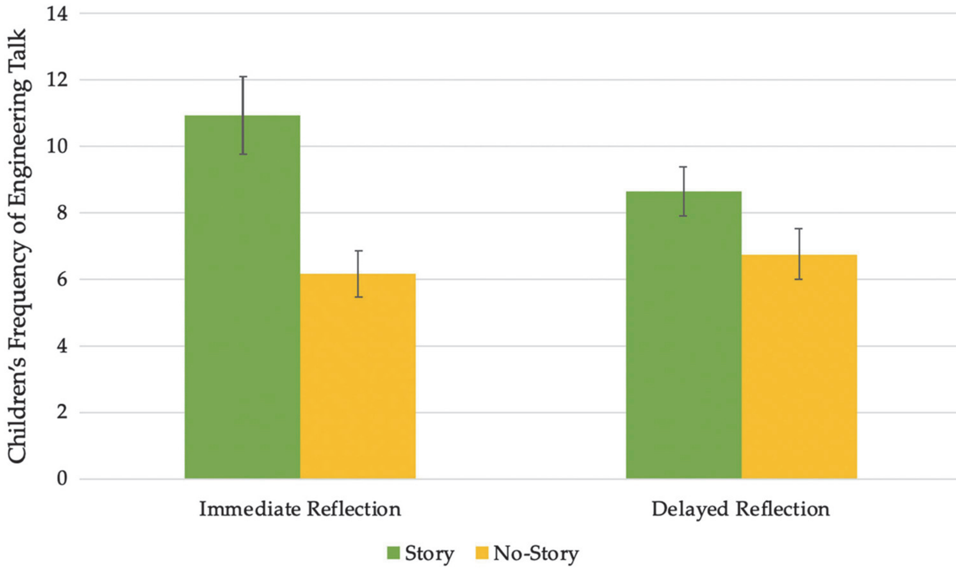
Engineering Talk During Tinkering and Reflections

Concerning families' talk during tinkering, we predicted that story-based tinkering would engender more engineering talk among parents and children compared to parents and children in the no-story condition. In support of our hypothesis, parents in the story condition talked more about engineering as they tinkered ($M = 19.16$, $SD = 8.83$) than parents in the no-story condition ($M = 12.77$, $SD = 6.75$) after controlling for where the parent was born, $F(1, 48) = 10.74$, $p = .002$, $\eta_p^2 = .18$. Likewise, children who received the story as a frame for the activity talked more about engineering during tinkering ($M = 9.19$, $SD = 5.29$) than children in the no-story group ($M = 5.84$, $SD = 4.24$), $F(1, 49) = 6.20$, $p = .016$, $\eta_p^2 = .11$; with outlier: $F(1, 50) = 2.39$, $p = .13$, $\eta_p^2 = .05$.

Turning to the reflections, to understand the effects of condition (story, no-story) and time (immediate, delayed) on children's engineering talk posttinkering, we conducted repeated measures ANOVAs. We hypothesized that children in the story condition would talk more about engineering in both reflections compared to

Figure 1

Condition × Time Interaction Effect on Children's Engineering Talk in Their Reflections



Note. See the online article for the color version of this figure.

children in the no-story condition. The mean number of days between the first reflection and the delayed reflection was 17.98 days ($SD = 7.48$), ranging from 14 to 50 days. Repeated measures analyses were initially conducted with the number of days between the two reflections as an additional covariate, but because the number of days was not a significant covariate, we report the analyses without it. As depicted in Figure 1, after controlling for child age, whether the child was a repeat participant, and parents' years of education, there was a significant main effect of condition, $F(1, 46) = 14.07$, $p < .001$, $\eta_p^2 = .23$, and no main effect of time, $F(1, 46) = 0.36$, $p = .55$, $\eta_p^2 = .01$, with these effects qualified by a significant Condition × Time interaction, $F(1, 46) = 6.63$, $p = .013$, $\eta_p^2 = .13$. In their reflections immediately posttinkering, children in the story condition talked more about engineering ($M = 10.92$, $SD = 5.99$) than children in the no-story condition ($M = 6.16$, $SD = 3.50$), $F(1, 46) = 16.45$, $p < .001$, $\eta_p^2 = .26$. Similarly, it was the children in the story condition who talked the most about engineering ($M = 8.65$, $SD = 3.86$) in their reflections weeks later compared to children in the no-story group ($M = 6.76$, $SD = 3.85$), $F(1, 46) = 4.75$, $p = .034$, $\eta_p^2 = .09$. There were no significant differences in children's engineering talk between the immediate and delayed reflection for either the story, $F(1, 22) = 0.86$, $p = .36$, $\eta_p^2 = .04$, nor the no-story group, $F(1, 21) = 0.00$, $p = .95$, $\eta_p^2 = .00$. In sum, children in the story condition continued to show greater recall of engineering across the delay than children in the no-story condition.

Finally, to gain a better understanding of the stories families created during tinkering, we holistically coded their interactions as either conveying a party script, relating a story about personal experiences, or involving no story. Eight families (15.4%), six from the story condition and two from the no-story condition, told stories involving a script for a party about their hat. Fourteen families (26.9%), all from the story condition, told stories about their party hats based on their personal experiences. Thirty families (57.7%), six from the story condition and 24 from the no-story condition, did not tell a story.

We asked whether there were differences among families who told scripted or personal stories about their hats in their engineering talk during tinkering. Due to the small *n*s, however, these analyses should be considered exploratory. There were no significant differences in parents' engineering talk between families who told party script ($M = 16.75$, $SD = 6.41$) or personal stories ($M = 20.69$, $SD = 9.48$), $F(1, 19) = 1.07$, $p = .31$, $\eta_p^2 = .05$. There were also no significant differences in children's engineering talk between party script families ($M = 9.43$, $SD = 5.97$) and personal story families ($M = 8.86$, $SD = 6.14$), $F(1, 19) = 0.04$, $p = .84$, $\eta_p^2 = .00$. Likewise, there were no differences as a function of the type of story shared for children's immediate and delayed reflections, $F\text{s} \leq 1.64$, $p\text{s} \geq .22$, $\eta_p^2 \leq .08$.

Discussion

Summary of Findings

We examined how Latine parents and their children engaged in a tinkering activity at home and whether encouraging storytelling during tinkering supported talk about engineering practices during and after tinkering. Our findings indicated linkages between the framing of the tinkering activity with a story and families' engineering talk during tinkering. Parents and children in the story condition talked more about engineering while making their hat than families who made a hat without the story frame. The effect of the story carried over to the children's reflections elicited immediately after tinkering and weeks later. Days and weeks after tinkering, children who were invited to create a story for their party hat talked more about engineering as they reflected on their tinkering experience than children who simply made a hat with no story context.

Tinkering and Storytelling Support Latine Families' Engineering Talk

Engineering-rich tinkering can help promote equity and access in engineering education for children and families from diverse backgrounds (Vossoughi & Bevan, 2014). In this project, families engaged in tinkering in a hands-on manner using familiar and everyday materials they had at home. Tinkering activities that include an engineering design challenge or a problem to be solved have the best potential to support engineering learning, as families have shown increased engagement in engineering talk and practices during these activities (Marcus, Acosta, et al., 2021; Pagano et al., 2020). Therefore, in this study, families had to consider two criteria: the hat had to fit their head, and the hat could not fall off when jumping up and down. We focused on talk that suggested engagement in engineering practices, such as testing and iterating/fixing one's design. Thinking about engineering as a set of problem-solving practices helps broaden the definition of engineering by recognizing that everyone, not just engineers, does engineering (Pattison et al., 2022).

We paired tinkering with storytelling to advance understanding of how this combination could play to the strengths of Latine families and support their engineering learning. Stories are culturally determined ways of sharing lived experiences that help us organize and make sense of the world around us (Bruner, 1996). Stories have been previously linked to the development of young children's academic skills (Schick & Melzi, 2010) and may be especially powerful for facilitating science and engineering learning (Callanan et al., 2021; Haden et al., 2023; Pattison et al., 2022). Our findings make a significant contribution to the literature by examining informal learning environments and the learning that is co-constructed by parents and children. Whereas prior work in formal educational settings has used stories in books with fictional characters (Cunningham & Lachapelle, 2014; McCormick & Hammer, 2016), we centered the tinkering activity around the child and their needs and desires, and allowed them to create their own story as part of their informal learning experience. Most importantly, our work focuses on families of Latine heritage, a group that is not only underrepresented in STEM but also in developmental science research. Guided by a strengths-based perspective, we included oral storytelling to capitalize on the ways stories are frequently shared among Latine families. Indeed, during tinkering, some families talked about how the act of creating and sharing stories was a familiar, everyday practice for them:

> Parent: Puedes hacer un cuento, mi amor. Así como cuando te imaginas un cuento y me lo cuentas, ¿te acuerdas? (You can create a story, honey. Just like when you make up a story and tell it to me, remember?)

As part of the activity, we asked families to create their own story for their party hat in whatever way they wanted. Most of these families organically created stories that were personally meaningful by including family and friends, or by referencing their prior experiences. This is consistent with research that has shown that stories of personal experience are highly valued among Latine families (Delgado-Gaitan, 1994; Reese, 2012). For instance, one parent asked their child to recall previously attended parties, saying, "Think about the parties that we've been to. What did you do at the parties?" Likewise, in the excerpt below, another parent drew from their child's school experiences to help build their party hat story:

> Child: Iba a haber una fiesta. (There was going to be a party).
>
> Parent: ¿Pero iban a hacer como algun concurso o algo? ¿En tu clase era hoy el día de qué? ¿Del sombrero loco? (But were they going to do a contest or something? In your class today, it was what? Crazy hat day?)
>
> Child: Sí. (Yes.)
>
> Parent: A lo mejor en la fiesta también iban a hacer un concurso de sombreros locos y por eso les pidieron que llevaran un sombrero. (Maybe at the party there was also going to be a crazy hat contest and that's why they asked you to bring a hat.)

The combination of tinkering and storytelling allowed the Latine families in our study to problem solve in ways that might connect with everyday practices and experiences. When families are able to make use of their prior experiences, there is an opportunity for parents and children to recognize the ways that engineering relates to their everyday lives and realize the value of their funds of knowledge for engineering (Wilson-Lopez et al., 2016). Our study suggests that story-based tinkering can present a promising pathway for Latine heritage families to engage in engineering in a way that recognizes and values their lived experiences and practices, which can help broaden participation in STEM.

We observed parents and children engage in engineering-rich conversations during story-based tinkering. This is important because prior work suggests engineering-rich language can help facilitate children's STEM understanding and remembering of the experience (Acosta et al., 2021; Haden et al., 2014), and other work has shown links between the frequency of specific types of talk (e.g., number words) during events and children's subsequent skills in corresponding domains (e.g., math; Gunderson & Levine, 2011; Pruden et al., 2011). Take for example the following conversation between a parent and child in the story condition as they worked to make their party hat. This conversation comes after the family was provided with the secondary engineering challenge, to secure their hat onto their head so it doesn't fall off when jumping up and down on a trampoline. This addition to the story becomes a reason for why the parent and child have to redesign or improve their hat, and the parent facilitates this by asking the child to call upon their prior knowledge:

> Parent: You have to use your imagination. You have a trampoline in your yard and you're gonna go with your party hat and jump in there.
>
> Child: Yeah because this party is for me, myself.
>
> Parent: So now we gotta figure out how this hat is not gonna fall off your head. What do you think we can do so this hat doesn't fall off? … Think of a party hat, what do party hats have so they don't fall off?
>
> Child: A string.

In this example, the story introduces a new problem that the parent and child must navigate while they build their hat. As the family engages in redesigning and making associations to prior personal experiences, it is possible that they are also engaging in problem scoping, or the process of understanding a problem and its boundaries (Watkins et al., 2014). The parent and child move into the problem space by identifying a new criteria (the hat cannot fall off when jumping), build an understanding of the problem by using their personal experiences, and then use this information to move into the solution space (adding a string to the hat). There is work demonstrating that elementary school-aged children engage in problem scoping behaviors during engineering design activities, with these behaviors varying across age groups, activities, and formal and informal settings (Dorie et al., 2014; Haluschak et al., 2018; Watkins et al., 2014). In our study, it may be that the story context made the activity more meaningful, essentially providing a realistic and motivating reason for having to redefine the problem. This, in turn, led to more sustained engagement in engineering practices, as well as making the experience more memorable.

Tinkering and Storytelling Support Latine Children's Memory and Learning

In addition to facilitating the engineering conversations happening between parents and children during tinkering, the story context also supported children's engineering talk in their reflections immediately after tinkering as well as weeks later. Our examination of the children's reflections demonstrated that children in the story condition talked more about engineering than children in the no-story condition, and this was evident across both time points. These findings provide support for the idea that reflection is important for consolidating the learning taking place from informal learning experiences (Haden et al., 2021). As a part of an extended learning process, reflections after events can facilitate the formation of lasting memories from labile and fleeting patterns of experience (Pagano et al., 2019). Reflecting after a hands-on experience, such as tinkering, may help promote *distancing* (Sigel, 1993) and *concreteness fading* (Goldstone & Sakamoto, 2003), both of which describe the opportunity for children to move beyond focusing on the objects themselves to focusing on the abstract knowledge and concepts learned from manipulating those objects (Acosta & Haden, 2022; Haden et al., 2014).

Our results revealed that story-based tinkering was especially helpful in facilitating children's remembering of their at-home tinkering experience. Somewhat surprisingly, we did not find forgetting of engineering information over time in children's reports of their tinkering experiences. Moreover, children in the story-based tinkering condition remained different from children in the no-story condition, recalling the most engineering information at both time points. This suggests that story-based tinkering was related to children's remembering of the experience, which was sustained over time. Our findings align with prior work in the event memory literature showing that mother–child conversational interactions during shared events are related to children's later remembering and recall of the experiences (Boland et al., 2003; Haden et al., 2001). This prior research, and our study, lend support to the idea that parent–child interactions as events unfold can focus children's attention to salient aspects of the shared experience. Therefore, what is happening *during* the event is facilitating children's encoding of the experience, which in turn, is related to what children remember *after* (Haden et al., 2001). Stories have the potential to make memories stronger and more meaningful (Haden et al., 2016), and storytelling during tinkering may have contributed to the engineering-rich reflections shared by the children. In the following example of a child's reflection 2 weeks posttinkering, the child links the creation of their party story with the creation of their hat and recalls the engineering process they had to undergo to get their hat to fit just right:

> Child: So the hat, while we were building it, we were thinking on a theme…and then we saw that we had red and black present wrapping paper, then it could be a red and black party. And then after that, we started wrapping up the cardboard box and cut it into shape. … We tried it on and then we saw that it didn't fit. And then I told my mom that we should make it like a circle. Then we did and we tried it on. It was a little too big so we cut the string a little bit. And after that, I tried it on and it was perfectly good.

Our project focused on storytelling in two ways. We framed the tinkering activity with a story context and elicited children's oral reflections or stories posttinkering. Driving this approach was an effort to understand the ways that we might create engineering-rich learning opportunities by leveraging storytelling. Given that oral storytelling is a frequent everyday practice for many Latine families and particularly for families in our sample, encouraging storytelling during tinkering has the potential to make engineering learning opportunities more accessible and equitable for children from traditionally underrepresented backgrounds. Our goal was to place value on the oral discourse practices observed among Latine families, and harness the power of oral storytelling to support children's informal engineering learning. The findings from our study revealed that story-based tinkering, and providing opportunities for children to reflect on their experiences orally, can serve to promote long-lasting learning and remembering and broaden participation in science and engineering for traditionally marginalized groups.

Limitations and Future Directions

Our work makes important contributions to the literature on children's informal learning and how more equitable engineering learning opportunities can be created for Latine families through tinkering and storytelling. Nevertheless, our findings are limited by the fact that we focused only on parents' and children's language use during tinkering. Not all of children's learning opportunities emerge in talk—children also learn through other forms of communication, such as observation and imitation, and by actively participating in their community's activities (Rogoff, 2003, 2014). Our focus on parent–child dyads, as opposed to including other family members, may have also underestimated children's learning opportunities from tinkering activities. Concerning our measure of learning, the children's verbal reflections rely on children's expressive language skills. Our aim was to understand what children remembered about their tinkering experience on their own. Alternatively, other work has shown that parent–child reflections can also reveal and support children's learning from tinkering experiences (Pagano et al., 2020). Finding ways to fully capture how and what children retain and are able to subsequently use to extend their learning is an important area for future research.

The story frame we designed for this activity was our attempt at tapping into the lived experiences of Latine families, as most children are familiar with the concept of a party by either having had or previously attended one. Most families who engaged in story-based tinkering created party hat stories that revolved around their family and used their personal experiences as a foundation for the stories they told. Thus, it may be fruitful to consider how personal storytelling could strengthen these informal learning experiences and how to best encourage this type of storytelling within these settings. We are currently pursuing this idea as we continue our design-based research at Chicago Children's Museum, prompting families to tell personal stories during tinkering. Our goal is to facilitate meaningful connections between the stories that frame the tinkering activity, the stories that are told by families during tinkering, and families' lived experiences.

Finally, parents reported sharing oral stories with their children often. Parents' oral storytelling transcended their schooling, income, and whether they were born in the United States or Latin America. Their sharing of oral stories also happened frequently regardless of their children's gender or age, suggesting that among our families, oral storytelling is an important everyday practice. A limitation of our work is that we cannot speak to how many of these family stories involved engineering or other STEM-related concepts, or problem-solving more generally. Future work that examines linkages between the content of Latine families' stories and engineering could help inform the design of informal learning opportunities that leverage families' strengths.

Implications for Practice

Informal learning institutions, museums, and science centers are designed to support visitors' STEM engagement and learning. However, people from minoritized backgrounds have expressed feeling excluded or unwelcomed in these places and may come to view museums as designed for dominant groups (Dawson, 2019). More recently, broad efforts have been made to design informal learning spaces for communities of color through an equity-based lens that values the practices and lived experiences of these communities (Calabrese Barton & Tan, 2018; Vossoughi et al., 2013). Our work contributes to these efforts. We were intentional in our study design to create a tinkering experience for U.S. Latine families that was accessible, culturally sensitive, and strengths-based. We ensured that all our materials, from the tinkering video invitations to the demographic questionnaire, were available in Spanish and English. Our study team was comprised of native Spanish speakers who could fluently communicate with parents and children in both languages. We designed the tinkering activity to be inexpensive and feasible at home, and loaned tablets to families who did not have a reliable device to connect with us on Zoom. In this way, our study attempted to remove structural barriers that often impede families from minoritized backgrounds from participating in learning opportunities designed by and for members of the dominant group.

Importantly, our study is helping advance an understanding of how engaging Latine families in storytelling can serve as an entry point for these families to connect their everyday practices with their museum tinkering experiences and other informal learning opportunities. This is crucial given that activities that connect to families' everyday practices have the best potential to support learning and engagement in STEM, particularly engineering (Pattison et al., 2022; Wilson-Lopez et al., 2016). Considering that deficit approaches often permeate the literature examining the practices of nondominant groups, our goal was to push back against these narratives. Our efforts allowed us to display the rich engineering conversations Latine families were having during tinkering, and revealed that those who engaged in story-based tinkering had the strongest outcomes. Therefore, activities and programs that are designed with equity and accessibility in mind have the best chance at illuminating the strengths of children and families from diverse backgrounds.

Our work also highlights the importance of providing children with opportunities for reflection after hands-on tinkering experiences to facilitate and sustain learning. These reflections can support children's understanding and consolidation of the experience, helping create a stronger representation in memory that is retrievable over time (Haden et al., 2021). Creating strong memories about informal learning experiences that connect to children's everyday practices may be especially important for diversifying science and engineering, as prominent scientists often recall early childhood experiences in museums as being influential in their pursuit of science careers (NRC, 2009). Museum staff and facilitators can and do engage children and families in reflection through the use of open-ended prompts similar to the way we elicited the children's reflections. Finally, our work points to other opportunities for practitioners and educators to extend tinkering experiences and engineering learning. For example, museums can capitalize on the increased use of digital technology and low-cost nature of tinkering activities to help educators reach a larger, more diverse audience outside the museum's walls. Relatedly, the use of a story frame during tinkering activities may be a way to connect with and draw in other diverse cultural communities who also have rich oral traditions. Stories may also serve to captivate other groups who are underrepresented in STEM, such as girls (Bennett et al., 2019), and broader audiences more generally who may not find tinkering activities compelling on their own. Therefore, stories may offer an accessible entry point for parent–child engagement in engineering conversations during tinkering for many families with different backgrounds, practices, and lived experiences.

Conclusion

The current study was designed to leverage the practice of oral storytelling to support Latine children's informal engineering learning. Our work suggests that tinkering, coupled with a story frame, was supportive of families' engineering practice talk during and after tinkering. Because stories are universal and an everyday practice for many communities, story-based tinkering presents a promising direction for future work focused on making engineering and STEM more equitable and inclusive for Latine children and families.

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