13 How Visitors Tame Exhibits

Using a design-based research method to understand visitors' performance

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Researchers who analyze the kinds of learning processes that unfold at science centers and interactive museums face the challenge of having limited control over the conditions under which their research is conducted. These conditions are unstable by definition: the visitors' behavior is uncontrollably influenced by that of others; this means that conversations and actions that were not anticipated by the research protocol naturally occur. In addition, noise and unexpected background events might distract the subjects. This ultimately makes the exhibition space quite remote from the usual standards upheld in a research laboratory; thus, the data obtained are inevitably at risk of being ambiguous and the replicability of the results is questionable. Consequently, conclusions based on such data are both limited and uncertain.

This article demonstrates how the design-based research (DBR) method can be applied to learning more about how people actually interact with exhibits. The DBR method is based on the premise that the messiness of real-world practice must be recognized, understood, and integrated as part of theoretical claims, if those claims are meant to have real-world explanatory value (Barab 2014) and is derived from the interdisciplinary learning sciences. DBR's goal, therefore, is to harness the study of learning, as it unfolds within a naturalistic context that contains theoretically inspired innovations, in order to develop new theories, artifacts, and practices that can be generalized to other contexts. This article consists of three parts. The first, introductory section describes the DBR method and its applications in analyzing the interaction between visitors and exhibits. In the second, we present analyses of the process whereby a visitor familiarizes herself with four (previously unfamiliar) exhibits. We use affordance theory as an explanatory concept in our analysis. In the article's third, and concluding, part we show the DBR approach's benefits in terms of developing knowledge about the »taming« of exhibits.

An important part of the Copernicus Science Center's exhibitions is that it offers visitors the experience of discovering natural phenomena on their own through exhibits. Visitors who use the interactive exhibits, thus, participate in a two-stage learning process. First, they recognize the exhibits; visitors learn how they work, what they are used for, and what they make possible. Second, having learned how to work with the exhibits, they start to recognize phenomena. Knowing how both processes work is crucial for designers. This is because it allows them to determine the interaction experience's educational value: to what extent does it develop procedural knowledge (how the devices work) and to what extent does it help visitors to develop substantive knowledge (regarding the phenomena)? A growing number of researchers are taking an interest in the cognitive processes that occur in exhibition spaces (e.g., Franse et al. 2023; Achiam et al. 2014). This is because, while it is tempting to transfer research (for example, on learning and interaction with exhibits) to the stable conditions of a lab, the resulting findings will nevertheless be of only limited help in understanding what actually happens in exhibitions' living and uncontained environment. The process of the development of epistemic practices (i.e., cognitive and discursive activities that engage learners in science's knowledge construction processes of) (Hofer 2001) taking place there eludes diagnosis; this is because the relationship between the participant and the educational object is severely deprived of context. It is also impossible to properly understand the actual role played and the use of the object/exhibit. The exhibition environment consists not only of the visitor and the exhibit, but also comprises the exhibition's overall curatorial concept, the rules and atmosphere prevailing at the institution, relations with other visitors etc. Cognitive practices are, thus, shaped by the exhibit and exhibitions only as elements of a broader, complex system; in this sense, abstracting away from that context means that the attendant conclusions lose ecological relevance (Greeno/Engeström 2014). To put it another way, one cannot abstract from details such as who the visitor arrived with, what he or she has seen and experienced previously, and what associations he or she has with the object in question as a result when analyzing cognitive processes at exhibitions.

DBR and its applications in analyzing interactions between visitors and exhibits

Design-based research (DBR) evolved around the beginning of the 21st century and was heralded as a practical research methodology that could effectively bridge the chasm between research and practice in education (Anderson/Shattuck 2012). Its methodological proposal is based on the premise that the messiness of real-world practice must be recognized, understood, and integrated as part of theoretical claims, provided that those claims are meant to have real-world explanatory value (Barab 2014). DBR's goal, therefore, is to harness the study of learning as it unfolds within a naturalistic context that contains theoretically inspired innovations; the aim is to develop new theories, artifacts, and practices that can be generalized to other contexts. The basic process of DBR involves developing solutions (called interventions) to problems or, to put it another way, understanding the task the visitor encounters. These interventions are then put to use to test how well they work. Successive interactions may then be adapted and re-tested to gather data (Barab 2014).

DBR has three key features: 1) collaboration with practitioners that is focused around actual problems, 2) a pragmatic approach to addressing complexity, and 3) theoretical and practical cycles of inquiry (Dede 2004; Tabak 2004). Researchers that employ DBR aim to utilize theoretical and practical knowledge to design solutions within local contexts and to then apply multiple iterations of tweaking the innovation and studying it. Being situated in a real educational context lends a sense of validity to the research and ensures that the results can be used effectively assess, inform, and improve practice in at least this one context (and likely others as well).

In this chapter, we show how DBR may help to answer some fundamental questions regarding the development of the relationship between exhibits and visitors. How is it that a visitor – often a child – is able to enter into a quick and spontaneous relationship with an object that they have never seen before? What is the process by which a hitherto unknown device becomes instrumentalized – assimilated, internalized – by visitors? How long does it take and what proportion of the overall process of interacting with the exhibit does it occupy?

The affordances of objects can be defined as »the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used« (Norman 1988: 9). The affordances of a designed object, therefore, greatly influences how and whether people interact with that object. The intervention analyzed involved selecting four exhibits at a science center that had different ranges of affordances: from overt (legible to the user), through mixed (with some elements legible, but others not), to covert affordances. We analyzed the progression of one child's interaction with all four unfamiliar objects, trying to discover what role »instrumentalizing« the object played within the entire interaction the Copernicus Science Centre's specific exhibits in Warsaw, Poland.

The theory of affordances as a concept explaining the process of instrumentalizing exhibits

The exhibits in a science center differ in their attendant features and functions. Although they are often lumped together into broad categories – e.g., as »interactive« or »hands-on« exhibits (Humphrey/Gutwill 2017); as objects, they nevertheless differ quite significantly from one another in term of their form, size, and how visitors interact with them. At the most basic level, the visitor encounters an individual exhibit; this exhibit presents the visitor with one or more allowable actions or tasks. At the next level, the visitor interacts with the exhibit by using their chosen techniques or ways of manipulation. At the third level, the visitor begins to generate an explanation of the phenomenon shown in the exhibit. Finally, at the fourth level, the visitor begins to generalize their ideas by including other, related exhibits (Achiam et al. 2014). However, how does it even become possible for a visitor to handle an exhibit that he or she has never worked with previously? What portion of the total interaction with the object is taken up by reconnaissance, the process of recognizing the object, and the »instrumentalizing« thereof?

The concept of affordances has been used to analyze the designing of interactive exhibits at science centers (Allen/Gutwill 2004), but also as part of a narrative framework through which to understand meaning-making and to support collaboration across different domains and practices – such as architectural design, landscape design and exhibition design (Austin 2012; Reich/Parks 2005). The concept of design affordances has implications for the way in which museum professionals design interactive learning experiences because visitor interactions with an exhibit are influenced by their perceptions of the types of actions that are permissible and possible on the basis of the interactive design. It is this latter relationship that makes exhibit developers try to look for design solutions wherever possible – elements that Norman calls signifiers which »communicate where the action should take place« (2013: 14) – which may be familiar to other contexts. Even if what is supposed to happen is not apparent when using an exhibit, the visitor still knows that a button is surely meant to be pressed, a pedal stepped on, or a knob turned; in other words, the user's perception of the exhibit's affordances dictates what actions will be possible.

In this article, we present a brief, preliminary analysis of how one child (an 11-year-old girl, given the pseudonym »Lilly«) interacted with four exhibits with different affordances. Data was collected during a 60-minute observation visit to the Copernicus Science Center exhibition, during which Lilly wore eye-tracking glasses and during which she was accompanied by her brother (age 9) and an adult family member. The multimodal analysis included data from all meaningful actions and gestures performed by Lilly within the observed interaction with the exhibit. Additionally, data analysis included the focus of visual attention and included the areas that Lilly looked at, as collected by the eye-tracker and her verbal expression: this included a recording of all of the conversations she had, comments she made, and her verbalizations as well as those of her co-visitors.

1. »Swirling Sand«: interaction with ambiguous affordances

The »Swirling Sand« exhibit consists of three identical stations and each has a spinning platform, a knob regulating rotation speed, sand, and additional tools such as shovels, boards, and brushes for drawing and erasing sand patterns (see Fig. 1). This exhibit was designed to encourage Active Prolonged Engagement (APE) on the part of visitors (Humphrey/Gutwill, 2017). The exhibit does not offer any clear task to perform; users can autonomously create various patterns from sand. Consequently, figuring out how to do something can occur at different moments during the interaction. In addition, the goal can change many times, as happened in Lilly's case. She stated that she had not set a goal and was more interested in the process itself. This exhibit's affordances, therefore, can be described as ambiguous.

Fig. 1 a. 2: Left: »Swirling Sands« exhibit and its instructions for use. Right: »Jumping ring« exhibit and its instructions for use. Copernicus Science Centre, 2022 (Photos: Katarzyna Potęga vel Żabik)

2. »Jumping Ring«: interaction with perceptible affordances

This exhibit consists of both a coil and a metal ring inside a transparent tube (see Fig. 2). When the visitor presses the »START« button, a current flows into the coil and a magnetic field appears and grows around it. This induces a current in the metal ring. In turn, this current is the source of a new magnetic field, this time forming around the ring. The coil and the ring become magnets, with fields oriented in such a manner as to cancel each other out. The opposite-directed magnets repel one another, so the ring shoots upward. Both behavioral analysis and eye-tracking data showed that Lilly knew how to handle the exhibit and noticed the effect of the metal ring leaping upwards.

3. »I am a Function«: interaction with covert affordances

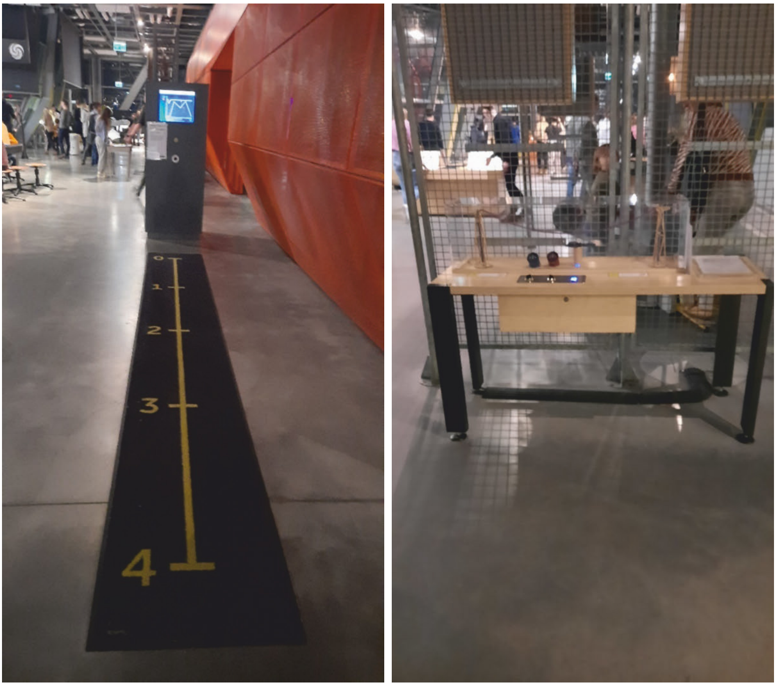

Fig. 3 a. 4: Left: »I am a function« exhibit and its instructions for use. Right: »Attracting Wires« exhibit and its instructions for use. Copernicus Science Centre, 2022 (Photos: Katarzyna Potęga vel Żabik)

The third exhibit described here has both a finite interaction time (23s) and a clear goal. The movement of the visitor's body (approaching and moving away from the exhibit sensor) gets mapped out on a screen in real time; the visitor's task is to move in such a way as to best align this representation with the graph being displayed of a certain mathematical function (see Fig. 3). The task requires that the user not only learn the implicit rules of interaction (approaching the exhibit is mapped onto a rightward movement, and vice-versa), but also that they be physically agile and be precise when adjusting their speed (this determines how sharply the line will rise or fall). The first stage (learning how the exhibit works) is crucial for understanding the relationship between movement and time, whereas the second stage depends on the user's goals and motivation (how precisely they want to perform the task). For Lilly, the exhibit proved puzzling at first: it displayed no signifiers indicating what should be done, except for the »Start« button. An analysis of the girl's behavior and expressions indicated that she was at a loss for the first 20 seconds of the interaction (her gaze flitted around, looking at her companions, and she directly asked the following question twice: »What am I supposed to do here?«). She then noticed the relationship between her movement and what was happening on the screen and made another attempt to map out the graph.

4. »Attracting Wires«: interaction with covert affordances

This exhibit consists of two current-carrying wires, a compass, and switches that alter the direction of the current flow (see Fig. 4). The current begins to flow in the wires, thereby generating magnetic fields around them, when the illuminated button is pressed and these fields may repel or attract each other, depending on the direction of the current flow. Lilly did not manage to observe this phenomenon; instead, she looked for a way to cause some action by squeezing or twisting the available elements after approaching the exhibit, but she was unable to identify the outcome of her action (she did not look at the wires long enough to observe the change in their position) and then walked away from the exhibit.

We classified the interactions of Lilly's that we observed with these four exhibits into two groups: a) learning how to use the object and b) exploring what to do with the object. The first group included »reconnaissance« activities that served to help Lilly to recognize the exhibit as a device: reading the instructions, observing another person using the exhibit, checking how the buttons work, and touching individual elements of the exhibit. These interactions did not involve Lilly's attention being directed to the phenomenon that the object was meant to demonstrate. The second group of activities were those directed toward active experimentation and exploration. This group included activities with the exhibit in which Lilly's attention was directed at following the outcomes of her manipulations of the device and at the phenomena that occurred (or did not occur as expected).

The results obtained were then analyzed from two perspectives. First, we wanted to know what percentage of the time spent with the device was spent on familiarizing herself with the object and on figuring out how to use it (i.e., on »instrumentalizing« the object). In other words, what share of her total time at the object did Lilly invest in learning about how the device worked? As shown in Figure 5 below, this percentage was 22 % for the »Swirling Sand« exhibit, 48 % for »Jumping Rings«, and 33 % for »I am a Function«. Lilly focused exclusively (100 % of time) on figuring out how the exhibit worked for the »Attracting wires« exhibit; she walked away from it after failing to understand how to use the object. At this stage of analysis, the relationship between the type of affordance and the time spent learning about the device may seem rather paradoxical: namely, the highest percentage of time spent learning about the device was recorded for an exhibit with overt affordance.

However, a different picture emerges if we factor in the total time spent interacting with each object overall. As Figure 6 shows, Lilly invested the most time trying to figure out the »Swirling Sand« exhibit (almost two minutes), and she also interacted with it the longest (a total of almost nine minutes). The shortest interaction, with the »Attracting wires« exhibit, lasted only ten seconds: Lilly left after a quick attempt to figure the object out. Her interaction with »Jumping Rings« and »I am a Function« – the former with overt, the latter with covert affordances – lasted a relatively short time and included both groups of activities.

What might we learn from such data? First, they allow us to assess the quality of a given exhibit and, therefore, to verify the appropriateness of the solutions selected by the designers. The less time a visitor spends learning about the device itself, and the more time spent on studying the effects of interacting with it and learning about the phenomenon being demonstrated, the higher the quality of the interaction is likely to be. This is because the primary purpose of working with an exhibit is to learn about a particular phenomenon. Second, we can discern that the type of affordances offered by an exhibit does not fundamentally affect the overall experience of working with that exhibit, although it does affect the time spent learning about it. Overt, perceptible affordances clearly reduce the time spent figuring out the device, whereas covert, implicit affordances run the risk of quickly discouraging the user (such as Lilly) who might decide not to work with an object. Interestingly, an object with ambiguous affordances may also lead to the longest engagement with the object, even though it requires the greatest investment of time from the user in learning how the device works. Thus, one can make a tentative hypothesis about the relationship between the duration of the device-recognition phase and the time spent engaged in exploratory activity actually using the device. The longer the phase of the exhibit's voluntary »instrumentalization« by the visitor, the longer the phase of subsequent interaction with the object is likely to be. This will be the subject of further planned research.

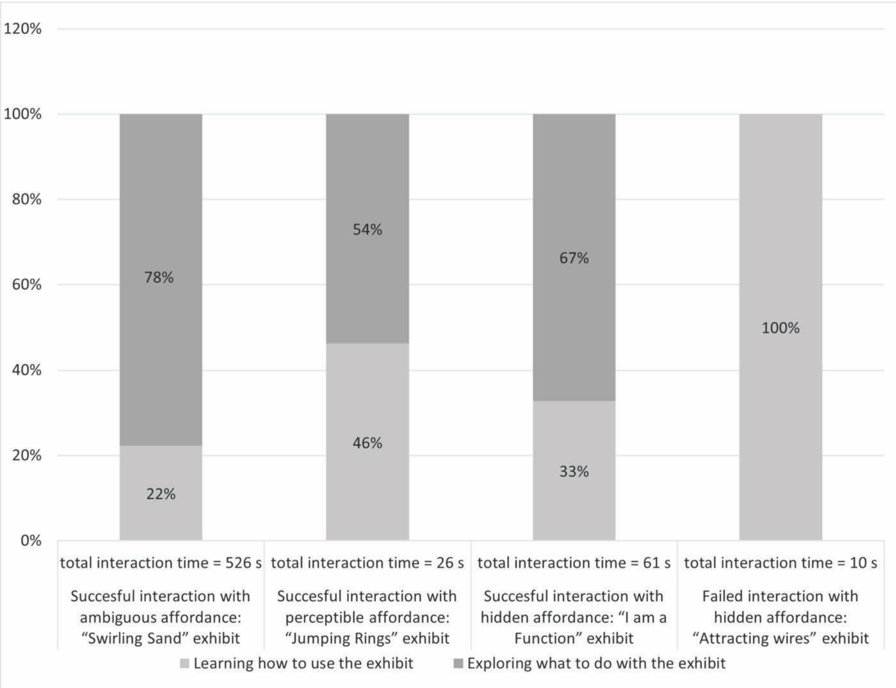

Fig. 5: Percentage breakdown of time spent interacting with four exhibits of differing affordances: time spent on »How to use the exhibit« vs. time spent on »Exploration what to do with the exhibit« (Iłowiecka-Tańska/Potęga vel Żabik 2023)

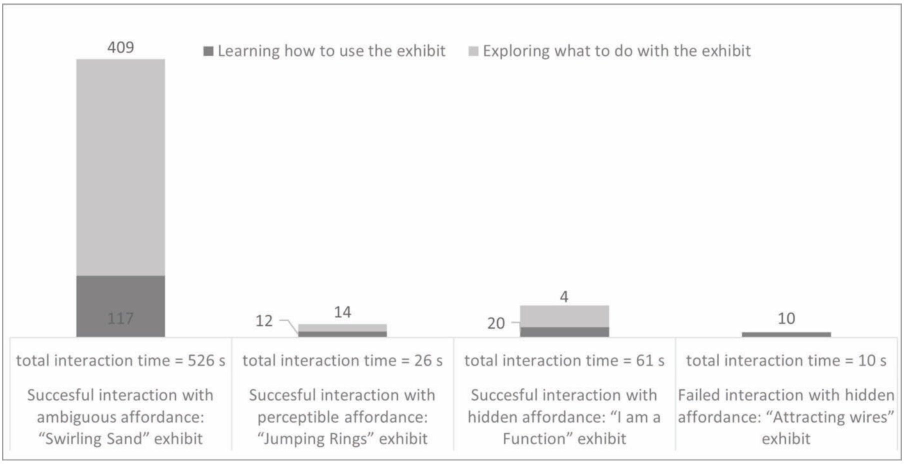

Fig. 6: Breakdown of time spent interacting with four exhibits of differing affordances: overall time spent on »How to use the exhibit« vs overall time spent on »Exploring what to do with the exhibit« (Iłowiecka-Tańska/Potęga vel Żabik 2023)

Benefits of using the DBR approach to develop knowledge about how visitors ›tame‹ exhibits

As noted previously, design-based research aims to study learning as it unfolds within a naturalistic context that contains theoretically inspired innovations, so as to then develop new theories, artifacts, and practices that can be generalized to other contexts. Therefore, we analyzed Lilly's interactions with different exhibits in a given exhibition space, which she explored together with other visitors (including her family) and she was free to either approach or to walk away from specific exhibits. We used the concept of affordances as an explanatory theory to analyze the structure of the girl's interactions.

Determining the different exhibits' different affordances helped us, on the one hand, to select objects for analysis, and to interpret the data obtained on the other. This research method has certain limitations. We were guided by the common prevalence of the solutions applied in judging the affordances offered by the exhibits. However, we did not take the individual participant's personal experience into account. The latter was indirectly evidenced by the intuitive use of signifiers (e.g., starting the interaction by pressing the »START« button) or, in the case of unfamiliar objects, by asking »What is this all about?« and glancing around to search for familiar cues. Such research is definitely of preliminary value for planning future evaluations, in view of the deep cultural determinants of affordances. Moreover, the data obtained at this stage allow us to assess the quality of the interactions analyzed by providing measurable data about the exhibits. They also provide an inspiring topic of discussion for both designers and curators of exhibitions; this was the primary goal of the research conducted.

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