Digital Cultural Items in Space: The Impact of Contextual Information on Presenting Digital Cultural Items

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Cultural heritage practitioners continue to engage with ever-changing technological opportunities and digital cultural items (DCIs) offer the potential for engaging interactive experiences. As DCIs become more prevalent, we are motivated to seek new presentation opportunities from the medium and understand its affordances with regards to contextual information. In this publication, through a series of Speak Aloud tasks with (n=15) participants, we explore how contextual information can improve user experiences with DCIs. The aforementioned study's results demonstrate that the inclusion of contextual information when presenting a DCI can, in fact, improve a visitor's understanding of a DCI's size and scale plus also the perceived realism of a DCI. Moreover, we observe that contextual information, and its recommended addition, supports the generation of a narrative by the visitor audience. In conclusion, we advise on how contextual information can improve the relationship between a visitor and a DCI, towards interacting with a DCI in a manner very similar to that of its analogue counterpart.

CCS Concepts: • **Human-centered computing** → **User studies**; **Systems and tools for interaction design**; • **Applied computing** → **Arts and humanities**.

Additional Key Words and Phrases: UX, cultural heritage, interaction design, digital items, experience design

1 INTRODUCTION

The perception of museums continues to evolve, from collectors and guardians of cultural items to educational institutions seeking to inform and educate [5] [22] [37]. Digital cultural items (DCIs), whether they are generated via scans from analogue items or 'born digital', irrespective of being part of online collections, shared interactive stories or virtual recreations of cultural sites [18], continue to play an important role in initiatives undertaken by cultural heritage institutions and cultural heritage practitioners (CHPs).

When encountered online, digital cultural items are often displayed in a grey void that lacks contextual information. The question thus becomes, do we need contextual information when presenting DCIs? If the intent is to simply present a digital model for inspection then it could be argued a grey void is all that is required. What might we gain however from including contextual information such as reference objects and scenery,

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when presenting DCIs? How will it shape the user experience, if at all? What do visitors expect from a DCI and, provided the opportunity, how might they alter their own experience if offered the tools to do so?

With the desire to provide improved experiences for visitors, both educational and entertaining, UX research informed design can be observed supporting the efforts of cultural institutions around the world [29] [43]. The recent COVID-19 pandemic saw a surge in the creation of DCIs from cultural heritage institutions as they sought to provide visitors with remote access to their cultural items [52]. This surge demanded CHPs engage with technologies and skill sets not commonly encountered within cultural heritage institutions.

The costs associated with capturing, preparing and displaying DCIs can be daunting for any institution [51]. Bespoke platforms are costly to develop and maintain, plus risk becoming redundant unless continually updated, reducing their long term survivability [58] [8] [31]. This has prompted the emergence and use of third-party platforms, such as Sketchfab, a 3D model presentation platform. The cultural heritage sector has embraced Sketchfab as a cost-effective and accessible tool for rapidly uploading and sharing DCIs.

For analogue artefacts we find that curators, often working with exhibition designers, invest considerable time and energy carefully crafting presentations for cultural items. It is via the inclusion of contextual information that learning experiences can be formed by CHPs, as they utilise a combination of architectural space, contextual association and additional themed assets in order to shape the experiences of their visitors, forming engaging narratives through which they might learn from [54].

The study in this publication investigates how context shapes user experiences with DCIs. We begin with a review of related works that explore the relationship between cultural heritage and digital technologies, including the advantages and challenges of working with DCIs. The following section will then define the research questions and also includes a description of a tool designed and developed in order to answer them. We then describe the study methodology and present an analysis of the data collected. Finally, the discussion and conclusion will interpret the results of the study.

Through exploring how contextual information affects the user experience, we aim to support CHPs, cultural heritage institutions and, finally, 3rd party developers involved with the cultural heritage sector in creating engaging, informative online experiences with DCIs.

2 BACKGROUND

Efforts persist towards digitizing cultural heritage collections and placing them 'online', for reasons such as the preservation of the original analogue item and education [25] [42]. While research in the area continues to grow, there is still an observed lack of literature that focuses on the theory and methodology of user interaction and experience regarding digital cultural experiences [25]. Instead, research within the cultural heritage community continues to explore how to incorporate seemingly ever-changing technologies within cultural heritage projects [13].

A critical component of digital cultural heritage revolves around the understanding of digital cultural items (DCIs) [16], cultural items that are generated from detailed scans before being prepared and rendered using 3D software. Cultural heritage scholars study how DCIs might be formed better, faster and with greater accuracy[23][14], while those focusing on UX informed research draw upon research into formal UX practices[46][20]and ask how we can use DCIs to create more compelling, more valuable, 'better', cultural user experiences[29][34]. Curators tackle the technical challenges of developing proficiency in, or gaining access to, an eclectic set of technical and artistic skills required to form and display DCIs, all the while working within strict professional deadlines and institutional budgets[42][27][47]. Meanwhile, visitors can access vast collections of DCIs from their portable devices and personal computers, with each DCI offering the potential for experiences formed from interactions that would simply be impossible with an analogue cultural item.

Understanding the experiences of visitors engaging with DCIs has formed the backbone of much of the work in digital cultural heritage. Efforts have been made to present complex historical narratives [44], to understand immersive technologies such as augmented and virtual reality [38] [48][24] and explore how we can use DCIs to form better visitor experiences [28][56][2]. And yet, the focus of efforts within digital cultural heritage research has been challenged, in a phenomenon that some scholars refer to as, 'the gap', representing the disconnect between research efforts and the every day needs of the cultural heritage practitioner [13].

The role of CHPs includes one of careful artefact selection, organization and presentation. CHPs present an interpretation of cultural items, often seeking to tell their story. Recently there has been a move in museum exhibitions towards visitor-centric experiences, where the visitors choose how and what they engage with, personalising their user experience [54]. Our previous study engaged with CHPs directly [16], asking them what role DCIs played in their working life and how they were used. Many institutions, notoriously deprived of funding and often lacking the technical skills required to create, host and display DCIs, rely on third-party sites such as the increasingly popular, popular, aforementioned Sketchfab [17].

While these third-party sites present a cost-effective and accessible means for institutions to display DCIs, CHPs often struggle with the technical and financial barriers that must be overcome to capture, process and present DCIs. Often, success is determined by merely managing to upload a DCI so that it might be accessed by as many people as possible. [16]. These barriers might explain why, when exhibited online, many DCIs appear to lack the attention afforded to their analogue counterparts, with them presented in 'grey voids', an environment familiar to those who have worked with CAD programs, such as Autodesk's Maya or 3D Studio Max.

Our study explores the benefits of gathering contextual information when presenting DCIs. The study was designed in response to a series of interviews with CHPs, where it was revealed that one of the main attractions of immersive technologies when presenting DCIs is their ability to convey size and scale. This was while noticing that when DCIs were presented using widely available non-immersive technologies, contextual information was minimal if not often absent. [16]. The connection between exhibiting and learning has been explored [54] and efforts have been made to investigate how best to leverage learning opportunities from interactions with DCIs[25][28]. However, while there has been a rise in popularity of third-party platforms for presenting DCIs [17], we find that DCIs are typically offered with little to no supporting contextual information and are often lacking in contextual clues, presenting potentially missed opportunities for learning.

DCIs offer experiences uncommonly available to their analogue counterparts, primarily in the form of interaction, providing visitors with the opportunity to engage in the act of inspection, through means of rotation, panning and zooming. The question of interaction and its effect on visitor enjoyment has been posed and explored [19], with researchers exploring the emotive qualities of interaction [39] and how we might better form relationships between visitor and analogue cultural artifacts through contextual interaction [1]. Technology enables new ways to create engaging visitor experiences, through 3D printing DCI for tactile interaction [12] to digitally fracturing DCIs so that they might be presented as puzzles [42]. We aim to align our study with these related research efforts as we take a typical use-case for DCIs; that of the DCI presented in the 'grey void', and then explore the benefits of gathering contextual information in their presentation.

Another popular path towards exploring learning through DCIs is that of Serious Games (SGs). Serious games can be seen as an effort to, 'bottle lightning' and capitalize on the enormous popularity of digital gaming [50], where scholars seek to learn from the incredibly popular media form [11] and apply lessons learnt to the creation of similarly engaging cultural experiences [10] [32]. Our work relates to the scholarly efforts of SGs through a shared desire to understand how a digital item might be presented in a manner that encourages engagement and is supportive of the user experience, a critical aspect of any game design project.

DCIs also provide tools for building narratives, an avenue of research explored by many scholars studying digital cultural heritage. Much work has been undertaken to better understand the role of narrative in learning and meaning-making [9] [30] and has been applied to cultural heritage, with scholars exploring how connections

between DCIs might support narrative, and therefore learning [55] [54] [35] [36], as well as the direct application of narrative, as a teaching aid [53] [33]. While our study did not intend to communicate a specific narrative, we observed that given the opportunity, visitors will provide their own narratives, as they engage in meaning-making.

With these angles of approach exploring how to best leverage DCIs to create positive learning experiences, our contribution focuses on the role of contextual information and its effects on the visitor user experience when presenting DCIs. Through interaction with our Contextual Information Presentation Tool (CIP), visitors were offered the opportunity to explore how contexual elements impacted the presentation of a DCI. This led to the creation of context, inquiry and then visitor-created narratives, which contributed to a positive learning experience and in its own respect represents an additional layer of interactivity, seemingly shifting the relationship between participant and DCI, from reacting to a mere digital item to engaging with a cultural artifact.

3 DCI CONTEXTUAL INFORMATION USER STUDY

To understand how contextual information affects the user experience of DCIs, we defined our research questions as:

- What are the benefits of gathering contextual information when presenting DCIs?
- How does contextual information impact the user experience of DCIs?
- How can we use contextual information to improve the user experience of DCIs?

To answer these questions we required a selection of DCIs to present to our participants. The study also required a tool that could present the DCIs in an environment devoid of contextual information, in keeping with how DCIs are commonly presented online. In addition to this, the tool required a system for introducing contextual information by adding and removing elements to the environment.

3.1 DCI selection

3 DCIs were selected from Sketchfab, a commercially-operated digital model presentation platform that has proven popular with cultural heritage professionals as a cost-effective manner of sharing DCIs [17]. Each DCI was built using photogrammetry and produced by a cultural heritage institution and was selected within the thematic grouping of, 'Ancient Egypt'. While a variety of themes were explored, it was found that a common theme unified our 3 DCIs collection and, critically, reduced the variety of supporting assets required, which minimised pre-production time for the bespoke study tool. The three DCIs selected were the sarcophagus of Taditjaina, the granite head of Amenemhat III and, finally, a predynastic bowl. These were chosen to present a cohesive theme, that of the aforementioned 'Ancient Egypt', but also for their variety in size and functionality. The DCIs originated from a time period that, combined, spanned 3500BC to 712BC.

3.2 Study tool

The study required participants to add elements to the digital environment within which the DCI was presented. For this purpose the Context Information Presentation Tool (CIP) was created, a bespoke tool designed by the researchers and created by a 3rd party professional with the Unity game engine. CIP presented the DCI in the 'grey space' commonly found in CAD systems and digital model presentation platforms, such as Sketchfab. Participants could then add elements before being prompted to 'think aloud' and then respond to the semi-structured interview questions. Five elements were selected based on psychological cues associated with perceiving and understanding size and space; three elements were selected to communicate provenance and were divided into place ('where'), a human figure styled for Ancient Egypt ('who') and timeline ('when') scale [26] [6]. Figure 1 shows the 3 DCIs and examples of the CIP tool with a selection of elements generated by the tool.
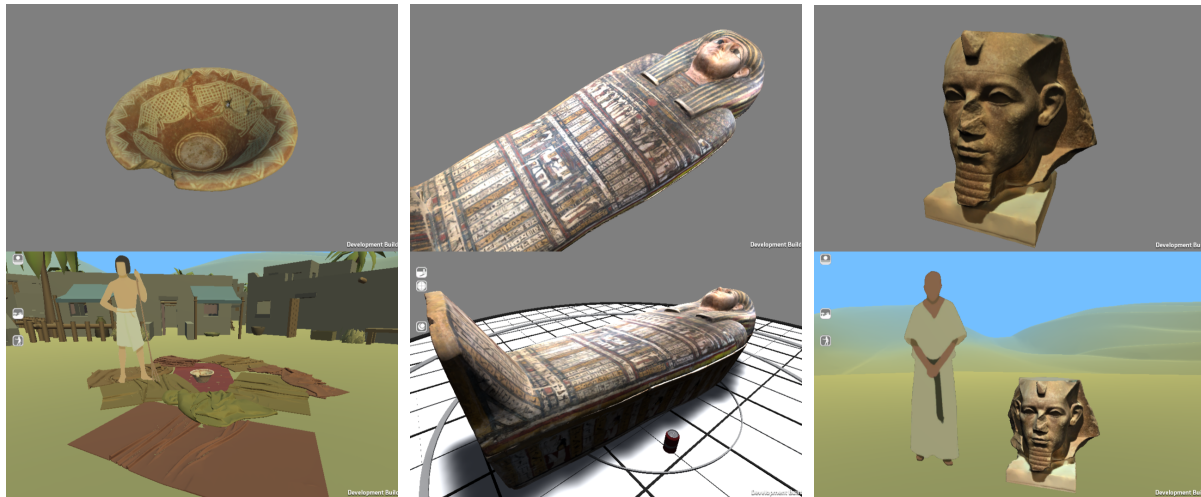
(a) **Top:** Predynastic C-Ware Bowl with Hippos (Originally scanned by danderson4) **Bottom:** Predynastic C-Ware Bowl with Hippo presented using SIT with Context Character, Context Scenery & Time Line elements

(b) **Top:** Coffin Ensemble of Taditjaina (Originally scanned by esciencetuebingen) **Bottom:** Coffin Ensemble of Taditjaina presented using SIT with Perspective Grid, Shadows & Common Reference elements

(c) **Top:** Granite head of Amenemhat III (Originally scanned by The British Museum) **Bottom:** Granite head of Amenemhat III presented using SIT with Atmosphere, Context Figure & Context Scenery elements

Fig. 1. DCIs and examples of presentations using SIT with various elements. All DCIs licensed under Creative Commons Attribution http://creativecommons.org/licenses/by-nc/4.0/. DCI models collected from sketchfab.com

3.2.1 Elements. SIT incorporated a selection of digital elements that acted as 'layers', where a participant could toggle one of these on and off before engaging with a DCI. These elements, their associated psychological cue and their implementation within CIP, are as follows:

- **Occlusion**. The element consisted of numerous digital poles placed in a pattern formed around where the DCI would be presented. In accordance with cue theory, we expected participants to experience occlusion, where the poles would obscure parts of the DCI and, after some experience with the DCI, would better understand a sense of depth relating to the environment and DCI.
- **Perspective**. Referred to by participants as the 'grid disk', this element was included to create 'perspective convergence', where lines are perceived as converging in the distance of an environment, included to further enhance the perspective of depth.
- **Common Reference Item**. This element was included based on the cue of familiar size, where we judge distance based on our prior knowledge of the size of objects. Participants could cycle between a selection of 'common items', including a tennis ball, coke can, laptop, meter and yard ruler plus a pencil.
- **Atmosphere**. Included in accordance with the cue 'atmospheric perspective', where distance objects appear less sharp than nearer objects and often have a light blue tint.
- **Shadows**. This element was included to make the location of the DCI within the environment clearer as well as enhance its three-dimensionality.
- **Timeline**. A graphical indication of time, from past to present, ranging from 5000BC to modern day, designed to communicate 'when' the DCI might have existed.

- **Context Figure**. A 2D illustration of a human figure, themed according to 'Ancient Egypt', included to communicate, 'who' the DCI might be associated with. Each DCI received its own Context Figure.
- **Context Scenery**. Comprising of numerous digital items that together formed a scene, themed according to 'Ancient Egypt'. Included to communicate, 'where' the DCI might have been originally located. Each DCI received its own Context Scenery element.

3.3 Participant DCI experience

Using the SIT tool, 5 tasks were designed for participants to complete:

- **Task 1:** Participants were presented with the DCI with no supporting elements; the DCI was, 'in a grey void', a style of presentation commonly encountered when searching for DCIs online on platforms such as Sketchfab and familiar to those with experience working with CAD tools. Participants were asked to, 'Consider the item for about one minute' while encouraged to voice their thoughts, feelings and reactions, in keeping with the Think Aloud technique. Next, the semi-structured interview questions were presented with participants first asked about the DCI and then about the space surrounding the DCI, specifically with regards to its impact on the presentation of the DCI.
- **Tasks 2, 3 & 4:** These tasks shared the same requirements. Participants were asked to select, by name only, three of the eight elements provided by the study tool. Subsequent tasks required the participant to select three different elements, until the participants had experienced all of the elements available. As with the first task, participants were asked to consider the DCI and encouraged to Think Aloud before they were asked two semi-structured interview questions regarding the elements selected and the impact of the elements on the presentation of the DCI.
- **Task 5:** Participants were asked to select three elements of their choice before considering the item for one minute. As before, participants were encouraged to voice their thoughts, feelings and reactions. Upon completion, participants were asked three semi-structured interview questions regarding the elements selected, their impact on the presentation of the DCI and what, if any, additional elements the participant might add to presentation of the DCI.

4 METHODOLOGY

Our study was structured to gather qualitative data directly from participants as they engaged with a selection of DCIs presented with a variety of digital elements, using a Think Aloud technique both in the moment and also just after task completion, which has been proven useful in eliciting participants' emotional reactions [40].

4.1 Participant Selection Criteria & Coordination

Each participant was contacted either directly on the Bournemouth University campus, online via social groups or through colleague recommendation. Participants were not required to have any specialist knowledge regarding cultural heritage or DCIs. All participants were selected on a first-come, first-served basis with each representing a possible visitor to a cultural institution.

15 participants were selected to achieve data saturation during the thematic analysis, in keeping with [21] [3]. Due to Covid-19 concerns at the time of the study, participants were given the option of face-to-face participation or online participation. Furthermore, the online study offered greater flexibility this way to participants who might find travelling difficult. In the end, participants opted for online participation.

4.2 Study Structure

15 participants were presented with 3 DCIs using the CIP tool and asked to complete 5 tasks, producing 45 discrete DCI interaction data sets. Due to limitations with the CIP tool, the order of tasks could not be changed for each

participant, which could introduce some selection bias. Participants where encouraged to 'think aloud', verbally expressing their thoughts, feelings and experiences. While Think Aloud tasks intend to generate dialogue formed from in-the-moment experiences for recording and analysis, these can be challenging and even uncomfortable for participants who are not used to such techniques [40]. In response, semi-structured interview questions were also presented to participants upon completion of each Think Aloud task.

5 ANALYSIS

Each participant's response to a task was recorded, presenting fifteen hours of audio for transcription. The transcripts were encoded using Exploratory Methods, where the researchers conducted open-ended investigation of the data before carrying out more refined coding passes. The interview transcripts were divided into two stages of coding. The initial stage focused on understanding the data but without creating a structured framework for organizing the results, while the second phase refined and organized the initial codes, resulting in the final codes used for analysis, as described by Saldana [45].

Each code had its own criteria for inclusion which determined if a block of text would be added. When a section of transcription text presented a previously uncoded concept, a new Node, an object in the NVIVO software we used to manage codes, was created with a brief title and description. If the section of text fit under the description of an already existing Node it was assigned to the appropriate Node. During the second stage of coding, the codes were refined and clarified before being divided into positive, neutral and negative blocks at the coder's discretion. The data was coded and analysed using Simultaneous Coding, where blocks of text could occupy different codes if they met the codes criteria for inclusion. The coding information included the number of unique participants involved with each code as well as the number of occurrences (references) each code received.

5.1 Key Themes

What are the benefits of gathering contextual information when presenting a DCI? From the thematic codes generated from our study, we suggest the benefits are a perceived, **Greater realism of the DCI**, an opportunity to, **Generate narrative** and an **Improved understanding of size and scale.** The thematic code **Nothing surrounding the DCI,** which focused on the 'grey void' in which DCIs are commonly displayed when presented online, indicated that participants preferred some form of context rather than none, and the thematic code **Interaction** provides some insight into how experience with analogue cultural items informs our expectation of interaction with their digital cultural counterparts.

5.2 Greater Realism of DCI

The thematic code **Greater Realism** received 111 references from 100% of the participants. References contributing to this code were primarily found under the Shadows element, as shown in Table 1. Participants reported that the Shadows element helped 'ground' the DCI, which made the DCI appear more realistic:

> The **shadows give a considerable amount of realism,** as you see how it interacts with light.

> I chose the shadow because again, **it creates this sensation of I'm in a place,** there's shadow, this object, the scale. Yes, than just this (item) floating in the virtual void.

Interestingly, participants also reported negatively on the Shadows element when the origin of the light source was not visible or aligned with their expectations of where a light source might be found in reality.

The Context Scenery element received the second highest number of positive references, with participants reporting on how the element made their experience with the DCI feel, 'more real' and was often supported by the Atmosphere element in order to create what was described as a 'sunny' or 'summery' feel:

Table 1. Thematic Code: Greater Realism

Positive: Greater Realism of DCI	Participant %	References
Context Scenery	60%	23
Context Figure	33%	8
Shadows	87%	56
Timeline	0%	0
Common Reference	0%	0
Atmosphere	33%	15
Occlusion	0%	0
Perspective	53%	16

> **They give a sense of context.** So, I would say that this item is probably found in the desert, probably, with some ruins, not just in the middle of the desert. **It gives a lot of context and some realism to the image as well.**

> I prefer this atmosphere, **definitely feels like I'm not just in the middle of nowhere. There's a summery feel to it almost,** the idea of the sky being very blue.

The Timeline and Common Item elements received no references, potentially due to the Timeline taking the form of an abstract visual indicator uncommon in reality. The Common Item reference, whilst useful for assessing size and scale, received some criticism due to the nature of the selected items. These items included a coke can, a laptop and a coffee mug that were considered by some participants as idiosyncratic and not in keeping with the theme of 'Ancient Egypt'.

5.3 Improved understanding of Size and Scale

The code **Improved understanding of Size and Scale** received 173 references from 100% of participants, with the Common Item Reference generating the highest total of positive responses. This element provided the participant with a selection of items that might be familiar, such as a coffee mug, meter and yard ruler, laptop and pencil, as shown in Table 2.

Table 2. Thematic Code: Understanding Size

Positive: Understanding of Size	Participant %	References
Context Scenery	27%	7
Context Figure	93%	54
Shadows	0%	0
Timeline	0%	0
Common Reference	93%	83
Atmosphere	33%	15
Occlusion	0%	0
Perspective	53%	16

Participants were limited to guessing the size and scale of the DCI when it was presented in an empty void. The bowl and the sarcophagus DCI provided some indication as to their size and scale due to their human-centric design. Participants reported that the Common Item element greatly helped with understanding the size and scale of the DCI, which contributed to a better user experience and also an improved learning experience:

> **The background definitely added in the concepts of the scale of the object that I'm looking at**, it definitely puts it in the kind of size that I think I was thinking about.

> I think **the context figure is the one that gives me a better impression of the scale, and helps me to see how I'm viewing the object.**

> I like the context figure. I think I've kind of set this up. So I've got a good idea. **I've got two things representing the scale of the object,** but neither of them are trying to tell me anything I don't want and they aren't overwhelming with information.

When criticised, the Common Item Reference element was considered to be 'unrealistic', when displayed alongside the DCI and some participants expressed frustration when they could not orientate the Common Item Reference in alignment with the DCI, so that they might better compare the size and scale.

The Context Figure received the second highest number of references from participants and was often favoured over the Common Item when participants focused on creating a realistic environment for presenting the DCI. Perhaps in response to this effort to create a realistic scence, criticism of the Context figure focused on it being two dimensional, contrasting with the many three dimensional elements and the DCI itself, with participants reporting that it negatively impacted the display of the DCI, decreasing the sense of realism.

5.4 Generate narrative

80% of participants reported that additional contextual elements supported the generation of narrative connected to the DCI, with the thematic code **Generate narrative** receiving 45 references. The two elements that provided the strongest positive response were Context Scenery and Context Figure, as shown in Table 3.

Table 3. Thematic Code: Generate Narrative

Positive: Generate Narrative	Participant %	References
Context Scenery	53%	22
Context Figure	60%	20
Shadows	13%	2
Timeline	7%	1
Common Reference	0%	0
Atmosphere	0%	0
Occlusion	0%	0
Perspective	0%	0

Despite the study not including any set narrative, participants inferred their own relationships and created their own stories from the elements provided:

> The scenery and the figure definitely helps. I love it. I'm just, **I'm living it, because I love being able to see these stories.** And this has a whole story going on right now. **There's a whole scene that plays in front of my eyes right now, so I love it.** The scene in the figure, perfect, definitely helps. I'm so glad it's here.

> **And the woman, I'm assuming has something to do with it. She's obviously got something to do with the sarcophagus.** But I don't know, is that the person in the sarcophagus? **Is that the mother or the caretaker of someone for the sarcophagus? Yes, that's it.**

Perhaps unsurprisingly, none of the more abstract elements were reported to support the generation of narrative. Criticism of the Context Scenery and Context Figure was concerned with aesthetic choices regarding their design, specifically colour choice and density of items within the environment.

5.5 Reactions to nothing

The majority of participants reacted negatively to presenting the DCI within an empty environment, often referring to it as, 'the grey void'. 67% of participants (14 references) supported the 'grey void' surrounding the DCI, reporting that it encouraged them to focus on the DCI.

100% of participants (53 references) reported that the grey void undermined attempts at better understanding the DCI's provenance, its size and scale and negatively impacted the viewing experience:

> The model itself? It's floating in space, somehow, **there's no information in the background, there's nothing to compare it to. So, it's difficult to understand how big this is.**

> It's a feeling, it seemed like I was quite close to it. **So, now this I've got no real sense of scale.**

> And it's a nicer viewing experience, **if the object is not floating in space.**

However, some participants initially reported some benefits to using a 'grey void', specifically a lack of 'distraction' which encouraged inspection of a DCI:

> It focuses my attention on the item because there's nothing behind it. **I'm not distracted by anything else in the background.** So, for inspecting this particular item, I'd say a plain background is good for me.

> So, the fact it's a dark grey makes it easier, I can see that I'm exposed to in the past, like designing items. **So, having that grey background really focuses on this subject.**

This aligns with the origins of the 'grey void', that of CAD programs such as Autodesk's Maya and the open source modelling and animating tool, Blender. Such tools are designed to support digital artists as they work to build digital assets and create animations. The default working environment for such tools is devoid of contextual information and both modelling and animation require continuous inspection of a digital asset.

5.6 Interaction

The thematic code **Interaction** provided insight into how participants expected to interact with a given DCI. For the bowl DCI, 40% (24 references) of participants reported how they wish they could 'pick the item' up in 'their hands':

> I want to zoom right in on it as if I was holding it in my hands. **I want to pick this up and turn it around in my hands rather than move or walk around it.**

> I feel like that would be a more natural interaction. If I were allowed to pick this up, **I wouldn't inspect a bowl by walking around it. I would inspect the bowl by picking it up and turning it around in my hands.**

These responses likely reflect the size and nature of the bowl DCI, something relatively small, hand-held and an item whose analogue counterpart would be picked up and manipulated.

Conversely, 27% (20 references) of participants reported how they expected to 'walk around' the sarcophagus DCI. Contrasting the relatively small bowl DCI, the sarcophagus DCI is larger and heavier, as it is larger than a human body and constructed from stone:

> **It gives me an opportunity to walk around it**, would be how I might proceed, **rather than spinning the object or spinning myself around the object.**

> It definitely feels like I've walked into a burial chamber or something like that. **I want to walk around it using this kind of motion.**

In contrast to the bowl DCI, a visitor is unlikely to expect, or be able to, pick up and digitally manipulate the sarcophagus's analogue counterpart but would instead walk around and visually inspect the cultural item.

Other themes within this code included **Museum**, with 40% of participants (13 references) likening their engagement with a DCI to that of a museum experience, suggesting how we draw upon our previous experiences and associate with the real-world when encountering the digital. A similar theme, one where 27% participants responded (11 references), was that of **Computer Games**, where participants described their engagement with the DCI in terms of a computer game experience.

6 DISCUSSION

The advantages of presenting contextual information when presenting DCIs can be summarised as an, 'improved user experience' consisting of improved realism, a better understanding of size and scale and increased opportunities for visitor-created narratives. Overall, every participant preferred some form of contextual information rather than none, which aligns with the idea that some form of context is required before meaning-making can be initiated [57].

Participants would engage with a variety of elements, adjusting the environment in accordance to their personal preference. Some focused on measuring and bettering their understanding of the digital physicality of the DCI. Others focused on adjusting the digital environment, attempting to reproduce what they considered to be a more 'realistic' scene within which to present the DCI. Most participants settled for a combination of **Shadows, Atmosphere and Context Scenery**, followed by **Shadows, Context Scenery and Context Figure**, with each receiving 34 and 22 references, respectively.

The benefits of providing contextual information, both contextual and physical, [55], provides participants with the opportunity to engage in meaning-making as they engage with the DCI and the elements provided by SIT. In essence, participants were self-motivated, exploring the DCI on their own terms, discovering connections and forming relationships in accordance with the visitor-as-curator model encouraged both in analogue and digital museum experiences [15].

6.1 Contexual elements

Regarding specific elements, a number of insights can be gained by the work carried out in this publication. Overall, participants favoured elements that could make the DCI and surrounding environment appear more realistic. When considering the value of a given element it is important to consider the technical challenges required to create and implement them, as this might impact a CHP or an institution's ability to include them in a cultural heritage project. For example, the Contextual Scenery element generated a considerable number of positive responses from participants but required a specific skill set to create and implement, including an advanced understanding of digital modelling and texturing. In contrast to this, the Shadow element generated a similar number of positive responses but only required a very basic understanding of digital modelling, as it was generated automatically by the CAD software.

The timeline, while abstract in nature, provided simple yet effective context with regards to time. Participants enjoyed relating one DCI with another as well as guessing their individual age. Often, participants would express surprise when their expectations were not met, especially with the bowl DCI which is nearly 5000 years old. Likewise, measuring the size and scale of the DCI generated similar excitement, as participants speculated, then confirmed, their understanding of a given DCI. Even items that presented clues to their size and scale by their design, such as the sarcophagus, an item whose very design must encapsulate a human-sized shape, managed to surprise participants who were amazed at how small a cultural item such as this could be.

The Common Item and Context Figure both served to communicate size and scale. However, while the Common Item promised greater accuracy it was often considered to be, 'out of place'. For the majority of participants, once the element had been selected it was replaced with the Context Figure, which not only communicated the

relative size of the DCI due to its human size and shape but also supported efforts to build a realistic environment within which to present the DCI.

Finally, some issues regarding the elements should be considered. The Context Scenery, whilst popular as both an element that improved realism, generated narratives and supported the understanding of size and scale risked becoming the focus of the participants' engagement, in preference to the DCI. This was most prominent with regards to the bowl DCI, a relatively small digital object that could become 'lost' in the intricacies of its Context Scenery. In this way, creating Context Scenery is similar to real-world exhibition design, where great care is exercised so that contextual elements support, rather than dominate, a cultural artifact on display.

Another issue that was observed is perhaps related to an effect referred to as the 'uncanny valley', where the closer to realism a human face approaches the more likely a viewer is to notice elements that undermine the perceived realism of the face, [49]. Participants became more critical the closer the DCI and its environment approached realism. Participants commented on the disparity in detail between the Context Figure and the DCI, asserting that the abstract art style of the Context Figure did not look 'realistic' when compared to highly detailed three-dimensional DCI. This criticism was also directed at the texturing on the floor of the sarcophagus DCI's Context Scenery as well as the lack of a visible light source when considering shadows.

6.2 Object to Artifact

Initially, when the DCI was presented in a grey void with no contextual information, participants focused on the digital physicality of the item with little to no regard for its provenance or its relationship to the broader historical context, such as its origin or age. When the DCI was devoid of context, participants primarily focused on the object digital physicality, with their attention directed to its details and the quality of the digital model itself:

> **"It piques my interest but it doesn't necessarily affect me emotionally.** But it piques my interest because **it's quite interesting to see all the little marking and how detailed it is."**

> **"You can very nicely see the hieroglyphics on it.** And the different stuff, like you can clearly see Anubis messing with the body parts of a deceased man."

> **"It looks fake. It feels fake. It feels too artificial.** Because, you know, the fact is that it's just floating in the middle of a grey neutral background. It doesn't feel natural. **I mean, naturally bowls don't float in real life. So, it feels too artificial for me."**

The role of narrative in human cognition has been described as a form in which we organize our experience and our memory, one that can lead to drama and believable historical accounts [9]. Likewise, narratives can be said to be one of the most fundamental ways we learn [4] and a powerful tool in the CHPs' tool kit as they seek to create engaging, educational experiences [54]. The addition of contextual information saw the formation of context required to generate narratives and when contextual elements were added, context was established where upon participants began to focus on the narrative role of the DCI, reacting to the the DCI as if it were a real-world cultural artifact, rather than just a digital model:

> "It makes it a lot more on show. **It definitely centralises this object and makes it more of a grand thing, than it already is, because it's the tomb of a dead person.** So, it's already supposed to be quite grand. Especially the Atmosphere and Context Scenery, **it really makes it a centralised object of importance."**

> ''You have this whole video game scene. You can clearly see this is bad news, if you were to stumble across this in a level. Yes, it makes the object look just a lot better.

> **"I do love seeing every item, especially items that I can't touch or interact with in real life**, things that belong in a museum, I love that I can interact with them in a safe way without hurting

them in a virtual scene. **So, I do love and enjoy it more when it feels more realistic, more like I am part of this bowl's day."**

These acts of meaning-making and narrative building suggest an additional mode of interactivity beyond that of inspection. As with our previous study [16], participants reported that they enjoyed 'playing detective' and 'puzzle solving' while interacting with a DCI. There have been many efforts within digital cultural heritage to gamify cultural heritage experiences or create serious games to support engagement with cultural heritage items[41][7]. Many focus on the fundamentals of game design in order to apply them to game making, while including cultural learning opportunities. As this study shows, we can support play by embracing a fundamental design point that drives game design, that of the creation of 'meaningful choice. Presenting DCIs in 'grey voids' might support their inspection as digital items. However, when removed of context, a DCI raises many questions, such as regarding its size, scale, origins and use. By providing contextual and narrative elements alongside a DCI a visitor can choose to interact in new ways as they engage in meaning-making. By presenting DCIs in more than just a grey void we can create an interesting challenge for participants, one that empowers the visitor-as-curator and promises to build long-remembered learning experiences with DCIs.

As our study shows, by providing contextual elements to participants when they engage with a DCI, participants considered the DCI as more than just a digital substitute for an analogue cultural item. Instead, participants considered the DCI as a cultural item on its own terms, with its own story to be discovered.

7 CONCLUSIONS

We started the research work in this publication attempting to answer the following questions: What are the advantages of gathering contextual information when presenting DCIs? How does contextual information information impact the user experience of DCIs? Finally, how can we use contextual information to improve the user experience of DCIs?

We have demonstrated that by including contextual information we can improve visitor interaction with DCIs, their understanding of size and scale and also increase the perception of realism with regards to the DCI. We have explored how giving visitors the choice to customise the contextual elements supporting a DCI supports the generation of narrative, which can be used to engage but also educate. Finally, we have posited that by gathering contextual information when presenting DCIs, we might change how visitors engage with a DCI, shaping through their experiences towards engaging with more than a mere digital copy of an analogue item and towards engaging with a digital cultural artifact.

Research focusing on cutting-edge technologies provides future opportunities for new cultural experiences and it remains important to consider what aspects of curation can improved, despite the challenge of capturing, maintaining and presenting DCIs. It is the authors' hope that the findings of this study can further support designers and serve as a reminder of the importance of including multiple contextual elements when presenting DCIs. Understanding the advantages, the impact of and how we might use contextual information when presenting DCIs, is another step towards supporting CHPs, and all those engaged with cultural heritage projects, create engaging, informative and memorable cultural experiences for their visitors.

8 ACKNOWLEDGEMENTS

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