Designing for Axiological Innovation Within Family-Centered Learning Environments

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Abstract: Learning environments based on *axiological innovations* (Bang, et al., 2016) recognize the resources learners of all ages bring and value learning based in commitments to expand relationships of collaboration. We take up lines of design-based research focused on the expansive engagement of families, where our goal was to create STEM-based intergenerational learning environments that center family collaboration to transform the process of partnering and increase collective capacity to make sense of the natural world, engage in practices, and reimagine participants' relationships to technologies (Bang, et al., 2012). The four studies that comprise the symposium shed light on the kinds of axiological innovations that guided the design of learning environments that created equitable and transformative STEM-based learning opportunities for families from nondominant communities. Through the symposium we will explore the implications of family-centered axiological innovation for learning theory and design knowledge related to the articulation of extended, cross-setting learning pathways.

Rationale and contribution: Reframing family learning

Recognizing that learning occurs across space and time, learning scientists have thought deeply about how to design learning environments were both children and their adult family members can learn (Barron & Bell, 2015). This approach is often rooted in a commitment to seeing learning as dynamic cultural processes, recognizing that people make sense of and shape their world in ways that are connected to the practices, values, and worldviews of their communities (Bang, et al., 2012; Bang, et al., 2016; Bell et al., 2012; Gutiérrez and Rogoff, 2003). This perspective is important not only because it opens new avenues of learning and participating for learners of all ages, but also because it can create opportunities for all learners to make sense of the world through leveraging meaningful cultural practices, identities, and places as they interact with those whom they have a deep connection with (Nasir, et al., 2014; Rosebery et al., 2005). However, we argue that educational contexts have not adequately explored how to leverage the shared history and intergenerational learning processes of families in support of their own STEM education. In this symposium, then, we pursue the question: *how can we design STEM-based learning environments founded on a set of values and ethics that create equitable and transformative learning opportunities for families?*

Intergenerational designs have been particularly popular with STEM-based learning environments, particularly MakerSpaces that have sprouted all over the US and bring children and adults together to design artifacts, solve problems, and learn about the natural world through engaging in science and engineering practices (Roque, 2016). However, the STEM-based intergenerational learning environments we design need to systematically work to push against boundaries of normative practices and tap into the repertoires of practice of nondominant learners and non-traditional configurations of learners (Bang, et al., 2012). Otherwise, the programs we design will reify the same systems of oppression that have shut the door of STEM learning for students from nondominant communities and their families, and interrupted productive identity-work that would allow learners to see themselves as being able to make sense of the natural world (Bell, et al., 2009; Calabrese Barton &

Brickhouse, 2006; Calabrese Barton, et al., 2013; Tzou, et al., 2017). A very common example of how STEM-based learning environments recreate these oppressive dynamics is the out-of-school learning program that positions families as consumers or users of technology, rather than creating opportunities for families to reimagine their relationships to technology and how it can be used as part of the cultural practices of their communities (Tzou, et al., 2017; Vossoughi, Hooper & Escudé, 2016). Consumer-framed programs, often inadvertently, are founded on a set of values and ethics that embody deficit perspectives of families, their experience, their expertise, and their relation to technology. If left unchecked, learning scientists can continue to design learning environments in which these oppressive dynamics are reified and reproduced, narrowing and limiting the kinds of meaningful learning that families can experience, rather than building upon the heterogeneous sense-making practices and knowledge that families bring to learning environments.

To overturn these kinds of oppressive and colonial dynamics within STEM-based programs, it is paramount that our designs for learning environments are based on *axiological innovations* (Bang, et al., 2016) that transform relational positionings and value the resources learners of all ages bring to the learning environment. We draw from the construct proposed by Bang and her collaborators, who define *axiological innovations* as "the theories, practices, and structures of values, ethics, and aesthetics (...) that shape current and possible meaning, meaning-making, positioning, and relations in cultural ecologies" (Bang, et al., 2016, p. 28-29). We argue it is key for learning scientists that engage in design-based research to attend to how the axiological commitments that undergird their designs create opportunities for all learners to experience transformative agency and disrupt historical inequities. Here, we call for creating STEM-based intergenerational learning environments that desettle normative expectations about what it means to make sense of the natural world, engage in practices, and reimagine participants' relationships to technologies (Bang, et al., 2012). We propose that family-centered, STEM-based learning environments provide a powerful context for exploring this perspective. Family-centered learning environments disrupt age segregation and the colonialist consequences of creating separate learning spaces for adults and children, which can be particularly disruptive for participants from nondominant communities. Nevertheless, much remains to be studied in terms of examining the axiological and ideological foundations of equity-oriented design and research in such environments, and we need to start by transparently communicating what those underpinnings are and how they inform our designs (Bang & Vossoughi, 2016). This is our plan for this symposium.

The four studies that comprise the symposium, all of which took place in the US, shed light on the kinds of axiological innovations that guided the design of learning environments to create equitable and transformative STEM-based learning opportunities for families from nondominant communities. The first study describes how youth and their families reframed their relations to technology, leveraging programming and robotics as tools for storytelling, memory-making, and STEAM learning, resisting being dominated by those technologies. The second study focuses on how engaging in computing practices supported children and their parents reframe how they saw themselves in relation to programming, and even each other. The third study highlights the importance of parent learning networks in the development of interest and experience with creative digital projects, and the importance of differentiating roles that parents can play as learning partners. The fourth study describes how families interacted and problematized natural phenomena together, in a learning environment designed to support intergenerational learning and recognize families' funds of knowledge as productive resources. Taken together, these studies make the contribution that family-centered learning environments that support axiological innovations can ground STEM learning in families' cultural knowledge and practices, promote role re-mediation through shifted social positioning, and support extended cultural learning pathways for youth and adults alike. Through the symposium we will explore the implications of family-centered axiological innovations for learning theory and design knowledge related to the articulation of extended, cross-setting learning pathways.

Paper 1: Technologies of remembering and learning with Indigenous Families: Storymaking, robotics, and computer science

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Framing and study design

The roles of science, engineering and technology in learning and learning environments are increasingly a focus and hope for more equitable and transformative learning, particularly for students from nondominant communities. However, these fields have not historically been attuned to culturally heterogeneous ways of knowing. Scholars are exploring how the cultivation of consequential learning environments (Gutiérrez & Jurow, 2016) are intimately intertwined with historicity, knowledge systems, and the agentic positioning of learners to be the designers of new technologies (e.g. Prins, 2002). This paper presents findings from a Participatory Design Research (PDR) (Bang & Vossoughi, 2016) project that brought together learning scientists into collaboration with public librarians, informal science education staff, and staff from Native American-serving community organizations who were jointly focused on designing family-centered and culturally expansive STEAM (science-technology-engineering-art-math) learning experiences working with nondominant communities. We designed TechTales, a five session, 3-hour weekly workshop series that centered nondominant families' stories and storymaking (Archibald, 2008) processes as a means of re-positioning families' relationships to technology and more specifically robotics. Families made a diorama of an important family story using Scratch (programming language) and a Hummingbird (microcontroller) to animate the artifact using outputs such as LED lights, sounds, and motors, and inputs, such as sensors of various kinds.

Data sources and analysis

In this paper, we examine the forms of learning and engagement of two Indigenous families across the five TechTales workshops. Data were collected utilizing multiple video streams and audio to capture the discursive as well as the embodied forms of activity that unfolded over the course of the workshop (Goodwin, 2000; 2007). The videos were content logged and key moments of project development were identified for interaction analysis (Jordan & Henderson, 1995). Key moments in this analysis were conceptualized as interactions in which the families' storyline and design development were dynamically intertwined. Further, we analyzed moments of refinement driven by interactions between design intentions and materiality. Finally, we explored the ways in which family identities were reinforced and expanded throughout the workshops.

Findings

We find that using story and storymaking as the focus of diorama building created learning environments where computer programming and robotics became dynamic tools towards family-making, collaboration, and learning simultaneously. Families' attention to aesthetics during the design reflected both family identity and memory and opened important disciplinary epistemic opportunities in order to produce affective responses to their stories. For example, one family wanted to capture a family memory of an annual trip traveling to their homeland and their daughter's first lightning storm. The family engaged in deeply agentic building to capture the aesthetic effects of both the lightning in a cloud and their hair standing on end when the lighting struck. In a post-interview with this family, the father indicated the important role this experience played in solidifying that memory for the family and especially for the daughter.

> Father: I don't remember much when I was 7 years old. By doing this whole TechTales story, we all have a shared memory... I'm curious to see if, you know when she (daughter) turns 12, when she turns 20, will she remember that whole lightning storm? Which if we hadn't talked about it, hadn't done the TechTales, it would be just totally lost.

In this way, we are interested in both the work that stories do as both tools for memory making and as drivers of innovation with the technology to capture aesthetic and affective dimensions of place. Family-making, collaboration, and storytelling in this case seemed to open up deeper re-mediations against domination by technology, as well as opportunities for re-mediating agency as families appropriated these tools towards their own ends.

Implications and contributions

In a digital age, assimilative technology is often blamed for mediating away from and severing familial connections. Through shared memory-making within families, we explore the possibilities with digital technologies to build intergenerational connections rather than divides. The interweaving of storytelling, computer programming, and epistemic practices brought families stories to life, and worked towards re-making relations both within family units and to technology. In this way, learning environments based in a commitment to family-centered and culturally expansive design projects is an axiological innovation that provided multiple entry points for family member participation and spaces for ongoing cultural contribution, collaboration, and STEAM learning.

Paper 2: Making projects, making identities: Families constructing their own computing identities

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Framing and study design

We will describe a study of families developing their identities as computational creators in a family learning program designed to support families to create and learn together with creative technologies. Through a series of workshops, Family Creative Learning (FCL) engages families, particularly from underrepresented groups in computing, and aims to support children and parents in developing roles and practices to support one another in a changing and increasingly important context in our digital society (Roque, 2016).

The design of FCL was inspired by constructionist approaches, which engage people in learning experiences where they can create personally and socially meaningful projects (Papert, 1980). Building on constructivist theory, as people build projects, they build ideas (Kafai & Resnick, 1996). To be personally meaningful, the design of FCL invites families to build on their diverse "repertoires of practices" and "funds of knowledge" (Gutiérrez & Rogoff, 2003; Moll, Amanti, Nef & Gonzalez, 1992). To be socially meaningful, the design of FCL has also leveraged learning theories that emphasize the social aspects of learning (Brown, Duguid, & Collins, 1989; Lave & Wenger, 1991). Families are encouraged to work together as well as interact with other families participating in FCL.

We argue that as people engage in building personally and socially meaningful projects, they have opportunities to build identities as creators with computing. We use sociocultural and practice-based views of learning and identity development to examine children's and their parents' developing a sense of self in computing in relation to their participation in FCL (Lave & Wenger, 1991; Nasir & Hand, 2008).

Data sources and analysis

We took an ethnographic approach to understand individual perspectives as well as to examine the social and cultural practices that emerge within the learning environment. The design and development of Family Creative Learning was inspired by design-based and participatory approaches, which emphasize being embedded in the local context, engaging people as collaborators rather than research subjects, and experimenting with multiple iterations (Stringer, 2013; Barab, et al., 2004).

We recorded observations and collected photos, videos, and project artifacts during the workshops. After the workshops, we conducted reflections with the facilitation team and 30-90 minute interviews with individual family members. We focused data collection on eight program implementations of FCL from 2012-2015, which engaged more than 60 families primarily from underrepresented groups in computing.

Findings

We describe the ways that children and parents' participation in this program influenced their identity development in the context of computing. For example, parents and children had opportunities to see themselves and each other in new ways. Initially, parents shared how uncertain they felt about their abilities with technology. Often their children echoed these perceptions of their parents. Through first-hand experience with the creative technologies, parents saw how they could "create something out of nothing" with computing. Similarly, as they worked with their children on family projects, parents shared the ways their children saw them. As one child said when asked about what surprised him about his mom, he said: "When she invented things." Additionally, we discuss the design of learning environment and its different aspects (tools, activities, facilitation, and space) in influencing their development as computational creators.

Implications and contributions

Often learning environments focus on developing skills and content knowledge and how these outcomes transfer in other settings. However, the shifting perspectives and identity development within these activities can have profound implications in how youth and their families decide to persist or pursue future opportunities (Beach, 1999; Nasir & Hand, 2008). Perspectives from parents and other adult caretakers can influence how they provide resources and broker new opportunities. We have an opportunity to design these learning environments and to engage children and their families to support children's identity work in the context of computing.

Paper 3: Parents collaborating to learn: Insights from family co-design workshops about reframing expert roles

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Framing and study design

Networked technologies and digital tools provide young people and their families with new forms of creative agency to pursue questions and activities of interest to them. They also provide rich opportunities for novel and varied forms of intergenerational learning with family members dynamically taking on roles as teachers, learners, collaborators and brokers (Barron, Martin, Takeuchi, & Fithian, 2009). The notion of families as a unique type of creative ensemble (John-Steiner, 2000) invites researchers and designers to expand our units of analyses to conceptualize parents, grandparents, and children as potential members of extended digital learning teams (Katz, 2014). In this framing, parents and children have unique and complementary funds of knowledge and repertoires of practice and are able to share them depending on what learning opportunities they have been provided at school, at work, and informally with friends or community-based organizations. How parents and children take up roles as more expert guides is also influenced by their cultural repertoires of practice around teaching and learning (Gutiérrez & Rogoff, 2003) as well as opportunities and needs that may present themselves because of rapidly changing technologies. In this paper, we share findings from a design experiment that created a novel learning experience for parents to connect with other parents about how they share and co-develop expertise with their children. The design of the workshop built on ethnographic studies of families in both Silicon Valley (Barron, et al., 2009) and in Chicago (Pinkard & Austin, 2014) that showed the varied ways that families learn to design and create together and how new roles as guides and learners emerged with changing expertise levels. A specific goal of the multi-sited ethnographic research was to support and make visible informal learning experiences that might contribute to future pathways as designers, digital artists and activists, and social advocates for one's own community.

Data sources and analysis

Workshops were designed to support a community of parents and other caring adults (grandparents, aunts, adult cousins) to develop agency and confidence in the roles they play in their children's technological learning, especially for those without perceived expertise. Workshops were developed for the families of middle school girls in an out-of-school computational making program. The majority of girls in the program were from non-dominant communities (59% African American; 18% Latina) underrepresented in STEM learning pathways. Sessions included an introduction to parent support roles, brokering STEM learning opportunities in Chicago, collaborating through co-design of an LED-embedded greeting card, and non-technical consulting through visibility of and discussion around their children's STEM projects. Each session included presentation, activities, and reflection/discussion with the community. Data collection (N = 113) includes surveys of roles played and reflections on workshop participation, attendance records, online participation traces in community groups, and observations from in-person sessions captured in field notes, photographs, and created artifacts.

Findings

Results fall into three clusters: (1) Existing intentionality alongside perceived need for more support: Parents were deeply engaged in their children's learning and hungry for opportunities to support STEM education. They were especially eager for ways to find quality STEM opportunities that could extend their child's learning beyond the focal program. (2) Workshops sparked collective creativity and broadened networks: Adults brought individual interests and knowledge to the workshops and engaged deeply in collaborative design work, learning from, sharing with, and helping each other during the sessions. Enhancing adult community connections can widen opportunities for youth through expanded parent brokering as individuals combined knowledge and ideas. (3) Opportunities for reframing expert roles and for bi-directional technology content learning and teaching: While half of parents reported regularly encouraging their daughter and playing the role of a learning broker and a quarter reported learning from or teaching their child regularly, only 11% reported collaborating on projects involving technology.

Implications and contributions

Generating expansive designs for intergenerational learning is a critical need in the learning sciences. In this paper, we highlight the importance of parent learning networks in the development of interest and experience with creative digital projects and the importance of differentiating roles that parents can play as learning partners. Our ultimate goal is to advance possible pathways for all young people and their families as everyday and professional designers of digital tools, and to generate new methods to document their evolution. To the extent that we have a more homogenous group of professionals imagining and building future tools we fail to capitalize on a diversity of perspectives, ultimately limiting potential solutions. It is generally agreed that this is a multidimensional problem that includes early gaps in experience, gender and racial stereotyping of technical work, and workplaces that create climates that suppress rather than invite contributions from all. Parent co-learning networks may be one resource that can foster resilience and boost collective creativity.

Paper 4: Eliciting family sense-making resources in scientific inquiry during multilingual family science nights

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Framing and study design

> "Yo decía que la ciencia era algo extraordinario, que no se podía entender. Pero es algo que... se puede ver, se puede hacer. Para mí era algo... ahh... que no entendía. Pero la semana pasada que vine dije, "¡Wow!" Entonces la ciencia es algo que se puede hacer fácil y sencillo y sin estudio." – Florencia
> *"I used to say that science was something extraordinary, that could not be understood. But it is something that… you can see, you can do. For me it used to be something…ahh…that I did not understand. But when I came last week I said, "Wow!" Then science is something you can do easily and simply and without studying."*

The above statement was made by a Spanish-speaking mother, Florencia, on the second night of our multilingual family science workshop, where children and adults collaboratively explored everyday materials and were invited to make sense of phenomena together. We had hypothesized that such experiences could shift families' perceptions of what counts as science, who can participate successfully, and the role families play in children's science learning. Florencia's reported shift in thought was not uncommon in our workshops. Such shifts served as an existence proof that our approach could be successful. We conducted a more in-depth analysis to understand what led to such shifts in perspective, and their effects on family sensemaking dynamics. How did we help Florencia see that she is capable of understanding science without having to "study" science? How did this shift in perspective influence her approach to learning science with her daughter? Did other families have similar experiences?

We see this effort as exploring the intersection of two axiological innovations (Bang, et al., 2016): 1) Intergenerational learning: We asked families to make sense of phenomena *together* instead of asking parents to "help" their children with the science activities; 2) Resources as strengths: The primary modes of inquiry and exploration came from families' own questions, their rich knowledge of the physical world, and their thoughtful engagement with scientific phenomena.

In designing and conducting the workshops we took a *resources* view of learning (Hammer, et al., 2005; Warren, et al., 2001) in which families use their linguistic and cognitive resources to construct their own understandings, in contrast with the dominant "deficit" view in which learners have robust scientific misconceptions that must be confronted and replaced. We used everyday materials (e.g., ice and water, flash lights, Slinky toys) and tied inquiry discussions to local contexts (e.g. a strange looking tree at their school), supporting families to draw upon their *funds of knowledge* (González, et al., 2005). For this ICLS session, we present the results of an in-depth analysis of moments of activity in which the design of our workshop supported intergenerational learning.

Data sources and analysis

We engaged families in an inquiry-based evening science program at four ethnically and linguistically diverse K-8 schools. Each school had four weekly two-hour sessions. Between eight and fifteen families attended each night. Sessions were conducted bilingually, with translation in real-time. In this paper, we present findings from an interaction analysis (Derry, et al., 2010; Jordan & Henderson, 1995) of video records of families' activities during the workshop, focusing on how our design choices supported collaborative intergenerational learning. In the first part of the analysis, we identified moments when intergenerational learning occurred, i.e., moments where parents and children were making sense of phenomena together. Then we analyzed what led up to these moments, and what sustained them, to identify factors that supported intergenerational learning.

Findings

We will present analysis of three moments of activity from three different families. For example, on the third evening of the workshop Florencia and her daughter discovered that a blue LED light connected to a battery would suddenly go out when a red LED was added. They disagreed about whether the blue light was completely extinguished and, rather than Florencia asserting her explanation to her daughter, they investigated together by going into a dark closet to examine the light levels more closely and puzzled about what could be happening to the electricity flow when the red light was added.

In-depth analysis of such moments reveals several factors that supported intergenerational learning: 1) utilizing familiar, inexpensive materials encouraged families to playfully discover and co-investigate novel phenomena, 2) a resources-based perspective encouraged parents and children to draw upon their own ideas and lived experiences, 3) bilingual translation afforded English-primary and Spanish-primary families to be able to engage together, and 4) in-the-moment marking of their reasoning as "scientific" helped parents and children to associate their funds of knowledge with doing science.

Implications and contributions

The analyses provide accounts of how a design focus on families' cognitive, linguistic, cultural resources can support intergenerational science learning and challenge dominant conceptions of what counts as science and who can participate. These findings provide additional support for the promise of design that encourages families' playful scientific sensemaking in informal environments (Luce, et al., 2017). One question for future research is how to design supports for families to learn together in relatively unstructured environments or during family time at home. We have incorporated these design innovations in developing a bilingual app to support families exploring science together, on their own time and in their own terms.

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