# Designing Embodied Interactions for Informal Learning: Two Open Research Challenges

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## ABSTRACT

Interactive installations that are controlled with gestures and body movements have been widely used in museums due to their tremendous educational potential. The design of such systems, however, remains problematic. In this paper, we reflect on two open research challenges that we observed when crafting a Kinect-based prototype installation for data exploration at a science museum: (1) making the user aware that the system is interactive; and, (2) increasing the discoverability of hand gestures and body movements.

## CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *HCI theory*; concepts and models.

## KEYWORDS

Embodied interaction, informal learning, human-data interaction

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## 1 INTRODUCTION

The availability of commercial motion tracking devices (*e.g.*, Microsoft Kinect) was initially met with great enthusiasm by early-adopters and by the research community, because of the promise to bring embodied interaction [7] to the masses. Such devices opened scenarios in which people no longer controlled large displays and interactive systems using traditional input devices (such as keyboard and mouse), but directly with their hand gestures and body movements. Museums, in particular, have embraced embodied interaction; its novelty generates buzz and excitement among their patrons and it has enormous educational potential. Designing gestures and body movements for embodied interaction is, however, still a challenge. In the following, we discuss two open research challenges that we identified during the two-year process of iteratively prototyping an interactive installation for data exploration (IDEA, see Figure 1). We are currently testing IDEA at Discovery Place, a science museum in Charlotte, NC.

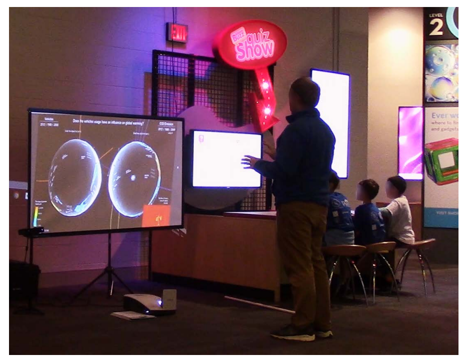

**Figure 1: A visitor interacts with IDEA (Interactive Data and Embodied Analysis), a prototype installation for data exploration. The visualization consists of two interactive globes that show data (*e.g.*, GDP and Tourism) at a country level.**

## 2 RELATED WORK

### 2.1 Embodied Interaction

According to Dourish [5], we construct meaning through our embodied (*i.e.* physical) interaction with the world. More recently, the term "embodied interaction" has also been used to denote interactive installations that are controlled by hand gestures and body movements (*e.g.*, [4, 7]).

### 2.2 Embodied Learning

According to the theory of embodied cognition [16], our body plays a fundamental role in our cognitive processes: our discoveries happen through the interaction between our body and the surrounding environment [14]. In the field of learning science, Embodied Learning [2] employs embodied cognition principles to design embodied interactions that facilitate learning. For example, Lindgren et al. showed that children better understand and remember physics concepts when they are asked to "embody" a meteor in an interactive simulation, rather than when they are introduced to similar concepts using a more traditional desktop simulation [9].


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## 3 DESIGN CHALLENGE NO.1: MAKING USERS AWARE THAT THE SYSTEM IS INTERACTIVE

Despite their tremendous potential to bring in patrons and to facilitate embodied learning, full-body installations have no utility if visitors do not notice that the system is interactive. If the system is not immediately responsive to their action, people generally leave thinking that the installation is broken. During our in-situ observations, we noticed that the visitors' experiences are completely derailed if they are not able to operate with an Human-Data Interaction system within 10 to 15 seconds [10]. Figure 2 portrays an even more problematic scenario that we observed. A user (who previously tried unsuccessfully to interact with the installation) left and, after coming back with a book, took a seat on the projector stool in front of the screen, inhibiting other visitors from accessing that exhibit and the nearby installations. Thus, this problem requires research aimed at identifying strategies to quickly engage visitors with such interactive installations. Inspiration may come from three sources: (1) work on proxemics in the context of ambient displays [6]; (2) research on how to engage visitors with interactive museum labels [12]; and, (3) applications of the users' silhouette to promote the interaction with displays in store windows [11].

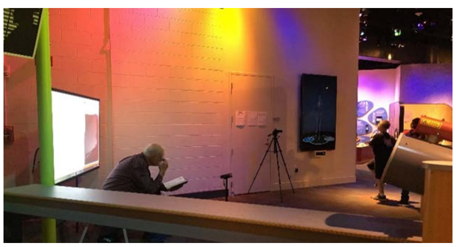

**Figure 2: A discouraged user sits in front of a prototype exhibit, preventing other people from using it.**

## 4 DESIGN CHALLENGE NO.2: INCREASING THE DISCOVERABILITY OF HAND GESTURES AND BODY MOVEMENTS

Even after they notice that a screen is interactive, museum visitors tend to spend a short amount of time with an installation (less than two minutes [13]), and quickly leave if it does not respond to their gestures. This problem is exacerbated by the fact that museum visitors cannot consult user manuals before interacting with an installation. Most work in the field is currently dominated by elicitation studies [17]: groups of potential users are exposed to functionalities of the system, and asked to recommend gestures to control each functionality. The lack of a reference context, however, often results in sets of gestures that are completely disconnected and may be difficult to discover. For example, the work in [15] recommends implementing a "Hand Wave" gesture to hide the menu of a smart TV, and a "Draw Letter M" gesture to open the menu. Being able to guess how to open the menu does not provide any clue as to which gesture should be used next. Inspiration may come from current attempts to identify intuitive cultural constructs that can inform the design. Examples include using embodied schemata [8] to map input actions into perceptual feedbacks [1], and incorporating frames into elicitation studies [3]. Foundational work, however, still needs to be done to understand how to generalize these approaches. For example, the work in [1] implies a 1:1 relationship between one concept and one action ("fast" tempo - running "fast"), which is not well-suited for installations that show data visualizations and support many functionalities.

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## REFERENCES

[1] Alissa N Antle, Greg Corness, and Milena Droumeva. 2008. What the body knows: Exploring the benefits of embodied metaphors in hybrid physical digital environments. *Interacting with Computers* 21, 1-2 (2008), 66–75.
[2] David Birchfield and Mina Johnson-Glenberg. 2012. A next gen interface for embodied learning: SMALLab and the geological layer cake. In *Interdisciplinary Advancements in Gaming, Simulations and Virtual Environments: Emerging Trends*. IGI Global, 51–60.
[3] Francesco Cafaro, Leilah Lyons, and Alissa N. Antle. 2018. Framed Guessability: Improving the Discoverability of Gestures and Body Movements for Full-Body Interaction. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 593, 12 pages. https://doi.org/10.1145/3173574.3174167
[4] Francesco Cafaro, Alessandro Panella, Leilah Lyons, Jessica Roberts, and Josh Radinsky. 2013. I See You There!: Developing Identity-preserving Embodied Interaction for Museum Exhibits. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. ACM, New York, NY, USA, 1911–1920. https://doi.org/10.1145/2470654.2466252
[5] Paul Dourish. 2004. *Where the action is: the foundations of embodied interaction*. MIT press.
[6] Saul Greenberg, Nicolai Marquardt, Till Ballendat, Rob Diaz-Marino, and Miaosen Wang. 2011. Proxemic Interactions: The New Ubicomp? *Interactions* 18, 1 (Jan. 2011), 42–50. https://doi.org/10.1145/1897239.1897250
[7] Eva Hornecker. 2010. Interactions Around a Contextually Embedded System. In *Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '10)*. ACM, New York, NY, USA, 169–176. https://doi.org/10.1145/1709886.1709916
[8] George Lakoff and Mark Johnson. 2008. *Metaphors we live by*. University of Chicago press.
[9] Robb Lindgren, Michael Tscholl, and J Michael Moshell. 2013. Meteor: Developing physics concepts through body-based interaction with a mixed reality simulation. In *Physics Education Research Conference-PERC'13*. 217–220.
[10] Swati Mishra and Francesco Cafaro. 2018. Full Body Interaction Beyond Fun: Engaging Museum Visitors in Human-Data Interaction. In *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '18)*. ACM, New York, NY, USA, 313–319. https://doi.org/10.1145/3173225.3173291
[11] Jörg Müller, Robert Walter, Gilles Bailly, Michael Nischt, and Florian Alt. 2012. Looking Glass: A Field Study on Noticing Interactivity of a Shop Window. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*. ACM, New York, NY, USA, 297–306. https://doi.org/10.1145/2207676.2207718
[12] Jessica Roberts, Amartya Banerjee, Annette Hong, Steven McGee, Michael Horn, and Matt Matcuk. 2018. Digital Exhibit Labels in Museums: Promoting Visitor Engagement with Cultural Artifacts. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 623, 12 pages. https://doi.org/10.1145/3173574.3174197
[13] Cody Sandifer. 1997. Time-based behaviors at an interactive science museum: Exploring the differences between weekday/weekend and family/nonfamily visitors. *Science Education* 81, 6 (1997), 689–701.
[14] Lawrence Shapiro. 2010. *Embodied cognition*. Routledge.
[15] Radu-Daniel Vatavu and Ionut-Alexandru Zaiti. 2014. Leap Gestures for TV: Insights from an Elicitation Study. In *Proceedings of the ACM International Conference on Interactive Experiences for TV and Online Video (TVX '14)*. ACM, New York, NY, USA, 131–138. https://doi.org/10.1145/2602299.2602316
[16] Robert A Wilson and Lucia Foglia. 2011. Embodied cognition. (2011).
[17] Jacob O. Wobbrock, Htet Htet Aung, Brandon Rothrock, and Brad A. Myers. 2005. Maximizing the Guessability of Symbolic Input. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems (CHI EA '05)*. ACM, New York, NY, USA, 1869–1872. https://doi.org/10.1145/1056808.1057043