Paper Title Uncovering Tensions in Families' Science Center Experiences Using Cultural Historical Activity Theory

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Uncovering tensions in families' science center experiences using cultural historical activity theory

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Objectives

Researchers in science education have increasingly advocated for shifting pedagogical approaches away from didactic instruction and toward approaches that give learners more agency to build on their prior experiences and investigate personally meaningful problems (National Academies of Science, Engineering, & Medicine, 2018). Supporting learners' agency in this way requires giving learners the authority to decide what is worth knowing and how to go about finding answers to their questions (Miller et al., 2018). Museums and science centers tend to position themselves as free-choice learning environments in which visitors can pursue their own interests and goals, and research on family learning in museums has documented how families navigate museum spaces based on their interests and past experiences (Falk & Dierking, 2016; Zimmerman et al., 2010). Nevertheless, practices in museums often replicate the same kinds of inequities as exist in other educational spaces (Dawson, 2019; Tran & Gupta, 2021; Vossoughi et al., 2016). In particular, STEM exhibits tend to guide visitors' exploration toward predetermined outcomes, limiting the questions visitors can ask and the ways they can explore. Even so, some structure or guidance may be necessary to help families orient themselves in potentially unfamiliar learning environments (Dawson, 2014). For these reasons, it is critical to examine how families interpret their museum experiences in order to understand how STEM exhibits might be designed to support the broadest possible audience. The present study addressed these issues by examining: 1) how diverse family groups described their learning experiences at a range of STEM exhibits with different affordances (from didactic to open-ended), and 2) the specific qualities of these exhibits that they believed supported or hindered their shared experiences.

Theoretical framework

Researchers conceptualize agency as the choices learners make about what to learn and how (Bandura, 2006; Miller et al., 2018), learners' perceptions of their roles in the learning process, and the opportunities that learners are afforded to shape the direction and outcome of their learning experiences (Barton & Tan, 2010; Miller et al., 2018; Stroupe et al., 2018). This work suggests that agency is multifaceted and deeply influenced by the structure of learning environments. The current study used Cultural Historical Activity Theory (CHAT) to analyze multiple interconnected elements of families' experiences at STEM exhibits. CHAT is a theoretical framework for describing various resources, knowledge, and processes that participants draw upon as they work toward their goals (Greeno & Engrestom, 2013). Activities are analyzed as systems that include multiple elements: the objectives for a given activity (from participants' own perspectives); the "tools" (physical or conceptual resources) that participants use; the "rules" (including norms, constraints, or beliefs) that shape how they approach the task; the communities involved in the activity; and the division of labor or responsibilities that

different individuals take on. The goal of CHAT analyses is to reveal tensions between these elements of the activity system, in order to identify opportunities to transform practice. In this study, we used CHAT to parse and code interview data with family groups, identifying how various features of STEM exhibits influenced families' perceptions of their experiences.

Methods and Data Sources

Fifteen families were interviewed at each of eight exhibits in a science center in the Northeast U.S. (total sample = 120). Families were defined as any multigenerational group visiting the museum together, and both children and caregivers within the group were interviewed. Exhibits included both traditional STEM exhibits that presented content via videos, labels, or simple interactives, and open-ended exhibits such as engineering challenges or maker activities with hands-on materials.

Interviews were semi-structured and focused on: Families' goals for their museum visits; their descriptions of how they explored the exhibit together and what they learned; their prior experiences with the museum and with STEM learning (e.g., whether they had existing interests in STEM); and their reactions to the exhibit (e.g., aspects of the exhibit that were interesting/engaging, or confusing/frustrating). Interviews lasted 10-20 minutes, and were conducted in English or Spanish. Families also completed a demographic questionnaire describing their genders and ethnicities using write-in responses.

Coding included three stages of analysis: 1) isolating interview excerpts that related to CHAT concepts (figure 1); 2) thematically coding family members' responses within each CHAT element; and 3) looking across CHAT elements within each family to identify any tensions between these elements (e.g., instances when families' objectives/expectations were not supported by the features of an exhibit). Two researchers coded the data and resolved disagreements through discussion. These analyses allowed an in-depth qualitative analysis of the types of tensions that arose across family groups, and the elements of STEM exhibits that were most often associated with these tensions.

Finally, we compared the tensions that arose for first-time, infrequent, and repeat visitors to the museum, hypothesizing that different types of tensions may emerge based on prior experience with museum environments.

Results

Families' goals for their museum experiences differed based on their past exposure to the museum. First-time visitors were most likely to report wanting to be exposed to new experiences and/or wanting to reinforce their interests in STEM. For repeat visitors, the most common objectives related to seeing parts of the museum itself (e.g., familiar or favorite spaces) and to get out of the house and have fun, although some repeat visitors also mentioned exposure to new experiences. Infrequent visitors were divided between these types of responses.

Families' existing perceptions of STEM learning (an aspect of the "rules" in our CHAT analysis) also influenced what they expected from their museum visits, and the aspects of exhibits that supported or hindered their experiences. In many cases, tensions arose due to the

roles that families expected museum exhibits or staff to play in their learning experiences, which at times conflicted with the division of labor within the family group.

For 38% of families interviewed, all family members expressed an interest in STEM describing it as interesting, fun, or important to learn. Families' objectives were to learn about new STEM topics, or topics that they were already interested in (e.g., space, robotics). Some of these families wanted to explore together, and caregivers viewed themselves as learners alongside their children. Tools, objectives, and rules were in alignment for these families; the variety of interactive experiences in the museum allowed everyone to find something interesting to do. For others, tensions arose when caregivers wanted to use the museum as a resource to teach their children about science by building on what children learned in school. These caregivers tended to view the museum as being primarily for children and not adults (e.g., one caregiver stated that they "already know" about STEM), and caregivers were often frustrated by open-ended exhibits without clear STEM explanations or child-friendly information. For example, in an exhibit with microscopes and microbe samples, one caregiver hoped to make science concepts seem "more real" to her child, and wanted "a little bit more information about the things we are looking at." Another wanted to use the museum to support homeschooling, but described being unsure about the science behind a sewing activity in the museum's makerspace.

Many other families (33%) included some individuals with positive views or existing interests in STEM, and others with negative views or a lack of interest. Most commonly, children but not caregivers were interested in STEM, although at times siblings also had different levels of STEM interest. For most of these families, caregivers' objectives were to support children's interests in STEM, even if they were not interested themselves, and this group included many repeat visitors. Two types of tensions were present for these families. First, some caregivers wanted to let children explore on their own, with the museum serving as a teacher to structure and support children's learning. These caregivers were frustrated by exhibits that were perceived not to be child-friendly enough for children to use on their own, or where staff were not available to help. Second, other caregivers wanted to be involved in children's STEM learning despite their own lack of interest. These caregivers experienced tensions with exhibits that lacked instructions and clear STEM explanations that they could use to support their children and perhaps build their own STEM interests. For example, one caregiver described STEM as boring, but also stated, "I try to be a little bit more active in it for [my daughter]." Both of these groups of caregivers viewed the museum as the primary source of expertise, but they differed in the perceived responsibilities of the museum versus the roles that caregivers wanted to play in their family's learning experiences (ie, the division of labor between the museum and caregivers).

Finally, 20% of families expressed generally negative views about STEM — describing STEM learning as usually being difficult, discouraging, or boring. The objectives of some of these families (most often, repeat visitors) related to getting children out of the house and letting children play, and therefore STEM learning was not central in their goals for their museum visits. When this was the case, families generally appreciated interactive and creative exhibit experiences, but occasionally they wanted more child-friendly options so that children could explore freely on their own. Others viewed the museum as an alternative to school-based STEM learning (for example, one family described learning at the museum as "the easy way... instead of studying the books"). Objectives for these groups related to being exposed to an educational environment and new STEM topics. Tensions arose when information in exhibits was viewed as being too complex, and when exhibits were either hard to use or broken. Families in this

category often wanted more instructions, examples, and guidance from staff, and expressed frustration when open-ended exhibits did not provide clear answers to their questions. For example, one caregiver described STEM as being "hard to understand" and said that their group "gave up pretty easy" at a hands-on engineering activity involving building an air-powered vehicle, because "kids just [started] playing with it, and they don't know what to do with it!" She said that it would have helped to have "a TED talk" with information about key concepts as "something for us to like, get started." These experiences highlight families' expectations that the museum should be easier and more engaging than their other STEM experiences. Discouraging aspects of families' experiences may have had a disproportionate impact on their learning experiences because these families entered with an existing sense of exclusion from STEM.

Significance

This study extends prior research that has explored how families navigate museum environments, and the differences between museums' expectations and the perceptions of museum visitors (Dawson, 2019; DeWitt & Pegram, 2014). The findings illustrate both positive and negative perceptions of STEM that exist even among families who choose to visit science centers, as well as the diversity that exists within family groups, and the range of expectations families may have about what the museum can or should offer. By examining the tensions that families experienced at STEM exhibits, this study highlights opportunities for science centers to be more intentional in reframing their approaches to STEM learning. Our findings suggest that some families' prior experiences may lead them to expect that STEM exhibits will offer established knowledge from an authoritative perspective, rather than providing open-ended experiences that prioritize scientific practices and ways of thinking, despite the fact that exhibit design practices in science centers are increasingly shifting toward open-ended experiences that attempt to engage visitors in creating, experimenting, and problem-solving (Humphrey & Gutwill, 2017). This mismatch suggests potential pitfalls of open-ended experiences in museums, and the need for science centers to attend to the ways they are (or are not) laying the groundwork to prepare families for the kinds of learning they will encounter in museums. These results add nuance to the tensions described in prior research between welcoming learners' own perspectives and teaching them the canonically correct knowledge within scientific disciplines (Penuel & Furtak, 2019). By examining the diversity of goals and expectations that exist within and across families, this study is an important first step in developing more inclusive approaches to designing interactive STEM exhibits for family audiences.

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Figures

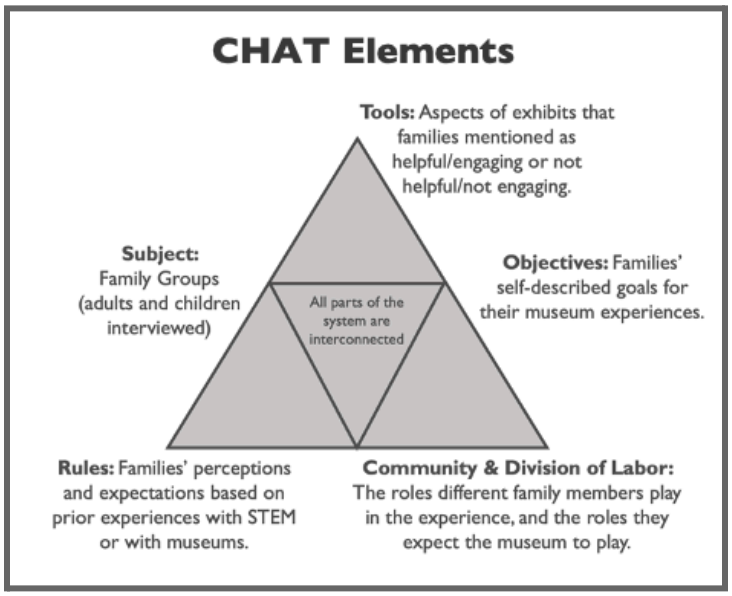

Figure 1. CHAT elements coded in interview data describing families' experiences at STEM exhibits