

Elevating the Ways in Which Latina Mothers Perceive, Do, and Envision Early STEM learning

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Abstract: Early STEM learning opportunities aligned with families' funds of knowledge can produce meaningful learning experiences for children. We investigated Latina mothers' perceptions and values of STEM learning, STEM-related activities with their children, and the early STEM learning experiences mothers designed for community spaces. In a research-practice partnership, we conducted seven virtual co-design sessions with 32 caregivers and individual interviews with a subset of 10 mothers. A thematic analysis revealed that Latina mothers' STEM perceptions were primarily informed by school-based notions, yet they also integrated STEM in everyday, family practices such as cultural games. Mothers valued experiences promoting family unity, intergenerational learning, heritage, active citizenship, and *ganas*. Finally, Latina mothers' values and practices informed their vision and design of early STEM learning artifacts in the community. Thus, diverse parents' contributions in design efforts can serve as a mechanism through which stakeholders connect and enhance children's learning experiences across contexts.

Introduction

Education researchers and learning designers recognize the critical role of caregivers in facilitating learning outside of school with their children. One ongoing effort is to create Playful Learning Landscapes (PLL), environments that combine science, technology, engineering and math (STEM) experiences, with play and family-interactions in everyday spaces (e.g., bus stops, grocery stores; Bustamante et al., 2019). Despite efforts to include diverse perspectives on STEM learning experiences (Garibay & Teasdale, 2019), much of the research on STEM learning activities may not accurately represent the diverse practices of families who are multilingual, from a lower socioeconomic status, and from underrepresented cultural groups. To promote STEM learning outside of school, it is critical to ground the design of learning experiences to support daily parent-child practices by recognizing and leveraging the ways caregivers already encourage STEM learning with their children. In this work, we unpack the current ways Latina mothers perceive STEM learning, how they naturally engage in STEM learning with their children, and the ideas they have for future experiences for their children. Our guiding research questions are:

RQ1: What are Latina mothers' perceptions and values for their children's STEM learning?

RQ2: What are the activities at home and in their community that Latina mothers engage in with their children that support STEM learning?

RQ3: How do Latina mothers' perceptions, values, and activities relate to the kinds of STEM learning experiences they design for the community?

To examine these research questions, we analyzed a research-practice partnership (RPP) with leaders and mothers of a community organization, and a university in Southern California focused on designing PLLs in community spaces. We analyzed seven virtual participatory design sessions where we engaged 32 caregivers to design STEM learning experiences. Our data set also included interviews with a subset of 10 mothers to gain an in-depth understanding of their experiences with STEM learning at home and in the community. We used theoretical frameworks from funds of knowledge (Moll et al., 1992) and speculative futures (Lukens & DiSalvo, 2011) to guide our analysis and research questions. We offer design implications for STEM learning experiences that honor the ways Latina mothers conceptualize STEM learning, are grounded in the concrete ways they already facilitate STEM learning, and are informed by their ideas for STEM learning futures.

Theoretical Framework

Funds of knowledge

Funds of Knowledge (FoK) refers to families' strategic and cultural "bodies of knowledge and skills" accumulated over time and with their communities that are "essential for household or individual functioning and well being"

(Moll et al., 1992, p. 133). The framework counters deficit thinking of linguistically, economically, and culturally diverse students and instead leverages the FoKs within diverse families and communities that are assets in supporting students' learning (Llopart & Esteban-Guitart, 2018). Across content domains, researchers have adopted FoK to align programs to families' values and practices and create more meaningful experiences for students (e.g., Olmedo, 1997; Riojas-Cortez & Bustos Flores, 2009). In K-12th grade STEM education, most recent studies using FoK have focused on curriculum development, improvement of teaching practices, and community-school connections (Denton & Borrego, 2021). Such approaches are crucial to address the systemic disadvantages underrepresented students undergo in the pursuit of STEM careers (Whitcomb & Sign, 2021). We aim to create community-home connections through designs that align with families' FoK and promote early STEM learning in out-of-school community spaces. We use FoK to identify the perceptions and values of Latina mothers and their family activities that support children's STEM learning.

Speculative futures

In the human-computer interaction literature, scholars describe the ways in which the act of creating design artifacts and envisioning those artifacts in an intended context is meaningful research of a speculative and desired future (Zimmerman & Forlizzi, 2014). Utilizing design as a reflective practice, the manner that a problem space is interpreted and framed by participants provides insight as to what the world can progress towards (Rittel & Webber, 1973; Schön, 1983). Lukens and Disalvo (2012) propose key characteristics of speculative design approaches which include projects that are future oriented, cross-disciplinary, and integrative. We build on a speculative future design framework to analyze the artifacts mothers created which not only focused on STEM learning principles but also the ecosystem within which these design ideas would be implemented in their neighborhoods. We intersect this lens with FoK to unveil the underlying perceptions, values, and assets that inform the design of playful learning landscapes.

Methods

Research-practice partnership

This project is part of a larger multi-year study to design playful learning landscapes with and for local community members using a research practice partnership (RPP) approach. The RPP involves partners from the university, the city, and nonprofit organizations. Our leading partner was a cross-sector community organization of caregivers, educators, and community leaders committed to enhancing early learning opportunities and outcomes for children in the local community. The local school district serves children who are predominantly Latine (80%), of low-income households (about 87%), and from families who speak Spanish at home (79%).

Participants

Participants were recruited with the help of the directors of the community organization. Participants were 32 caregivers of children enrolled in kindergarten through 12th grade and members of the organization. Latina mothers composed almost all of our participants (N= 31) and one participant was a Latino father. Our sample is primarily representative of Latina mothers' viewpoints and therefore we represent our findings as such. Participants were predominantly of immigrant backgrounds, mainly of Mexican descent, and Spanish-speaking.

Procedure

Between November 2020 and May 2021, we conducted seven monthly 2-hour codesign sessions over a video conferencing platform due to the COVID-19 pandemic. The virtual sessions consisted of whole group discussions and six breakout groups of 4-7 parents. Participants' attendance per session ranged from 72% to 97%, with most parents (81%) attending six or seven sessions. We also conducted 1-hour individual interviews with a subset of 10 mothers who volunteered. The design sessions and interviews were all facilitated in Spanish to allow for more comfortable and genuine discussions, with a translator present for non-Spanish speaking researchers. We compensated participants \$50 for attendance to every 2-hour session and \$25 for interviews.

Each codesign session was structured to facilitate three types of activities. The first two types were conducted in breakout groups and facilitated by Spanish speakers who were instructed on the activity goals prior to the session. The first was a reflective activity focused on eliciting prior experience and knowledge of the topic. For example, we used storytelling to learn about families' everyday experiences and practices centered on science and math learning across contexts. We asked questions such as, "*What are everyday science things you do as a family?*" and "*Tell us a story about grocery shopping with your family when you were little and now with your children.*" The second type of activity was design-based where we asked mothers to use arts and crafts to create

low-fidelity mock-ups of the type of installations they would like to see in their community spaces that bridged their backgrounds and values with general learning principles (e.g., active, meaningful, joyful; Hirsh-Pasek et al., 2020) and practices and cross-cutting concepts that support STEM learning (e.g., making observations, asking questions, cause and effect; National Research Council, 2012). Finally, we concluded the sessions by sharing key themes from our small group discussions as a community.

The second codesign session focused on eliciting core values mothers wanted the installations to perpetuate for their community. First, mothers engaged in a reflective activity in breakout groups, where they shared photos of their community and gave stories of those spaces, described the characteristics of people or things in that space, the feelings evoked, and what they valued about those spaces. In those same groups, we then asked mothers to complete a mad-lib design activity that completes a statement on principles. The purpose of the task was to convert values into community design principles to serve as a foundation for future designs emerging from our partnership. The mad-lib was presented in Spanish and read:

I would like for us to create something _ (a descriptive word)_ while upholding _ (value)_ while making sure people who are _ (characteristics)_ feel welcomed, and feel _ (feeling)_ while interacting with the playful learning landscape.

In the individual interviews, we aimed to gain a deeper understanding of families' STEM activities, and their perceptions and values on STEM learning. We asked questions on math and science such as, *"What themes or concepts do you relate to learning science,"* and *"What feelings do you associate with science and its learning?"* Furthermore, we inquired about science and math activities at home with questions like *"What type of activities do you and your family engage in at home related to science and math learning?"*

Data analysis

We video recorded, transcribed, and translated all sessions and interviews using software programs and Spanish speaking members of our team for reliability. We obtained a total of 47 recorded codesign sessions (~ 42 hours total) composed of whole group and breakout room discussions. For this study, we analyzed 24 codesign video sessions and all 10 interviews. The analyzed codesign sessions included at least two breakout videos of each of the seven sessions, with a focus on the first two sessions due to the emphasis on family practices. We analyzed the data in Spanish using two phases. First, four researchers approached the data with inductive thematic analysis (Guest et al., 2012). At this stage, four progressions of a codebook included codes of *Described Parental Roles*, *General Learning Values*, and *Doing STEM with Children*. In the second phase, three researchers reviewed the codebook in conversation with existing literature, a deductive process (Azungah, 2018) that primarily informed subcodes such as *Activity Transfer Across Settings* and *Cultural Artifacts* for the root code of *Doing STEM*.

Findings

We divide our findings into three parts. First, we describe how Latina mothers perceive STEM learning and its relation to values they want to instill in their children. Second, we illustrate the ways Latina mothers currently enact STEM learning experiences in the home. Third, we provide an overview of the imagined futures mothers wanted for STEM learning experiences for the children in their community through the designs they developed.

Latina Mothers' STEM perceptions and values

Perceptions

The mothers' perceptions of STEM learning were informed by school-based learning experiences: STEM learning experiences in their youth and their child's learning journey at school. When asked what math and science meant, mothers defined the "doing" of math and science under the academic lens of school, with math associated with skills such as recalling numbers and conducting operations while science was often associated with hands-on school experiments and projects. One mother stated, *"For example, for the kids to learn numbers. I would really like for designs to have numbers, and to have those [geometric] shapes. And for them to say on their own that 1+1 is 2."* While mothers saw the importance of math and science as disciplines that are *"necessary for any career because in reality... in a job it is what is needed"*, many admitted to a negative sentiment towards the field due to its difficulty or lack of experience in applying the disciplines beyond everyday practices. As one mother noted, *"Mathematics, it is a very important subject to which I have panicked about,"* despite describing the use of math when managing money everyday.

Yet mothers acknowledged that school-based or formal ways of learning were not the only way, nor the best, to learn these disciplines, “*I think that it would be very, very rewarding ... for children in these times to not see something repetitive in science, something boring ... They are very intelligent so if they do it in a more fun way they can obtain more... like deeper into something.*” Furthermore, mothers envisioned STEM learning as a process to promote agency, intergenerational interactions, and fun in their child’s learning experience; one mother mentioned, “*I would like us to create something fun... to promote learning and family bonding.*”

Values

We observed five core values mothers defined and abided by when tasked to design STEM learning spaces: family unity, intergenerational learning, heritage, active citizenship, and *ganas* or a will to succeed. Family unity or a sense of togetherness through activities echoed the concept of *familismo* that represents interdependence, loyalty, and cooperation in Latine households and that places family at the core (Espinoza, 2010). Mothers extended *familismo* to a learning value of intergenerational learning, which they defined as experiences that promoted family learning regardless of age, such as between grandparents and grandchildren. Mothers wanted installations to represent their heritage, and allow for the opportunity to teach children about their culture, the history of their city, and for a majority of mothers, their homeland of Mexico.

Mothers voiced the value of active citizenship or giving back to the community under the premise of *respeto* and *bien educado*. These values consisted of cultivating positive relationships and acting “appropriately” to others (Espinoza, 2010). While this premise is often associated with the concept of “good behavior” (Valdés, 1996), the mothers oriented this concept of *respeto* and *bien educado* to active citizenship and defined ways they wanted their children to conduct positive actions for the benefit of their community and beyond their immediate family household. Additionally, most of our mothers model active citizenship to their children by being involved in grass-roots initiatives such as park reconstruction. One mother expressed:

I am doing it for my children, I am doing it for the children, I am doing it for, wanting to leave a better future for them... At first I began to want to give my children values, even if it was to participate in church. Then at school and then at the community level.

Finally as mothers described what they wanted children to take away from these playful learning landscapes, they referred to the notion of *ganas*, that evokes the motivation and the will to overcome challenges. *Ganas* is often used to instill perseverance and confidence in order to believe one can succeed and be able to take actions toward success (Barrios Gutierrez, 2010). As one mother mentioned: “*Having two girls here in [city anonymized] has given me the opportunity to get involved in many [educational] programs so that they see that I am interested in their progression ... they are in a place where 'Si se puede' and 'Echarle ganas' [Give it all].*”

Mother-Child STEM activities

As mothers reflected on family activities associated with STEM learning, many described structured activities that entailed a prescribed approach or a clear end-goal as opposed to a discovery approach. Cultural game-based activities were the most prominent way that mothers facilitated STEM learning opportunities, such as *loteria* or *pirinola* games. Mothers described how actions required to play the game can develop and reinforce math skills such as recalling numbers or math operations like summation. For example, one mother stated:

We try to find table games... that I used to play with my mother, my sisters. Like Juego de la Oca [Game of the Goose], Lotería [Bingo], Serpientes y Escaleras [Snakes and Ladders]. I would explain how to play them.... There is a game that I love; it has always fascinated me since I was little, the Basta one... I like it because we are learning, even if we think we are not. We put in a little bit of math, counting squares, counting the dots in the dice, and adding.

The quote above emphasizes how games are a cultural socialization practice that Latina mothers transmit to their children and are valuable due to the memories, enjoyment and connection between family members, and learning they facilitate. To further support their children’s learning, mothers also demonstrated high agency in looking to community video platforms like Youtube and TikTok, afterschool programs, and school activities for inspiration to expand learning in the home. Mothers noticed the benefits of these platforms, “*My daughter, the little one, has a lot of that [behavior] of going to YouTube and doing many things*” and utilized the learning affordances that technology provides in scientific practice (Yip et al., 2014). Mothers reported how these resources promoted structured STEM learning activities at home like making slime, volcanoes, or crystals.

Despite the prominence of structured activities, mothers also viewed everyday practices as opportunities for STEM learning. Mothers actively connected math and science ideas to their daily actions like running and measurement of speed, daily practices like counting money or cooking, and utilized daily surroundings such as learning about ecosystems and plants at the park. Without using the specific terminology, mothers alluded to the teaching of various science *crosscutting concepts* and *practices* (as specified in the Next Generation Science Standards; National Research Council, 2012) as they conducted activities and catered discussions with their children. Cooking is a prominent family activity that supports the learning of practices like making observations of food texture or taste, and crosscutting concepts such as quantity, proportion, and numbers. One mother said, *“On the example of cooking, if you want to make cookies, you are going to use a certain amount of sugar and if you want twenty cookies, you are going to double the amount of sugar. Like the idea of proportion, but in this concept of science.”* Cooking at home which requires experimenting with recipes represent open-ended explorations as opposed to the prescribed nature of formal learning environments.

As mothers described their learning practices at home, they simultaneously revealed their approach to facilitate these learning opportunities by taking on co-learner roles and child-centered teaching. Despite having revealed negative sentiments or fear of not knowing enough about STEM, mothers often placed themselves as co-learners with their child and expressed a willingness to learn alongside their children. As a parent mentioned, *“Well, when they have any questions related to any of these [science or math] topics, I try to help them the best I can. If I don't have the answer, I go to Google and we look for it together and I learn at the same time.”* Mothers still viewed their participation in their child's learning as essential to teach kids how to navigate learning more so than teaching content *“because we ourselves are the teachers in which we are teaching them how to participate.”* Furthermore, mothers noticed that young children were naturally curious and were filled with questions about their world. Thus, they embraced this natural curiosity to promote child-centered ways of learning where the child was encouraged to think through a problem with the scaffolding and guidance of the parent. They did so by giving responsibilities to their children that required the use of STEM skills, such as collecting the right number of food items when cooking at home or shopping at a grocery store.

Imagined STEM learning experiences

Overall, in our design sessions caregivers came up with ideas that echo their values, existing practices, and perceptions of learning. In this section, we provide two illustrative examples that highlight key themes caregivers emphasized throughout our design sessions toward their imagined futures ideas for playful learning landscapes that promote STEM learning: sustainability and games.

Sustainability vignette

The third co-design session had mothers design an installation for their community with three constraints. Mothers were randomly assigned an object or place, a value, and a science practice (e.g. making observations, making predictions) or crosscutting concepts (e.g. patterns, cause and effect) to guide ideation. Mothers were provided with crafting materials, paper, and markers to create a visual representation of their idea at home.

One group was assigned the design constraints of a street as the place, intergenerational learning as their value, and scale/proportions as their science focus. Their design idea was centered around a community trash awareness activity that helped people learn about scale, proportion, and quantity. When sharing their idea, the mothers noted that the inspiration for their design was their observation of community members constantly throwing their trash on the streets and the desire for more civic responsibility among them, especially their children. The mothers explained that if the community were more conscious about the impact of waste habits, trash would be disposed of and placed in the appropriate waste bins. One caregiver noted, *“like a community we could come together or as families...we could come together as one to maintain our streets clean and we can teach our kids how to properly dispose of their trash.”*

Despite the focus on the intergenerational value where they designed an opportunity to teach their children about wasteful habits, this idea also echoes the value of active citizenship where mothers want their children to be positive members of their community. The group resorted to varied math measurement systems to measure waste in a way that would encourage comparing trash weights across streets, including a height or measurement feature across the bins. Thus we note that they viewed mathematics as a mediator for community action and promotion of active citizenship. Mothers explained that the design would motivate children to separate the trash into recyclable, non-recyclable, organic, and inorganic trash to teach children how to differentiate between the trash contents. Related to the community value of intergenerational learning, this design idea shows how it would be meaningful to the community to improve the neighborhood as a collective activity that includes people from all ages, and through an active manner that involves collecting, separating based on observations of the characteristics of items, and measuring.

Gaming Vignette

Just as game-based activities were a primary mechanism to learn STEM in the household, mothers designed a plethora of ideas for games that could promote STEM learning with their children in their community. In another case, we saw how mothers' prior experiences in STEM learning and perceptions of what counts as STEM played a key role in the majority of brainstormed activities. These games included competitive and active versions of card games, puzzles, memory games, and physical challenges that would test or familiarize children to fundamental skills or content. Among these game-based ideas, Hopscotch was prominent throughout the codesign sessions as mothers shared that they played Hopscotch to actively learn colors, shapes, and numbers.

Juego de avión [Hopscotch] is what we call it in Mexico and I think the children are playing it here [United States]. They are having fun and they are also learning mathematics because they are jumping ... to number ten and ... you can also ask what number you stayed at.

Mothers redesigned Hopscotch to include prompts or questions that would reinforce children's math and science skills, including jumping to a shape of a certain color or size or integrating math questions. While these ideas were grounded in mothers' experiences, they used their values as a guide to modify those experiences towards a specific learning goal. In this example, intergenerational learning informed the manner in which parents modified Hopscotch in order to share a piece of their past with their children. Family unity was also a prominent value as mothers proposed to infuse hopscotch into everyday, family spaces such as integrating this activity into the sidewalks that families use to walk children to school.

Discussion

Our findings reveal how mothers approach and conduct early STEM learning as informed by cultural values and evolving perceptions of what counts as STEM. The FoK lens unveiled existing practices and knowledge that mothers contributed to early STEM learning. Mothers largely refer to school-based content for the “what” of STEM such as math operations, and utilize child-centered approaches for impactful learning. We saw mothers encourage the transfer of activities from school or online platforms into the home to support their child's natural curiosities and take on co-learner approaches despite their lack of confidence in the topic. Additionally, mothers leveraged everyday practices such as cooking or grocery shopping to incorporate STEM concepts relevant to a child's daily life. This is essential for youth to become full participants in the field (Yip et al., 2012) and mothers are a clear resource to promote relevance. As such, their cultural values represent the deeper lessons and morals they want to instill in their children, thus viewing STEM learning as an opportunity to promote family unity, intergenerational learning, heritage, active citizenship, and *gananas*. Instilling these values in the design of future STEM learning experiences symbolizes the desired or speculative future mothers wish for their children.

Implications

Our analysis of mother's perceptions shed light on research studies of Latine parent perceptions in early STEM. Most research on Latine parents' perceptions and involvement have focused on general education (Valdes, 1996; Tinkler, 2002) and those focused on STEM subjects have yet to explore current family practices for young age groups (Deleon, 2018; Hernandez et al., 2016). We build on this past work through an FoK and speculative futures lens to show how mothers immediately resorted to school-based notions of what counts as science and math, however, through further prompting and designing for speculative futures in community, they revealed the need for and practice of informal, everyday approaches that instill values in their children. This aligns with Latine families' notion of education, where academic goals and morality are seen as interconnected and not mutually exclusive learning experiences (Halgunseth et al., 2006).

FoK is a lens that reveals opportunities for designers to actively design for inclusion that is built on families' values and the ways that diverse parents support children's learning. Understanding the cultural knowledge of underrepresented families when designing for spaces that are not historically inclusive of diverse practices is an important step towards validating and leveraging their forms of learning (Aschbacher et al., 2010). For example, *familismo* is critical in the development of STEM identities of Latine students, as they often rely on friends and family as a source of aspirational capital (Matos, 2021). Yet such value contradicts values upheld by academic institutions which embrace the US culture of independence and self sufficiency (Espinoza, 2010; Rodriguez, 2021). In the context of designing playful learning landscapes, the focus on FoK and cultural assets allowed us to reimagine ways that STEM learning can embrace community values explicitly using math and science learning opportunities. Through the lens of speculative futures, this awareness resulted in design ideas

such as an activity that focuses on environmental sustainability through the measurement of community waste. The idea was meant to take advantage of moments of family unity and togetherness, such as walking around the community or waiting for a bus stop, to encourage active citizenship through math.

Involving caregivers in the design of STEM learning installations in their community ensures that ideas are grounded in the lived experience of families who will use them. Designing from an approach that builds on families' experiences and incorporates parents in the design process can result in greater usability of artifacts, more rich learning experiences for children facilitated by family members, and families feeling greater ownership of the artifacts resulting in their long-term sustainability. In this paper, we have shown that Latine mothers' values and practices are reflected in their design ideas, and as such the contributions of diverse parents in design efforts can serve as a mechanism through which researchers and practitioners connect and enhance children's learning experiences across home, school, and other community spaces. This contributes to ongoing research on the development of meaningful STEM experiences that is inclusive of different cultural communities through community-based informal learning (Clegg et al., 2014; Santo et al., 2019). We extend this body of research with the perspective of Latina mothers' practices for early STEM education through play.

Limitations and Further Research

One limitation to our research are the missing perspectives of Latino fathers in the design of STEM learning artifacts. Prior research suggests that mothers and fathers in Latine families do not always socialize their children in the same ways and that children's responses to a specific practice sometimes vary depending on which parent it involves (e.g., Kuhns & Cabrera, 2020). Thus, future research in STEM learning should include fathers and potentially extended family members (e.g., grandparents, aunts or uncles, godparents) that might have an additional contribution to the learning experiences of underrepresented young children. Another limitation in our study is that our team is currently working on the final designs of playful learning landscapes and as such we have not yet examined the extent to which families' cultural knowledge is maintained and incorporated in the final artifacts resulting from the elaboration process between community members and the research team in RPP work. Our next steps are to evaluate the alignment between families' cultural assets and learning principles in the final artifacts and whether installing those artifacts in community spaces result in greater opportunities for families to engage in STEM learning interactions.

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