Linger: Extending Museum Experiences to Post-Visit Phases

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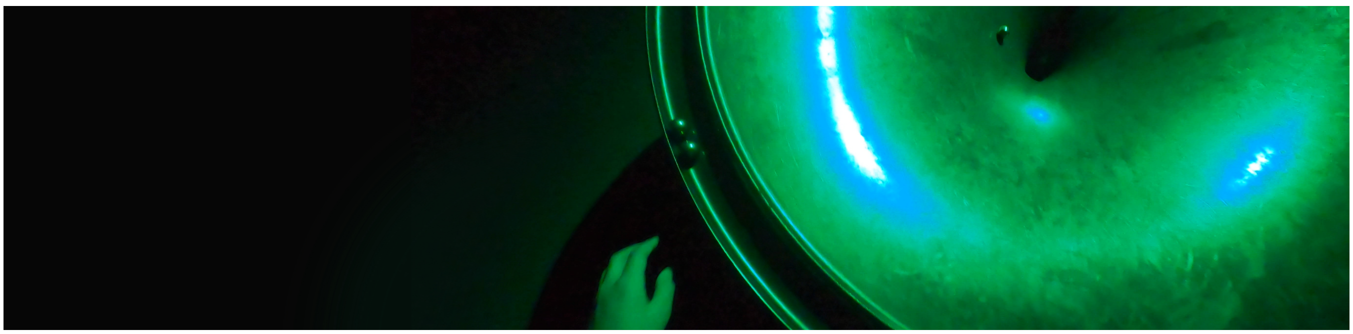

Figure 1: A first-person view taken from a head-mounted GoPro action camera of a visitor throwing a ball into a gravity well.

ABSTRACT

Over the past decade, Human-Computer Interaction (HCI) studies have explored ways to improve onsite museum visitor experience and foster interactive exhibitions. However, seldom studies have holistically looked at museum experiences including what happens after the visit. This paper explores ways to bridge the onsite and post-visit phases in a museum in the context of informal learning. Following a scoping review, we conducted observations where student dyads freely explored a science museum wearing a GoPro camera, followed by interviews with students (n=5) and museum staff (n=1). We identified science museum strategies and concerns that need to be taken into account when designing a program for visitors that aims to extend a museum onsite visit.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design**.

KEYWORDS

user experience; science museum; informal learning; visitor experience

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1 INTRODUCTION

A museum is important for visitors to learn about exhibits, see new ones, and experience them. Hong et al. [21] stated a distinguishable experiential model for interactive exhibitions of museums, the model was broken down into the pre-, onsite, and post-visit phases. Over the past decade, Human-Computer Interaction (HCI) studies have explored ways to improve onsite visitor experience and foster interactive exhibitions. However, seldom studies have holistically looked at museum experiences including what happens after the visit. The learning process is not limited to the duration of the visit, and learners need time to inquire questions and understand them, then finish acquiring knowledge. As Hong et al. [21] mentioned, memory and reminiscence are the mental processes for the post-visit phase. Based on memory and reminiscence, it is important to inspire visitors to continue learning and to understand the knowledge. This paper explores ways to bridge the onsite and post-visit phases through the following research questions (RQ):

- **RQ1:** How can science museum onsite and post-visit experiences be bridged in informal learning?
- **RQ2:** How can students' informal learning in a science museum be captured without disturbing the process?
- **RQ3:** How do gaps in research on science museum learning in HCI suggest opportunities for future research?

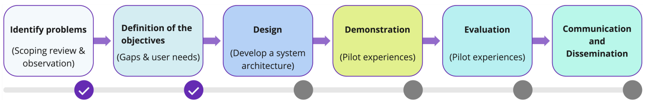

Figure 2: Six phases of the design science research methodology (DSRM).

This research follows the design science research methodology (DSRM) [19], which suggests a way to conduct design science research in information systems. It consists of six phases: (1) identify problem and motivation, (2) define objectives, (3) design, (4) demonstration, (5) evaluation, and (6) communication. This paper introduces ongoing work covering the first two phases (Figure 2). For phase 1, we conducted a scoping review and observations in a science museum with students and staff. For phase 2, we analyzed the resulting data to define objectives.

2 RELATED WORK

We identified three main areas of related work: *museum research in HCI, informal learning,* and *technologies in museum learning*. First, HCI studies have been conducted in several contexts, including history museums, cultural heritage, science museums, art museums, galleries, and comprehensive museums. Numerous interactive Exhibits in museums are equipped with sensors and communication to focus visitors' attention and capabilities [7, 11]. Educational robotics is a quickly growing field which already significantly impacts visitor experience in museums [20]. Several studies were published presenting the cutting edge of mobile guides [13, 22], emphasizing the challenges and opportunities provided by on-site or online museum visitors' guide systems. Additionally, museums continuously facilitate visitors' collaboration and group interaction through collaborative exhibitions [3]. Second, according to Johnson and Majewska [10], the definition of Informal learning is not structured but promoted through non-direct teaching behaviours, and informal learning has a cognitive, emotional, social, and behavioural emphasis. Informal learning in museums and other cultural heritage sites is a popular choice to supplement formal education because it can help people observe and comprehend the world around them [15]. Previous research in HCI acknowledged that visitors gain the learning experience in museums and comparable settings like science centres, aquariums and cultural heritages[8, 9, 24]. Finally, the past decade has seen a surge in research on the impact of technologies on museum learning. The main technologies used include mobile apps, Extended Reality (XR), and Artificial Intelligence (AI). Notably, Kontiza et al. [12] illustrated that mobile apps connect existing digital cultural assets and combine them with interactive experiences using state-of-the-art technologies like recommendation systems and semantic reasoning. Also, XR has the potential to enhance the visitor experience. In a study of augmented reality (AR) in a historical site, Wu, Chou and Li [28] identified three effective design methods for creating AR content to help visitors understand the history. Unsurprisingly, AI technologies are applied in museum learning. For instance, one multimodal learning analytics [9] is applied to investigate visitor engagement by multimodal sensor containing eye gaze, facial expression, posture, and interaction log data.

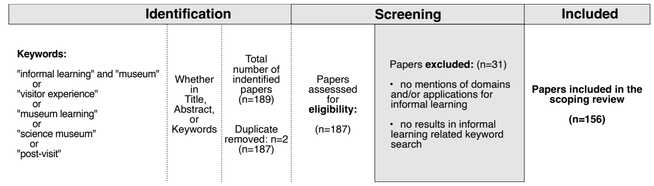

Figure 3: Flow diagram of search strategy consisting of identification and screening following the PRISMA-ScR procedure.

3 SCOPING REVIEW

3.1 Identification

To better understand the study on museum learning and visitor experience in HCI, we began with a scoping review following the PRISMA-ScR procedure (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) [23]. We chose the ACM Digital library as a database and conducted the latest search on April 3, 2024. We searched for all records whether 5 keywords appear in the title, the abstract, or the paper's keywords. The search yielded 189 results as the initial corpus for the further study selection (Figure 3).

3.2 Data Screening

In our initial screening, we excluded two duplicate papers from our initial corpus. Following this, from the remaining 187 papers, we identified and excluded 31 papers after reviewing the titles and abstracts, as they were off-topic and irrelevant to our research focus. For example, there is no mentioning of domains and/or applications for informal learning [27]. We also excluded papers that present no results in informal learning related keyword search [25]. After screening, we had 156 eligible papers in total for analysis.

3.3 Initial Analysis

To document and track our progress, we used colour-coding in Google Sheets and made notes on a Miro board to record the progress of characterisation. The first author conducted a preliminary categorisation of these studies, resulting in 13 initial categories: Collaboration Interaction, Post-visit, Methodology, Visitor Experience, System to Support Learning, Application, Serious Game, Exhibition or Exhibits, XR, AI Technology, Personalised Souvenirs, Special People and Science Museum. The first and the second authors then engaged in a collaborative discussion to refine those initial categories. Through this discussion, we identified five initial categories of museum learning in HCI:

(1) ***Applications***: novel applications for museum learning (App [6], Exhibitions or Exhibits / Installations [17], Serious Games [14] and System to Support Learning [13]).
(2) ***Research Methods***: studies on current methodologies for museum learning ([13]).
(3) ***Technologies***: proposed technologies for museum learning (Extended Reality [28]and AI Technology [9]).
(4) ***Visitor Experiences***: studies on personalised or collaborative visitor experiences in museum learning (Collaboration Interaction [5], Post-visit [1], Personalised Souvenirs [18] and Special People [26]).

(5) ***Science Museum***: studies and challenges in research on science museum learning in HCI [2].

4 MUSEUM OBSERVATIONS AND INTERVIEWS

4.1 Data Collection and Analysis

First, we invited five international students aged 12-14 (3 women, 2 men) to visit the Heureka science museum in Espoo, Finland. Participants freely explored the premises in pairs (one solo), while one wore a GoPro action camera to record their visit experience. After the visit, we conducted semi-structured interviews to gather participants' thoughts and feelings (e.g., *What impressed you the most from the exhibition? Was the exhibit related to your usual study? Did you learn from your friend during the visit? Were any installations difficult to understand?*). Each session lasted one hour. We obtained informed consent from all participants' parents prior to starting the research. Second, we interviewed an experienced Heureka staff member on informal learning, which was audio-recorded.

We used digital affinity diagramming [16] on a Miro board to analyze the qualitative data from the five students and one museum staff. Two researchers familiarized themselves with the data through videos of participants' visits and transcripts of interviews, then made notes independently. Each researcher chose a specific sticky note colour on the Miro board, which resulted in 245 affinity notes. In the end, 178 notes were chosen for categorization. Discarded notes (n=67) consisted of duplicates or contextual observations. Finally, we grouped all notes thematically into three categories including 11 sub-topics which are presented in the following section.

4.2 Findings

4.2.1 Learning Behavior in a Science Museum. Following Barriault and Pearson's visitor-based framework for assessing visitor learning experiences with exhibits in a science museum [4], we categorized the participants' emotions, actions, reactions, conversations, and interviews into four behaviours: *initiation, transition, breakthrough,* and *visitors' thoughts and association.* First, regarding *initiation*, visitors displayed learning behaviour such as: interacting with exhibits, spending time watching others engaging in an activity, or observing the exhibit. During this stage, visitors expressed their interest but without further exploration. For instance, P1 quickly lost patience with simple displays and turned to something new, upon which he got bored again, and turned to his friends and began playing with them. Timely feedback was the key element when he explored the exhibition. Several times, P1 just stepped forward and pressed the handle directly, trying to see what the reaction would be rather than reading any description. Second, during *transition*, visitors demonstrated the following learning behaviour: repeating the activity, and expressing strong emotional reactions while engaging with the visit. As P2 tried the bed of nails exhibit, he repeated the word *"torture"* while lying down. Later in the interview, he explained to the researcher how the bed of nails worked, saying that it was easy to understand. P3 tried to observe the installation from different angles even when she was visiting alone. When P5 encountered a term she did not understand, she took out her phone to searched for the term, a strategy used multiple times. Third, positive emotional responses showed participants engaging in the activity, while sometimes negative signs indicated a *breakthrough* learning behavior when visitors sought and shared information with others. We observed that in the case of paired visitors, during the visit P1 and P2 assumed a mechanical gears exhibit was broken and that there was no connection between gears. One of them called his family member to look at the exhibit and told them it was broken. However, later in the interview, one participant found that the exhibit was not broken and that small gears at the bottom connected the ones that looked broken. Similarly, P4 and P5 explored the entire museum almost simultaneously, with P5 often explaining to P4 and inviting her to read the instructions together. In contrast, we did not observe any active interaction with others in the case of the solo visitor, whereas visitors seemed to frequently share information with each other as a pair. Finally, we found that P3, who was also in a solo tour, expressed frustration when there was no pen to allow her to interact with the exhibit: *"This is so disappointing."* The negative evaluation demonstrated participants had some thoughts on the exhibits, whether their views were right or wrong. The behavior created an opportunity for discussions and questions about the exhibit with staff or a family member and friends. Crucially, they are more likely to find out more information or change their current impressions if they continue to look for answers.

4.2.2 The Relation Between Informal and Formal Learning. Throughout these observations, we witnessed the interplay between the informal learning context and visitors' habits. When participants are in an informal setting of the onsite museum, they prefer hands-on activities where fun experiences are important for their visit. P1 said in an interview that he likes the design of the museum, not the particular exhibition. The carefully designed environment of the science museum provides a platform for them to explore by using their natural behaviour. Participants were familiar with learning from the internet. Both P2 and P3 mentioned some funny and attractive learning material found on YouTube. P2 recommended a good learning website: *"It's really fun and stupid at the same time." "There are interactive things that can help you learn up to six times faster."* Meanwhile, P3 showed critical thinking and selection of information sources, *"I don't know if I should trust them because, you know, Tiktok is not a very nice platform to get information from."* The experiences of these teenagers show that besides school study, informal learning also accompanies their growth, in a pleasant and interesting environment, inspiring them to think and ask questions. Interactivity and fun can be part of what future researchers and designers should consider when designing informal learning systems. There are also connections and collaboration between formal and informal learning, for instance, teachers in school take students to the science museum, and they can also use material from the science museum and evaluate the outcome. On the other hand, the museum collaborates with universities to research and takes advice from industry specialists.

4.2.3 Science Museum Strategies. From the museum staff interview, we noted the museum is aiming to bring inspiration and encourage hands-on learning experiences instead of being an educational institution intended to teach officially. She shared concerns and gave advice that needs to be taken into account when designing a program for visitors: *"One program doesn't work for everybody. [...] Because you only have 45 minutes, theory in the beginning, can only take max 3 minutes. So after three minutes, they should already have something to do with their hands."* When designing for a group, there are different stages of knowledge in the group, the science museum aims to provide a positive experience to every participant and inspire everyone to get satisfaction, visiting at their own pace. Moreover, they presented the significance of the balance between theory and practice, for example, in a 45-minute science museum workshop, the instructor usually introduces the theory in the first three minutes, after that, they give more time and space for visitors to practice hands-on activities.

5 DISCUSSION

5.1 Capturing Onsite Experiences

In this museum observation and study, we used the GoPro action camera as our tracking tool for data collection. The GoPro is particularly well-suited for capturing both audio and visual data, providing a comprehensive record of the user experience. During our observations, we noted that when users wore the GoPro on their heads, some consciously attempted to display their activities to the camera; some occasionally adjusting the camera when it began to slip. P2 reported that although he experienced some sweating on his forehead, the headset did not significantly impact his overall experience. However, P3 and P4 mentioned several times that wearing the GoPro made their hair uncomfortable and that the camera affected viewing during their visit. We remain cautious about the future use of the GoPro for documentation purposes. Despite its capabilities, the GoPro remains an additional piece of equipment that is not ideal for prolonged experiences and does not facilitate real-time data transmission, analysis and storage. Therefore, it may not be the most practical choice for such studies.

5.2 Sharing Onsite Experiences

To bridge the gap between teenagers' onsite and post-visit experiences, we think that design applications may better document and facilitate subsequent informal learning opportunities. In an informal learning environment, it is hard to track behaviour without influencing visitors. Therefore, the main purpose of using documentation tools in science museums is to provide a portable way of recording images, allowing visitors to freely choose the experiences and information they are interested in recording. By playing such a connecting role, the app can serve as a way to mark significant moments throughout their visits, thereby providing materials and information for later informal learning. Teenagers could share their photos with family or friends and talk about their interesting experiences and newly acquired knowledge, which can become an additional learning opportunity. This reflective process can help teenagers revisit their previous experiences and extend their learning beyond an onsite visit.

5.3 Evaluating Paired Visits and Individual Visits

Two cousins visited the exhibition together, which made it easier to generate interactive discussions and opportunities to find answers. The older one (P5) sometimes explained the principle of exhibits to the younger one (P4), encouraging her to ask questions. They spent more time collaboratively interacting with the exhibit in a large space. For example, they adjusted the speed of a rotating plate. In particular, P4 invented a new rule for the game: "*Let's see which ball can keep spinning to the end without being rolled off the wheel.*" Similarly, the group of P1 and P2 spent a considerable amount of time at the black hole installation, engaging in comparisons and deriving satisfaction from the experience. On the other hand, a solo visitor could significantly reduce his or her interaction with the people around them, for example, when P3 found all the markers were out of ink during her attempt to draw, she said to herself: "*Can I ask someone for a pen?*" But in the end, she walked away instead of asking for any help. P3 was also very attentive to the exhibition and stayed in the area for more than 50 minutes, but she said she did not feel the passage of time at all. The solo visitor reduced the conversation and interaction with others but is immersed in thinking and interacting with the exhibition, thus entering a flow state. Besides, from her mutter, we observed she tried to summarise the phenomenon by herself, though she did not understand the correct principle of the exhibit. More importantly, she did not realise her guess was not right. The understanding of visitors during the visit are not necessarily correct, however they could miss information and not get feedback if they do not continue to search or look up the knowledge. The correct answer may not be crucial, but there is a need to inspire or motivate visitors to keep asking, thinking, discussing and exploring after the visit.

6 CONCLUSIONS AND FUTURE DIRECTIONS

In this paper, we have presented a scoping review on museum learning and conducted an observation in a science museum. We discovered and documented factors to take into account when designing museum experiences. Following the DSRM methodology, the study will design a system based on user needs for later demonstration, evaluation, and communication. We will continue to investigate teenagers' museum experience. Based on their behavior using a game-based mobile app, the system could motivate them to take pictures or videos during their visit, and when they upload pictures to the app, the related information or knowledge of the corresponding exhibits could be retrieved and a personalised map of the visitor be created to keep it as a digital souvenir or to extend the visiting experience. Another feature is that visitors could chat with a chatbot with an organized database based on exhibits' information, could ask questions', as well as send feedback. Moreover, students could leave comments on a bulletin board and interact with other people in the game.

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