Participation patterns of interactive playful museum exhibits: evaluating the participant journey map through situated observations

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Participation Patterns of Interactive Playful Museum Exhibits: Evaluating the Participant Journey Map through Situated Observations

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ABSTRACT

The Participant Journey Map (PJM) provides structured insight into participation with interactive play in (semi-) public environments. It supports understanding of participants' behavior and was developed based on experiences with previously developed playful interfaces, related research and expert interviews. We apply the PJM to interactive playful museum exhibits and evaluate and refine it based on its usage in a situated context. We observed 672 play sessions with 6 interactive playful museum exhibits. The observation data was visualized and analyzed using the PJM. This study shows that the PJM provides a realistic representation of participant behaviour, can be used to identify stagnations and progressions in participation flow, and support identification of influencing design and contextual factors. With this paper we contribute by presenting the PJM as a well-grounded, valuable and realistic framework for evaluating and understanding participation with situated interactive play, based on post-hoc evaluation of multiple interfaces with many users.

CCS CONCEPTS

• **Human-centered computing**; • **Interaction design process and methods**; • **User interface design**; • **Human computer interaction (HCI)**; • **HCI theory, concepts and models**; • **HCI design and evaluation methods**; • **User studies**;

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KEYWORDS

Interactive Play, Playful Interaction, Play Design, User Experience Design, Interactive Museum Exhibit, Public Interface, Exhibit, Museum, Science Centre, Framework, Journey Map, Interactive Trajectory, Participation Patterns, Situated Observations, Public Space, Evaluation

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1 INTRODUCTION

Interactive play (IP) is increasingly present in (semi-) public environments as interactive museum exhibits, playgrounds [1, 2, 24, 87] and media art a.o. IP can be found in locations such as museums [16, 46], science centers [25], schools [48], libraries, city squares and as part of building facades [20].

Interactive Play can be defined as interactive systems that facilitate and/or evoke playful (lusory [72]) attitude and behaviour. Interactive play [1, 41, 44, 51, 67] is also known by definitions such as interactive play installations [2], interactive play experiences [19], interactive play objects [3, 4], (interactive [12]) play systems [54, 55], (open-ended) play environments [45, 76], (augmented [22, 49, 50], social [28]) play spaces, interactive playgrounds [23, 24, 71], pervasive games [43], ambient gaming and play [70]. Besides the aforementioned systems that primarily focus on play, there is much overlap with systems known as ambient intelligence environments [57], interactive design installations [62] and active (or activating) (urban) environments [61, 63]. Within the research described in this article, we focus on interactive playful museum exhibits that convey an experience and support information transfer.

Within the HCI community attention has been paid to the design, development and evaluation of interactive play systems for quite some time [85]. In this context, it is important to understand how to design for when people are playing. But, to ensure that people reach this 'state of playing' it is equally important to understand how people can be motivated to engage with these exhibits. Insight into the full interactive trajectories for these types of interfaces helps to understand how to design for optimal engagement and experience.

To improve understanding of the (design) factors that influence participation and user experience of interactive play, more research is needed. To address this, the Participant Journey Map (PJM) was developed [49]. The PJM is a framework providing structured insight into the full participation journey for interactive play in (semi-)public environments. It was developed based on experiences with previous interactive play design and research projects in situated contexts, related research and expert interviews and provides an abstract representation of participation journeys. The PJM resembles the structure of a customer journey map and consists of four layers: two overarching phases (Onboarding and Participation), six underlying states (Awareness, Interest, Intention, Exploration, Continuation, and Finishing), transitions between states and factors influencing these transitions.

The PJM distinguishes itself by incorporating the full participation journey, including what occurs before the actual interaction (Onboarding), allowing disrupted, partial journeys (through exits at any state), allowing non-linear journeys (by moving back to previously visited states), including a state of finishing and a detailed layer of influential (design) factors.

For interaction in public places there is a need to understand users' context, situated interactions, and their interplay [58]. It is therefore important to study user behaviour in 'the wild', in their 'natural', 'situated' contexts [13] and evaluate such technologies in their intended setting [65]. This will lead to results that are more realistic and better represent the actual, situated use of interfaces compared to lab studies [64, 80].

Few frameworks and models are post-hoc evaluated in a situated context with a substantial population and multiple interfaces. This is important, as for example Hornecker et al. [34] observed museum exhibits in both a semi-realistic controlled setting, and in situ and mention a strong discrepancy of behavior between the semi-realistic controlled and situated setting and not being able to replicate the same social dynamics that occur in museums. This illustrates the importance of researching these interfaces in their situated environments.

Therefore, the main objective of the study presented in this paper is to evaluate the Participant Journey Map through situated observations of interactive playful museum exhibits.

We focus on the following questions:

- Does the PJM provide a realistic representation of PI participation journeys that occur in a situated context?
- How does the PJM support evaluation of PI participation journeys in a situated context?

In order to answer these questions, we observed, visualized and analyzed participation journeys and resulting patterns of 672 play sessions with six interactive playful museum exhibits.

Figure 1: The Sidewalk Harp by Jen Lewin Studio (photograph (CC BY-SA 4.0, by Fanaddict 82)

Through the study presented in this paper we make the following contributions:

- Provide an evaluation of a framework for participant journeys with interactive play in (semi-)public spaces;
- Show how the PJM can be used as a framework for observations of interactive play in a situated context;
- Provide insights into how differences in design and context factors influence different participation journey patterns;
- Contribute to a better understanding of the full participant journey, including what happens before people start interacting, and how they end their participation.

2 BACKGROUND & RELATED RESEARCH

2.1 Interactive Play in (semi-)Public Spaces

Interactive play can take many forms and can be implemented in various environments. Examples of Interactive play in (semi-)public spaces include interactive media façades [20] as part of a building, such as Sidewalk Harp [38] (Figure 1); interactive lighting in a city square, such as The Pool [37] (Figure 2). Other examples include interactive playgrounds such as the Yalp Sona interactive dance and play arch (Figure 3) [83] and Yalp Memo interactive play pillars [84] (Figure 4) [9]; and the interactive projected floor for elementary schools and daycare by Springlab [68] (Figure 5). They can also be found in museums, in the form of interactive media art, such as the work of Teamlab [73] (Figure 6), but specifically within museums with an informative, educational objective such as science centers and natural history museums, such as Connected Worlds (Design I/O) (Figure 7) [25] and Globe4D (Figure 8) [17, 18].

These examples have in common that they are spatial, require physical or tangible input, can be used by several users simultaneously (thus facilitating social interaction), but can also be used individually. Many of the examples mentioned above are open-ended by design, however, interactive play can also be more structured and have a predefined, closed ending such as the games present in the Yalp and Springlab interfaces.

Figure 2: The Pool by Jen Lewin Studio ("The Pool" (CC BY-NC-SA 2.0) by chooyutshing)

Figure 3: Yalp Sona (Image by Gouwenaar, CC0, via Wikimedia Commons)

Figure 4: Yalp Memo (Image from: Objekte Basisdatenbank - Eichsfeld)

Figure 5: Springlab interactive play floor (Image by Springlab)

Figure 6: Teamlab Borderless ("TeamLab Borderless, Odaiba, Tokyo, Japan" (CC BY-SA 2.0) by dconvertini)

2.2 Frameworks and models

When people encounter an interactive playful system in a public space, they move through different states of engagement. Within the domain of Human-Computer Interaction and Designing Interactive Systems, interactive trajectories and experience journey maps to describe these processes are an emerging area of research.

Previous research relating to interactive trajectories in public spaces includes work focusing on situated social play experiences [40], implicit and explicit interaction [79], passive and active engagement zones [53], spatial configuration [27], intuitive interaction [33], and attracting, engaging and motivating the user [56].

Other frameworks are developed for evaluation or analysis of public (museum) installations, such as the Evaluation Framework for Public Installations [39], M-dimensions [31] and the participation gestalt framework [21]. For a detailed overview of related work and how this influenced the PJM we refer to its introductory paper [49].

2.3 Grounding and Evaluation

Frameworks and models that describe the use of interactive installations in a public context have the potential to increase our

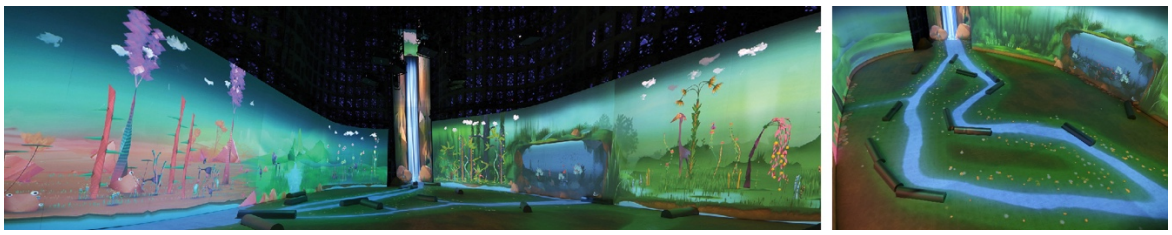


Figure 7: Connected Worlds - Design I/O (Images by Design I/O)

Figure 8: Globe4D

understanding, the development, design and evaluation of such systems. A generic framework should have a broad basis and be developed based on both theory and substantial experience (of experts, through observations etc.). Furthermore, it is essential to evaluate the framework after development in various contexts through different interfaces.

Most related frameworks and models (Appendix A.1) lack substantial grounding, being based on only a single interface in a limited context with few users. Furthermore, few frameworks and models are post-hoc evaluated in a situated context with a substantial population and multiple interfaces. In the study presented in this paper we evaluate the Participant Journey Map in a broader context by applying it to and evaluating it with 6 interactive museum exhibits with various designs in a broader context.

2.4 Participant Journey Map

In the study presented in this paper, we evaluate the Participant Journey Map (PJM) [49]. The PJM is a framework that provides structured insight into the different participation phases and influential factors for interactive play in (semi-) public environments. It was developed based on experiences with previously developed playful interfaces, related research [5, 6, 11, 14, 27, 29, 52, 54, 56, 74, 77] and six expert interviews. It was developed to help understand (and facilitate research into) the working mechanisms and the design of interactive play in a (semi-) public context.

The structure resembles that of customer [30, 35] and experience [30] journey maps, in the sense that it visualizes the process (journey) that a person (potential participant) goes through in order to reach a goal (participating in an interactive augmented play space).

The PJM consists of four layers: two overarching phases, six underlying states, transitions between them and (design) factors that influence these transitions. It visualizes the phases (Onboarding and Participation) that a (potential) participant moves through towards (potential) participation in an interactive play environment. The *Onboarding* phase contains the states *Awareness*, *Interest* and *Intention*. The *Participation* phase contains the states *Exploration*, *Continuation* and *Finishing*.

Figure 9 shows a simplified version of the Participant Journey Map [49]. A full version, including the layer of influential factors can be found in the appendices section at the end of this paper (Appendix A.2) [49]. Table 1 provides an overview of what the various states entail and the behaviour that is associated with each state.

2.5 The PJM Structure in the Context of Related Work

There are several other frameworks in the HCI domain that focus on journey maps and trajectories in relation to interactive systems in public space. In this section we discuss similarities and differences with respect to states and transitions between states.

The Audience Funnel Framework (AFM) [54] is based on experiences with an interactive 'Magical Mirror' installation in a public context. The AFM and PJM have in common that their phases don't necessarily have to be sequential and through each transition from phase to another phase only a percentage of the audience is retained. The authors categorize interaction in attracting, engaging and motivating, resulting in a phased structure (AFM) consisting of: passing by; viewing and reacting; subtle interaction; direct interaction; multiple interactions and follow-up actions. What in the Audience Funnel Framework is regarded as one phase: 'Viewing and Reacting', is in the PJM considered as two separate states: 'Awareness' and 'Interest'. Furthermore, the PJM has an extra 'Intention' phase. This adds detail and allows in observation and analysis of participation patterns for a more distinguished journey and better helps identify potential stagnations in participation flow, as shown by the data in our study.

Jacucci et al. [36] describe a phase of Testing, similar to 'Exploration' in the PJM leading to Play ('Participation' in the PJM). The Audience Funnel Framework [54] and Opinionizer framework [11] both have a 'Subtle Interaction' phase that is not as such present

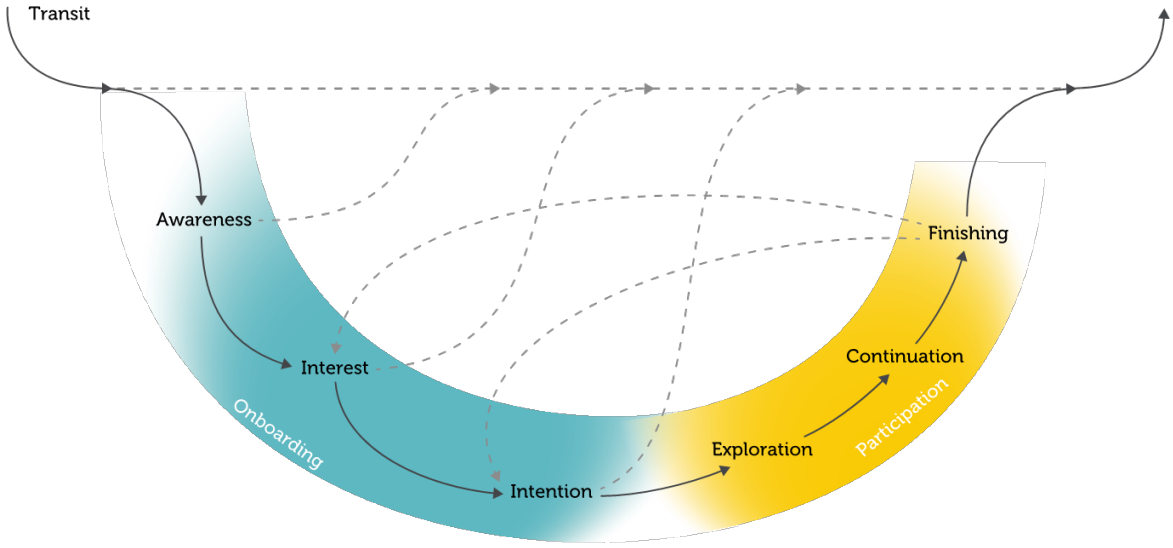


Figure 9: Participant Journey Map (simplified) showing Phases, States, and Transitions

Table 1: Participant Journey Map Phases, States, Descriptions and Behaviour

Phase	State	Description	Behaviour
Onboarding	Awareness	A visitor is aware of the exhibit	A visitor notices the exhibit by sensing (seeing, hearing, feeling, or even smelling) it.
	Interest	A visitor is interested in the exhibit.	A visitor shows interest in the exhibit, by standing still or moving closer and observing the exhibit. There are two modes of interest: Passive interest – merely observing the exhibit; Active interest – reacting to the exhibit by commenting, cheering or providing feedback.
	Intention	A visitor has the intention to interact with the exhibit.	A visitor wants to participate but doesn't (yet). A visitor waits for an opportunity to join or another player to finish their game. A visitor doesn't join (yet) because of a (perceived) lack of space (spatial opportunity) for them to join. A visitor looks for the options available to operate the exhibit but doesn't yet attempt to interact. E.g., a visitor looking for a button to start a game but doesn't try to touch anything yet.
Participation	Exploration	A visitor becomes a participant and starts to interact with the exhibit and explores its controls and content	A visitor attempts to interact with the exhibit, by touching a part of it, or intentionally moving in its vicinity. E.g., a visitor that presses the 'start' button or touches the glass of one of the cases of the 'Music Memory' exhibit. A visitor tries a (few) combinations exploring the interface and its contents.
	Continuation	The participant continues interaction, repeats actions, deeper engagement beyond exploration.	A participant continues using the interface after initial exploration. Several consecutive operations are performed, beyond first exploration.
	Finishing	The participant has the intention to stop participating.	A participant fully explored the exhibit's content. A participant finishes the closed-ended game.

in the PJM. In the PJM behavior associated with this phase is part of 'Exploration'. If the PJM in future research would be used in the context of an interface that allows more subtle interaction, for example when a passerby merely passed by, it would be interesting to evaluate if this is properly facilitated in the PJM or could be improved with an addition based on these frameworks.

The 'Urban HCI Model' [27] is focused on spatial configuration of urban technology interventions. Different types of (engagement) spaces are identified: Display; Interaction; Potential Interaction; Gap; Social Interaction; Comfort; and Activation Spaces. The 'Potential Interaction Space' and 'comfort zones', allow people to comfortably observe, which corresponds to the 'Interest' state of the PJM.

The 'Interactive Public Ambient Displays Framework' [79] supports the transition from implicit to explicit interaction through four interaction phases: Ambient, Implicit, Subtle and Personal interaction. Similar to the PJM and as observed in our study, the 'Interactive Public Ambient Displays Framework' allows moving back and forth between stages. Because this framework focuses on design factors for facilitating interaction there is no mention on how to establish an interest and intention for participating. This is a notable feature of the PJM. Our results show that the onboarding is a key phase leading to participation in interactive play. During the onboarding we observed many factors that disrupted or facilitated participation flow. The supporting design principles in this framework are similar to the layer of influential factors in the PJM. The PJM however also includes contextual factors, that we have found to be also important in facilitation participation flow, which is important as designers and developers should be aware of influential contextual factors even if they don't have direct influence on them.

The 'Stages of Interactive play' [5] consists of an invitation, exploration and immersion stage of play. It starts with a 'not yet noticing the design', in the PJM this is a state of 'Transit'. This is followed by 'noticing the design', which corresponds to 'Awareness' in the PJM and subsequently 'initial action towards the design' that resembles the PJM state of 'Intention'. Furthermore, this model also entails both an 'Exploration' and 'Immersion' phase that resemble the 'Exploration' and 'Continuation' states of the PJM and are observed in our study. This model however doesn't support full non-linearity, merely going back from 'Immersion' to 'Exploration'. It also doesn't mention preliminary exits during the participation journey. Something that does occur in the PJM and was clearly observed on many occasions.

Benford et al. [7, 8] present the concept of trajectories of interaction focusing on spatial and temporal structures, and performance roles. The authors of this work mention visitors 'dipping in and out of the game', an aspect that the PJM supports and was observed in our study. They also mention a need to facilitate spectating, something we find an important aspect for potential users to understand an interface and learn its controls.

De Kort and IJsselsteijn [40] focus on social play experiences. They present, based on a review of related work, how co-players, audience, and their spatial organization shape play and player experience. They mention that 'gaming is often as much about social interaction', something we recognize from our observations. Social behaviour is also identified as a factor facilitating (and sometimes disrupting) transitions in our model. However, the PJM doesn't support this yet and for full understanding of participation journeys it is worth considering creating a 'social, multiuser version' or extension to the PJM for supporting this.

The PJM distinguishes itself from other work by incorporating the full participation journey, including what occurs before the actual interaction (Onboarding), allowing disrupted, partial journeys (through exits at any state), allowing non-linear journeys (by moving back to previously visited states), including a state of finishing and a detailed layer of influential (design) factors.

2.6 Visualizing Customer Journeys

Visualizing interactive trajectories can help designers and other stakeholders better understand the user experience, touch points and make informed (design) decisions.

In our study we visualize participation journeys of interactive playful museum exhibits. Related work into visualizing spatiotemporal data provides inspiration for visualizing the observation data in our study. The PJM [49] provides a visual structure inspired by customer journey maps [35] and can be used as a template to map visitor data. Related techniques for the visualization of spatiotemporal data include Flow diagrams (such as Alluvial diagrams [66]) and Sankey diagrams [32, 86] (such as Minard's Map). Parra et al. [59, 60] visualize flow stages using the structure of a Sankey diagram, clearly illustrating changes throughout a participation journey for three conditions, allowing easy comparison. These provide valuable design resources for visualizing data such as the visualization of amounts in density or volume of graphic elements. Strohmaier et al. [69] visualize visitor flows in a museum exhibit using accumulation of visitor paths and heatmapping to visualize behavioral data, clearly visualizing the number of visitors. Martella et al. visualized observed objects, duration, and sequence [47] by visualizing heat mapped data.

3 METHOD

3.1 In Situ Evaluation

We have selected six interactive playful exhibits to observe, because they facilitate interactive play, have a spatial design, are suitable for different age groups and can be used by several people simultaneously. These exhibits were selected because of their features, variation between them and availability.

Three exhibits (*'Dance Along'*, *'Sperm Race'* and *'Life after Death'*) are part of the permanent exhibition of Naturalis, the National Museum of Natural History in Leiden in the Netherlands, the other three (*'Drum Game'*, *'Music Memory'* and *'Floor Circle'*) are part of a (travelling) exhibit about music at Museon, Museum of Culture and Science in the Hague in the Netherlands. The observations were carried out over five days (without COVID-19-restrictions) between August and November 2021. Appendix A.3 provides an overview of the observed exhibits and notable circumstances per observation day.

3.1.1 Dance Along. The 'Dance Along' exhibit (Figure 10) is located in a separate room within a larger exhibition space (about the role of seduction in nature). Visitors can see the exhibit through the doorways and a window when they pass by. The room has to be

Figure 10: Dance Along exhibit

entered to participate. Within the room there is a bench on the side where onlookers can take a seat. In the room, there is a wall projection with a camera mounted in the center. In the projected game, participants are prompted to copy an animated stick figure making dance moves. These moves are recorded. After a series of moves, the game gives a grid overview of all recorded and presented dance moves in the form of mating dances. It is a closed-ended game and takes approximately 3 minutes to play.

3.1.2 Sperm Race. The *'Sperm Race'* exhibit (Figure 11) is located in a corner of the exhibition space and also part of a larger exhibit on seduction in nature. It is very clearly visible from all sides and nearly

Figure 11: Sperm Race exhibit

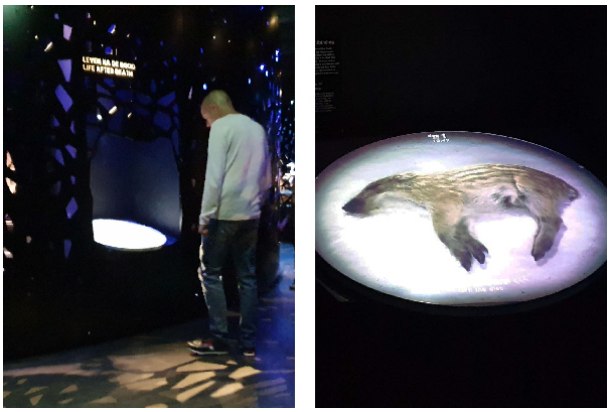


Figure 12: Life after Death Exhibit

impossible to miss when passing by due to its obtrusive location. It is a closed-ended game. Participants sit on a skippy ball (with a cover creating the appearance of a sperm cell). The game is displayed on a screen that is mounted to the wall. It can be played either alone or together in parallel play. To start playing, participants have to first choose a one- or two-player game, by hopping on the arrows, printed on the floor. The participant controls a sperm cell that has to find its way to an egg cell. The sperm cell can be controlled by jumping with the skippy ball on the arrows on the floor. One game takes approximately 3:20 minutes. The participant who gets their sperm cell to the egg cell first wins.

3.1.3 Life After Death. 'Life after Death' (Figure 12) is part of an exhibit on death. It consists of a rotating disk, placed horizontally, extending from the display wall. A video of a decomposing animal is projected from above, on top of the disk. By physically rotating the disk, participants scroll back and forth through the video, exploring the decay process. The setup of this exhibit allows from multiple people to stand in front of the disk together. It is an open-ended playful interface.

3.1.4 Music Memory. 'Music Memory' is a wall exhibit (Figure 13A, Figure 13B), located in a sub room of the larger exhibition space. It consists of a grid of 15 boxes, each with a record or photo, covered with one-way mirror glass, beneath each window there is a metal strip, acting as a button. Underneath all the boxes at approximately 40 cm of the ground, beneath the center of the grid there is an arcade button to start the memory game. Upon starting the game, the interface does not provide feedback. Participants can select items by pressing the metal strip underneath a box, a light will turn on inside, showing the contents of that box. The objective of the game is to match pairs of artists photographs and album covers. 'Music Memory' is a closed-ended game.

3.1.5 Floor Circle. The 'Floor Circle' exhibit (Figure 13A, Figure 13C) consists of a circular floor projection on a slightly raised circular part of the exhibit floor. It is an open-ended playful interface. A participant can interact with the content by stepping onto virtual 'buttons' and browse through musical history, play songs and get information that is then projected onto the floor. The exhibit is part of the same sub-room as 'Music Memory' and can be seen from outside the room though both entryways of the room.

3.1.6 Drum Game. The '*Drum Game*' exhibit (Figure 14) consists of two stations facing each other, each has an electronic drum kit and a screen with a game indicating which drums the participant should hit and when. It is a competitive 1 vs. 1 player game. Although the game could technically allow a single participant to play, it is set up as a competitive two-player exhibit requiring a game to be started at both stations in order to play. The game can either be played as a single set or series of consecutive sets.

3.2 Observation method

The naturalistic behaviour of 687 visitors have been observed who self-selected to approach the (observed) exhibit area. The observations were carried out with the explicit permission of the museum and science center.

In accordance with the ethics checklist of the ethics committee of the Science Faculty of Leiden University, no further ethics approval was required because no personal data is being collected and the research that is being conducted cannot (potentially) cause harm or lead to misuse.

A covert observation technique has been used to avoid disrupting the visitor's natural behaviour. Because of availability, one observer (first author of this paper) conducted the observations. They sat or stood at a distance of approximately 5-8 meters, having a clear overview of the exhibits and its surroundings. Their presence had no impact on visitor behaviour (most visitors did not notice the observer). No museum employees were constantly present at the locations of the observed exhibits. Thus, there was no instruction or supervision of its use.

The observer used a paper template with the 6 states of the PJM and space for metadata and notes. For each (potential) play session, the following metadata was noted for each visitor: exhibit, social group the user was part of (polyad) and estimated age group (child, adult). The social group was estimated based on observed mutual visitor interaction and behavior (walking together, talking to each other etc.). During the observation, it was noted which

Figure 13: (a) Music Memory and Floor Circle exhibits. (b) Music Memory exhibit. (c) Floor Circle exhibit

Figure 14: Drum Game exhibit

phases each participant went through, using the PJM as a template. Table 1 provides an overview of what each state entails and the behaviour that was associated with it that was used for deciding how to categorize visitor behavior. Additional notes were made that related to the behaviour of the visitor(s), the context and any additional noteworthy details. For each observation day, general information was recorded (date, day, museum, contextual details for that day (Appendix A.3)). During the observation days, there were no COVID-19 restrictions for museum visitors.

3.3 Data Analysis

All collected data was gathered and the occurrences of each state for each exhibit for each visitor and per estimated age group were counted. The conditional probability that a visitor would enter a certain state, given they were in the previous state was calculated for the total population, for all children and for all adults, per exhibit, *P(State|Previous State)* by taking the sum of people in a state and dividing that by sum of people in the previous state. Full quantitative results are included in Appendix A.4.

3.4 Participant Journey Visualizations

The aggregated data was visualized, using the PJM as a structure to visualize the states and transitions. This enabled us to generate visualizations of observation data per museum, per exhibit (Section 4.1), and per day (Figure 21, Figure 22, Figure 23). Adults are indicated with red lines, children with blue lines. Each line in the visualization represents one participant journey and is half transparent, allowing overlapping colors to create red-purple-blue hues. Concentration of colors indicates presence of user groups in the observations for those states and transitions in the PJM. This resembles the information visualization design of heat maps [69]. For example, predominantly red means there are more adults observed for that transition, purple indicates that both groups are observed more or less equally, reddish purple indicates that both user groups were observed but that adults predominate. Density indicates the number of observations for that transition.

4 RESULTS

We collected and visualized observational data to assess whether the PJM states and transitions occur in a situated context and whether the PJM can be used to analyze and assess participation patterns of PI exhibits.

In this section we present the results of our observations, following the structure below:

- Section 4.1: Visualizations of quantitative aggregated observation data, per exhibit. Indicating participation patterns in observation data.
- Section 4.2: Observed cases illustrating archetypical participant journeys.

In section 5.1 we discuss context for progressions and stagnations in participation flow, structured following the PJM states.

In total, 687 individuals were observed. 15 observations were excluded because their data was incomplete. This resulted in 672 observations that were analyzed and visualized. The conditional probabilities for Awareness were not included because not all visitors in the transit state were observed and including them in analysis would lead to an unreliable probability of entering awareness.

4.1 Participation Patterns per Exhibit

In this section we present the visualizations of aggregated observation data (Appendix A.4) for each exhibit (Figure 15, Figure 16, Figure 17, Figure 18, Figure 19, Figure 20). Each visualization is accompanied by a brief explanation of notable insights/patterns and reference to the quantitative data (children (c): blue lines; adults (a): red lines).

These results help us assess whether the PJM states and transitions occur in a situated context. And furthermore, give insight in to whether the PJM can be used to analyze and assess participation patterns of exhibits.

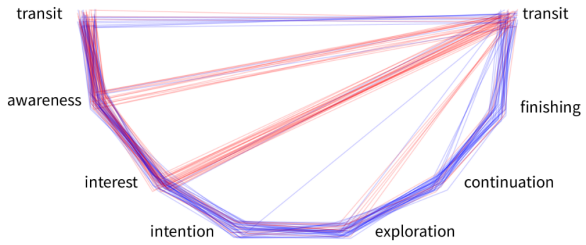


Figure 15: Dance Along Exhibit(children (c): blue lines; a dults (a): red lines)

4.1.1 Dance Along. We observed 99 (c: 49; a: 50) 'Dance Along' visitors (Figure 15). Many adults (27.7%, 13/47) and only a few children (5%, 2/40) left after the state 'awareness'. Even more adults (70.6%, 24/34) left after the state 'interest', and again only a few children (5.3%, 2/38). Adults leaving after awareness and interest

states can be seen in the visualization by the thick concentration of red lines leaving from 'awareness' and 'interest'. We observed only 5 adults without children showing interest in this exhibit of which only two started exploring and then left. All (10) adults that showed intention to participate continued to the state 'exploration'. Only half of them (5) continued and finished playing. Out of the children that showed intention (36), nearly all explored (35), continued (34) and finished playing (30). This continuation can be seen in the visualization by the thick concentration of blue lines that continue till the end of the PJM.

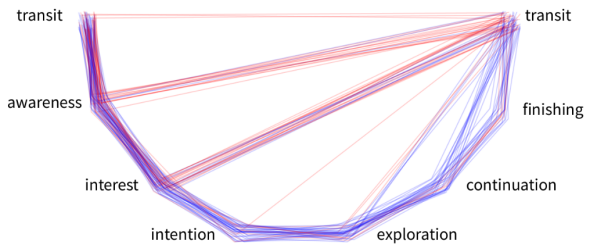


Figure 16: Sperm Race Exhibit (children (c): blue lines; adults (a): red lines)

4.1.2 Sperm Race. The observations (n=89; c: 45; a: 44) for the 'Sperm Race' exhibit (Figure 16) show that many adults (36.6%, 15/41) left after the state of awareness compared to only a few children (6.7%, 3/45). Very few (34.6%, 9/26) of the interested adults showed an intention to participate. Only 8 adults started exploration, of which 5 finished playing. Many children (80.9%, 34/42) had the intention to participate after the state of interest, all (34) started exploration, and many (88.2%, 30/34) continued, but only half of them (17) finished.

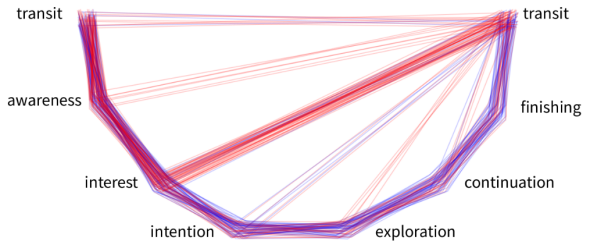


Figure 17: Life after Death Exhibit (children (c): blue lines; adults (a): red lines)

4.1.3 Life after Death. The visualization of the observations (n=155; c: 97, a: 58) of the 'Life after Death' exhibit (Figure 17) shows a different pattern than the two previous exhibits. All children (55) and many (92.1%, 82/89) adults who noticed the exhibit were interested. Only less than half of the adults (41.5%, 34/82) continued to intention. Of the remaining interested adults, most (88.2%, 30/34) started exploring, continued (83.3%, 25/30) and finished (84%, 21/25). Children show a different pattern, most (87.3%, 48/55) showed intention after interest, started exploring (91.7%, 44/48) and finished (95.5%, 42/44).

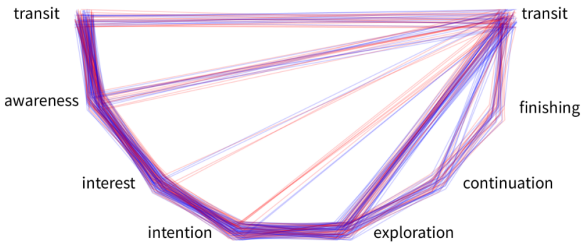


Figure 18: Music Memory Exhibit (children (c): blue lines; adults (a): red lines)

4.1.4 Music Memory. We observed 156 'Music Memory' visitors (Figure 18) (c: 82; a: 74). Of those who showed interest after awareness (c: 74.3%, 61/82; a: 64.7%, 48/74) most entered the state of intention (a: 93.8%, 45/48; c: 96.7%, 59/61). Many of the adults (86.7%, 39 out of 45) and most children (96,6%, 57/59) started exploration after intention. But more than half (a: 48.7%, 19/39; c: 45.6%, 26/57) stopped after exploration.

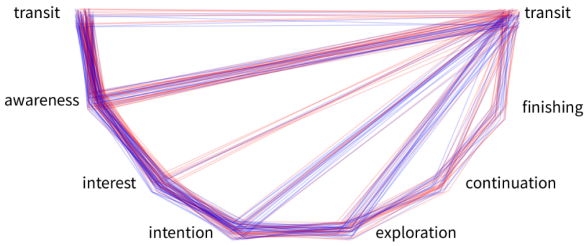


Figure 19: Floor Circle Exhibit (children (c): blue lines; adults (a): red lines)

4.1.5 Floor Circle. We observed 140 (c: 68, a: 72) visitors (Figure 19) who encountered the 'Floor Circle' exhibit. Only about two third of the visitors that noticed the exhibit showed interest (all: 66.4 %, 85/128; c: 71.4 %, 45/63; a: 61.5%, 40/65) after awareness. This is considerably less than for the other exhibits. Less adults (82.5%, 33/40) than children (95.6%, 43/45) continued to intention after interest. But after that less children (69.6%, 30/40) than adults (81.8%, 27/30) continued to exploration. Even less children continued into participation (46.7%, 14/30), compared to adults (74.1%, 14/20).

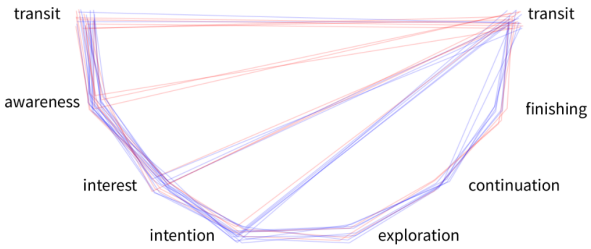
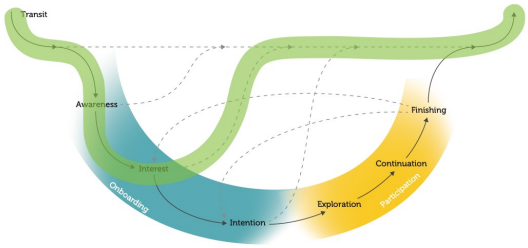


Figure 20: Drum Game Exhibit (children (c): blue lines; adults (a): red lines)

Table 2: Participation Journey illustration and case description for Exiting after Interest

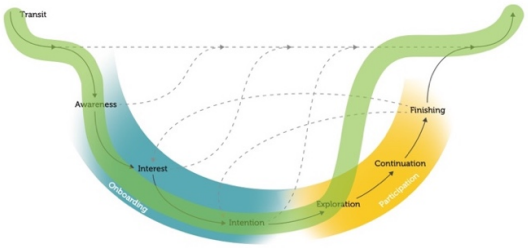
Exit after Interest



Transit	Mother and two daughters walk by.
Awareness	They notice the 'Floor Circle' exhibit.
Interest	The daughter watches the exhibit for a moment. (Mother quickly walks by (clearly is on her way to something else) and calls daughter.) Daughter follows mother.

Table 3: Participation Journey illustration and case description for Exiting after Exploration

Exit after Exploration



Transit	Young man and woman enter the 'Music Memory' exhibition space.
Awareness	They see the exhibit.
Interest	They look for a while.
Exploration	Then press one of the squares. Nothing happens. They walk on.

4.1.6 Drum Game. The 'Drum Game' exhibit (Figure 20) was least observed (n=33, c: 18; c: 15), because not much variation was seen between visitors during the first observation day. Much of the time there was a queue to participate. Some visitors left after interest (c: 18.7%, 3/16; a: 42.9%, 3/7), others after intention (c: 38.5%, 5/13; a: 25%, 1/4). Of the visitors who started participation (c: 8, a: 3) all continued playing. Some children dropped out before finishing (25%, 2/8).

4.2 Observed Cases illustrating Participant Journeys

One of the objectives of our study is to determine if the paths proposed in the PJM correspond with participant journeys in a situated context. In Appendix A.5, we present observed play sessions that illustrate the different participant paths of the PJM. The graphical representations of participation paths are visualized in green as a layer on top of the PJM, accompanied by the description of an illustrative case from our observations. An example of an observed participant journey that was suggested in the PJM is 'Exit after Interest' (Table 2). There were also journeys observed that were not yet included in the PJM, but clearly should have been. An example is 'Exit after Exploration' (Table 3).

5 DISCUSSION

The aim of this study was to evaluate the Participant Journey Map through situated observations of interactive playful museum exhibits. The study focuses on two research questions:

- Does the PJM provide a realistic representation of PI participation journeys that occur in a situated context?
- How does the PJM support evaluation of PI participation journeys in a situated context?

The observation data, visualizations (section 4.1), illustrative observed cases (section 4.2) and context (section 5.2) show that the PJM is a valid abstraction of participant journeys in a situated context.

In section 4.1, we present observation data and visualizations of participation patterns for six different interactive playful museum exhibits. By using the PJM for our observations, visualizations, and analysis, we were able to easily identify changes in flow (density) throughout the PJM trajectories for different exhibits, user groups, and circumstances. The results show similar patterns for exhibits with similar characteristics (e.g., *Dance Along* and *Sperm Race*). While exhibits with different characteristics (e.g., *Life after Death* and *Music Memory*) or under different conditions (e.g., *Music Memory* - observation days) show different patterns. This suggests that the PJM is effective in indicating differences and similarities and can be used for comparison of exhibits and exhibit conditions. The visualizations (section 4.1) facilitate the identification of stagnations and progressions in participation flow. This helps to understand when participation problems occur. This information can be used to identify areas for improvement and hereby support exhibit design and evaluation.

Section 5.1 presents context for the stagnations and progressions in participation flow. This results in (design) factors that provide plausible causes for the flows we observed. These factors correspond with the factors in the original PJM, supporting the validity of the PJM as a method for structuring the visitor's journey.

Through the visualizations and observations, it becomes obvious how the observed exhibits can be improved. We think that the PJM proves itself to be a valuable tool for quantifying participation patterns of Interactive Playful museum exhibits. Further research is needed to elaborate on this and to develop the PJM as a design and evaluation tool for interactive play in (semi-)public environments.

5.1 Influential Design and Contextual Factors

In this section we discuss contextual and design factors for the progressions and stagnations in participation flows presented in

Table 4: Overview of influential (design) factors providing context for transitions

	Onboarding			*Participation*		
	Awareness	*Interest*	*Intention*	*Exploration*	*Continuation*	*Finishing*
Music Memory	- Seeing others play - Indication of interactivity	- Purpose of presence		- Affordance - Seeing others play - Opportunity	- System feedback - Difficulty - Time-out - Competition	- Difficulty
Floor Circle		- Content - Indication of interactivity - Purpose of presence	- Content	- Seeing others play - Opportunity		
Drum Game	- Visibility, Spatial design			- Play design - Opportunity		
Dance Along	- Visibility	- Perceived target group	- Social dynamics - Perceived target group	- Play design	- Self-consciousness	- Social dynamics - Play design
Sperm Race	- Visibility, Spatial design		- Perceived target group - Content - Spatial Design	- Play design	- Feedback of controllers	- Play design - Social dynamics - External reasons
Life after Death	- Visibility	- Indication of interactivity	- Social Dynamics - Spatial design	- Display form - Opportunity	- Perceived target group - Security - Social Dynamics	- Social dynamics

the previous section. This section is structured following the PJM states. We categorized the insights and Table 4 gives an overview of notable influential (design) factors that we learned from our observations. The factors are classified according to PJM-state.

5.1.1 Awareness. A public display needs to grab the attention of passersby [56]. We observed that many visitors did not notice the 'Life after Death' exhibit (Figure 17). when it was poorly visible due to many people using or watching it, blocking their view. Not all visitors passing by the 'Dance Along' (Figure 15) exhibit, noticed it because it was located in a separate, less visible space. This explains the cluster of lines continuing transit (not going to awareness).

Spatial distribution [15] and configuration [27] are important for visibility and noticeability. The 'Sperm Race' exhibit (Figure 16) was very noticeable because of its location (central as part of a larger exhibit) and spatial setting (no objects or architectural elements that blocked the view). The Drum Game exhibit was also placed centrally and easily noticed by passersby. This is indicated by only a low-density cluster continuing transit (not transitioning to awareness) for these exhibits.

For the Music Memory exhibit, we noticed that on a very quiet day in the museum (Figure 22) most people did not notice the exhibit. On this day visitors had little opportunity to see others play and the system itself showed no sign of being (inter)active. In the visualization for this day this is illustrated by only a few lines continuing towards Awareness.

5.1.2 Interest. We observed only 5 adults without children showing interest in the 'Dance Along' exhibit (Figure 15). A speculative reason for this could be that adults consider the exhibit targeted towards children and not for them. This is a factor present in the original PJM, but we did not find mention of perceived target group as a factor in related work.

The subtle animation that auto-played in the 'Life after Death' during an idle state seemed successful in triggering interest of passers-by. This can be seen by the dense cluster leading to Interest in Figure 17. This resonates with the phase of 'subtle interaction' mentioned in the Audience Funnel Framework [54].

The 'Floor Circle' exhibit (Figure 19) aroused much less interest from visitors compared to other exhibits. A reason for this is could be that the content triggered little curiosity and did not give the impression of interactivity.

The 'Music Memory' (Figure 18) and 'Floor Circle' (Figure 19) exhibits are located adjacent to the exit to the gift shop. Many visitors who passed the exhibits at the end of the day seemed to have already planned to leave and came across the exhibits on their way to the exit, only fleetingly paying attention to it, then continuing towards the exit. In the visualizations this can be seen by the dense clusters leaving from awareness, illustrating purpose of presence as a factor facilitating interest.

5.1.3 Intention. When families visit the 'Dance Along' exhibit (Figure 15), parents are interested but children are given priority by their parents to operate the interface. Parents often stood back and were active bystanders but did not participate themselves. Reasons

could be that they believe it to be more of a kid's game or a lack of space - there are visual markers on the floor (footsteps) indicating space for only two participants.

For the 'Sperm Race' exhibit (Figure 16) we also suspect that many adults do not show the intention to participate because they possibly perceive this exhibit as a game for children and not for them. Also, the subject and spatial design (people playing are very visible) of this exhibit could make adults feel more self-conscious.

For the 'Life after Death' exhibit (Figure 17), the data shows a high 'dropout' of adults after interest (a dense red cluster leaving from Interest). We noticed that many parents who visited with their children showed interest, then let their children control the exhibit. In our data (visualization) it seems that they stopped participating, while they actually took on the role of active bystander and actively giving directions but not directly interacting with the exhibit themselves. Further research into the role of an active bystander would be interesting.

5.1.4 Exploration. The spatial design of the 'Life after Death' exhibit (Figure 17) does not allow everyone to stand around it. At times this seemed to cause children leaving because they could not reach the exhibit. The visualization shows this by a group of blue lines leaving from intention. This illustrates display form[10] and opportunity as influential factors.

For the 'Drum Game' (Figure 20) we noticed opportunity as an influencing factor when people who had the intention to participate, waited for their turn and then left because they either had to leave or thought the wait was too long. This can be seen as a cluster of lines leaving from intention.

The data visualization of the 'Floor Circle' exhibit (Figure 19) shows that it appealed to and activated adults more than children. We suspect that the reason for this to be its content., that was targeted towards adults and consisted of textual information together with music clips from previous decades.

For the 'Music Memory' exhibit there are interesting differences between different observation day circumstances (Figure 21, Figure 22, Figure 23). On the second observation day (Day 2 – Figure 22) it was very quiet in the museum. Not a single successful session with the 'Music Memory' exhibit was observed. Many visitors did not even notice the exhibit. On the final observation day (Day 3 – Figure 23) it was fairly busy, and the walking and throughput speed was low. Visitors had to wait for each other and could not quickly continue to the next exhibit. We noticed that people attempted to interact with the 'Music Memory' and 'Floor Circle' exhibits more. This was one of the first occasions that we noticed the 'Floor Circle' was being used properly and for a longer period of time. On a busy day, a relatively inconspicuous exhibit is more easily noticed because visitors have more time to look at it and are more likely to try while waiting. Because of the higher use, it was easier for others to observe how to play. At the end of that day, when it was quieter on the exhibition floor, the attention and interactions of visitors seemed to become more fleeting again.

5.1.5 Continuation. For the 'Sperm Race' exhibit (Figure 16) a cluster of lines leaving after Exploration can be seen in the visualization. On multiple occasions, a single player game was mistakenly selected at the start without participants realizing this. Both participants then started playing and did not realize at all, or only very

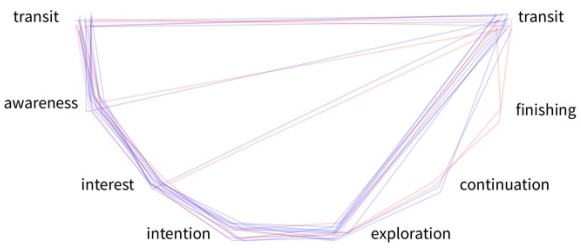


Figure 21: Music Memory observation day 1 (n=24)

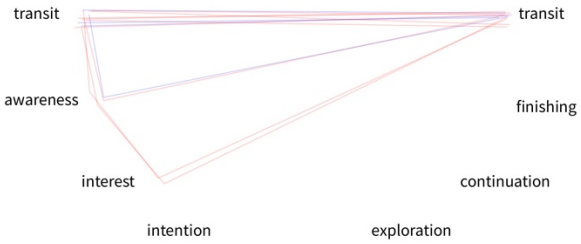


Figure 22: Music Memory observation day 2 (n=13)

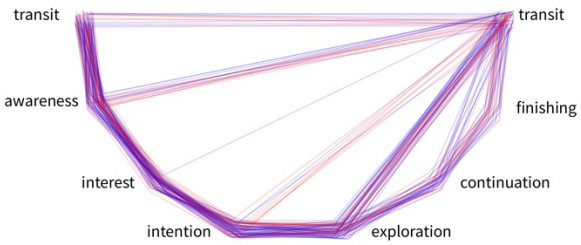


Figure 23: Music Memory observation day 3 (n=119)

far into the game, that only one of them was actually operating the interface. This indicates a problem with the controls and feedback of the game.

The 'Music Memory' exhibit (Figure 18) had a high barrier to start exploring because visitors could not find the start button. Those who did find the start button (at knee level), became confused after pressing it because the system did not provide feedback, appearing inactive. Many visitors then gave up and left. Some tried to touch the mirror glass, others discovered by chance that the metal strips underneath were buttons. This clearly indicates many affordance issues with this exhibit. Furthermore, frequently participants waited too long to continue after a successful action, causing the game to stop, disrupting game play. Once participants have made a few combinations and understand the objective, it becomes an engaging challenge to continue to try to finish the game. Nonetheless, many participants generally stopped after exploring. We noticed that the game is fairly difficult and, in particular, for children (who lack

essential knowledge) is sometimes too difficult to finish. This can be seen in the data by many visitors leaving after Exploration.

For the 'Dance Along' exhibit (Figure 15) we saw that half of the adults who started paying stopped after exploration. We noticed that parents who started playing together with their kids, often stopped once their kids were engaged.

In the 'Life after Death' exhibit (Figure 17), we saw a lot of joint interaction between family members once they started participating. This interface probably gave adults less of a feeling that it was too playful or childish for them and also the feeling of vulnerability in this interface was lower than with the 'Dance Along' and 'Sperm Race' exhibits. It also spatially allows multiple people to use it simultaneously, indicating the importance of display form [10].

5.1.6 Finishing. In the 'Sperm Race' (Figure16), we noticed that the losing participant often left before the end of their game. This occurred because when the winner has reached the sperm cell, the loser still confusingly has to finish the game to properly end the game (instead of being 'game over'). This creates a confusing situation for the next participant(s), since they must first complete the game of their losing predecessor to start a new game. In the visualization this shows by the cluster of blue lines leaving from continuation. Other reasons for leaving before finishing the game were others in their social group who wanted to continue or participants who had to go somewhere else.

We observed confusion about the objective in Dance Along (Figure 15) when participants started playing halfway through. This caused people to leave early. This shows in the visualization as a small cluster of lines leaving after continuation.

5.2 Refinement and Improvements of the PJM

5.2.1 Extra Paths. The observation data shows that many visitors leave after exploration or continuation (section 4.2). The PJM however does not yet have paths from exploration and continuation to transit. In order for the PJM to realistically reflect visitor behaviour, we suggest adding two extra paths to the PJM: Exploration > Transit, and Continuation > Transit (Figure 24).

Several situations were observed where participants temporarily moved back into a previous state. The PJM has multiple paths that allow loops back. It however does not yet have paths from exploration back to interest and back to intention. We suggest adding these paths to the PJM to fully support all possible user journeys (Figure 24).

5.2.2 Passive vs. Active Interest. Visitors in a state of interest can be categorized into two types: Passive or Active. A passive interested visitor can just watch silently and not affect current play. An active interested visitor might engage more by cheering or commenting, reacting to current play. It can be argued that a visitor, when engaged in exploring the exhibit content by having a conversation about it, is in a sense also participating in the experience. Although the PJM was not developed to indicate other types of engagement and primarily focuses on the actual interaction, it could provide interesting insights to be able to include these roles in observations. This could be done by distinguishing these roles in the observation form and the journey map visualization for the state of Interest.

5.3 Reflection on the Research Approach

Evaluation revealed advantages and limitations of our approach in situ. Based on this, we make recommendations for future research.

5.3.1 Covert Observation. The covert, non-participant observation worked well in this study. The observer was hardly noticed by visitors and their presence did not seem to have had any effect on visitor behaviour. We did not influence the visitors to act in any other way than they would normally behave during their museum visit. This was a successful approach in avoiding the Hawthorne effect [42] and with consent of the museum. However, we should mention that in similar cases it should always be critically considered whether this risk of influencing participants is sufficiently important to outweigh the participants' right to freely giving informed consent.

Having one observer was sufficient for our research since the main objective of our study was to evaluate a framework for analyzing visitor behavior, rather than to provide an in-depth analysis of the exhibits themselves. For further observations we would recommend having multiple (trained) observers instead of one. This can increase the reliability and validity of the data collected and help to minimize the impact of individual biases and errors, as well as increase the accuracy of observations through triangulation.

Reliably observing the phase of 'viewing or reacting' is previously mentioned at potentially difficult because of the observers location and because 'almost all passers-by obviously looked at the displays anyway' [54]. During our observations we did not have similar experiences. The behavior that in the PJM is associated with Awareness and especially Interest was clear and did not provide problems during observation.

5.3.2 PJM as a template. Our experiences with using the PJM as a template for observations and visualizing data is positive. We experienced the states of the PJM to be convenient for categorizing behaviour and allocating observed behaviour into states during observation. However, it should be noted that using a structured observation method can create some distortion in reporting of visitor actions. This is because there can always actions that don't fit with the model perfectly. We attempted to resolve this by allowing extra notes during observation. We however did not end up needing these notes for processing our data. We did use our notes for information about the influential factors.

Our visualization proved to be insightful and valuable in evaluating participation patterns and effective in indicating stagnations and progressions in participation flow. The density was a good indicator for numbers of visitors transitioning from state to state. However, for future work, using the PJM as a template we think it is also worth exploring additional or alternative data visualization methods (in combination with the PJM structure) such as Sankey diagrams [32].

5.3.3 Group behaviour. Tracking the behaviour of just one visitor, without including their entire social group, is not desirable because members of a group have a lot of mutual interaction and influence on each other and this would lead to information loss. We decided to track the behaviour of multiple visitors at the same time when possible. As the PJM is a model representing individual participant journeys, the influence that visitors have on each other is currently

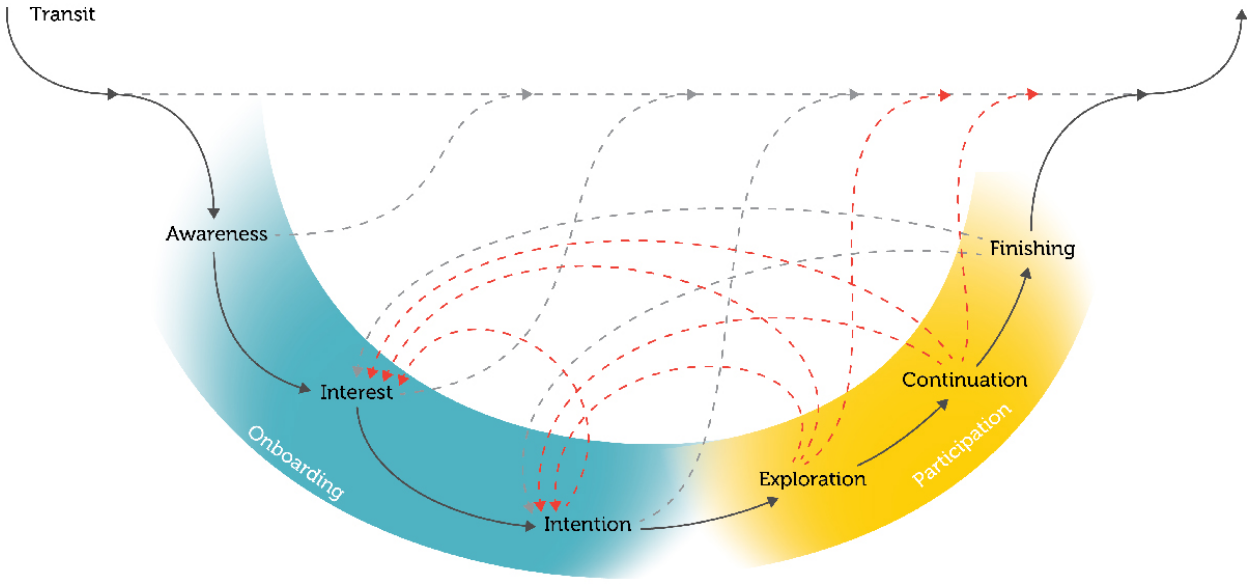


Figure 24: Improved PJM with extra paths (orange)

difficult to visualize with the PJM as a foundation. More detailed annotation of user groups would be beneficial to understand social dynamics within user groups and the influence of social factors on user behaviour.

Based on our observations we recognize the need for facilitating 'seeing others play' and allowing potential participants to observe and assess how the installation works and whether or not they want to interact with. In the Urban HCI Model [27] this corresponds with a need for 'good visibility of the interaction', an aspect that also clearly occurred in our analysis and in previous work on the PJM.

5.3.4 Duration. Further, the PJM in its current form does not take into account the duration of the interactive play. In one of the observed playing situations with the 'Floor Circle' exhibit, a visitor played for a remarkably long time and was completely absorbed in all its possibilities. In other situations, participants explored exhibits over very different time spans. Some visitors only performed a single action, others tried to explore multiple actions within the interface. There was no possibility to indicate these variations in exploration depth during observation. An ordinal "weight" value for a visitor in a phase would be an addition to the framework that could cover such differences and is easy to use compared to keeping track of time per visit during a live observation and per state, which is often impractical. We suggest arranging video observation when this is desirable.

5.3.5 Observing Replay & non-Linearity. Although twenty-one cases of replay or non-linear journeys were observed, it was complicated to indicate this clearly in the data visualization. When processing the observation data, the question arose whether replay should be scored extra, as a new journey or as a double count of the presence in a specific state. In the observations it was merely noted if replay occurred with a note from which phase it happens, lacking full details about the exact replay journey. We did note the exact first run but could not record in detail what happened if someone decided to replay. More detailed notation in case of replay would be useful to gain insight into replay behaviour, its occurrence and context. This is however a limitation of our approach, not of the PJM (that can facilitate non-linearity as described in the illustrative case for Replay in Appendix A.5).

5.3.6 Awareness. We were not able to calculate conditional probability of awareness given people are visiting. This is because we did not observe all visitors in our approach, which means that we were not able to determine which part of the visitors noticed the exhibit. It would be interesting to observe all visitors in an exhibit area. This provides practical challenges when there are many visitors and few observers. This could be solved by video observations and post hoc assessment of the video data.

5.3.7 Open-endedness. In the cases of open-ended play, it sometimes proved difficult during observation to determine whether someone leaves in a state of continuation or finishing. For example, in the 'Life after Death' exhibit it was difficult to tell the difference between a state of continuation or finishing and if someone left because of some reason during exploration or continuation or truly felt fulfilled. This is because there are few easily observable behavioral characteristics that indicate a phase in which the game is ending. It is difficult for an observer to determine a participant's motives for stopping based on observation alone. Interviewing a participant afterwards could provide more insight into this. For now, we have handled this by categorizing the behavior as finished when a visitor seems satisfied and done participating when they leave. Unless there is a clearly identifiable factor that resulted in

the decision to stop or if participants gave the impression that they were unsatisfied with having to end the interaction. (For example, when someone is aware of other visitors waiting for the exhibit to be available and this motivates their decision to quit).

5.4 Further Work

We believe that the PJM is useful for both evaluating existing interfaces but also for developing and communicating about interactive play in public context that is yet to be developed. Thus, facilitating conversations between developers, designer and stakeholders, and hereby facilitating the design process.

This study provides inspiration and ideas for further research. Many influencing factors have emerged that are interesting for studying in more depth. We suggest multivariate prototype testing, in order to gain insight into the working mechanisms behind influential design factors. Topics that we consider worthwhile to explore are: the role of ending on experience, designing for idle exhibits (specifically indicating interactivity for passersby); spatial facilitation of visibility; visibility of play as a facilitator and disruptor; facilitating simultaneous interaction of multiple users with an interface, how to persuade adults in exhibits that they believe to be too childish; the role of active and passive bystanders and the reasons why participants stop participating and how to avoid these disruptions.

The study presented in this paper illustrates the importance of observing user behaviour in situ. To enable the development of useful frameworks for understanding and developing interfaces it is important to have good insight into actual user behaviour 'in the wild'. While many HCI frameworks and models have some grounding in actual user behaviour (being based on related or previous research, lab and/or situated studies), few are post-hoc validated in a situated context with many users.

The PJM was developed for the context of playful interaction in (semi-) public environments. It however has potential be adapted to a broader a range of settings, types of technology, environments, experiences and interfaces. It can be valuable for evaluating, understanding and improving user experiences for diverse contexts and applications, potentially even offering a standardized approach.

6 CONCLUSION

We evaluated the Participant Journey Map (PJM) by analyzing situated observation data of 672 play sessions with six interactive playful museum exhibits. Participant journey patterns of adults and children for all exhibits were visualized and analyzed using the PJM. The results show that the PJM provides a realistic representation of situated visitor behaviour.

The PJM can be used to visualize participation patterns for different exhibits, indicating variations for user groups and circumstances. It can be used to recognize stagnations and progressions in participation flow and provide support for the identification of factors influencing that flow. This shows that the PJM is useful for the critical assessment of interactive installations.

This research contributes to a better understanding of the design and implementation of interactive play in (semi-) public spaces. For future research we suggest (multivariate) prototype testing of playful interfaces to identify and better understand the working mechanisms behind the design factors that influence participation in interactive play.

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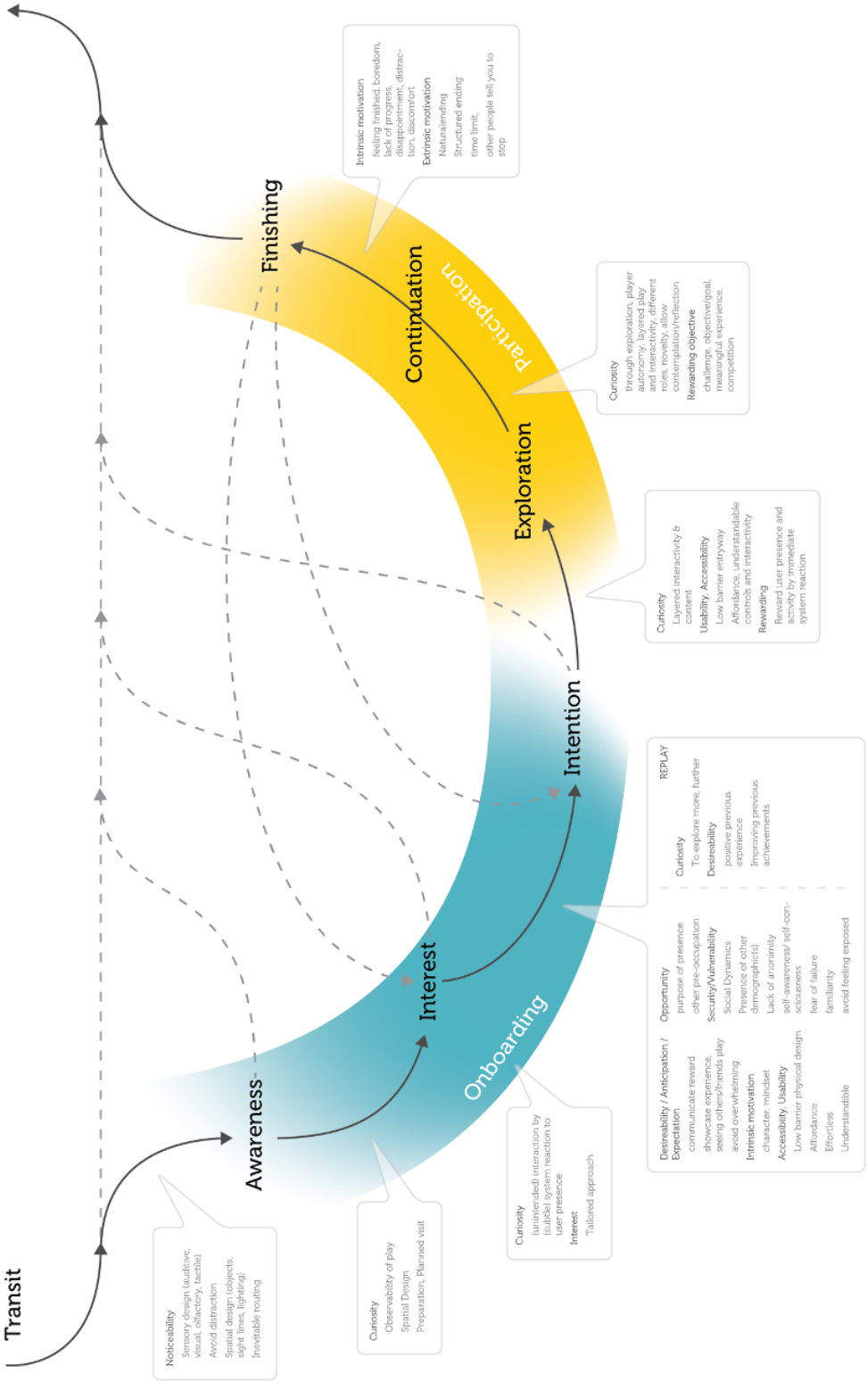
A APPENDICES

A.1 Overview of practical grounding and post-hoc evaluation of related work

Model/Framework	Interface	Practical Grounding	Post-hoc Evaluation
The user interaction framework [26]	Polar Defence, an interactive game for a large public display.	Four-day user study of this system in a public space	
Honeypot model [82]	Encounters, a public, interactive installation that encouraged people to playfully explore a variety of dynamic visuals and sound scapes.	Installed in a public courtyard during a summer festival in Melbourne, Australia, which ran over four evenings.	
Audience Funnel Framework [54, 56]	Magical Mirrors, a set of four large public displays with gesture-based interaction installed in downtown Berlin, Germany.	Observations of 660 passers-by on 2 weekend evenings.	See Proxemic Peddler [81]
The peddler framework [81]	Proxemic Peddler	(Extends the Audience Funnel Framework) No documentation of method.	
Participant behavior coding [29]	Situated kiosk with a simple interface to touch (click) showing various screen conditions	Field study (n = 32) implementing both implicit and explicit screen-based prompts.	
Flow stages model [59,60]	An interactive public display for a real-life campaign that aims to increase awareness on cardiac arrests and Cardio-Pulmonary Resuscitation (CPR)	Two public displays with interactive prototypes in the biggest railway station of Brussels (Belgium), 10,000+ passers-by and more than 1,000 reactions	Three different locations (train station, hospital, and university restaurant)
PACD model [53]	FunSquare is a public display application that creates self-generative content.	18+ hours of observations, roughly 130 people	
ELSI model [52]		(Based on other frameworks)	
Opinionizer [11]	A shared display that people could add their views and opinions to, which they and others could observe and then add further comments to if they felt inclined.	Two authentic social gatherings	
Urban HCI model [27]	A media facade installation called SMSlingshot that allowed users to shoot virtual paint balls and "paint" the media facade using a slingshot-like device.	Spread.gun and the SMSlingshot, exhibited at several venues over three years, each constituting a different architectural setting and context.	
Interactive Public Ambient Displays Framework [79]	Ambient display consists of a series of visual elements representing four information sources. As a user enters the tracking volume surrounding the display, their body location and orientation are translated into an abstract representation of that user and their associated information displayed in the form of a vertical bar.		Used as design guidelines for system design
Stages of Play Model [75, 77]	FlowSteps and Wobble	Flowsteps - Twenty children (ten pairs) aged 7-8 years old interacted with the design during a free play session.	Flowsteps - 36 children during a two-day explorative user study at a primary school Wobble - eighteen children, eight girls and ten boys aged 4-6 years old

Evaluation Framework for Public Interactive Installations [39]		(Small scope literature review)	
M-dimensions [31]		(Based on current usability evaluation methods and principles as well as museology literature.)	Iteratively refined, finally validated with and a long-term study about interactivity in all the interactive museums of a specific geographic region.
Participation Gestalt Framework [21]	15 digital public installations from own design portfolio (8 outdoors, 7 semi-public)	First round - 18 qualities selected, refined to 5 qualities Second round - 5 qualities evaluated with same installations	Application of the gestalt framework onto four installations.
Interactional trajectories conceptual framework [7, 8]	Desert Rain Uncle Roy All Around You Fairground: Thrill Laboratory Day of the Figurines	Key user experiences learned from previous studies: *Desert Rain* toured to more than ten cities worldwide between 1999 and 2006 *Uncle Roy All Around You* – (not mentioned in paper) *Fairground: Thrill Laboratory* - Initially deployed on three hired rides as part of a public performance event at a major science center. A second version of the technology was subsequently deployed on a vertical drop rollercoaster' at a major amusement park. *Day of the Figurines* - Touring performance, running twenty-four days, active ten hours a day. Over 750 players on tour to Berlin, Singapore and the UK.	Translations of the trajectories conceptual framework for and with UX practitioners through 4 interventions [78]
Participant Journey Map [49]	Various previous PI research and design projects (Harmonoise, Globe4D, Cooperative Tetris)	Review of experiences with previous projects (e.g., Globe4D had been exhibited both temporarily and permanent for 12+ years, worldwide), interviews with expert developers (with years of experience exhibiting PI in situated contexts)	Observations of 672 players with six interactive playful museum exhibits [this paper]

A.2 Original Participant Journey Map



A.3 Overview of observation days, circumstances, museums and exhibits

Overview of observation days, circumstances, museums and exhibits

Observation Day	Circumstances	Museum	Exhibits
Day 1	Thursday Summer Holiday Busy	National Museum of Natural History	Sperm Race Dance Along Life after Death
Day 2	Friday Summer holiday Normal crowd	Museum of Culture and Science	Music Memory Floor Circle Drum Game
Day 3	Regular Friday Normal crowd	National Museum of Natural History	Sperm Race Dance Along Life after Death
Day 4	Regular Friday Very quiet day	Museum of Culture and Science	Music Memory Floor Circle Drum Game
Day 5	Tuesday Autumn Holiday Very busy day	Museum of Culture and Science	Music Memory Floor Circle

A.4 Quantitative Observation Data

The table below gives an overview of all observation data (black), split by age group: children (blue/☼) (estimated age <18 years) and adults (red/☆). Conditional probabilities were calculated for all states, starting with P(Interest|Awareness). The conditional probabilities for Awareness were not included because not all visitors in the transit phase were observed and doing so would thus lead to an unreliable picture of the probability of entering awareness.

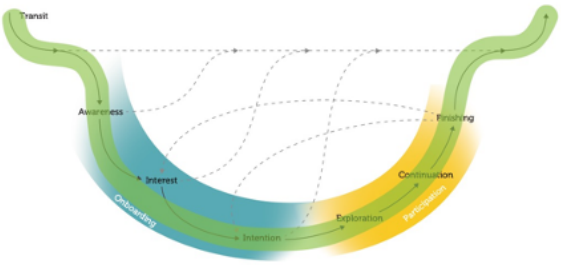
Overview of all observation data (black), split by age group: children (blue/☼) and adults (red/☆)

	All observations	Awareness	Interest		Intention		Exploration		Continuation		Finishing	
	n	n	n	*P (Interest| Awareness)*	n	*P (Intention| Interest)*	N	*P (Exploration| Intention)*	n	*P (Continuation| Exploration)*	n	*P (Continuation| Finishing)*
	Child☼ Adult☆ All	Child☼ Adult☆ All	Child☼ Adult☆ All		Child☼ Adult☆ All		Child☼ Adult☆ All		Child☼ Adult☆ All		Child☼ Adult☆ All	
All exhibits (Sum of all exhibits)	**320☼ 352☆ 672**	**289☼ 311☆ 600**	**257☼ 237☆ 494**	***0,889☼ 0,762☆ 0,823***	**233☼ 135☆ 368**	***0,907☼ 0,570☆ 0,745***	**208☼ 117☆ 325**	***0,893☼ 0,867☆ 0,883***	**156☼ 77☆ 233**	***0,750☼ 0,658☆ 0,717***	**120☼ 64☆ 184**	***0,769☼ 0,831☆ 0,790***
Dance Along	**49☼ 50☆ 99**	40☼ 47☆ 87	38☼ 34☆ 72	*0,950☼ 0,723☆ 0,828*	36☼ 10☆ 46	*0,947☼ 0,294☆ 0,639*	35☼ 10☆ 45	*0,972☼ 1,000☆ 0,978*	34☼ 5☆ 39	*0,971☼ 0,500☆ 0,867*	30☼ 5☆ 35	*0,882☼ 1,000☆ 0,897*
Sperm Race	**45☼ 44☆ 89**	45☼ 41☆ 86	42☼ 26☆ 68	*0,933☼ 0,634☆ 0,791*	34☼ 9☆ 43	*0,810☼ 0,346☆ 0,632*	34☼ 8☆ 42	*1,000☼ 0,889☆ 0,977*	30☼ 5☆ 35	*0,882☼ 0,625☆ 0,833*	17☼ 5☆ 22	*0,567☼ 1,000☆ 0,629*
Life after Death	**58☼ 97☆ 155**	55☼ 89☆ 144	55☼ 82☆ 137	*1,000☼ 0,921☆ 0,951*	48☼ 34☆ 82	*0,873☼ 0,415☆ 0,599*	44☼ 30☆ 74	*0,917☼ 0,882☆ 0,902*	44☼ 25☆ 69	*1,000☼ 0,833☆ 0,932*	42☼ 21☆ 63	*0,955☼ 0,840☆ 0,913*
Music Memory	**82☼ 74☆ 156**	70☼ 59☆ 129	61☼ 48☆ 109	*0,871☼ 0,814☆ 0,845*	59☼ 45☆ 104	*0,967☼ 0,938☆ 0,954*	57☼ 39☆ 96	*0,966☼ 0,867☆ 0,923*	26☼ 19☆ 45	*0,456☼ 0,487☆ 0,469*	15☼ 16☆ 31	*0,577☼ 0,842☆ 0,689*
Floor Circle	**68☼ 72☆ 140**	63☼ 65☆ 128	45☼ 40☆ 85	*0,714☼ 0,615☆ 0,664*	43☼ 33☆ 76	*0,956☼ 0,825☆ 0,894*	30☼ 27☆ 57	*0,698☼ 0,818☆ 0,750*	14☼ 20☆ 34	*0,467☼ 0,741☆ 0,596*	10☼ 14☆ 24	*0,714☼ 0,700☆ 0,706*
Drum Game	**18☼ 15☆ 33**	16☼ 10☆ 26	16☼ 7☆ 23	*1,000☼ 0,700☆ 0,885*	13☼ 4☆ 17	*0,813☼ 0,571☆ 0,739*	8☼ 3☆ 11	*0,615☼ 0,750☆ 0,647*	8☼ 3☆ 11	*1,000☼ 1,000☆ 1,000*	6☼ 3☆ 9	*0,750☼ 1,000☆ 0,818*

A.5 Observed Participant Journeys

Participation Journey illustration and case description for a Full Participant Journey

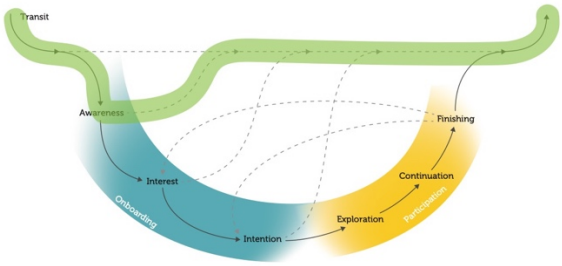
Full Participant Journey



Transit	Two children and their parent enter the room where the 'Drum Game' exhibit is located.
Awareness	They see the exhibit.
Interest	They immediately seem to understand what it is and does.
Intention	They (seem to be) waiting for an opportunity to join. When the previous players are ready and standing up, they sit behind one of the drum sets.
Exploration	They start playing, the interface is so intuitive that it is immediately clear how it works. As a result, there is hardly any 'exploration'.
Continuation	They play, siblings change in between games.
Finishing	There is a natural ending when the game ends. They get up (and a new family goes to play).

Participation Journey illustration and case description for Exiting after Awareness

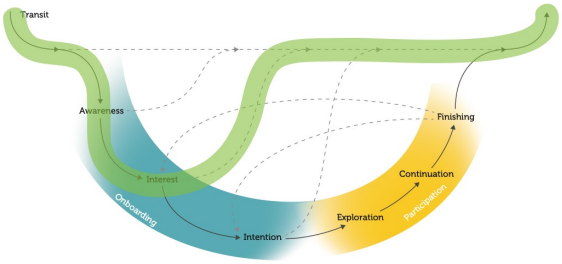
Exit after Awareness



Transit	Father and toddler walk past the 'Dance Along' exhibit.
Awareness	Father looks into the exhibition room. He doesn't find it interesting and continues.

Participation Journey illustration and case description for Exiting after Interest

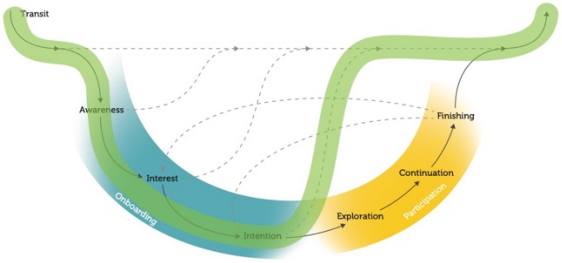
Exit after Interest



Transit	Mother and two daughters walk by.
Awareness	They notice the 'Floor Circle' exhibit.
Interest	The daughter watches the exhibit for a moment.
	(Mother quickly walks by (clearly is on her way to something else) and calls daughter.)
	Daughter follows mother.

Participation Journey illustration and case description for Exiting after Intention

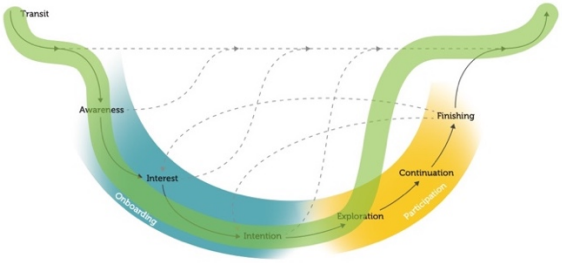
Exit after Intention



Transit	A couple visits the 'Death' exhibition.
Awareness	They notice the "Life after Death' exhibit.
Interest	They observe the exhibit being used from a distance of approximately 1m.
Intention	They wait for an opportunity to explore the exhibit.
	Other people are still occupying the exhibit.
	They continue into the exhibition feeling it's taking too long.

Participation Journey illustration and case description for Exiting after Exploration

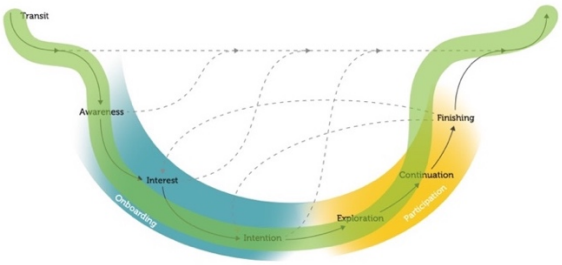
Exit after Exploration



Transit	Young man and woman enter the 'Music Memory' exhibition space.
Awareness	They see the exhibit.
Interest	They look for a while.
Exploration	Then press one of the squares.
	Nothing happens.
	They walk on.

Participation Journey illustration and case description for Exiting after Continuation

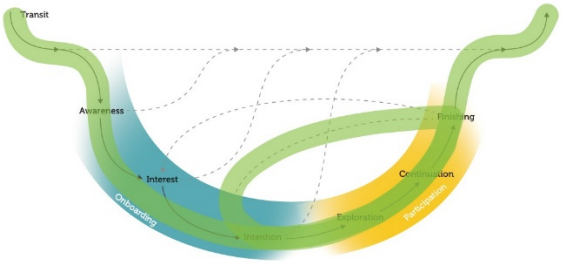
Exit after Continuation



Transit	Two children are visiting the 'Music Memory' exhibit with their daycare group.
Awareness	The children notice the 'Music Memory' exhibit.
Interest	They walk towards it.
Exploration	They start using the interface.
Continuation	They make a few combinations.
	They are distracted by sounds coming from the 'Floor Circle' exhibit and leave in its direction.

Participation Journey illustration and case description for Replay

Replay



Transit	A family enters the 'Life after Death' exhibit
Awareness	A child notices the 'Life after Death' exhibit
Interest	The child moves nearer
Exploration	The child interacts with the exhibit
Continuation	Continues
Finishing	Leaves because their family have already continued
Replay – intention	The child comes back with their parent to show the exhibit
Replay - exploration	They explore the exhibit together. The child explains to their family member
Replay - Continuation	They continue further exploring the content.
Replay -Finishing	They are done and leave