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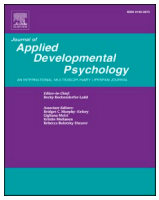

Using a participatory design approach for co-creating culturally situated STEM enrichment activities

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ABSTRACT

Researchers can use a participatory design approach to produce sustainable interventions that leverage the cultural values and practices of ethnoculturally and linguistically diverse populations. PD is underutilized in developmental psychology, but can be a powerful tool for creating culturally situated interventions that bridge gaps in research applicability, inclusivity, and effectiveness. We provide our design narrative for creating grocery store signage promoting early STEM learning in a predominantly low-income, Latine community. We conducted two design sessions with our research team and community members (n = 20) to learn about their past and present intergenerational grocery-shopping experiences and integrated their values into signage. This paper outlines the PD process we undertook and its implications for the field of developmental psychology. We argue that developmental psychologists would benefit from adopting PD as a methodology to build on diverse populations' strengths. This approach can produce relevant interventions that support children's learning in various community settings.

Introduction

A participatory design (PD) approach to research can be leveraged to improve the inclusivity of developmental psychology by honoring knowledge that exists outside of western, educated, industrialized, rich, and democratic (WEIRD) cultures (Henrich, Heine, & Norenzayan, 2010). Research that relies on communities from WEIRD cultural backgrounds is the base of behavioral sciences, and it is often used to make conclusions regarding universal human behavior. This is an issue because studies using only WEIRD samples do not accurately represent the range of global populations and cultures (Henrich et al., 2010; Legare & Harris, 2016). Scholars conducting research with culturally diverse communities must mutually value their participants' cultures and practices, and ensure that the theories and methods guiding the research do not subscribe to the hegemony of Western ideals (Chaudhary, 2020; Serpell, 2021). Applying WEIRD-centered research to diverse populations maintains Eurocentric values as the standard by which minoritized populations are compared; often through a deficit framing (Henrich et al., 2010; Melzi, Schick, & Scarola, 2019; Pérez-Brena, Rivas-Drake, Toomey, & Umaña-Taylor, 2018; Weisner, 2002).

Participatory research approaches can be used to address inequities within research (Wallerstein & Duran, 2003). There has been use of participatory approaches within areas of the social sciences such as psychology (see Levac, Ronis, Cowper-Smith, & Vaccarino, 2019 for a review) and education. In developmental psychology, Thomas and O'Kane (1998) discuss how using participatory approaches when working with children can increase research validity, reliability, and address ethical concerns such as power imbalances by using an approach that centers the way children see the world. A 2000 study conducted with youth to gain insight regarding how the students themselves and their neighbors experienced living in an urban community is considered to be one of the earliest uses of youth participatory action research in the field of education (Caraballo, Lozenski, Lyiscott, & Morrell, 2017; McIntyre, 2000). Additionally, community-based participatory research is another participatory research approach that involves elements of research, action, and education in which researchers provide community members with resources and community members share their knowledge with researchers (Wallerstein & Duran, 2003; Wallerstein, Duran, & Oetzel, 2018).

Participatory Design describes methodological tools to engage community partners' insights in designing new innovations (i.e., social services, educational programs, policies, and technologies) and learning

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tools that leverage cultural values and practices of diverse populations through integrating the ideas of the people that the innovation is being designed for (Broadley, 2020; Carroll & Rosson, 2007; Chew, Lin, Bermudez, Bustamante, & Ahn, 2021; DiSalvo, DiSalvo, Yip, Bonsignore, & Eds.)., 2017; Kuhn & Muller, 1993; Lerner, Wertlieb, & Jacobs, 2005). The PD methodology originated from participatory action research frameworks—influenced by the longstanding lineage of social movements in Latin America which reconceptualized social science as a "people's science" accountable to social justice movements (Fals-Borda, 1987) —that were being used in collaborations between Scandinavian academics and trade unions in the 1970s and 1980s (Spinuzzi, 2005). PD has a history of being employed for empowerment of marginalized communities; for example, collaborative work by Kristen Nygaard and the Norwegian Metal Workers Union's work on local knowledge production and Paulo Freire's "Pedagogy of the Oppressed" (Blomberg & Henderson, 1990; Ehn, 2017). Participatory design can be used to support developmental psychologists' goals of understanding how development occurs within a cultural community by centering users' experiences through iteratively and collaboratively developing interventions that are better integrated into users' everyday practices (Bannon & Ehn, 2012; Blomberg & Henderson, 1990; Greenfield, 1997; Kensing & Blomberg, 1998). This manuscript describes a participatory design process for developing culturally situated grocery store signage aimed to promote STEM adult-child interaction in a Latine community, highlighting important practices and considerations for valuing our community partners' cultural practices.

Problems with dominant intervention approaches

Eurocentric research and interventions might not be appropriate or relevant for low-income, minoritized families (Henrich et al., 2010), producing a cultural mismatch and loss of opportunity to identify and build on cultural strengths and assets of different communities. Many researchers in the field of cross-cultural psychology and others working with diverse communities in the field of psychology highlight the issues with culturally misaligned research: communities are not positioned as experts of their own experiences, and cultural values are often disregarded leading to a disconnect between interventions and the local context (Chaudhary & Sriram, 2020; Serpell, 2019).

Serpell (2019) discusses the risks of imposing WEIRD practices onto communities without adapting said practices to the cultural context, thereby subscribing to an expert paradigm which holds researchers as the only experts. Serpell argued that the expert paradigm is more suitable for interventions addressing biological processes (such as the treatment of intestinal parasites in Zambia); whereas interventions seeking to address social aspects of interactions should position community members as the experts. Positioning community members as experts can aid researchers in building from the knowledge and practices within the community, whereas failing to do so and imposing researchers' ideas and standards calls into question community ways of knowing (Serpell, 2019).

Chaudhary and Sriram (2020) discuss how schooling interventions that are based on Western schooling ideals contribute to a disconnect from local cultural practices. Interventions during the early childhood period center on preparing children for future schooling in areas such as math and literacy while shifting away from languages, foods, or other cultural practices that may be more familiar to young children (Chaudhary & Sriram, 2020).

Additionally, research within developmental psychology discusses the implications of favoritism regarding Western practices. For example, biases in favor of the English language continue to maintain the assumption that English is the standard for assessing knowledge which overlooks the cognitive benefits of speaking multiple languages, and the strengths and competencies of different racial and ethnic communities in the United States (Cabrera, Beeghly, & Eisenberg, 2012; García-Coll et al., 1996; Henrich et al., 2010; Wadams & Park, 2018). Understanding the ways in which culture shapes development is critical for shifting away from applying one set of cultural standards as ideal practices.

Culturally situated learning and design

Culture (dynamic practices for sensemaking of everyday life based on historical knowledge and participation in social practices) conveys goals and values through relationships and routines and cultivates developmental pathways through everyday activities (Bang, Faber, Gurneau, Marin, & Soto, 2015; Weisner, 2002). Culturally situated approaches acknowledge that learning is a cultural process through which people make sense of their worlds (Bang et al., 2015; Rogoff, 2003). Culturally situated approaches emphasize funds of knowledge— skills and knowledge essential for functioning that are developed within social and historical contexts and passed down through cultural practices such as languages and familial traditions— as central to learning (Melzi et al., 2019; Moll, Amanti, Neff, & Gonzalez, 1992; Nasir & Hand, 2006; Stevens, Andrade, & Page, 2016; Vélez-Ibáñez & Greenberg, 1992).

There are several recent examples of culturally situated programs that address community-based family STEM interactions. *Playful Learning Landscapes* (PLL) is a project that infuses community spaces (e.g., parks, bus stops, grocery stores) with culturally situated learning opportunities for children and families (Bustamante, Hassinger-Das, Hirsh-Pasek, & Golinkoff, 2019). PLL installations are informed by research in developmental science and designed in partnership with community members to incorporate local and cultural knowledge into design decisions and outputs. For example, Hassinger-Das, Palti, Golinkoff, and Hirsh-Pasek (2019) worked with a local civic association to design a playful learning bus stop called *Urban Thinkscape* in a predominantly low-income African American community. *Urban Thinkscape* features puzzles, executive function hopscotch, and a storytelling activity, all designed using insights from developmental research on how children learn and community input regarding the location of the installation and how designs could reflect the local culture. The community chose a location for the installation where Dr. Martin Luther King Jr. started a freedom rally in the 1960's and Dr. King's image was featured on the puzzle that was built into the bus stop. *Urban Thinkscape* was locally fabricated and hundreds of children and adults from the community assisted in construction during a grand opening block party. Community involvement was sustained throughout the project, including the evaluation phase in which community members led the efforts through on-site interviews and observations. *Urban Thinkscape* successfully elicited the types of caregiver-child conversations and interactions that lead to learning (Hassinger-Das et al., 2019). Additionally, community ownership, pride, engagement, protection, and upkeep of the installation have been maintained because of the community's involvement in the design process. *Urban Thinkscape* provides a model for the viability of developmental science beyond the confines of the laboratory to support caregiver-child interaction and playful learning through leveraging local cultural capital.

McWayne, Mistry, Brenneman, Zan and Greenfield (2020) co-developed an early childhood science and engineering curriculum for preschool classrooms — Readiness through Integrative Science and Engineering (RISE)— with local Head Start families and teachers to leverage different community strengths and explore topics relevant to children's daily lives. For example, in one science and engineering unit on living versus non-living things, teachers in a predominantly Chinese heritage community noticed children's interest in bamboo— a common gift for Lunar New Year— and embarked on a set of activities around bamboo, exploring the characteristics of living vs. non-living things (see McWayne, Mistry, Brenneman, Greenfield, & Zan, 2018). Teachers guided children through an engineering design process where they made replicas of bamboo using recyclable materials, as well as observed real bamboo growing in the classroom. In this project, children's interests and cultural festivities were the impetus for high-quality science and engineering learning experiences that centered their everyday lives and

cultural identities.

Although there is substantial literature in developmental science on the importance of culturally situated research, the field could benefit from systematic methodologies that guide the design of culturally situated interventions in partnership with the communities that will use them. Interventions that are centered solely on researchers' expertise are less likely to properly identify the assets and strengths of community partners.

Community-based participatory design

Researchers using a community-based participatory design approach focus on centering the values and norms of traditionally minoritized communities. Understanding the importance of culture within community learning contexts is imperative for prioritizing community values, and is an indispensable component of community-based PD (Bang et al., 2015; Gutiérrez, 2002) as opposed to traditional ways of designing that focus on what users lack, or need, and then trying to fill those needs. Community-based PD addresses power hierarchies between researchers and community members as it involves collaborative and iterative processes of exploration, discovery, and prototyping throughout each phase of the design process (Guha, Druin, & Fails, 2013; Spinuzzi, 2005) so that the products of the design process build on the strengths and expertise of community partners. Designers and researchers in this paradigm pay special attention to "what forms of knowledge are generated, how, why, where and by whom" by positioning community partners as experts through a range of methods aimed at avoiding possible cultural mismatches by integrating participants' experiences into intervention design (Bang & Vossoughi, 2016, p. 174; Blum & Boyden, 2018).

Funds of knowledge that may be overlooked by non-culturally-situated approaches are centered during the community-based PD process to democratize designing (Bang & Vossoughi, 2016; Kensing & Blomberg, 1998) through various ways such as storytelling, asset mapping, focus groups, or encouraging participants to create their own designs. Democratizing the design process means design sessions must be facilitated in ways that further both the development of new interventions and the personal needs and goals of community co-designers (Yip et al., 2016); therefore, researchers strive to work from the fundamental values and norms of a given community by integrating them into the core research and intervention design choices beyond superficial connections. Community partners can and should have different roles within the design process: users (those who used the designed artifact), testers (those who test design prototypes), informants (those whose input informs the design of an artifact), design partners (those who engage in designing long term) that expand over time (Guha et al., 2013; Walsh, Foss, Yip, & Druin, 2013). Using community-based PD when working with ethnically and racially diverse communities strengthens culturally-situated work as community members join researchers as co-learners and co-creators of knowledge to create learning artifacts relatable to participants' experiences (Bang & Vossoughi, 2016). This feature of community-based PD methodology has particular implications for issues that are salient for developmental psychologists who seek to create interventions that are strength-based, culturally responsive, and address long-standing issues around the usability, relevance, and sustainability of interventions.

There has been growing interest in utilizing design methods and community-based participatory design approaches to create new learning innovations that build from the cultural, social and organizational experiences of diverse educators, students, and communities (Ahn, 2019; Ahn et al., 2016; Ahn, Campos, Hays, & Digiacomo, 2019; Bonsignore et al., 2013; Bonsignore et al., 2016; DiSalvo et al., 2017; Wong-Villacres et al., 2020; Yip et al., 2014). An asset-based design philosophy calls for working directly with partners to first illuminate their knowledge and skills, what organizations and institutions they have, and build from the rich social and cultural practices already in place. Guha et al. (2013) had children and adults engaged in the design process using the Bags of Stuff technique which is when a bag of low technology supplies (i.e., glue, markers, clay, and scissors) is given to a group of children so that they can design in mediums familiar to them and have appropriate means for sharing their input. They also engaged participants in a Layered Elaboration activity in which participants build off each others' ideas by providing child participants with a base design, laying a transparency on the base design, encouraging a group of children to draw on the transparency and make changes to the original design, then repeating the process with a new transparency placed over the first group's changes so that the next group can continue elaborating on the ideas presented.

PD Projects such as *ScienceEverywhere* have engaged families and neighborhoods to create public STEM learning opportunities (Ahn et al., 2018). The process of co-creating with families from low-income, and racialized backgrounds, helped to reveal the rich family learning practices they bring to the design process (Uchidiuno et al., 2017; Yip et al., 2016). Designing with families and other intergenerational groups requires researchers to adapt and modify their design techniques to be interactive and usable for different age groups (Walsh et al., 2013) ensuring that design researchers are not just applying a general design technique but are making changes during the research process to properly serve the communities they are working with.

The narrative below demonstrates how community-based PD techniques can be applied in the field of developmental psychology to create more culturally situated interventions (Gutiérrez & Jurow, 2016).

Design narrative of culturally situated grocery store signage

This work is situated within the Playful Learning Landscapes initiative which infuses neighborhoods with interactive STEM learning opportunities (Bustamante et al., 2020) to promote educational caregiver-child interactions within the community. In this section we present a design narrative on the use of community-based participatory design to create culturally situated grocery store signage in collaboration with our community partners. A design narrative is a genre of scholarly writing that documents how a design came into being (Bell, Haodley, & Linn, 2004; Hoadley, 2002). The goal of design narratives is two-fold. First, the narrative relays important details about community partners, context, aims, activities, and key design choices. These details help others in the field replicate and adapt practices in future design research projects. Second, the narrative describes key moments and cases in the design process that contribute to theoretical understanding about how one might employ methods or concepts that the project sheds light on.

Our use of community-based PD consists of understanding our partners' values and context, thematic analysis, translating data to design, drafting and developing artifacts, then returning back to our community partners for feedback and continuing the iteration process (see Fig. 1). We describe our PD process below, as an example of how developmental psychologists can utilize PD strategies to build on diverse populations' strengths and produce culturally situated interventions to support children's STEM learning in community settings.

Community partners

This PD project was conducted in partnership with the Santa Ana Healthy Retail Team (SAHRT), a local community organization which focuses on promoting health within the Santa Ana (a southwest region of California) community by working with residents, community groups, retailers, the local government, and other partners such as our research team. Santa Ana is a predominantly Latine community with roughly 76.8% of its population of 332,318 people identifying as Hispanic, or Latino, approximately 43.4% of the population being born outside of the United States between the years 2015 and 2019, and a median household income of $66,145 which is considered low-income by federal guidelines (Census, 2019). At a community meeting where our research

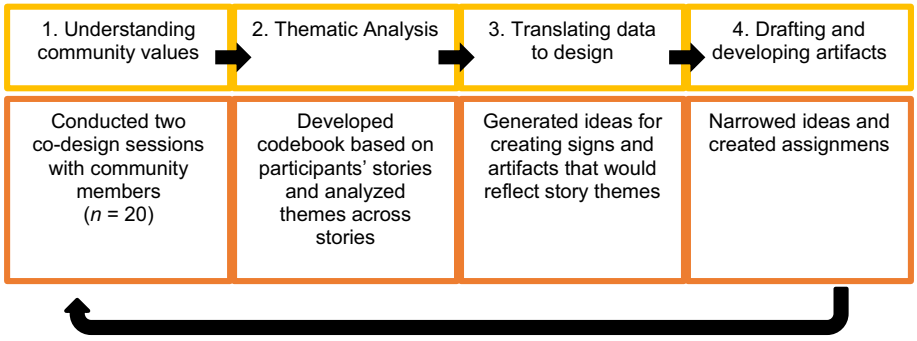

Fig. 1. Community-based participatory design process.

team presented on the Playful Learning Landscapes initiative, SAHRT invited us to join their efforts to promote educational opportunities within the community.

We planned two in-person focus group design sessions with SAHRT. SAHRT recruited participants through flyers in English and Spanish inviting community members to help create signs that promote learning. SAHRT participants (n = 5) and community members (n = 8) were Spanish-English bilinguals of Latine descent, in particular of Mexican heritage. The community members recruited by SAHRT were parents (mostly mothers with children whose ages ranged from early childhood to adolescence) and grandparents.

Participatory design sessions

Our research team (n = 7; two faculty and five graduate students) also represented various ethnocultural groups, including Asian, African American, and Latine. We met before we began the design sessions with community members to orient ourselves to the work. We reflected on our experiences at grocery stores and how they were influenced by our contexts and communities' cultures as an exercise to place ourselves in our partners' shoes in preparation for asking community partners to share their experiences. As a team, we were excited to share stories of our experiences with our participants to establish rapport, but were mindful of how we could end up dominating the conversation and discussed how we would bracket ourselves as facilitators (bounding our thoughts and ideas for a moment in time) to make and hold space for our community partners to share (Creswell & Poth, 2018). Each research team member prepared their own reflective story of experiences within the grocery store context that did not feature obvious or traditional rote learning experiences, but stories of spending time with family or fond memories of going to the grocery store as a child or with a child to model how participants could make connections to their own lives in preparation for the design sessions.

The two in-person PD sessions were conducted in Spanish (translation was available for participants who did not speak Spanish) with our team and Santa Ana community members (n = 20). The goal of our PD sessions was to understand the cultural values of the Santa Ana community as a research team before creating signage. The design sessions lasted 90 min and were structured into three parts: introductions and presentation of the project, storytelling to reveal community assets and practices (see Pstross, Talmage, & Knopf, 2014 for one example of a community storytelling technique), and a technique called layered elaboration where community partners redesigned existing signs (Walsh et al., 2010). We started with introductions of all individuals and a presentation on the *Playful Learning Landscape* initiative, as a technique for the research team and community members to learn about each other and build mutual understanding of the project's goals (promoting healthy eating and STEM learning for children 0 to 8) through grocery store signage and the partnership with SAHRT.

Uncovering funds of knowledge through storytelling

Sharing stories is a widely used practice for communicating cultural knowledge and is particularly salient in Latine communities who have a rich history of oral storytelling (Melzi, Schick, & Wuest, 2022). We began the storytelling activity by having one member of our research team model a story of their grocery story experience, as an example, and had other members of the team prepare their own examples in case the partners needed them in the design session. Our goal with the example stories was to convey that sometimes the most valuable contributions of the stories come from the interpersonal relationships, routines, and emotions that are elicited.

We prompted community members to think about when they go to the grocery store with their child, and to tell us the story of what happens (e.g. the funny things or anxieties about the experience) and recorded the conversations for later coding. We encouraged community members to share how they imagine their children experiencing the grocery store and discuss what is important to them as parents and caregivers when they are at the grocery store with their children. While we were transparent that the end goal of these signs was to promote early learning, we did not want stories to simply explain how learning could happen in the store (e.g., counting objects, or reading food labels); we were interested in authentic experiences from our partners' lives, such as the frustration of not knowing how many pounds of ham to order when converting from the metric system, or the joy of recognizing a community member who you only see at the grocery store. The storytelling activity enabled participants to recall their time in grocery stores and highlighted experiences that are meaningful and memorable to them and provided insights to inform our grocery store signage. Consider the following vignettes from one of our PD sessions in Table 1 below:

Community members shared stories within focus groups regarding passed down traditions, for example, family practices for how to pick the best produce. Picking produce was an opportunity that our partners mentioned allowed them to share and receive knowledge with their families. Community members illuminated how children were developing their agency and observation skills by making comparisons on produce quality. In the first vignette, a daughter wondered what criteria her mother used when choosing perfectly ripe avocados and the mother modeled the use of senses to feel the firmness of the avocado and called back to this conversation at home when she was cutting the avocado for further observation. In the second vignette, a mother gave her child the space to explore and choose tomatoes, while pointing out specific qualities for her daughter to notice when making her choices; helping to build child agency, observational skills, and food knowledge. The third vignette demonstrates the power of providing children agency as a mother allows her son to pick the apples they bring home because she knows he is more likely to eat an apple he chose, even if it's bruised. This vignette also includes ideas of nutrition, numeracy, and planning.

Table 1
Participant vignettes in Spanish with English translation.

Vignette	Spanish transcription	English translation
First vignette	Participante A: Como dicen, los aguacates, además me gustan que estén firmes, que no estén [aguados]– Y mi hija [me dice], "Mamá, ¿cómo sabes?"	Participant A: As they say, avocados, plus I like them to be firm, that they are not [soft]– And my daughter [says], "Mom, how do you know?"
	Participante A: Y ellos dicen como, "Oh." Porque cuando llegamos a la casa, ve que los abre uno y-y todos están bien y yo le digo, "No", yo le digo, "No sé como. Solamente sé al sentirlos, ¿sabes?"	Participant A: They're like, "Oh." Because when we get to the house, she sees when one [I] open them and- and they're all fine. I tell her, "No," I say, "I don't know how. I just know by feeling it, you know?"
Second vignette	Participante B: No, por lo menos ella [su hija] los escoge [los tomates] y-y los pone todos en la bolsa y yo reviso y le digo, "Mami, mira ese, está muy aguadito, mira el mío, yo lo tengo firme así."	Participant B: No, at least [my daughter] picks [the tomatoes] out and […] puts it all in the bag and I look at it and I say, "Mami, look at that one, it's too soft, look at mine it's firm."
	Moderadora: Ajá.	Moderator: Uh-huh.
	Participante B: Sí, ella lo saca y agarra otro. "¿Qué te parece éste?", le digo, "Sí, éste me parece bien.	Participant B: Yes, she takes it out and replaces it. "What do you think of this one?" I say, "Yeah, this one looks good."
Third vignette	Participante C: Yo tengo otra historia-	Participant C: I have a story-
	Participante C: -Mi hijo tiene ya 12 años-	Participant C: - My son is already 12 years old-
	Participante C: -entonces, uh, cuando se convierten en adolescentes, a veces es un poquito más difícil que coman ellos fruta, verduras. Entonces tengo que saber cuáles son sus frutas favoritas, entonces yo sé que las manzanas rojas– A él le encantan las manzanas rojas	Participant C: -so, uh, when they become teenagers, sometimes it's a little bit harder for them to eat fruit, vegetables, so so I have to know what their favorite fruits are. I know that red apples– He loves red apples
	pero si yo llevo manzanas rojas y si una manzana está mallugada o algo, él no se la va a comer, entonces cuando yo lo llevo a la tienda-	but if I bring red apples and if an apple is bruised or something, he's not going to eat it, so when I bring him to the store-
	Participante C: -[le digo], "Te toca escoger las manzanas." Entonces él va y escoge las manzanas rojas. Entonces luego me dice, "¿Cuántas escojo?" Y siempre le doy el número siete, no sé por qué [risas]	Participant C: [I say] "It's your turn to pick the apples." Then he goes and picks the red apples. So, then he tells me, "How many do I pick?" And I always give him number seven, I don't know why [laughs]
	Participante C: Obviamente está bien. Empiezo lunes, martes, miércoles, una manzana por día. Entonces él va y yo he notado que, si alguna manzana a él se le pasa que esté un poquito mallugada, porque él las escogió, él se las va a comer. Él no va a poner pretexto porque él las escogió y esa es una de las historias que a mí me ha gustado, y así lo hago con naranjas, con bananas.	Participant C: Obviously it's okay, I start Monday, Tuesday, Wednesday, one apple a day… I've noticed if an apple slips by him that is a bit bruised [but] because he chose it, he's going to eat it, he's not going to make an excuse because he chose it and that's one of the stories that I like, and I do it with oranges, with bananas.

Layered elaboration activity

Following storytelling, community members were invited to participate in a layered elaboration activity (Guha et al., 2013) to develop ideas that built from or improved past signage from the Ridge, Weisberg, Ilgaz, Hirsh-Pasek, & Golinkoff, 2015 grocery store study (a similar intervention study producing conversational signage in grocery stores). Paper copies of signage, transparencies, tape, and markers were provided and participants were instructed to tape the transparency over the past sign to the table, and make revisions or extensions (see Fig. 2 for examples). Participants were instructed to draw from scratch or redesign the existing signage by thinking about what they liked and disliked about them and how they could be changed to reflect the culture in their Santa Ana community as understanding community values was the first step in our community-based PD process (Fig. 1). Participants provided feedback regarding the presentation of the signage (e.g. the cosmetics, placement, and language), and several participants suggested that we add a lot of color to draw attention and that bright colors are a part of Mexican culture. Additionally, participants suggested that both Spanish and English be represented in the signage to create multilingual learning opportunities.

Thematic analysis

Audio recordings of the two design sessions were transcribed, translated into English so that data could be analyzed by the full research team (some of whom did not speak Spanish), and reviewed by Spanish-speaking members of the research team to assure accurate translations. We used an inductive coding approach to gain insight into the interactions in grocery store spaces that create rich culturally-situated learning experiences within the Santa Ana community (Thomas, 2006). Our team's faculty ($n = 2$), graduate students ($n = 5$), and undergraduate research assistants ($n = 4$) conducted one joint inductive coding session to identify prevalent themes in the data, which then became an initial coding scheme. Two graduate students elaborated on this initial coding scheme and sifted through the data to ensure thematic relevance. The research team split into sub teams and engaged in additional rounds of coding with two members assigned per code, and a period of debriefing between the members assigned to the particular code for consistency in code application. We met again after four iterations of coding in sub teams to finalize a coding scheme that centered the interactions, learning experiences, and values of community members as informed by the transcripts from the design sessions; the final code book included 20 total codes.

The research team used the developed codebook to tease out interactions between families that highlight rich cultural values and learning opportunities in non-school contexts such as grocery stores. Using Dedoose analytic software, we coded the transcriptions of our partners' stories for learning areas (e.g. math, food, language) and content of interactions (e.g. agency, making comparisons, storytelling) as well as further identifying the cross-generational familial interactions (e.g. between parents and children, grandparents and parents, etc.) that emerged. We also coded for instances of tradition and immigration as cultural content (e.g. discussions regarding holiday meals and differences between their home country and the U.S.) that was salient to our partners' stories. Transcriptions were coded for physical environments and communal spaces where these familial interactions took place such as grocery stores, schools, and participants' homes. Lastly, we coded for participants' affect associated with their experiences within grocery store spaces (e.g., enjoyment, accomplishment, indifference, frustration, curiosity). After coding the transcriptions, the research team wrote analytic memos to capture salient insights from major and co-occurring themes.

Prototyping

Prototyping is a systematic process for translating data and insights from the design sessions into concrete design ideas. The goal of prototyping in our project was not to create "high-fidelity" final, polished versions of the product or tool (in our case the grocery store signage). Instead, we created simple, scaled down versions – usually written ideas, sketches, paper prototypes – that help us move from the broad themes of our analysis to more refined proposals for the signage. The scaled-down prototypes can be easily discussed, be objects of reflection, and tested to validate our assumptions. As we further refined our ideas, our research team worked with graphic designers to create the final versions of the designs.

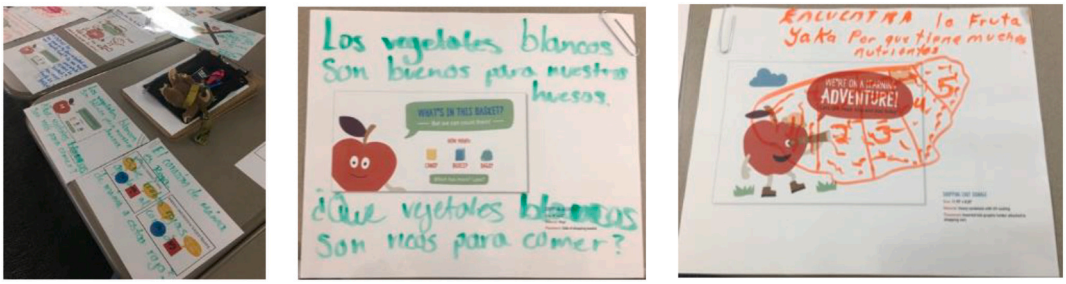

Fig. 2. Layered elaboration activity.
Note. Examples of signage redesigned by our community partners during design sessions. The picture on the left contains multiple redesigned signs. The middle picture translated says "White vegetables are good for your bones. What white vegetables are good to eat?" and encourages families to discuss nutrition and children to make observations about vegetables and discuss what vegetables they know and like. The picture on the right asks children to find the fruit "Yaka" (jackfruit) which intends to introduce children to cultural fruits they may not be exposed to in the US and discuss the nutritional properties.

Translating data to signage design ideas

"How might we" technique. To translate the insights from our analytic memos and codebook into concrete ideas for signage design, we conducted a brainstorming session with an activity called "How might we?" to generate unconstrained prototype ideas around the main interactions identified in our analysis (Siemon, Becker, & Robra-Bissantz, 2018). Each team member picked a code from the code book and asked, "how might we" promote culturally-situated experiences that support that code, such as "how might we integrate cultural foods and produce into signage?" After the initial question the next task was to curate possible ideas to answer our question. For example, a research team member came up with the possibility of signage showing ingredients and how they are used in cultural cuisine. We asked ourselves what links to STEM learning are embedded within the sign ideas, how are they connected to the themes that emerged from parents' stories, what interactions are we intending with an idea, and how signs promote the interactions we are intending for each "how might we" question that was created (see Table 2 for examples).

Synthesis and translation technique. At this juncture of the project, our team elaborated on and connected the ideas generated through the "how might we" technique from community members' experiences to an early childhood version of the Next Generation Science Standards (National Research Council, 2012). The Early Science Framework (Greenfield, Alexander, & Frechette, 2017) includes the following science and engineering practices which describe what children "do" while learning science: observing, questioning and defining problems, predicting, developing and using models, planning and conducting investigations, using math and computational thinking, documenting, analyzing, and interpreting data, constructing explanations and designing solutions, as well as communicating information. We voted on "how might we" ideas based on their correspondence with early science and engineering practices, how closely they were related to our partners' experiences, and the feasibility for families to engage with the sign. We then selected the top five most voted on "how might we" ideas by the research team to develop into design prototypes.

Table 2
Examples of questions and prototype ideas from the "how might we" technique.

"How might we" questions	Prototype ideas
"How might we share the best tricks for knowing what produce to pick?"	Somehow integrate the idea of letting kids pick out which one to take. Would also be good if there was some way for ppl to leave their tips (chalk board?).
"How might we broaden exploration of food in the grocery store?"	Spotlight the produce in season (where it is from, facts about how it grows, how it is regarded, what it is used for in different cultures).
"How might we promote adults' thinking/talking about foods/produce in different contexts?"	The journey of an avocado, how it was grown in southern California versus in Mexico.
"How might we help children have agency for what to ask for (negotiate what to buy) in positive ways?"	"Kids pick" signs: For every X types of fruit an adult picks, the kid gets to pick a type of fruit.

We merged our partners' cultural practices with the Early Science Framework by selecting vignettes from the stories they told that demonstrated cultural values that surfaced during the thematic analysis and best captured STEM practices that were already occurring in our partners' communities. One example of this is highlighting the local knowledge that families had in selecting the best produce. One of our top "how might we" choices was, "how might we share the best tricks for knowing what produce to pick?" seen in Table 2.

Family experiences of learning how to pick produce are examples of STEM learning opportunities embedded within familial interactions in the grocery store context. The "¿Por qué me escogiste? (Why'd you pick me?)" sign was created with the objective of highlighting locally passed down knowledge and prompting adults to model how to select produce and prompting children to practice STEM learning by attending to their senses and making observations to obtain certain types of produce (e.g. a ripe avocado, firm tomato). When children learn to pick produce, they learn to *make observations* using their senses, like seeing the different colors and quality of fruit, feeling the produce in their hand, or smelling how fragrant it is. Picking produce in the grocery store can also teach children how to *plan and carry out investigations* by making connections between the outside characteristics of a fruit (i.e., green vs. black avocados) and other non-visual characteristics, such as firmness and taste of the fruit. For example, one participant mentioned how they would open several avocados at home with their children and talk about the characteristics of the good ones. Children can *ask questions and define a problem* or a goal around ideal produce qualities (e.g. what type of tomato or avocado would we need for dinner tomorrow?), observe the produce using their senses (e.g. this tomato is soft/this avocado is green), then interpret their results to see if their observations were successful (i.e. parents providing feedback and modeling how to look for ideal tomatoes/avocados). By learning and elaborating on families' practices at the grocery store, we helped create STEM learning opportunities with signage designs that are integrated into everyday routines (Weisner, 2002).

Developing signage design

We developed creative briefs to communicate the assignment, objective, key message, target audience, musts, and deliverables/ requirements and goals of the signs to our graphic design partners (see Table 3). Intergenerational learning was a prevalent theme in the stories our partners shared during design sessions and is central to sharing funds of knowledge; therefore, the target audience of all signage were children ages 0 to 8 and their caregivers, as well as siblings so that younger children who may not be able to read and comprehend the

Table 3
Content of the creative brief sent to graphic designers for the "¿Por Qué Me Escogiste? (why'd you pick me?)" sign.

Section	Description
Assignment	Create an engaging sign that encourages parents to facilitate conversations about the produce they are picking and why they are picking it. "Why'd you pick me?" – a big sign with different characters (avocado, apple etc.); general prompts for parents, to give different conversational hooks for parents to share a story with their children; letting the kids pick (instructing your kids to pick avocados like _____). Bigger sign where people can put sticky notes with their family's knowledge (crowdsourced). Have signs where children and parents can investigate a "common knowledge" goal/reason to choose a given item. For example, picking a hard avocado means it will last longer because it takes more time to ripen.
Extension	Signs that point children/parents to talk about "color" as one kind of observation, as a clue into what fruit is ready. How do different colors relate to the readiness/stage of fruits. Have a sign where children/families can give recommendations that describe what to pick for (a given produce), to focus on a particular characteristic to observe or look for.
Section	Description
Objective	As we pick whatever produce we are purchasing, going through the process of which ones are good to pick. Local (passed down) knowledge, prompting adults to model how they are doing that, what senses they are using, making observations and seeing the results (e.g. if you pop the top of the avocado, it should be a certain color, pick the ones that are hard so it doesn't rot too soon; knocking the watermelon and listening to the sound etc.).
Connections to early science framework	Setting/optimizing for a goal: making this dish, sweetness etc. Making observations: using senses (touch, smell, taste etc) Investigating the features of produce/fruit Interpreting results (did the selection work?)
Key messages to communicate	Giving children agency – power to pick produce/fruits – is a key goal for the investigations.
Section	Description
Target audience	Children age 0–8 and their caregivers. Predominantly Latino population (so all signage In English and Spanish) also likely that literacy levels are going to be vary a lot so keep vocabulary and reading level demands low.
Musts	Must give kids agency over what fruits to pick. Can't be complicated (minimal text) easily communicated quickly engaging and fun. Deliverables/requirements: A graphic design of the sign that we can take to a local printer.

signage would have the opportunity to learn from those closest to them in an engaging way with a focus on creativity and learning value. Additionally, we hope that signage can prompt interactions beyond the grocery store like in homes and other community spaces. Our graphic design partners translated the design briefs into graphic content and reviewed the design product with the research team. Our team evaluated and revised signage with designers for two iterations (see Fig. 3 for final design).

We followed this same process to develop more signs based on other family experiences vocalized by community members. Parents reflected explicitly on differences in their experience with the metric system compared to their children's and grandchildren's experiences with the imperial system of measurement and how both groups can learn about each from one another. This prompted the design of a sign based on several stories about parents immigrating to the US from Mexico and getting the wrong amount of food at the deli because they had to order in

Fig. 3. Final signage design: ¿Por Qué Me Escogiste? (why'd you pick me?)
Note. Created by Artisan Media Group [Graphic Design], 2020.

pounds when they were used to kilos. Participants discussed the importance of dynamic and adaptive funds of knowledge that change according to changes in reality (Vélez-Ibáñez & Greenberg, 1992) such as strategies for knowing how much meat to purchase in the grocery store when immigrating from one country to another. The sign, titled "Tiempo de conversión (Conversion Time)" (see Fig. 4), will support families when converting between pounds and kilos and involve children directly in the process by providing a sliding scale for children to interact with. Additionally, we developed a sign titled "¡*Descubra nuestra habilidad secreta*! (Discover our Secret Skill!)" based on stories around building a sense of community (another prominent Latine cultural value; Melzi et al., 2019) with staff and other community members in grocery stores through conversation. The aim of this sign was to aid in building community by prompting children and their families to speak with participating employees (who will have on a sticker indicating their involvement) to find out about their "secret skill" (e.g., knowing what produce is in season, how to bake bread, or where certain products are from), which are examples of funds of knowledge relevant to their functioning as grocery store employees and may be influenced by their cultural backgrounds (see Fig. 5).

Discussion

In this study, we shared a few techniques— out of the diverse array of design techniques that make up PD (see Bratteteig, Bødker, Dittrich, Holst Mogensen, & Simonsen, 2012 for review of PD methods) — to illuminate several key design processes: centering family practices and values within a community context, using culturally congruent methods, and identifying connections to early science learning in grocery stores informed by community members' experiences. This study extends previous work from the Playful Learning Landscapes initiative that leveraged everyday spaces, such as grocery stores and food pantries, to increase caregiver-child interactions that facilitate learning (Hanner, Braham, Elliott, & Libertus, 2019; Ridge et al., 2015; Hespos et al., 2020). We extend this line of research by adding a community-based PD process to design signage with local community members centering their everyday practices and cultural values.

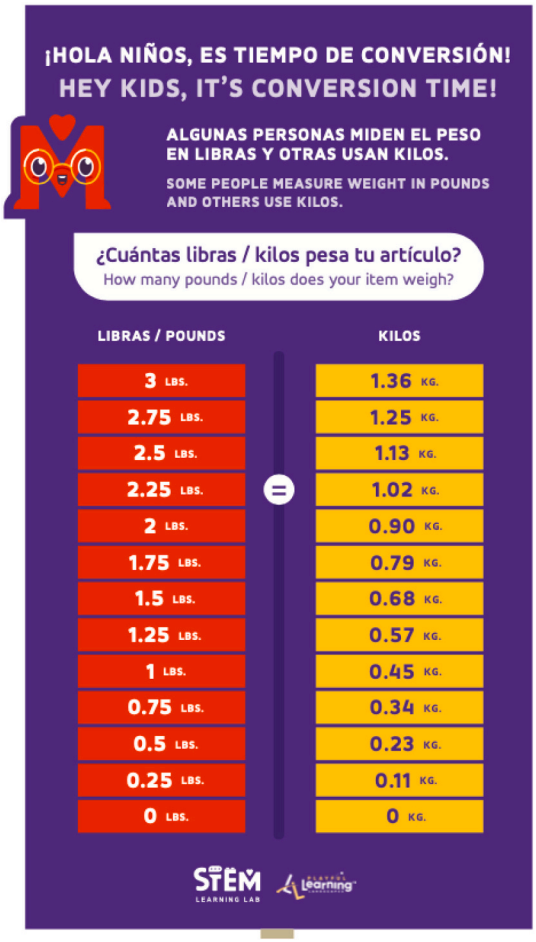

Fig. 4. Final signage design: Tiempo de conversión (conversion time).
Note. Created by Artisan Media Group [Graphic Design], 2020.

Fig. 5. Final signage design: ¡Descubra nuestra habilidad secreta! (discover our secret skill!)
Note. Created by Artisan Media Group [Graphic Design], 2020.

Latine family values

We examined the values and norms surrounding food routines, such as grocery shopping, which is a prominent socialization practice in the everyday life of Latine families and how the grocery shopping experience can be leveraged for STEM learning (Leyva & Skorb, 2017). Latine community values highlight the importance of the family, food preparation, kinship and network ties, and interactions that teach children cultural routines and values (Melzi et al., 2019). Community members discussed the importance of their children joining them in their grocery store trips and knowing what goods to buy to be able to share with their household which included parents, grandparents, aunts, and other extended family; especially during the holiday season. *Familismo* (the importance of close families, family unity and solidarity, and the ways in which familial and kin networks interact) is a core value within the Latine community as families are regarded as a main socializing agent and have profound impacts on children's prosocial behavior (Carlo, Mestre, Samper, Tur, & Armenta, 2010; Cauce & Domenech Rodriguez, 2002). Using community-based PD allowed for us to be privy to specific ways *familismo* operated within our partners' lives (e.g., sharing knowledge within and across families in the community, and intergenerational collaboration to pick the best produce items) and is consistent with current literature on Latine families' emphasis on family unity (Alcalá, Rogoff, & Fraire, 2018; Cauce & Domenech Rodriguez, 2002), manifested within the context of grocery shopping.

Culturally congruent methodology

Another important component of the methodological approach to this study is the congruence with Latine families' cultural funds of knowledge. Storytelling is a powerful tool for understanding the ways in which people learn through their cultural, familial, social, and communal groups and contexts (Bell & Roberts, 2010). Our focus on the use of oral storytelling and the experiences of Latine families' grocery-shopping also aligns with previous literature that identifies those as prominent and valuable practices in Latine communities (Billings, 2009; Leyva & Skorb, 2017). Many Latine families identify oral storytelling as a practice in their daily interactions (Billings, 2009; Steidel & Contreras, 2003; Villarreal, Blozis, & Widaman, 2005), and Latine families' use of oral storytelling (i.e., family anecdotes, jokes, legends or children's stories, horror stories, and historical anecdotes that serve multiple purposes like giving advice) provide affordances for strengthening children's early learning (Reese, 2012). By centering this cultural asset in our design methodology, this study takes a strength based approach to designing interventions with and for Latine families.

Culturally-situated connections to early science learning

When Latine children and their caregivers engage in food-oriented activities (e.g., meal preparation, gathering ingredients) parents tend to follow their children's interest, ask more questions, and discuss more complex concepts in comparison to interactions involving other types of

activities (i.e., playing with cars or blocks, book sharing) (Eisenberg, 2002; Kermani & Janes, 1999; Tenenbaum & Leaper, 1997). Parents in our design sessions shared the different practices they learned for food selection and preparation with their families, such as how to pick the right produce and how to measure food when cooking (i.e., fistfuls, pinches). The signage designed in this study supports opportunities for STEM learning that are integrated into families' existing practices in the grocery store. By designing signage that builds from families' everyday routines we can support caregivers' in initiating culturally-situated STEM conversation (Weisner, 2002). The passed down strategies for picking produce are an example of intergenerational dissemination of cultural knowledge that is rich with science learning opportunities including *asking questions and defining problems* when children want to know why their parents picked the fruits and vegetables that they did, using their senses for *making observations* around the properties of produce (e.g., color, firmness, smell), as well as *planning and carrying out investigations* when families take the produce home and explore its uses. These are foundational science practices that children can use in future science learning experiences and contribute to high-quality inquiry driven learning environments (Greenfield et al., 2017).

Key features of community-based participatory design

Creating culturally situated STEM interventions requires researchers to have shared values of foregrounding community partners in the design process. In preparation for our sessions we spoke about focus group etiquette (e.g., validating participants' experiences, seating those who needed translation were closest to the translator who could quietly translate to not impact the flow of conversation, and the positioning of the recording device). We also discussed how language could affect our conversations and avoided certain language (e.g., labeling practices or experiences normatively as "bad" or "good"). The storytelling techniques that we utilized and how we coded the transcriptions of these stories highlight ways of eliciting rich accounts of community practices, histories, and assets. An inductive coding approach enabled us to center our partners' expertise (cultural and family practices) and integrate our own expertise (science learning standards) later on in the design process to address our goal of co-creation. Brainstorming how to create educational activities using the "how might we" technique helped us translate these culturally relevant STEM learning opportunities into ideas for design prototypes. Meanwhile, elaborative techniques (e.g., the transparency overlay activity to redesign signage) helped us create learning opportunities for children based on science learning standards to yield high-quality learning environments situated in local culture and experience.

The practice of self-reflexivity is a major part of the PD process and is an area where researchers in developmental psychology could also deepen our engagement. One research team member connected this design experience to their personal history of how their grandparents would turn every grocery store outing into a learning activity; her grandfather taught her to estimate the cost of cassava based on its weight, and her grandmother had tricks for picking the best mangoes. This team member did not realize how powerful those experiences were as a child, but now recognizes her grandparents were teaching aligned with learning standards such as the Early Science Framework. Understanding the value in her own experiences as a child influenced how the researcher approached centering the practices of members of the Santa Ana community. This personal reflection reinforced the importance of creating opportunities for learning based on community funds of knowledge and valuing these practices as high quality STEM practices.

Limitations

In an ideal PD process we would have maintained engagement with our SAHRT partners throughout all phases of the project, but our plans for continued collaboration were disrupted when the state of California went into lockdown on March 20, 2020 (shortly after our second design session) due to the COVID-19 pandemic. The pandemic lockdown shifted our design process to an online format which resulted in less opportunities for member checking in the initial phases of the project as our community partners had to attend to more pressing projects related to public health and safety. However, this manuscript represents a meaningful contribution to the literature, as it describes a design process for creating culturally situated STEM learning interventions for Latine families by focusing on a culturally relevant family routine (grocery shopping) and a culturally congruent methodology (storytelling) for accessing families' funds of knowledge.

Lessons learned

We bracketed ourselves purposefully at the outset of the design process, and engaged in reflexive memos to process our thoughts regarding each phase of designing (e.g., how we chose to recognize and value the cultural insight of our community partners, and what we could and/or should have done differently) and considered logistics of design sessions. This process allowed us to make adjustments during the design and analysis processes. For example, the first session we held had lower turn out from parent participants. During a team reflection after the session we discussed that the location of the meeting may have played a role in the lower parent attendance. The first session was held in a local government agency building that the invited parents had not been to before and may have felt unfamiliar with. In response, we switched the location of our second design session to a local school and used the school's network to invite additional parents which greatly improved parent attendance at the second session.

While our team was intentional about bracketing ourselves when sharing with parents, we did not have the opportunity to share this technique with our colleagues from the local health agency. We noticed that their contributions focused on health and nutrition, which was their main priority, but not necessarily the main priority of the parents in attendance. Discussions prompted by our health agency partners focused on nutrition and influenced the contributions of some parents resulting in an overrepresentation of this topic in the data. By reflecting and becoming aware of this issue, we were able to adjust our interpretation of the data and center other themes that arose from families' stories. In future collaborations, we will hold a training session with any facilitation partners prior to design sessions to familiarize them with techniques like bracketing (and other PD facilitation moves) to ensure that we center the voices and stories of community members.

Future directions

A full design process includes understanding community values and context, prototyping based on those values, testing and validating the created prototypes, and revising prototypes based on feedback given during the testing and validating phase. We provided the design narrative for the first two phases of design and will continue to share our process and design outputs with our community partners, solicit feedback, and share the final signage (pending approval from our community partners) for implementation in local retail stores. Once the signs are installed, we will observe how families interact with the signage in real-time and examine the resulting language use and caregiver-child interactions that directly or indirectly reflect STEM learning processes. We will offer our community members opportunities to help collect the observations and conduct on-site interviews with store patrons to gauge their attitudes and opinions of the signage created based on our community participants' stories. Additionally, we will disseminate signage designs to other community organizations so they can adapt and refine the designs based on the goals of their unique initiatives and communities.

Conclusion

Our goal for developmental scientists is to understand the interdisciplinary, practical, and philosophical implications of using community-based PD within their work. Researchers in developmental psychology would benefit from a critical shift in how we center the strengths and knowledge of ethnocultural and linguistically diverse communities historically excluded from research. The PD method was particularly useful for translating cultural funds of knowledge into design artifacts and allowed us to reposition ourselves as learners alongside our community partners to highlight their cultural strengths (Yosso, 2005). Our partners' grocery store experiences illuminated the ways in which STEM learning is prevalent in family routines such as grocery shopping.

Applied developmental researchers, specifically those creating interventions for under-represented communities, should widen our theoretical frameworks to include equity-oriented insights and methodologies from the learning sciences discipline, like participatory design. A growing literature that documents the many ways researchers in our field could adapt different methods, would then provide a rich, nuanced library of ways to develop more culturally sensitive interventions that foreground the local knowledge of community partners. Merging participatory design with developmental science makes room for the expansion of the field's cultural applicability. This design narrative serves as just one illustration of many possible ways to bridge research and real-world settings for sustainable interventions designed for and with communities.

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Author statement

Our authorship team does not have any financial or personal relationships with other people or organizations that could inappropriately influence (bias) this work.

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