



## THE ROLE OF TANGIBLE INTERACTION FOR COMMUNICATING QUALITATIVE INFORMATION OF BUILT HERITAGE

Eslam Nofal<sup>a,b,\*</sup>, Vanessa Boschloos<sup>c</sup>, Hendrik Hameeuw<sup>c</sup>, Andrew Vande Moere<sup>a</sup>

<sup>a</sup> Research[x]Design, Department of Architecture, KU Leuven, Kasteelpark Arenberg 1, 3001, Leuven, Belgium.  
[eslam.nofal@kuleuven.be](mailto:eslam.nofal@kuleuven.be); [andrew.vandemoere@kuleuven.be](mailto:andrew.vandemoere@kuleuven.be)

<sup>b</sup> Department of Architecture, Assiut University, 71516, Assiut, Egypt.

<sup>c</sup> Antiquity Department, Royal Museums of Art and History, Jubelpark 10, B-1000 Brussels, Belgium. [v.boschloos@kmg-mrah.be](mailto:v.boschloos@kmg-mrah.be);  
[h.hameeuw@kmg-mrah.be](mailto:h.hameeuw@kmg-mrah.be)

### Abstract:

Each built heritage artifact possesses multiple types of information, varying from simple, factual aspects to more complex qualitative and tacit qualities and values like the architectural symbolism of a monument. This paper investigates how tangible interaction can enable the communication of qualitative information of built heritage to lay visitors. Through a comparative, field study in a real-world museum context, we examined how the tangible characteristics of an interactive prototype museum installation influence how visitors perceive a particular story. The communicated story relates a historical journey in ancient Egypt to the physical and architectural characteristics of the entrance colonnade at the Djoser Complex in Saqqara. The first preliminary findings indicate how tangible interaction is able to engage museum visitors more to accomplish additional efforts, facilitating a vivid understanding of cultural values and architectural qualities of built heritage.

**Keywords:** Tangible interaction, physical visualization, qualitative information, built heritage, cultural learning, Saqqara.

### 1. Introduction

Our heritage sites and monuments are not just physical objects, but also communicate particular meanings and values over time. The built heritage can therefore be characterized as a communication process, in which each artifact potentially carries different types of information that visitors are invited to perceive and interpret differently (Kepczynska-Walczak and Walczak 2015). These information types tend to vary from factual or quantitative information (e.g. monument functions or building date), which are relatively easy to represent, to more tacit qualities and values (e.g. architectural qualities, cultural values, symbolic meaning of a monument) that due to their abstract and subjective character are typically more challenging to transfer to visitors. Recent digital technology advancements have enabled various innovative opportunities for more engaging, informative and potentially enjoyable way of communicating heritage information. As a result, built heritage information has already been represented via a variety of paradigms, such as virtual reality (VR) for visualizing the virtual reconstruction of ancient worlds, or augmented reality (AR) for immersing users in historical stories. We believe that tangible interaction is also a promising paradigm for communicating heritage information, which has the added quality to be relatively

affordable, collaborative and requiring little experience or skills. For instance, particular qualities of tangible interaction have been demonstrated in a wide range of applications in different realms, such as its effectiveness for collaborative and participative processes in public space in comparison to touch interfaces (Claes and VandeMoere 2015), and its touch and manipulation affordance in interactive exhibits, which attracts more visitors and prompts them for further exploration (Ma *et al.* 2015).

In comparison to graphical user interfaces (GUIs), tangible user interfaces (TUIs) are relatively intuitive and they do not only afford objects in an abstract physical form, but they can also incorporate particular material attributes (e.g. size, shape, texture, color, weight) that to convey information in addition to the digital representation (Macaranas *et al.* 2012). The feel of these physical attributes can aid recall, and can be perceptually re-accessed (Seo *et al.* 2015). It is no surprise then that tangible interaction has been exploited to communicate heritage information, such as providing immersive and more engaging experiences to support intuitive handling and to fit in with outdoor heritage environments (Ciolfi *et al.* 2013), or allowing visitors to explore background information in museum context (Schneegass *et al.* 2014). These studies focused on the engagement level and content personalization more than

\* Corresponding Author: Eslam Nofal, [eslam.nofal@kuleuven.be](mailto:eslam.nofal@kuleuven.be)

the level of understanding and knowledge gain that leads to cultural learning. Cultural learning is an informal learning style (Ibrahim *et al.* 2015), its setting stimulates users into thinking to explore and realize the cultural value. This style suits users who seek knowledge for pleasure or those who seek knowledge based on genuine motivation; such as enjoyer or general visitor.

For our study, we aimed to investigate how visitors can be provided with a meaningful and interactive experience that stimulates people to think, discover and make meaningful connections with built heritage without any external help. We are particularly interested in discovering ways how tacit and qualitative information can be indirectly and intuitively communicated in an informal cultural learning context. In order to discover the causal effect of tangible interaction on the sensemaking of the visitors, we developed a comparative, field study in a real-world museum context. This paper reports on the first findings of our preliminary study, providing the first hints towards how tangible interaction influences knowledge gain and user engagement.

## 2. Context

The Djoser pyramid complex is a funerary complex in Saqqara designed by Imhotep, one of the greatest architects in ancient Egypt. It was built for pharaoh Djoser around 2630 BCE, and is believed to be the world's oldest large-scale stone structure. For the purpose of this research, we have chosen an historical story of how the pharaoh journeyed along the Nile to visit each of the nomes (the territorial divisions of ancient Egypt) and their local Gods, and how this story was translated in the physical architecture of the entrance colonnade of this complex: it has been suggested that each niche (the space created between adjacent columns) in the entrance colonnade represents a shrine where the nome gods of ancient Egypt were accommodated during the Heb-Sed (a festival celebrating the continued rule of the king through rituals that symbolically rejuvenate him) (Hermann 1932). This working hypothesis is plausible because the number of niches and nomes are equal (42). The architect Imhotep may have designed the architectural layout of the colonnade to portray the Nile river; the end chamber could represent the delta; and the processing of pharaoh Djoser along the corridor and passing by each nome shrine may evoke a ritualized version of the pharaoh's journey along the Nile to visit each of the nomes and their local gods.

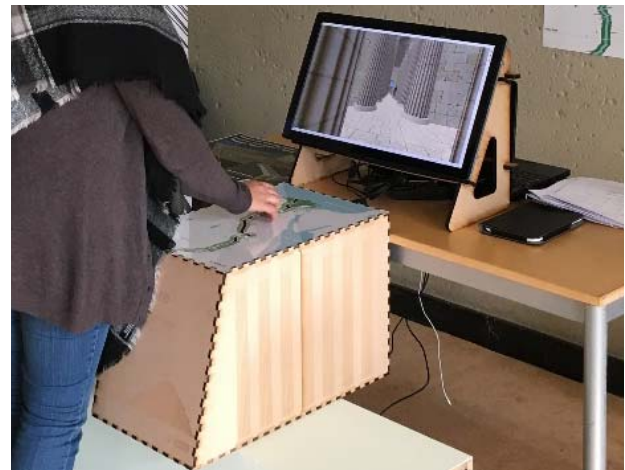
## 3. Methodology

For the aim of this study, we developed three different interactive installations (and experimental conditions) in order to compare the causal influence of the tangible interaction on the sensemaking of the visitors, as shown in Figure 1. Each condition consisted of an interactive navigation (input) and a passive representation (output) element. For the navigation, a map of ancient Egypt with its territorial divisions of 42 nomes was used as the main interaction method, either via touch screen (*Touch-Dix*) or via a tangible interactive surface featuring a movable 3D-printed statue of pharaoh Djoser on the map (*Tang-Dix* and *Tang-Phys*). Each condition contained a representation view of the entrance colonnade that dynamically changed according to the user interaction.

This view varied from a digital display showing a walk-through in a rendered 3D model of the colonnade (*Touch-Dix* and *Tang-Dix*) to a 3D, physical rendition of the colonnade that was semi-attached to the installation (*Tang-Phys*), as summarized in Table 1.



a)



b)



c)

**Figure 1:** Different conditions for communicating the architectural story of the entrance colonnade of Djoser Pyramid Complex: a) *Touch-Dix*; b) *Tang-Dix*; c) *Tang-Phys*.

We carried out a two-day pilot study at the Antiquity Department of the Royal Museums of Art and History in Brussels (in the exhibition rooms of the Egyptian

Collection), to estimate general usability issues like whether museum visitors would be sufficiently intrigued by the interactive designs to start interacting with them, and whether they would intuitively understand the functionalities of the interactive features. This museum comprises the largest collection of Egyptian antiquities in Belgium. During the study, each condition was introduced with a brief explanation about the general context of the building (i.e. location and historical period) and about their purpose of interaction (i.e. exploring the architectural symbolism of the entrance colonnade). Visitors were allowed to participate individually or in groups, and as such included couples and dozens of children on a museum school trip. All of the participants signed an informed consent form to confirm that they voluntarily participate in this study, and the results of this research can be used only for scientific purposes. All the interactions were observed, logged and video recorded. The experiment finished with a semi-structured ad hoc interview that was audio-taped, and which focused on the comprehension of the meaningful relationship between the map and the colonnade. The interview also included questions about how the colonnade looked like, in order to capture how people perceived the architectural characteristics of the space (e.g. height, fluting of the columns) that were not explicitly relevant to understand the story, yet still are valuable heritage qualities to be appreciated or remembered. Next to measuring the level of appreciation via open questions, visitors also filled in a user experience questionnaire (ueq-online.org), covering both classical usability aspects (i.e. efficiency, perspicuity, dependability) and user experience aspects (i.e. originality, stimulation)

**Table 1:** Navigation and representation means of the three experimental conditions

	<i>Touch-Dix</i>	<i>Tang-Dix</i>	<i>Tang-Phys</i>
Navigation	touch screen	tangible installation	tangible installation
Representation	2.5 D digital display	2.5 D digital display	3D physical rendition

**Touch-Dix.** The navigation technique is via touch screen (7 inch tablet computer), dragging 'you are here' icon on the map causes a corresponding walk-through (position and rotation) in the colonnade representation displayed on the larger digital screen (Figure 1.a). The connection between the map on the touch screen and the rendered 3D model of the colonnade on the digital display was accomplished via the Eddison plugin (edddison.com), which simplifies the controlling of 3D applications.

**Tang-Dix.** A 3D printed statue of pharaoh Djoser was physically moved along the Nile river through a tangible installation of ancient Egypt map. This movement causes a corresponding walk-through (position and rotation) in the colonnade representation displayed on the digital display (Figure 1.b). This link is also attained via the tracking properties of the same plugin Eddison.

**Tang- Phys.** The same tangible installation of the previous condition is used as a navigation technique. Moving the statue along the Nile river causes a sequence illumination in the physical rendition of the colonnade, each nome with its corresponding niche (Figure 1.c). This condition has been experimented in

two different setups; a) fixed: the colonnade mock-up is fixed in the installation, users can only look at it and they may touch it, and b) graspable: users in this condition are allowed to grasp the colonnade mock-up, touch it, look through it, etc.

## 4. Results and Discussion

The pilot study involved 13 participants (i.e. 3 individuals and 10 groups varying between 2 and 10 visitors). Participants varied in terms of gender, age range, and the motivation behind their museum visit (e.g. school or family visit, local or international tourists, or museum staff). Most of the participants expressed a personal interest in information related to cultural heritage, they regularly visited museums, and they claimed to have general knowledge about the Egyptian heritage. But most of them were not familiar with interactive installations.

### 4.1. Comprehension and Perception

In the condition of *Touch-Dix*, we discovered that participants paid more attention to navigate in the touch screen than the second display that showed the 3D representation of the colonnade. This behavior naturally lead to relatively poor comprehension of the relationship between the map and the colonnade. In contrary, the condition *Tang-Phys* enabled visitors to understand the general meaning of the story behind the architecture of the entrance colonnade because of the clear link between the movement of the statue along the Nile and the corresponding lights in the physical colonnade. As a result, they appreciated the interaction method because they found it provokes visitors to do an extra effort, which facilitates their understanding. However, in condition *Tang-Dix*, some participants had only understood that meaning during the interview after asking the question about the corridor's representation.

All of the participants described the colonnade as a linear space with a lot of columns and unclosed chambers (niches). Dimensionally, participants in all conditions estimated its height as a double normal height which is relatively correct (6.60 m), while their perception of the length of the corridor varied from the real length (in fifties) to overestimations in hundreds. It is worth mentioning that in the condition of *Tang-Phys*, participants perceived the proportions and an overview of the space better than in the conditions of digital display. For instance, some of the participants in that condition mentioned correctly that the columns were attached to walls. They also better perceived the number of the columns (42). On the other hand, in digital display conditions (*Touch-Dix* and *Tang-Dix*), participants had better perception of the architectural details and styles. Some of the participants described the columns as rounded columns with vertical grooves. Unexpectedly, nobody in *Tang-Phys* perceived the fluting columns.

### 4.2. Engagement and Likeability

Individuals spent remarkably less time in interaction than groups; discussion in groups prompted them to explore more, which in terms increased the interaction time. On the other hand, in conditions of screen display (*Touch-Dix* and *Tang-Dix*), the time of interaction was clearly longer than in *Tang-Phys*. With regard to the design

likeability, participants generally appreciated *Tang-Dix* condition, and they found it interesting. *Tang-Phys* was considered fun and more suitable for children. In contrast, they seemed not to appreciate *Touch-Dix* that much, but this was probably due to some ergonomics issues. It is acknowledged the touch screen should be larger for fairer comparison.

#### 4. Conclusion

In this work-in-progress paper, we described the design, implementation and comparison between three different conditions for a novel communication of built heritage qualitative information in a real-world museum context. We showed how these conditions achieve different forms of engagement. The findings of our preliminary study indicated how tangible interaction stimulates museum visitors to accomplish additional efforts, facilitating an understanding of cultural values and architectural qualities of built heritage.

Future directions include a more thorough study with a larger number of participants, taking into consideration the ergonomic and technical limitations of the pilot study. The study will be followed by quantitative analysis of the user experience questionnaire and a qualitative analysis of the observation and participants' answers of the interview based on existing learning models.

#### Acknowledgements

We would like to thank the Antiquity Department of the Royal Museums of Art and History in Brussels; Luc Delvaux and Eric Gubel for their support and assistance during the museum experiment. We would like also to thank all the volunteers for their participation during their museum visit. The corresponding author gratefully acknowledges the PhD scholarship funded by the Egyptian Ministry of Higher Education.

#### References

- CIOLFI, L., PETRELLI, D., GOLDBERG, R., DULAKE, N., WILLOX, M., MARSHALL, M. and CAPARRELLI, F., 2013. Exploring historical, social and natural heritage: challenges for tangible interaction design at Sheffield General Cemetery. In: *NODEM 2013: Beyond Control - The Collaborative Museum and Its Challenges*.
- CLAES, S. and VANDEMOERE, A., 2015. The role of tangible interaction in exploring information on public visualization displays, In *Symposium on Pervasive Displays (PerDis'15)*, pp. 201-207. DOI: 10.1145/2757710.2757733
- HERMANN, A., 1938. Führer durch die Altertümer von Memphis und Sakkara, Berlin, p.32.
- IBRAHIM, N., ALI, N.M., and YATIM, N.F.M., 2015. Factors facilitating cultural learning in virtual architectural heritage environments: end user perspective. *ACM Journal on Computing and Cultural Heritage (JOCCH)*, 8 (2), Article 8. DOI: 10.1145/2660776
- KEPCZYNSKA-WALCZAK, A. and WALCZAK, B. M., 2015. Built heritage perception through representation of its atmosphere. *Ambiances Experiential Simulation*. Available <http://ambiances.revues.org/640> [2/21, 2016].
- MA, J., SINDORF, L., LIAO, I., and FRAZIER, J., 2015. Using a tangible versus a multi-touch graphical user interface to support data exploration at a museum exhibit, *Conference on Tangible, Embedded, and Embodied Interaction (TEI'15)*, pp. 33-40. DOI: 10.1145/2677199.2680555
- MACARANAS, A., ANTLE, A. N. and RIECKE, B. E., 2012. Bridging the gap: attribute and spatial metaphors for tangible interface design, *Conference on Tangible, Embedded and Embodied Interaction (TEI'12)*, pp. 161-168. DOI: 10.1145/2148131.2148166
- SCHNEEGASS, S., KNITTEL, J., RAU, B. and ABDELRAHMAN, Y., 2014. Exploring exhibits: Interactive methods for enriching cultural heritage items, In *Poster session at International Conference on Tangible, Embedded and Embodied Interaction (TEI'14)*.
- SEO, J.H., ARITA, J., CHU, S. L., QUEK, F. and ALDRIEDGE, S., 2015. Material significance of tangibles for young children, *Conference on Tangible, Embedded, and Embodied Interaction (TEI'15)*, pp. 53-56. DOI: 10.1145/2677199.2680583