Puppeteers and Forecasters: How Children Engage with Human-Data Interactions in Museums

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Abstract

Human-Data Interaction (HDI) installations offer engaging ways for children to explore data, yet little is known about how children interact with and around HDI screens. We deployed an HDI display in a museum with K-12 school groups. Our qualitative analysis of children's interactions revealed rich social behaviors, from direct peer instructions (like one child "puppeteering" another's arms to teach a gesture) to imaginative role-playing (such as acting as "weather forecasters" using the data visualization). While children collaborated to explore the data, they also competed for control and struggled with non-intuitive gestures. We present design recommendations to support children's exploration of interactive data visualizations.

CCS Concepts

• **Human-centered computing → Visualization application domains**; *Interaction paradigms*; *Gestural input*; **Field studies**.

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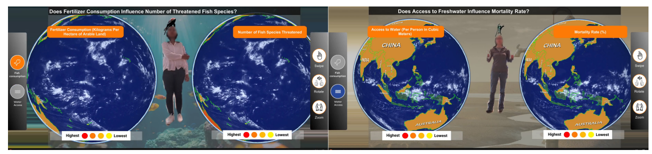

Figure 1: Screenshots of our interactive data visualization. The interactive display features two backgrounds: the ocean scene on the left for the fish endangerment scenario and the water-themed backdrop on the right for the water access scenario.

1 Introduction

Fostering data literacy in children is a crucial goal in our data-driven world [30]. While interactive data visualizations in museums offer a promising way to engage young audiences, children often struggle with the complexity of data [3–5, 13, 23, 24]. Human-Data Interaction (HDI) installations, which allow users to explore data through gestures and body movements [8, 12], present a unique opportunity to engage children with data by encouraging physical and social interaction. However, there's limited research on how children specifically (not museum visitors in general) engage with each other and with data in front of HDI displays.

To address this gap, we conducted an exploratory, qualitative study of over 200 museum visitors, mostly from K-12 school groups. We deployed an HDI prototype (Figure 1) at the Indiana State Museum in Indianapolis and analyzed video recordings to understand how groups of children interacted with the display, the data, and each other. Our work provides key insights into children's social and physical interactions with HDI prototypes and offers design recommendations for HDI installations.

2 Background and Related Work

Our study is grounded in Embodied Interaction [11], a theory in Human-Computer Interaction (HCI) that posits that physical actions are integral to cognition, making abstract concepts more understandable through bodily engagement [4, 11, 16]. This approach is especially relevant for child-centered design, where interactive gestures like swiping or zooming make technology more accessible and encourage exploratory, playful behavior [17]. Human-Data Interaction (HDI) builds on this framework: a key design principle is to use gestures to facilitate data exploration and meaning-making, especially in informal learning settings like museums [9].

Human-Data Interaction systems are often deployed as public interactive displays (PIDs), which allow users to actively interact with the content of the display [19–21]. Our work specifically investigates how K-12 children interact with PIDs that are used for gesture-controlled data visualizations. These interactions are viewed through the lens of social learning theory [28], which emphasizes that children learn through observation, imitation, and collaboration with peers, rather than from structured tasks [6, 9, 22, 25].

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Our work also draws upon extensive research in museum literature, which has investigated how children explore and learn in museums for many decades [2, 3, 10, 15, 26, 29]. This body of work highlights the influence of sociocultural, personal, and physical contexts on children's learning experiences in museums [14].

3 Methodology

We developed an HDI prototype on a 65" TV with an Azure Kinect camera that showed a live video feed of the visitors against a virtual background (Figure 1). This setup is used in HDI literature to capture and maintain attention in busy museum environments [18, 27]. The prototype featured two scenarios, each presenting a scaffolding question and visualizing two related datasets on interactive 3D globes.

Fish Endangerment. "Does fertilizer consumption influence the number of threatened fish species?" This scenario includes an ocean background and a virtual fish icon over the active user's head.

Water Access. "Does access to fresh water influence the mortality rate?" This scenario shows a water-themed background and a water pump icon to indicate who is controlling the interaction.

We implemented gestures and body movements adopted in prior HDI literature (swiping, jumping, moving hands apart/together) to switch datasets, rotate, and zoom the globes [1, 27]. The study took place on weekdays at the Indiana State Museum, with over 200 participants, mostly K-12 students on school field trips. We obtained a waiver of consent to observe public behavior naturally; data was collected via screen captures and separate camera footage. A team of four researchers analyzed video segments and transcripts using a thematic analysis approach [7], guided by two primary questions: (RQ1) How do children interact socially and physically with data-centric interactive displays in a museum setting? (RQ2) What hindered children's engagement with the data on display?

4 Results

4.1 Interaction Patterns

4.1.1 Peer Instruction. Children frequently taught each other how to use the interface. This ranged from verbal guidance to one child physically moving another child's arms in a "puppeteering" motion to demonstrate a gesture. In one case, we noticed a child explaining the visualization's color scale to her friend, directly engaging in data interpretation.

4.1.2 Taking Turns and Collaboration. Children often spontaneously took turns, with one child acting as the "actor" while others watched as "spectators." They also made coordinated team efforts, such as attempting a synchronized group jump to switch datasets.

4.1.3 Role-Playing and Imagination. The themes of the display often sparked imaginative play. For instance, children integrated the data into their own creative narratives by pretending to swim in the ocean background (fish scenario) or acting as weather forecasters.

4.2 Barriers to Data Engagement

4.2.1 Children Disrupting Each Other. Competitive behaviors sometimes derailed the data exploration experience. For instance, some children would intentionally block or push others, while a few would dominate the interaction, preventing peers from participating. Overcrowding the camera was a common issue, with children getting too close to see their faces on the screen, which prevented the system from tracking gestures and other children.

4.2.2 Exaggerated Gestures. Children often used large, exaggerated gestures that the system, designed for more precise movements, failed to recognize. This led to visible frustration.

5 Discussion

Our findings offer three major implications for designing HDI installations for children.

5.1 Embrace Play and Imagination

Children naturally approach exhibits with a desire to play. HDI designers should capitalize on these playful aspects of data exploration. Data should be embedded within a consistent visual narrative that sparks imagination. Design features like the control icon (a fish or water pump) proved to be effective catalysts for role-playing.

5.2 Support Peer Collaboration

Since children learn from each other, HDI displays should actively foster peer collaboration [23]. For example, creating designated roles (e.g., "navigator" and "data analyst") or interactive elements that require multiple users to be activated could transform competition into collaboration.

5.3 Facilitate Control and Turn-Taking

Gestures and body movements should be designed to match children's natural, often larger movements. To manage turn-taking, HDI installations could be designed to periodically and automatically switch control between users, a behavior that children in our study seemed to interpret as a cue to take turns.

6 Conclusion and Future Work

This study explored how children interact with a large, interactive data visualization in a museum setting. Our findings highlight the importance of designing HDI installations for children that support collaborative data exploration and foster children's imagination and role-play. During our deployment, we could not interview visitors about their learning, relying solely on observing children's interactions. Future research should prioritize direct measurement of learning outcomes, using user feedback to assess comprehension and engagement.

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