Context in Space

The Value of Contextual Information in the Presentation of Digital Cultural Items

Christopher J Ferraris

Faculty of Science and Technology
Bournemouth University

September 2024

Abstract

Cultural heritage is an essential component of human history, and its preservation and presentation to future generations are paramount. Cultural heritage practitioners (CHPs) have a vital role in ensuring that cultural items are appropriately preserved and presented to visitors. The rapid advancement of technology necessitates that CHPs continually adapt to provide the best possible cultural heritage experiences.

Generated through the scanning of analogue cultural items such as photographs, paintings, or artefacts, DCIs offer a unique opportunity to conserve cultural information, enhance accessibility via the internet, and provide innovative means of interaction that significantly enriches visitor learning experiences. Despite the potential benefits of DCIs, academic efforts often overlook the value of providing practical guidance on utilising the current technology available to CHPs. This thesis aims to support CHPs by contributing to the body of knowledge to better understand DCIs and how they can be used to preserve and share cultural heritage.

We begin the journey of this body of work with a practical, hands-on project that involved the capture, preparation, and presentation of cultural items by artist Werner Strub in Geneva, Switzerland. This project provided first-hand experience of the challenges faced by CHPs. A series of face-to-face interviews with CHPs was conducted in order to learn about their experience working with DCIs and the challenges they face. The research then explores how contextual information can be used by CHPs to improve their cultural presentations when using DCIs. Using a bespoke tool, the study evaluates the value of contextual information and explores various contextual elements to determine which ones support the presentation of DCIs. Finally, findings are refined and presented as design principles, which are then challenged and refined.

The research reveals several benefits of including contextual information, such as enhanced understanding of the DCI's size, scale, and provenance; more meaningful visitor interactions; increased perceived realism; and an overall improved visitor experience. In addition, the research suggests that incorporating contextual elements, like reference objects or stylised features, enables visitors to engage in self-guided interpretation and meaning-making, leading to a deeper connection with the cultural heritage displayed. This approach also aligns the interaction with DCIs more closely with that of their analogue counterparts, enhancing the visitor experience, through immersion and an improved sense of authenticity.

This thesis addresses a critical issue facing cultural heritage practitioners by examining the role of contextual information in DCI presentation. It offers practical assistance to CHPs who are navigating the constraints of technology, providing actionable advice on how to enrich the conveyance of cultural information to visitors. By embracing the potential of DCIs and the value of contextual information, CHPs can significantly enhance visitors' experiences and preserve cultural heritage for future generations.

Declaration of publications

The paper titled 'Capturing, Processing, and Presentation of Digital Cultural Items: Feedback from Cultural Heritage Practitioners' was presented at the Eurographics Workshop in 2021. It is comprised from data gathered from face-to-face interviews with cultural heritage practitioners and supporting staff, discussing their concerns and challenges related to the creation and presentation of Digital Cultural Items (DCIs). Excerpts from this publication are included in Chapter 3.

The paper titled 'Digital Cultural Items in Space: The Impact of Contextual Information on Presenting Digital Cultural Items' has been published in the ACM Journal of Computing and Cultural Heritage (JOCCH). It explores the impact of contextual information on the presentation of Digital Cultural Items (DCIs). Text from this publication is incorporated into this thesis and contribute to the content of Chapter 4.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

In this thesis, the inclusion of contextual information as impacting the user experience of those engaging with DCIs (digital cultural items). This thesis presents several novel contributions to this research space which are briefly outline below and detailed in the Conclusion section:

- In Study 1 a summary of the challenges and concerns has been collected from cultural heritage practitioners (CHPS) and those that support them in their, 'day to day' work with digital cultural items. This study informs the research direction towards exploring the impact of contextual information on the user experience when presenting DCIs.
- In Study 2 and 3, the Spatial Information Tool (SIT) was design is described and enables the testing of selected contextual elements in order to assess their impact on the presentation of DCIs.
- In Study 2 and 3, a data set has been generated from face-to-face interviews with participants, which analyses the impact of contextual information on the presentation of DCIs.
- Study 3 presents five principles of design for the presentation of DCIs using contextual elements. These principles support the presentation of DCIs using contextual information.

Definitions

Cultural institutions have been exploring ways to incorporate new technologies since their founding. They utilize these technologies in their exhibits and day-to-day efforts to preserve and share cultural information. During the COVID-19 lockdowns, DCIs saw a surge in popularity as cultural institutions sought to capitalize on their increased accessibility compared to their analogue counterparts. However, capturing, processing, and presenting DCIs require specific technical skills that are uncommonly practiced by CHPs. Often, cultural institutions rely on skilled third parties who work alongside them to support CHPs. This relationship is mutually beneficial, since both parties rarely possess the resources individually to make informed choices on how best to present DCIs.

This thesis contributes to the growing academic effort where in UX researchers seek to support CHPs and their institutions by providing presenting cultural information, specifically regarding digital cultural items. Through doing so, it is hoped that CHPs can design and create more informative and engaging cultural presentations.

Cultural Heritage Practitioner (CHP)

Within this thesis, Cultural Heritage Practitioners (CHPs) are defined as individuals who work in the field of cultural heritage preservation, conservation, interpretation, and management. In other works, these individuals can be referred to as heritage practitioners and the terms are used interchangeably across various sources (Byrne, 2008; Kim et al., 2019; UNESCO, 2023).

CHPs perform a vital role in the safeguarding and promoting of cultural heritage, ensuring its preservation and accessibility for present and future generations. CHPs encompass a wide range of professionals, including archaeologists, curators, conservators, historians, educators, librarians, archivists, museum professionals, plus community leaders.

The role of a CHP is multi-faceted and encompasses various responsibilities. They are responsible for the preservation and conservation of cultural artifacts, sites, documents, and also intangible heritage such as songs and stories. CHPs also curate cultural knowledge, presenting collections and creating exhibitions by carefully selecting and organising artifacts and information in order to create meaningful and engaging experiences for visitors. Through their efforts, they bridge the gap between cultural items and their audience by carefully selecting and presenting information to communicate the significance and context of cultural heritage.

Additionally, cultural heritage practitioners conduct research to expand knowledge about cultural heritage. They delve into its historical context, significance, and related aspects, gathering and analysing data to contribute to scholarly discourse and a deeper understanding of cultural heritage. CHPs also contribute towards knowledge sharing and education, designing and delivering educational programs and initiatives to promote public awareness and understanding of cultural heritage in order to foster a sense of ownership and responsibility (Niccolucci et al., 2022; Zandi, 2023.).

Furthermore, CHPs engage in advocacy and policy development. They advocate for the protection, conservation, and sustainable management of cultural heritage. Their contributions aid in the development of policies, guidelines, and legal frameworks that support the preservation and accessibility of cultural heritage for future generations (Costanza-Chock, 2020; Snydman, 2015).

CHPs play a vital role in society as custodians of our shared heritage. Their dedication to preserving and promoting cultural heritage ensures that the cultural knowledge that shapes both our collective identity and our cultural legacy are preserved, for the benefit of present but also future generations.

Digital Cultural Items (DCIs)

Digital cultural items (DCIs) come in many forms and have gained increasing popularity in the cultural heritage sector (Beraldin et al., 1999; Bernardini & Rushmeier, 2002; Di Franco et al., 2015; Levoy et al., 2000; Portalés et al., 2009; Wachowiak & Karas, 2009). Within digital cultural heritage, DCIs can take the form of a photograph of a historical person, a

recording of culturally significant figure or a digitally reconstruction of a cultural site, such as the Roman Colosseum.

We will divide digital items into two categories; those DCIs that are 'born digital' and those that are generated from data collected from analogue items. DCIs that are 'born digital' have no-real world counterpart and include 3D models of Julius Caesar's skull, the recreation of a Native American warrior's battle chant, built from the amalgamation of historical data or a virtual environment populated by animated digital models of popular musicians from the 1980s.

DCIs generated from analogue items have a real-world counterpart and can be created through several techniques, all of which involve capturing data in some form, processing it and creating a digital representation. One such technique is scanning an analogue cultural item to capture surface geometry, texture (which includes colour), and volume of most objects, without contacting an object's surface (Wachowiak & Karas, 2009). It is this latter group of DCIs that are referred to when discussing digital items in this thesis.

Contextual Information

Contextual information includes the supplementary details, background knowledge, and explanations that accompany cultural heritage items, sites, plus practices. This information enhances our understanding of the historical, social, cultural, and artistic contexts of these elements. Cultural Heritage Practitioners (CHPs) often present this information in both textual and visual forms, curating details such as an object's origin, age, and purpose. By incorporating contextual information, CHPs can enrich visitor experiences, crafting engaging narratives through a combination of architectural space, contextual associations, and themed assets.

The Significance of Contextual Information

Preservation and Conservation: Contextual information plays a crucial role in the preservation and conservation of cultural heritage. It assists in documenting the historical and cultural significance of artifacts, sites, or practices, providing valuable data for their preservation, restoration, and future research. This information can guide the identification of suitable conservation techniques and ethical considerations, informing decision-making processes for the long-term preservation of cultural heritage.

Educational and Public Engagement: Contextual information is vital in education and fostering public engagement with cultural heritage. It enables the creation of educational programmes, exhibitions, and experiences that convey the significance and meaning of cultural heritage to diverse audiences. By crafting narratives, interpretive frameworks, and multimedia resources, CHPs can use contextual information to make cultural heritage accessible and engaging, fostering a deeper connection and appreciation amongst both local and global audiences.

Supporting Interpretation: Contextual information provides essential details that help users interpret and understand the significance of digital cultural items. It offers insights into the

historical period, cultural practices, artistic movements, and societal influences that shaped the creation and meaning of these artifacts. Without such information, users may only grasp the surface-level aesthetics, missing out on the deeper layers of cultural significance.

Identity and Community Building: Contextual information can foster identity formation and community cohesion around cultural heritage. It enables communities to connect with their shared history, traditions, and values, fostering a sense of belonging and pride. Cultural heritage, enriched with contextual information, can serve as a tool for community empowerment and the intergenerational transmission of knowledge and values.

Enriching User Experience*:* Contextual information contributes to a more engaging and immersive user experience. It allows users to connect with cultural items on a deeper level, fostering emotional connections and a sense of cultural appreciation. By providing a comprehensive context, users can better appreciate the stories, symbolism, and also messages embedded within the digital cultural items.

The importance of contextual information in cultural heritage lies in its ability to provide a comprehensive understanding, interpretation, and appreciation of cultural artifacts, sites, or practices. It enriches the experiences of visitors, researchers, and communities, enabling them to engage with cultural heritage in a meaningful and informed manner. Contextual information ensures that cultural heritage is not only preserved but also valued, understood plus cherished for its cultural, historical, and social significance.

Contextual Information and the Presentation of DCIs

The absence of contextual information is noticeable when presenting DCIs. These items, with their origins in computer graphics, are prepared for presentation using similar CAD tools. These tools present a user with a "grey void," a neutral space within which a skilled user can build a 3D model. When presented, the DCI is often shown within this same "grey void" or a similar neutral space, devoid of contextual information. This is understandable as DCIs are created by scanning analogue cultural items, so background elements such as setting, and presentation space are not considered a priority and can often interfere with the production process. As such, they are often removed whenever possible.
However, in doing so, DCIs are often presented without essential contextual information that could readily be added to improve a visitor's user experience.

Lack of Interpretive Framework: Contextual information provides the necessary framework for interpreting and understanding cultural heritage. Without it, users may struggle to grasp the historical, cultural, or social significance of the digital items. This absence limits the depth of interpretation and prevents users from fully engaging with the cultural narrative and symbolism embedded in each cultural item.

Shallow Engagement: Contextual information deepens the user's connection and engagement with cultural heritage. It allows users to link digital items to their broader historical or cultural contexts, supporting a richer and more meaningful experience. Without this information, users may only engage with the superficial aspects of the digital items and miss out on the underlying stories, symbolism, and cultural messages they convey.

Limited Understanding: Contextual information enhances the understanding of digital items by providing insights into their origin, purpose, and significance. Without this information, users may struggle to comprehend the cultural, social, or historical relevance of the artifacts. This lack of understanding can potentially impede a user's ability to appreciate the nuances and complexities of the cultural heritage being presented.

Misinterpretation and Misrepresentation: Without contextual information, there is a higher risk of misinterpretation and also misrepresentation of digital items. Users may project their own assumptions, biases, or limited knowledge onto the item, distorting their appreciating of size, scale, intended meaning or historical context. In this way, the absence of contextual information leaves room for misunderstanding and inaccuracies, potentially leading to the perpetuation of stereotypes or misinformed narratives.

Incomplete Historical and Cultural Narrative: Contextual information contributes to the broader historical and cultural narrative surrounding digital items. It can help place a cultural item within a larger context, emphasising its connections to specific time periods, cultural movements, or significant events. The presentation of a cultural item without contextual information can undermine the understanding of cultural heritage and associated narratives, hindering the exploration of its interconnectedness.

RESEARCH QUESTIONS AND SCOPE

This thesis explores the following research question:

- How does contextual information impact the user experience when presenting digital cultural items?

This research question serves as the foundation of this thesis and focuses on understanding the role of contextual information in the presentation of DCIs. It was defined to better understand the role of contextual information in presenting digital cultural heritage items, and how it can enhance the user experience.

The question was developed from an earlier research question, which asked "How can we improve the presentation of DCIs?". This earlier research question was developed in response to Study 1, where CHPs and supporting practitioners were interviewed to better understand the challenges and concerns of those working with DCIs. From these interviews, it was determined that CHPs and practitioners reported a lack of ‘practical' information regarding the presentation of DCIs. As there are many elements that can impact the user experience of the presentation of DCIs, covering them all sufficiently would be beyond the scope of this PhD. Therefore, one specific element was selected to focus on, specifically the role of contextual information and its impact on the presentation of DCIs.

To explore the thesis’ main research question, we will need to identify which contextual elements to include in the presentation of a DCI. We will then need to identify the impact of each selected contextual element on the user experience. To this we will require a tool that can present DCIs both with and without our selection of contextual information. From this process we will define principles of design that can be applied by those presenting DCIs.

Finally, we will evaluate these principles, determining which elements have the greatest impact and potential to improve but also to undermine the user experience.

Thesis Structure

This thesis makes several contributions to the understanding of how to improve the presentation of DCIs using contextual information which are distributed throughout the six chapters that comprise of the document body.

This first chapter has presented the thesis topic and its underlying motivations. Additionally, it identified the research question that this thesis aims to address and has provided an overview of the thesis structure.

The second chapter presents significant related background material beginning with a brief history of cultural heritage and the role of academic research. The chapter then discusses technology, the role of the CHP and curation and the emergence of digital cultural heritage. This is followed by a discussion on virtual museums and digital items, including their creation, preparation, and presentation. The chapter then moves on to the challenges faced by CHPS working on digital cultural heritage projects and including accessibility, the role of interactivity and the challenges of sustainability. The first half of the chapter then concludes with a detailed exploration of the importance of interoperability and shared practice. The second half of the chapter presents the field of UX, and the academic efforts made to further improve UX design theory and practice. Finally, the chapter concludes by bringing together UX and its application to supporting CHPS in the curation of digital cultural heritage experiences.

The third chapter commences with a concise summary of a cultural heritage project undertaken at the start of the PhD. The project involved capturing, preparing, and presenting a selection of DCIs. Through its completion, it was determined that direct interaction with CHPs and their supporting professionals is necessary to gain a better understanding of their experiences in working with DCIs. The chapter then describes the preparation, execution, and analysis of the first major study, in which a series of face-to-face interviews were conducted with CHPs and their supporting practitioners to explore their experiences working with DCIs. From these interviews, challenges and concerns were identified, with one of them being selected for further analysis in subsequent chapters - the impact of contextual information on the presentation of DCIs.

Chapter four details the preparation, execution, and analysis of the second major study that evaluates the impact of contextual information on the presentation of DCIs. To facilitate this study, I designed the Spatial Information Tool (SIT) which is built by a third-party developer. The SIT enables researchers to present DCIs with or without contextual elements to determine their impact on the user experience. Based on the findings of this study, five design principles are developed to aid CHPs in creating cultural experiences using DCIs.

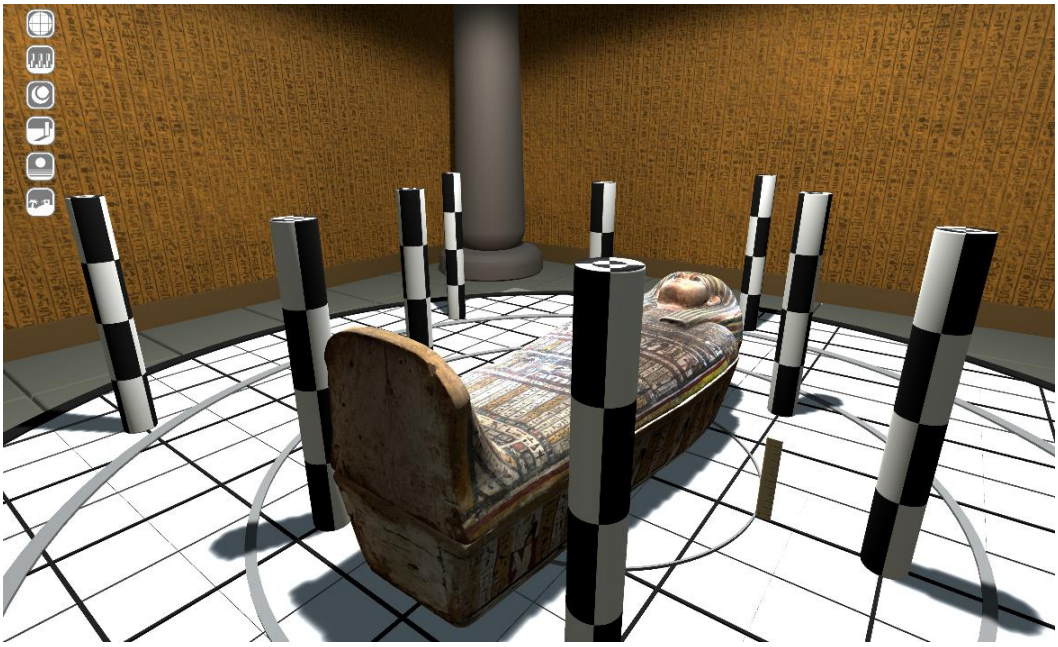

Figure 1: SIT tool displaying DCI with selected contextual elements.[1]

The fifth chapter focuses on testing the assumptions from which the design principles presented in the fourth chapter were formed. Utilising the SIT once more, an online questionnaire was designed which was used to generate both qualitative and quantitative data. This is followed by a complete report analysing and refining the five design principles pertaining to the use of contextual information when presenting DCIs.

The sixth chapter of this thesis provides a comprehensive summary of the research conducted, highlighting its key contributions to the field. In addition, it discusses related publications that were produced during the course of the PhD and how they tie in with the individual chapters. The chapter also outlines potential avenues for future research based on the findings presented in this thesis.

[1] Sarcophagus of Taditjaina taken from Sketchfab creative commons collection, available at https://sketchfab.com/3d-models/coffin-ensemble-of-taditjaina-fc25f30a113d4056b7575686f712ff26, last accessed 21.02.25

Chapter 2

Related Background

Cultural Heritage

Cultural heritage encompasses the preservation, study, and education of artefacts, monuments, buildings, sites, and museums. It includes practices and topics that span the aesthetic, artistic, historical, and symbolic, as well as the ethnological, anthropological, scientific, and social realms ((Pessoa et al., 2009)). Cultural heritage comprises both tangible aspects, such as objects and sites, and intangible elements embedded within cultural and natural heritage sites, artefacts, and monuments.

To better understand cultural heritage, it is essential to explore its origins, trace its development, and examine the reasons and driving forces behind its evolution. The term 'cultural heritage' was not officially used until 1972, with the word 'heritage' being used in its place. However, while the term heritage first appeared in the Athens Charter, where consideration was given to the conservation of artistic and archaeological heritage, no definition was provided (Vecco, 2010). The concept of heritage was first defined through the ideals expressed in the International Charter of Venice in 1964:

> "Imbued with a message from the past, the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions. People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on in the full richness of their authenticity is found".

Early efforts of heritage preservation, which focused on securing sites and items of cultural interest, were undertaken through the creation of legislation to 'protect monuments and works of art' (Prott & O'Keefe, 1984). Heritage was first addressed in international law in 1907, and since the 1950s, UNESCO and other organisations have developed a body of international treaties and texts concerning the protection of heritage (Second International Peace Conference, 1910). This treaty emerged in response to the events of the Second World War, which witnessed the looting and destruction of monuments and works of art. Consequently, the Convention for the Protection of Cultural Property in the Event of Armed Conflict was established in 1954, further reflecting the growing notion that the preservation of cultural heritage was an international responsibility.

Additional safeguards, specifically addressing the need to protect landscapes, natural environments, and took the form of the UNESCO Recommendation of 1962. These efforts continued with the Venice Charter, which attempted to integrate the principles of protection with territorial control, as well as economic and social development (Vecco, 2010). It was not until 1972, with the UNESCO Convention on the Protection of World

Cultural and Natural Heritage, that the expression 'cultural heritage' finally appeared in texts. This convention emphasised the value of preservation and accessibility of cultural information with UNSECO referring to cultural sites, monuments, and items as being of 'exceptional universal value from the point of view of history, art, or science.'

In response to the proliferation of digital technologies, the European Commission supported the ideals of accessibility and preservation through its recommendation for the digitization and online accessibility of cultural material in 2006. At the same time, UNESCO advocated for the digital documentation of heritage collections as a means of preventative conservation and to 'combat illicit traffic' (Navarrete, 2013).

These concepts of 'common responsibility' and 'safeguarding for future generations' underpin heritage practice and represent a concerted effort by institutions and practitioners to establish a legacy that encompassed items, sites, traditions, monuments, and more, for the benefit of both current and future generations. Critically, the value of heritage preservation is considered universal, transcending the confines of a single group(s), people, or nation and recognized as beneficial to all of humanity.
These ideals are further reflected in the UNESCO Recommendation on the Conduct of Archaeological Excavations, adopted in 1956, which states that "the protection of cultural heritage is incumbent upon States, owing to the importance it holds for all of Mankind and as a means of encouraging international cooperation and thus preventing international conflict" (Blake, 2000).

Academic practice

Over the last 40 years, academic heritage research has shifted its focus from cultural items themselves; their classification, conservation, and interpretation to the ways in which they are engaged with and used to create experiences that express notions of identity, culture, and politics. Preservation of the physical, while still important, has evolved into an exploration of what the physical represents, the lessons that can be learned, and the contextual information through which all cultural items are connected to human history in some way.

Early heritage academic efforts are nebulous, being notoriously difficult to pin down and understand exactly what happened, when, and why (Harvey, 2001). On an individual level, we can assert that the human need to collect, the urge to hoard, and the desire to have one's accomplishments recognised both during and after a lifetime have been with us for at least as long as recorded history, (and likely much longer). These primal tendencies have been reflected on a national level, where we find cultural heritage used to glorify a nation's identity, presenting its accomplishments, preserving its legacy through time, and through doing so, attempting to secure its future. Perhaps it is no coincidence that one of the more obvious examples of this application of cultural heritage practice emerged during the rise of nationalism across Europe in the 15th century. Cultural heritage practice was closely aligned with the collective interests of industrialised societies, with a slew of national and international heritage policies, treaties, policies, charters, and recommendations that continued until the mid-twentieth century (Cleere, 2020).

From the 1960s to the 1980s, scholarly efforts increasingly sought to understand the different perspectives that formed the provenance of a cultural heritage item, especially with regards to exploring the philosophies and principles of how cultural heritage could be interpreted, what makes interpretation good, and how it could be improved. These ideas and theories, while almost commonplace today in the cultural heritage sector, were explored in a particularly famous text by Freeman Tilden, first published in 1957, which in turn provided a solid foundation for early cultural heritage studies (Tilden, 2009).

The early 1980s witnessed an increase in global tourism, with holidaymakers travelling across continents and overseas. The tourist sector responded to this influx of travellers, and cultural heritage scholars began to focus on supporting tourism studies, serving to inform the new, emerging identity of cultural tourism (Hewison, 1987; Wright, 2009). Academic attention to cultural heritage studies began to develop in tandem with museum studies, archaeology, and tourism. Heritage and tourism formed a mutually beneficial partnership; academics explored an interesting new frontier of research while the tourism sector enjoyed stamps of authenticity by academia, and heritage items and sites came to represent an authorized version of the past. This relationship between heritage studies and the tourism sector did not escape criticism but continues to this very day (Cranmer et al., 2023; Schmutz & Elliott, 2016)

Around this time, there was a shift by scholars from focusing on heritage items, moving towards an interrogation of heritage through the lens of social and cultural context. This shift can generally be divided into two themes: a focus on the operational, the practical application of heritage, especially to the tourist sector (such as management) (Buhalis, 2000; Leask & Yeoman, 1999; Swarbrooke, 2012), and 'critical' heritage, which scrutinised heritage practice, challenging the 'predatory' way of scholarly research efforts and thinking (Byrne, 1991; Graham et al., 2016; Harrison, 2008; Smith & Waterton, 2013; Tunbridge et al, 1984).

Today, ethics and heritage continue to reflect the trends of society, shifting in response to societal changes, with scholars exploring human rights and social justice (Ireland & Schofield, 2015). Despite the ideals of heritage preservation and intention to provide access to all, the way cultural heritage institutions have acquired and claimed responsibility for cultural items and presented the historical record has been the target of criticism and discontent throughout much of the international community, raising issues of access and ownership (Ireland and Schofield, 2015). Many cultural heritage institutions have attempted to address these criticisms by returning items from their collections, when possible, and improving accessibility further. And while brick-and-mortar cultural heritage institution sites can strive to provide access to their collections, they are limited by the physicality and location. It is then perhaps a boon that technological advancements have provided the cultural heritage sector in the form of digitization.

Technology, Digital Cultural Heritage

Digitization offers news ways for practitioners to preserve and share heritage. The inclusion of computer-based technologies in the cultural heritage sector has increased over the decades, starting with the cataloguing of collections, before moving on to networking

resources between intuitions globally. Efforts continue to explore computer technologies to digitize collections and make them available 'online'.
This integration of technology and cultural heritage has led to the formation of Digital Cultural Heritage and is represented by institutions integrating technology across the sector, from curators sharing cultural knowledge online, the formation of virtual museums, to providing interactive experience with digital representations of cultural items.

Digital Cultural Heritage and Curation

Curation can be described as a collection of skills wherein a cultural heritage practitioner selects, prepares, and presents a cultural item for audience (Wolff & Mulholland, 2013). While in the past, curators were constrained by the physicality of exhibition spaces and visitation schedules, today items can be curated and presented online. Still, much of the curator's role remains unchanged. Cultural content can be presented and used in a variety of ways, and it is the role of the curator to tell a story, framed by the items and sites managed by their given institution.

A curator is an expert in each field, be it Ancient Greek vases or contemporary pop music and this expertise is applied to selecting what cultural elements are required to create a given narrative. The narrative can be conveyed explicitly, through verbal, audio or textual means or it can be suggested at through association, as the curator makes use of proximity and placement to form context within an exhibition space. Increasingly, especially with regards to museum exhibitions, there has been a move towards interactivity, following the Constructivist views of learning, where in the curator carefully selects cultural items and presents them in a way where in the visitor can choose how they engage, participate in meaning-making and learn (Dewey, 1933;Hooper-Greenhill, 2020).

Virtual Museums

Museums, and by extension their digital counterparts, are considered learning environments, where users can engage in informal learning (Falk et al., 2007; Hooper-Greenhill, 2007; Walker, 2008). The study of virtual museums, while we can position it within digital cultural heritage research, is specifically tackled by researchers engaged with museology. Museology has shifted from focusing on museum exhibits to understanding the experience of visitors in the museum. Museology views the museum as an education tool, echoing the ideals discussed earlier as they act in the service of society (Vergo, 1997).

With advances in communication technologies providing the world with internet and digitisation technologies supporting the generation of digital cultural items, digital cultural heritage has seen the creation of virtual museums, sites for cultural heritage experiences that were first introduced by André Malraux in 1947, where he proposed the concept of an imaginary museum, one without walls, physical location or spatial boundaries (Malraux, 1947). Virtual museums have been defined as:

> "..a logically related collection of digital objects composed in a variety of media, and, because of its capacity to provide connectedness and various points of access, it lends itself to transcending traditional methods of communicating and interacting with the visitors being flexible toward their needs and interests; it has no real place or space, its

objects and the related information can be disseminated all over the world (Schweibenz, 1998). '

According to the International Council of Museums (ICOM), virtual museums can be classified into three categories: the brochure museum, the content museum, and the learning museum (of Museums, 2007). The brochure museum serves as a marketing tool, providing basic information about the museum, such as location, opening times, and event schedules. The content museum, on the other hand, focuses on presenting detailed information about the museum's collections in an object-oriented manner, typically connected to a database. Finally, the learning museum is a website that offers one or more educational experiences in a context-oriented manner based on the visitors' backgrounds and needs. Some argue that the goal of the museum is to encourage the user to return for future experiences, and through doing so build a personal relationship between user and museum. It is this definition of virtual museum that this thesis will be focusing on.
Virtual museums offer the opportunity to both preserve and increase the accessibility of cultural information. They can both promote real-world museums, augment real-world museums, and stand alone as discrete sites of cultural learning (Carrozzino and Bergamasco, 2010).

Virtual museums enrich the cultural educational experience by promising and presenting opportunities for interaction that are not possible within their real-world counterparts. Due to their accessibility, users gain control of the learning experience, choosing when and often how to engage with heritage items. Presenting themselves as virtual environments, virtual museums are highly customizable, capable of being built to support and even adapt the learning needs of an individual user and can encourage communication and interaction, between curators and users. They provide novel approaches to engage visitors in new personalised experiences, responding to a user's learning style and interest (Mundy and Burton, 2013). While engaged with a virtual museum a user that prefers images over text can focus on visual media, while another user might prefer to access and read textual information at their leisure. Additionally, repeated interactions can be built to provide additional and added information each time a user access a given cultural item, promoting engagement (Oberlander et al., 2008).

Academic scholars studying virtual museums have also explored the how computer games might influence their design and the experiences they present. This is not surprising as superficially, computer games share a lot of similarities with virtual museums; they can be designed to respond the users' (or players') needs, plus present information and promise to entertain through the delivery of a digital experience. The main strength of integrating game design practices into virtual museums is the communication of learning goals, visual expression of information, the potential for multi-user experiences, improved interactivity and learning via entertainment (Paliokas and Sylaiou, 2016; Zyda, 2005).

However, the development of computer games is notoriously time consuming, and the development of computer games that successfully engage their users is even harder still. While academic scholars have sought to, 'copy and paste' elements from computer games and apply them to virtual museum design, far too often they do not fully commit to the design practices employed by game designers, resulting in digital experiences that are lacklustre and missing the appeal of their computer game counterparts (Sylaiou et al., 2017).

Digital Cultural Items & Cultural Heritage

The process of creating a DCI involves converting analogue items, cultural sites, or information into digital formats, enabling their preservation, dissemination, and accessibility through digital platforms such as websites, databases, virtual museums, or interactive applications (Ferraris et al., 2021; Niccolucci et al., 2022). This process helps reduce the risks of physical deterioration, loss, or damage, ensuring that cultural heritage is safeguarded for future generations. Digital formats also promote accessibility, as DCIs can be shared through the internet globally, transcending geographic and temporal boundaries(Ferraris et al., 2021; Harvey, 2001; Selmanović et al., 2020).

DCIs facilitate documentation and research activities. They serve as valuable resources for scholars, researchers, and cultural heritage professionals, offering extensive and easily accessible collections for study and analysis. Digital platforms provide tools for organising, cataloguing, and managing cultural heritage data, enabling efficient research and knowledge dissemination (Dragoni et al., 2017a; Kim et al., 2019; Mi & Pollock, 2018). DCIs can also be used to promote public engagement with cultural heritage by providing opportunities for diverse audiences, including those unable to physically visit cultural sites or museums, in order to access and engage with heritage objects and knowledge remotely (Selmanović et al., 2020). Moreover, digital platforms can offer interactive features, immersive experiences, and educational resources that generate interest, understanding, and a connection with cultural heritage, fostering a sense of ownership (Clini et al., 2018; Rodriguez Echavarria et al., 2021).

Furthermore, DCIs facilitate global cultural exchange and collaboration. They enable the sharing of cultural heritage between institutions, researchers, and communities across borders, encouraging collaboration, comparative studies, and the exploration of interconnectedness among different cultures. DCIs can be utilised in crowd-sourcing initiatives, inviting public contributions and collective interpretation of cultural heritage (Machidon et al., 2020; Navarrete, 2013; Rongqian Ma, 2022). They can also provide opportunities for creative and interactive storytelling, incorporating multimedia elements, virtual reality, augmented reality, and other emerging technologies. Such innovations promise to improve the user experience, making cultural heritage more accessible, engaging, and relevant to users(Bedford, 2001; Vrettakis et al., 2019; Wolff et al., 2012).

The importance of DCIs in cultural heritage is its ability to increase access, promote preservation, facilitate research, foster engagement, and encourage innovation. DCIs connect the physical and digital, ensuring the continuity, appreciation, and relevance of cultural heritage.

Creating a DCI

The specific focus of this thesis is on DCIs generated through the process of capturing digital information from analogue items through digital scanning to produce 3D digital objects. Various digital scanning techniques are utilised to create these digital items, each offering unique advantages and disadvantages. Amongst the most commonly used techniques are structured light scanning, laser scanning, and photogrammetry (Ferraris et al., 2021, 2023).

Structured light scanning involves projecting patterns onto the surface of the object and capturing the distortions caused by the patterns. One advantage of structured light scanning is its ability to capture intricate details and textures with a level of accuracy higher than both laser scanning and photogrammetry. However, structure light scanning is impacted by lighting conditions which can make capturing reflective or transparent surfaces accurately a challenge.

Laser scanning, on the other hand, utilises lasers to measure distances and create a point cloud that represents the shape of the object. This technique is known for its speed and precision in capturing complex geometries and is particularly effective in capturing large-scale objects and architectural spaces. However, laser scanning can struggle when trying to capture fine details and textures.

Photogrammetry relies on capturing multiple photographs of an object from various angles and using specialised software to build a 3D model. This technique is accessible and cost-effective, as it only requires a camera and appropriate software. Photogrammetry is versatile and can be used to capture a wide range of objects, from small artifacts to large structures. However, it can be sensitive to changes in lighting conditions and has trouble capturing reflective or transparent materials, such as glass or certain metals.

DCIs & Authenticity

Creating a Digital Cultural Item (DCI) often presents an intriguing challenge in maintaining authenticity. This involves preserving the integrity and essence of cultural items, narratives, traditions, and practices while incorporating innovation and digitisation to enhance user experiences (A. S. Lee et al., 2019; Vrettakis et al., 2019).

Take, for instance, the digitisation of globes, which are spherical maps of the Earth. Institutions like the British Library house many of these globes, some dating back hundreds of years. Due to their fragility, digitisation, often achieved through photogrammetry, is essential for their preservation (Ferraris et al., 2021).However, a globe map consists of two key components: the globe itself and the stand that supports it. The stand includes a rod that passes through the globe, securing the entire item by capping itself at both ends.

While the globe represents valuable cultural information, the cap, rod, and stand are often not deemed significant enough to capture. Removing the stand leaves a hole in the globe map, leading to the question, 'What to do with the hole?'. One might choose to ignore it, but this could be unsightly if the globe is to be presented to an audience. However, if the

practitioner opts to 'fill' the hole, can we still consider the DCI 'authentic'? After all, it has been modified, with the data that was so carefully captured and preserved now subject to the practitioner's discretion.

In terms of preserving the authenticity of DCIs, there is an argument to be made that focuses on the balance between opportunity cost and benefits. While practitioners might need to modify the data captured from a cultural item, potentially challenging its authenticity, the advantages of making digital cultural items accessible can outweigh the cost. Some liberties may need to be taken with their presentation, while ensuring the captured data is stored for future works.

Cultural Heritage Practitioners (CHPs) must grapple with the dilemma of preserving cultural authenticity while enhancing the digital experience. The decision of what to include in the DCI requires careful consideration, striking the right balance between preserving the original analogue item and providing a comprehensive and engaging digital representation.

Challenges of Digital Cultural Heritage

Access to skills

Understanding how to incorporate new technologies into cultural heritage practice is only part of the challenge. Each new technology demands the application of an, often specific, skill set and accessing these skill sets has proven problematic. Few cultural heritage practitioners enter the cultural heritage sector with the dream of digital modelling or developing databases. Sharing skill sets has formed a critical part of cultural heritage sector practice, with initiatives such as 'Glam Labs' forming a vital forum for knowledge exchange on new practices and technological developments. However, being informed of new technologies does not impart training in using them. As a result of this, cultural heritage institutions are often driven to seek essential skill sets from third party practitioners.

Accessibility & Interactivity

Digital cultural items support their analogue counterparts. They provide a record, through the raw data from which they are generated, that can be used to reproduce, and thus secure cultural information which can be shared with future generations, long past the degradation or destruction of their analogue counterparts. And while questions of authenticity might linger, they appear to have the advantage in this regard over their analogue counterparts, specifically in terms of accessibility and interactivity.

An analogue cultural item typically requires a real-world location, in which it might be stored and protected. These real-world locations, often cultural institutions (but not limited to) are by their very nature sited somewhere on the planet, being firmly rooted in the physical world. Accessing such cultural institutions is then a matter of geography and mobility and presents a challenge to many potential visitors, in terms of the cost of transportation and time.

In contrast, digital cultural items can be accessed by theoretically anyone with a computer or mobile device. This level accessibility aligns with the ideals of heritage, as first espoused and codified in law and convention and offers an opportunity for sharing cultural information globally. Furthermore, copies can be made of digital cultural items, which can be studied, shared or even incorporated into other digital systems, such as computer games (Ubisoft, 2007).

This level of access is unprecedented in the history of cultural heritage, but it also provides another benefit which aligns with the other core value of heritage, that of preservation. Whilst institutions take great efforts to secure their digital collections, the accessibility of digital cultural items leads to their proliferation around the world, with copies stored on the hard drives and storage devices on universities, private companies and the public. This decentralisation of digital cultural data, while not perfect, affords another level of protection unavailable to their analogue counterparts.

Interactivity

Analogue cultural items are, by their very nature, unique and thus often irreplaceable. While some items might share an origin or similar aesthetic, each will have its own provenance. Naturally, institutions and curators invest considerable time and resources in protecting their analogue cultural items, which includes the implementation of common-sense practices, such as not allowing anyone other than trained experts from interacting with a given analogue item.

DCIs, being near-infinitely replicable and potentially replicable, are not constrained by such measures. Their digital nature supports interaction experiences that their analogue counterparts could not risk providing. A user can rotate and pan a DCI to better inspect facets of its design and structure and they can zoom in and out, either by moving the camera in relation to the DCI or by virtually moving the DCI closer or farther away. Due to the level of fidelity that can be registered with modern capturing technology, a user can even zoom into a DCI to view elements that are not or barely visible to the human eye, supporting the inspecting of strands of fabric, cloth, fingerprints in clay and other details.

Beyond this support for inspection, DCIs can utilise physics simulation systems, available through game engines such as Unreal Engine and Unity, to provide novel interactions. Users can 'drop', 'throw' and even 'break' DCIs within virtual environments, allowing them to explore qualities such as mass, fragility and structure. In addition, when combined with immersive technologies such as virtual reality, users can, 'walk' around, upon the the surface or even inside a DCI. Furthermore, interactions with DCIs are not limited to a single user and can instead include multiple participants, forming collaborative learning experiences.

Sustainability

Collaborations with third party practitioners has been with considerable success and has resulted in a 'cottage industry' of technologically skilled experts providing their services to the cultural heritage sector. However, without the in-house skill sets essential for maintaining digital projects, institutions have two choices. The first, and the least feasible, is to retain the services of a supporting professional. This represents a long-term commitment and with it, a long-term cost that is often beyond the capacity of most institutions. The other option is to train cultural heritage practitioners in an effort to move the required skill sets,

'in house'. As such, skill sets can take years to develop and as many cultural heritage practitioners are reluctant to engage in practice outside of their job remit, this is not very popular or viable.

A misconception regarding DCIs is that they are permanent and are somehow not subject to entropy. While compared to their analogue counterparts DCIs do promise increased resilience to the wear and tear associated with the passing of time, out-dated versions of technology, retired code, terminated websites, and software entropy which can all threaten to undermine DCIs, in what is often referred to as, 'bit rot'. Likewise, one of the challenges faced by institutions with extensive collections of analogue cultural items is one of storage. Due to their digital nature, DCIs can circumvent these issues of physical storage. However, DCIs still require hardware to support their existence, and such hardware must be carefully managed and maintained to avoid data corruption or loss.

Interoperability, Shared practice

Another challenge facing digital cultural heritage is that of interoperability. With the advent of computing and communication technologies, efforts were made to share cultural knowledge, though early efforts were challenged due to a lack of shared practice. Institutions were gathering, collecting, annotating and cataloguing their collections in their own way with little effort made to adopt common practice. The result of this was, when institutions reached out to share their collection, the realisation that a common ground needed to be built. Even today, despite efforts made by groups such as the International Image Interoperability Framework (IIIF), this common ground, essential to promote accessibility between cultural heritage groups, remains fragile, with constant effort required to maintain and preserve standards.

User Experience Design & Research

UX revolves around people, specifically their experiences, and systems. The field of UX has proven highly adaptable and its techniques can be applied to many scenarios and thus found in practically every sector and industry where designers must facilitate the needs of human users. UX practices have been adapted to wide range of practical applications, from theme parks (Hamid, 2021; Trischler & Zehrer, 2012), to the developing of digital avatars of videogames (McArthur, 2017).

Where it is important to understand the experience of a user engaging with a system, UX practices can, and have, been adapted, and applied. UX study, the practices and theory from which it has evolved from, draws on a range of academic disciplines including psychology, sociology/anthropology, and industrial design (Rusu & Rusu, 2007), each in their own way exploring the philosophies of 'experience'. UX is then the natural extension of these efforts in any understanding required, focusing on the hedonic qualities of experience, such the sensual, cognitive, emotional, aesthetic and the ethical (Forlizzi & Battarbee, 2004; Pettersson et al., 2018).

The origins of UX can be traced back to the Human Factors Engineering Department of Bell Labs, established by John Karlin in 1947. The Department focused their efforts on understanding user-orientated design, evolving design practices to mark the rise of

behavioural analysis with systems. Understanding experience is a critical issue for a variety of professions, especially design. During the formative days of what would become UX research, Lauralee Alben sought to define the qualities which constituted an 'experience' (Alben, 1996). Alben cited her research within interaction design, with a focus on user sensation, understanding how things work, the user's feelings during usage and their achievement of goals while engaging with a system.

It was Donald Norman who first coined the term 'User Experience' while working at Apple, in their User Experience Architect Office. For Norman, studying useability was not enough and it was in his book, The Psychology of Everyday, where he began to codify a character of design practice that was to be included at all stages of the design process and cover, 'all aspects of a person's experience with a system, including the industrial design, graphics, the interface, the physical interaction, and the manual' (D. Norman, 2002; D. A. Norman, 1988).

HCI, UX

UX and usability are interconnected yet distinct concepts within the field of Human-Computer Interaction (HCI). While both aim to enhance the user's interaction with a system or product, they differ in terms of scope and objectives. Usability primarily focuses on the effectiveness, efficiency, and satisfaction with which users can accomplish specific tasks within a system (ISO 9241-11, 2018). It emphasizes factors such as ease of use, learnability, and error prevention in the design of interactive systems. Evaluation methods, such as usability testing and heuristic evaluation, are employed to assess and improve the efficiency and effectiveness of user interactions ((Nielsen et al., 1990, Nielsen 1994.Nielsen, 1993).

However, researchers and practitioners within the field of Human-Computer Interaction (HCI) have increasingly recognized the limitations of the traditional usability frameworks. It fails to fully capture the complexity and subjectivity of the user experience (Law et al., 2009). UX represents a shift in HCI towards considering the human aspect within the interaction. This broader perspective includes aspects such as hedonic qualities, sensory experiences, cognitive processes, emotional responses, aesthetic considerations, and ethical dimensions (Pettersson, 2018; Showcase et al., 2004) UX design aims to create meaningful, engaging, and enjoyable experiences for users by considering their goals, expectations, and contextual factors (Preece, 2015). It involves understanding the user's motivations, desires, and the overall impact of the interaction on their satisfaction and well-being.

It is recognised that UX is dynamic and multidimensional, influenced by personal, social, and cultural factors (E. L. C. Law et al., 2009). Context plays a crucial role in understanding and interpreting UX, as the user's goals, expectations, and environmental factors contribute to their overall experience. UX encompasses the user's entire experience and perception, including their emotions, attitudes, and subjective evaluations during and after interacting with a product or system (Hassenzahl, 2018; Hassenzahl and Tractinsky, 2006; E. L. C. Law et al., 2009).

Differentiating between UX and usability is crucial for designing products and systems that not only function effectively but also provide satisfying and engaging experiences for users. The focus of HCI questions has evolved from "How does a user do this?" and "How can we

improve a user's doing of this?" to questions posed by UX, such as "Why does a user do this?" and "How can we improve the doing of this for the user?"

Defining UX

Scholars have grappled with the complexities of defining UX due to its subjective, multidimensional nature(J. and F. S. Forlizzi, 2000.; E. Law et al., 2008; E. L. C. Law et al., 2009; Preece, 2015). Some have even questioned the value of UX, compared to established concepts such as usability, ergonomics, and user acceptance(Barcenilla, 2009). This lack of consensus also arises from the diversity of perspectives, contexts, and user preferences that shape overall experience. Due to the multidisciplinary nature of UX and study of 'fuzzy' evolving' concepts (E. L. C. Law et al., 2009), there remains an active discussion as to how we might define UX (Bargas-Avila and Hornbæk, 2011; Hassenzahl & Tractinsky, 2006; E. Law et al., 2008; E. L.-C. Law et al., 2009; Robinson et al., 2018).

Tractinsky highlights the role of aesthetics in shaping user experience. The aesthetic appeal of a product or system contributes to the overall user experience, influencing their perceptions, attitudes, and satisfaction (Tractinsky, 2004). Aesthetics encompass visual design, layout, colour schemes, and other sensory elements that contribute to the overall impression of a product. Norman emphasizes the significance of emotional reactions and experiential aspects in understanding user experience (D. Norman, 2002). Emotions play a crucial role in shaping user perceptions and engagement with interactive systems. Norman also suggests that the design of interactive systems should elicit positive emotions and create a pleasant and engaging user experience.

In addition to aesthetics and emotions, temporal factors, including overall judgement and physiological reactions, are integral to the conceptualization of UX. Overbeeke, Monk, and Wright underscore the significance of incorporating these temporal dimensions when evaluating the user experience (Blythe, 2003; Monk et al., 2002.). The overall judgement that users form regarding a system is influenced by their cumulative experiences over time. Moreover, physiological reactions offer valuable insights into the affective and cognitive aspects of the user experience, providing a deeper understanding of users' emotional and cognitive engagement with interactive systems. By considering these temporal dimensions, researchers and practitioners gain a more comprehensive perspective on the multifaceted nature of UX and can better design interactive systems that cater to users' evolving needs and perceptions.

UX has been described as, 'All the aspects of how people use an interactive product' (Alben, 1996), as a 'users' judgement of product quality arising from their experience of interaction' and 'the product qualities which engender effective use and pleasure.' (Alben, 1996; (Sutcliffe, 2009;McNamara and Kirakowski, 2006). Progress towards an agreed definition of UX was made during a roundtable involving 30 experts from industry and academia (Roto et al., 2011). Ultimately, it was reasoned that there is no one definition of UX that suits all perspectives, but a description of UX could be agreed upon. The panel divided UX into three discrete categories: as a phenomenon, a field of study, and a practice. They concluded that UX specifically pertains to the interaction between users and systems. This is considered a subset of the broader concept of experiences, which includes aspects like customer, brand,

or consumer experiences. In addition to this, it was recognised that prior experiences with a system can impact the user experience, that UX is rooted in a social and cultural context and that while they can impact the user experience, UX is more than the study of interface design, cognitive task analysis or usability testing.

Critically, the panel provided definitions which help distinguish between 'experiencing' and 'use experience'. The former encompasses the 'moment to moment' encounter between a user and a system, subjective and personal to each user, while the latter presents 'experienced' as the memories and outcomes generated from a complete encounter between one or more users and a system.

UX Research Methods and Evaluation

Within the field of UX, a diverse range of theories, models, and frameworks comprising over 36 unique approaches have been identified (Lesselroth et al., 2020). However, an exploration of every approach would require considerable coverage to describe in detail and would be out of scope for this thesis. However, we can explore the role of a selection of qualitative and quantitative research methods and how they are applied by UX researchers.

UX researchers utilise a combination of qualitative and quantitative research methods to decipher insights about user experiences. Qualitative methods are integral in comprehending users' subjective experiences, motivations, and requirements. They offer a more profound understanding of the contextual factors that influence user interactions with digital systems (Roto et al., 2016). Such methodologies facilitate the discovery of design opportunities, identification of usability problems, and the development of user-centric solutions. Tools such as interviews, contextual inquiries, and ethnographic studies equip UX researchers with the capability to glean rich and comprehensive insights into users' experiences.

Interacting directly with users to understand their viewpoints allows researchers to uncover subtle aspects of user experience that may elude capture by quantitative methods (Hassenzahl, 2010). In contrast, quantitative methods, deliver objective and statistically sound data that can be analysed to pinpoint trends, patterns, and statistical correlations. They empower researchers to measure user performance, evaluate the impact of design, and assess the effectiveness and efficiency of the UX (Lai-Chong Law et al., 2014). Using surveys, questionnaires, and behavioural analysis, researchers can gather numerical data to expose trends, patterns, and statistical relationships. Thus, quantitative methods provide researchers with the means to assess the efficiency and effectiveness of UX designs, evaluate user satisfaction, and make data-driven design decisions.

However, the work of UX researchers has occasionally been criticized for lacking meaningful contributions. Bargas-Avila and Hornbæk contend that a significant number of studies do not offer fresh insights, often reiterating well-established findings or focusing merely on the superficial aspects of UX (Bargas-Avila and Hornbæk, 2011; Tuch et al., 2012). They propose that UX researchers should incorporate advanced methodologies and theoretical frameworks, underlining the importance of a comprehensive approach to UX research. They also highlight the necessity of considering contextual elements like the user's social and

cultural background, and integrating theoretical perspectives from fields such as psychology, sociology, and other related disciplines.

Usability testing and user feedback in UX

We have discussed the role of quantitative and qualitative methods in UX research and shown how, while each has its merits, UX researchers benefit from adopting a holistic approach through their combination. In the realm of UX research and evaluation, usability testing and user feedback collection techniques play a vital role in understanding and enhancing the usability of interactive systems. For this thesis, a synthesis of some of the relevant literature provides insights into various aspects of these techniques and their implications for UX practitioners.

Think-aloud protocol

Usability testing plays a pivotal role in identifying usability issues by observing user interactions, collecting feedback, and analysing user behaviour. Central to the core philosophies of UX, the user is given a central role in the design and evaluation process. One form of usability testing that was incorporated in two of the studies within this thesis was that of the, 'think-aloud' method (Als et al., 2005; Fan et al., 2019). The think-aloud protocol participants verbalizing their thoughts and actions in real-time as they engage with the interface being tested (Lewis, 1982). This protocol provides immediate insights into participants' cognitive processes and decision-making during the interaction. However, it may lead to increased cognitive load for participants, potentially affecting their performance and potentially introducing biases due to the simultaneous cognitive and verbal tasks(Abdel Latif, 2019; Als et al., 2005; Fan et al., 2019; Li et al., 2012) .

> **The retrospective think-aloud protocol**, in contrast, requires participants to perform the task silently first and then recall and verbalize their thoughts and actions afterward. This approach reduces the cognitive load during the task performance phase, allowing participants to focus on the task. However, it relies on participants' memory and may result in recall bias or incomplete information, impacting the accuracy of the collected data (Als et al., 2005; Fan et al., 2019).
>
> These protocols can be combined to form a hybrid approach that combines elements of concurrent and retrospective think-aloud where participants are encouraged to think aloud during critical or challenging moments of the task, while remaining silent for the rest. This protocol aims to strike a balance between capturing real-time thoughts and minimizing the cognitive load on participants. It provides insights into both immediate reactions and subsequent reflections (Als et al., 2005; Fan et al., 2019).
>
> As we have covered, a key challenge with employing think-aloud protocols is the impact of cognitive load and distraction caused by verbalization. Retrospective think-aloud protocol can potentially mitigate the negative effects of concurrent think-aloud protocol, though it is reliant on a participant's memory. Researchers have

explored ways to overcome these challenges, using screen capture, eye-tracking, and other technologies, such as logging tools that can be used to record system events, user actions, and timestamps during think-aloud sessions (Fan et al., 2019; Gerjets et al., n.d.; Li et al., 2012).

Screen capture enables researchers to record participants' on-screen activities during usability testing. It provides a visual record of user interactions, enabling researchers to observe participants' on-screen behaviours, decision-making processes, and navigation patterns (Li et al., 2012). By synchronizing screen capture with audio recordings, researchers can analyse the correlation between participants' on-screen actions and their verbalized thoughts, facilitating a comprehensive analysis of the user experience. Screen capture helps identify usability issues, inform design improvements, and enhance the overall understanding of the user interface.

Eye-tracking data enables the collection of information about participants' visual attention, revealing where their gaze is directed on the screen. Combining eye-tracking data with think-aloud verbalizations offers a more comprehensive understanding of cognitive processes, mental workload, and visual attention patterns, contributing to a richer interpretation of think-aloud data (Bergstrom et al., n.d.).

Logging tools allow researchers to track user actions, and timestamps during think-aloud sessions. These tools complement think-aloud verbalisations by capturing a detailed sequence of actions and interactions. The reconstruction of participants' experiences enables more thorough analyses, facilitating an enhanced understanding of user behaviour and informing iterative design improvements (Fan et al., 2019). By employing these advanced techniques, the challenges of cognitive load, distraction, and reliance on memory in traditional think-aloud protocols can be mitigated.

Surveys, interviews, and observational studies

Surveys, interviews, and observational studies are fundamental research methods by UX researchers to gather insightful data and gain a comprehensive understanding of user experiences. Each method offers unique advantages and contributes to the holistic examination of user perspectives, preferences, behaviours, and needs.

Researchers can employ surveys to collect of data from a large sample of participants using standardized questionnaires or online forms. This method allows researchers to gather data on user opinions, satisfaction levels, preferences, and demographic information. Surveys provide statistical information, enabling the analysis of patterns, trends, and correlations among variables of interest. They offer a broad perspective on user perceptions and can generate quantitative insights that inform decision-making processes (E. L. C. Law et al., 2009). However, surveys have their weaknesses. They often provide limited depth of insights due to predefined questions and answer choices, leading to a lack of detailed participant responses. Response bias and social desirability bias can affect the accuracy of data collected. Surveys may not capture social or cultural contextual information or non-verbal cues, limiting the understanding of user experiences (Gove and Geerken, 1977; Lallemand et al., 2015).

On the other hand, interviews facilitate in-depth exploration of user experiences by engaging participants in one-on-one or group discussions and allow researchers to delve into users' thoughts, motivations, and subjective interpretations of their experiences. Through open-ended questions and active listening, researchers can uncover rich and nuanced insights into user behaviours, needs, pain points, and desires (Wilson, n.d.). Interviews provide the opportunity for probing and follow-up questions, allowing for a deeper understanding of user perspectives and enabling the discovery of underlying motivations and emotions. However, like surveys, interviews have the potential to present challenges to UX researchers, including bias and subjectivity in participants' responses, limited sample size, interviewer influence on participant answers, recall bias, interpretation complexities, time and resource constraints plus and potential limitations in generalizability (Rubin & Rubin, 2011).

Observational studies involve direct observation of users in real-world or controlled settings, without intervention or manipulation. By closely observing users' behaviours, actions, and interactions with products or interfaces, researchers can gain first-hand insights into their natural behaviours and experiences (Kuniavsky, 2003). This approach can reveal usage patterns, challenges, and usability issues that may arise during real-world interactions. One of the advantages of observational studies is that they can take place in laboratory environments and on-site, in field settings, or through remote methods such as screen recording and user tracking, the latter of which proved essential for many researchers during the COVID-19 pandemic. Again, like the other methods discussed, observational studies are not without their challenges, which can include observer bias, limited generalisability, subjective interpretation, ethical considerations, the influence of the visible observer, the Hawthorne effect, and time/resource constraints (Adair, 1984; J. Jones and Smith, 2017; Song & Chung, 2010).

Evaluation frameworks and metrics

Evaluation frameworks and metrics play a crucial role in the field of UX research, providing structured approaches to assess and measure the effectiveness, satisfaction, and other dimensions of user interactions with products, systems, or services. These frameworks and metrics enable researchers and practitioners to gather meaningful data, identify usability issues, and make informed design decisions. While there are many evaluation frameworks and metrics, their presentation is beyond the scope of this thesis, though we can present a summary of those that are widely recognised and have had a substantial impact on the practice of UX research:

> **System Usability Scale (SUS):** The System Usability Scale (SUS) is a widely used questionnaire-based evaluation method that measures the perceived usability of a system or interface. Originally introduced by Brooke in 1996, it consists of ten items, with respondents rating their agreement on a five-point Likert scale (Brooke, 1996). The SUS provides a quantitative measure of the overall usability of a system and helps identify areas for improvement. The SUS can be considered straightforward and despite its apparent simplicity and ease of use remains versatile. Additionally, it offers the advantage of being cost-effective. However, it only provides a general

measure of usability and interpreting SUS scores can be unintuitive and even confusing (Lewis Senior HF Engineer and Sauro, 2017).

User Experience Questionnaire (UEQ): The User Experience Questionnaire (UEQ) is a measurement instrument that assesses the user experience across multiple dimensions. It consists of 26 items that capture different aspects, including attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty. Originally presented by Laugwitz, the UEQ provides a holistic understanding of the user experience and can be used to compare different designs or products . While it is easy to implement and provides a single score that can be compared across different systems and iteration, it provides a general measure of usability and thus does not offer specific insights into what an element of a product or system might be causing usability issues. Furthermore, while cost-efficient in that it requires minimal commitment in terms of time and resources to implement, the scores generated are not always intuitive to interpret (Laugwitz et al., 2008).

Task Success Rate: Task success rate is a metric that measures the percentage of users who successfully complete a specific task or set of tasks within a usability evaluation. It is a metric that indicates the effectiveness of a system or interface in supporting users' task completion. Dumas and Redish discuss task success rate and other usability metrics in their book "A Practical Guide to Usability Testing" (1999), providing guidance on how to define, measure, and interpret task success in UX evaluations (Dumas, 1999). Offering a clear measure as to whether a user could complete a task, the Task Success Rate does not provide insight as to why a user struggled or failed nor does it account for learning curve, where some users might initially fail but achieve success after some practice (W. D. Gray and Fu, 2004; Hertzum and Jacobsen, 2001).

Heuristic Evaluation: Heuristic evaluation involves experts systematically assessing a system's usability against a set of established usability principles or heuristics. It enables researchers to identify potential usability issues early in the design process. Nielsen's article "10 Usability Heuristics for User Interface Design" (published in 1994) outlines ten heuristics that have been widely adopted and serve as a basis for heuristic evaluations (Nielsen, 2014; Nielsen et al., 1990). Evaluators apply these heuristics to identify usability problems and provide recommendations for improving the user interface. Heuristic evaluation can be considered flexible, and due to being carried out by experts often quick to employ, yet because of this reliance on expert evaluation it is also dependant on their knowledge and experience and thus findings may vary based on who conducts the evaluation. It also lacks for user perspective and, as it is not performed with real users, may miss usability issues that arise from the context of actual use (Nielsen, 1994; Nielsen et al., 1990).

Cognitive Walkthrough: Presented in the paper, "The Cognitive Walkthrough Method: A Practitioner's Guide" (Wharton, 1994), cognitive walkthrough is a usability evaluation method where evaluators simulate users' cognitive processes and step through specific tasks or scenarios to assess the usability of a system (Wharton, 1994). It focuses on understanding how users learn and make decisions while interacting with an interface. The cognitive walkthrough method can be effective in

identifying usability issues early in the design process, cost-effective and also relatively quick (Nielsen et al., 1990; Wharton, 1994). However, as it primarily focuses on the cognitive aspects of usability it may not represent issues with usability, such as emotional or aesthetic experiences. Finally, due to typically conducted in controlled environments, the cognitive walkthrough might not capture real-world user interaction and as it requires expertise in HCI and usability evaluation, can be difficult to implement effectively (Kujala et al., 2011; Nielsen et al., 1990).

These evaluation frameworks and metrics have had significant impact on the field of UX research by offering structured approaches to assess and measure the user experience. The System Usability Scale (SUS) provides a standardised questionnaire to measure perceived usability, while the User Experience Questionnaire (UEQ) offers a comprehensive instrument to evaluate the user experience across multiple dimensions. Task success rate serves as a clear and interpretable metric to measure the effectiveness of task completion, while heuristic evaluation and cognitive walkthrough provide expert-based evaluation methods to identify usability issues and inform design improvements. Together, evaluation frameworks such as these support UX researchers in data-driven decision-making and contributed to the development of user-centred design practice.

Ethical Challenges in UX Research

UX researchers must regularly engage with people or data generated by people. As a result ethics becomes one of the most important factors that researchers must consider when engaging in UX research. The discourse surrounding ethics in UX research is complex and multifaceted and to remain within the scope of this thesis the relative discourse is divided into three parts: Fundamental Ethical Principles, Application of Principles, and Challenges and Considerations.

Guiding Principles

Scholarly efforts to tackle the challenges of ethics in UX research are considerable. To establish our guiding principles, we will refer to the oft cited Belmont Report which was created by created by the National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research and presents three principles, specifically Respect for Persons, Beneficence and Justice. While the Belmont Report has received criticism, such as its blurred lines between research and practice and its limited scope on community harms, it is often cited by scholars studying ethics, both within and outside of UX research, and serves to provide a framework for discussing the guiding principles of ethics in UX research within this thesis (Shore, 2006).

The principle of respect for persons acknowledges the autonomy of individuals who participate in research and recognises their right to make informed decisions about their involvement (Munteanu et al., 2015). Respect for persons entails that participation must be voluntary, that participants must possess a comprehensive understanding of the nature and implications of their involvement. In practice, this means that participants should have the freedom to choose whether they participate in a study without coercion or undue influence,

with some scholars arguing that consent must be procured even if a person's data is publicly available (Fiesler and Proferes, 2018). To this end, participants must be provided with comprehensive information about the purpose, the procedures and any potential risks involved at every stage of a study (Scherling, 2020). This information should be presented clearly, in a manner that the participant can comprehend and also readily access.

The principle of beneficence can be summarised as the need to ensure that research does no harm to participants and maximises possible benefits. UX researchers must carefully consider the potential impact of their research on participants and consider their physical, psychological, and emotional well-being. To support this principle, researchers employ techniques to create a supportive and comfortable environment, providing participants with information and the resources to cope with any challenges that may arise (B. Friedman et al., 2013; Munteanu et al., 2015). Protecting a participant's privacy and confidentiality is a critical component of beneficence, with researchers striving to ensure that personal information and data are processed with the care and confidentiality through techniques such as data anonymisation and storing data on secure systems.

Finally, the principle of justice demands that research efforts distribute their benefits and burdens equally which is especially relevant to recruitment and the treatment of participants in UX research (David, 2015). Furthermore, all participants should have equal opportunities to participate in research, and characteristics such as socioeconomic status, age, race, or gender should not be grounds for excluding individuals from research participation (Schlesinger et al., 2017). The principle of justice is also concerned with how research outcomes might impact different groups of users and therefore, researchers should be mindful of potential disparities that may arise from their (Schlesinger et al., 2017) UX researchers should actively assess how the outcomes and benefits of their research can be distributed in a manner that promotes fairness.

Application of Ethical Principles in UX Research

Privacy and confidentiality, ethical considerations for vulnerable populations, and bias in research are critical considerations for UX scholars practicing ethical researchers.

With regards to privacy and confidentiality, UX researchers are encouraged to ensure that personally identifiable information is secure, and participant identities are protected when sharing findings (B. Friedman et al., 2013). To this end, numerous tools and techniques have been created to support researchers seeking to protect their participant data, such as data anonymization, secure data transfer and storage, and restrictive data access protocols (Kushniruk and Nøhr, 2016).

Ethical considerations for vulnerable populations are essential if we are to protect the well-being of participants. Vulnerable populations are generally considered groups or individuals who may be at a heightened risk of being adversely affected by the research or may not have the full capacity to provide informed consent and can include children, the elderly or those with cognitive impairments. For UX researchers working with these groups, one challenge is obtaining consent. In these instances, researchers may need to secure consent from a legally authorised representative, such as a parent or guardian, in addition to assent

from the participant (Buchanan and Hvizdak, 2009). Vulnerable groups should also be considered when designing studies, with researchers adopting non-intrusive methods that respect the physical and emotional well-being of these individuals (Bruckman et al., 2015).

Bias continues to present a challenge to researchers engaging in UX research. During study design, researchers must be careful when designing research questions as the design can detrimentally impact the results (D'lgnazio C, 2023; B. and H. D. G. Friedman, 2019). During data collection, UX researchers must also be aware of how bias during participant selection can impact their findings. If selected participants are skewed towards a specific demographic or do not representative the larger population then any findings generated are at risk of being non-generalisable, greatly undermining their value. To combat bias in data collection, researchers are encouraged to practice participant diversity and avoid recruiting participants from pools with a homogeneous and predictable demographic bias, such as universities (Pannucci and Wilkins, 2010).

Challenge and Consideration for Ethical UX Research

Ethical design remains of great importance to those in the field of UX research. Moreover, with a technological landscape that seems to shift continuously, UX researchers are presented with numerous challenges that threaten to impede their efforts and impact the quality of their research.

While UX can produce highly effective designs that support users, they can also be applied unethically, producing systems, techniques and tools that can manipulate users. The application of UX research towards fulfilling business objectives without adequate constraints for users can produce serious and sometimes life-threatening, consequences. To guard against these practices, UX researchers must become advocates for the user at all stages of the design process, ensuring that the products produced from their work do not just offer quality user experiences but are also safe, inclusive, accessible, and respectful of a user's well-being (Balagia, 2018).

With regards to technology, it remains imperative that UX researchers inform themselves about the latest advancements in technology and their potential ethical implications (van Wynsberghe and Robbins, 2019). Data breaches, security concerns or other potential abuses or misuses of technology are a threat to ethical research practice. For example, the with the rise of artificial intelligence (AI) and machine learning (ML) technologies, there are concerns about data protection and maintaining privacy. UX researchers must remain vigilant in a world where powerful computer systems and tools are becoming widely available.

Innovations, such as big data algorithms can be abused, challenging efforts to promote fairness, transparency, and accountability and tools such as large language models (LLMs) and generative AI tools potentially threaten ethical practice when trained on vast quantities of public data or are expected to function in an automated manner (David, 2015; Spi Ekermann, n.d.; Verma, 2019).

Regularly reviewing ethical guidelines and best practices, seeking advice from other professionals such as ethics committees and review boards is important (David, 2015). In

this way, UX researchers must remain vigilant and strive to reflect on and assess the ethical quality of their work considering new technologies if they are to adapt as needed.

UX Design Guidelines and Principles

The ever-changing technological landscape that shapes modern society demands that organisations invest in delivering the best possible user experiences. Whether it is a university designing a course or new tool for applicant registration, a games company seeking to captivate and entertain their player base or a private business wishing to survive a hostile market space, UX research has become increasingly valuable.

Achieving the best possible user experiences requires the use of design principles and guidelines, which serve as tools for UX researchers to navigate through the research and design process. The following is an overview of some of the key design guidelines and principles that support successful design.

User-Centred Design

User-Centred Design (UCD) focuses on the needs, wants, and limitations of users, placing them at the centre of the design process. It involves understanding user behaviour, attitudes, and expectations and acknowledges the significance of user diversity, which includes background, skillsets, and preferences. To acquire these insights into user behaviour and preferences, UX researchers and designers employ various methods as discussed earlier in this chapter and in so doing can discover a user's motivations, goals and identify challenges. Numerous studies support the importance of UCD principles and have demonstrated the importance of early, iterative usability testing with real users and the role of user involvement in creating usable and satisfying designs (Nielsen et al., 1990; Tan et al., 2011).

Visibility

Visibility is important to those wishing to create user-friendly designs. It ensures that important elements, functions, and system status are clearly visible and perceptible to users (D. A. Norman, 1988). In his book, 'The Psychology of Everyday Things', Donald Norman emphasises the role of visibility in design and highlights how affordances and signifiers contribute to making elements and functions visually perceivable to users. Affordances represent the perceived actions or function offered by an object or interface, while signifiers are visual or auditory cues that provide clues about a given element's purpose. Norman stresses that visibility encompasses not only visual clarity but also the perceptibility of affordances and signifiers which designers can then use to create effective sensory cues to reduces cognitive load, enabling users to engage with systems with confidence. The significance of visibility in design aligns with the broader understanding in the UX community and is supported by various contemporary studies and best practices (Feng et al., 2023; Rousi, 2023).

Feedback

Feedback provides users with meaningful responses and acknowledgments of their actions., Animations, interactive elements and various sensory cues can contribute to the immersive nature of the user experience. These feedback mechanisms create a dynamic and engaging environment, making the experience more captivating and memorable (Szwillus & Ziegler, 2003). Feedback can provide confirmation to users that their actions have been successfully executed through sensory cues which can provide a sense of control and understanding and in turn this can support learning through interaction. Feedback can also aid UX researchers in the development of user-centred, evidence-based design and support their understanding across a design's lifecycle (Buxton, 2010; Lidwell et al., 2010; Preece, 2015).

Consistency

Consistency of design is concerned with uniformity when designing elements, interactions, and defining terminology. It aims to reduce cognitive load, increase predictability, and improve usability. It allows users to transfer their knowledge and skills across different parts of the system, resulting in a smoother and more efficient user experience (D. A. Norman, 1988). Consistency plays a vital role in reducing the cognitive load experienced by users when trying to understand and interact with a design (Shneiderman, 2016). When design elements follow consistent patterns, such as buttons, icons, and typography, users can quickly understand their purpose and can provide users with familiar and predictable ways to navigate and interact with a design, thus improving efficiency and ease of use (Tidwell, 2010).

Accessibility

Accessibility in UX design focuses on promoting inclusivity for all users, including those with disabilities. Accessible design aims to provide equal opportunities and a seamless user experience for individuals with diverse abilities (Mark & Douglas, n.d.; 为, 2023). This involves implementing specific practices to accommodate different needs and enable effective interaction with the product. An example of accessibility in action is the use of alternative text for images to support users with visual impairments in order to understand content using screen readers or other assistive technologies (WebAim, 2021). Keeping within the theme of text, another example of accessibility is the practice of using adequate contrast for text. Text that is larger and has wider character strokes is easier to read at lower contrast. The contrast requirement for larger text is, therefore, lower. This allows authors to use a wider range of colour choices for large text, which is helpful for the design of pages, particularly titles. By adopting this practice, designers can make it easier for individuals with visual impairments or colour deficiencies to read and understand textual content (*Contrast (Minimum): Understanding SC 1.4.3*, 2016). A final example of accessibility in UX design is the practice of ensuring that a website or product is navigable using a keyboard. This is because there are users who rely on keyboard navigable due to motor disabilities or other impairments that limit their ability to use a mouse or touch screen (Caldwell B, 2008).

Efficiency

Efficiency aims to minimise user steps, time and effort in task completion and can improve productivity and user satisfaction (Nielsen, 1993; Tractinsky et al., 2000). By studying the user journey, simplifying processes, eliminating redundancies, and consolidating actions,

designers can reduce the cognitive load and physical effort required from a user (Xu, 2023) . In addition to this, practicing efficiency requires designers to prioritise time management to ensure tasks can be completed within reasonable time frames by designing fast-loading interfaces, offering responsive feedback, and optimising information retrieval and data entry processes (Fan et al., 2022). When designers create intuitive interfaces that minimise cognitive effort and provide clear guidance, they enable users to focus on task accomplishment with greater ease (Feng et al., 2023).

Learnability

Learnability is concerned with designs that are easy for users to learn and use. In doing so, UX designers reduce barriers to improves the onboarding experience and encourage users to explore and adopt a system (Gilbert, 2019; Nielsen, 1993; D. A. Norman, 1988; Preece, 2015). Moreover, scholars have also explored how learnability can contribute towards better design in areas such as collaborative tool design and AI-assisted UX evaluation systems (Fan et al., 2022; Rousi, 2023).

Minimalism

Minimalism in UX design focuses on creating simple and streamlined user interfaces by reducing complexity and clutter. It involves removing unnecessary elements, simplifying interactions, and prioritizing essential features, emphasising the importance of reducing complexity and creating elegant and efficient solutions (Maeda, 2006). It has been reported that users perceive minimalist user interfaces as more visually appealing, more enjoyable, and easier to use compared to feature-rich interfaces (Tuch et al., 2012). The company Apple provides an example of practically employing the UX design principle of minimalism, with their design philosophy focusing on simplicity and clarity, which has been proven successful through sale reports and academic study (Chandon et al., 2000).

User Control

User control is a key principle in UX research, emphasising the importance of empowering users and giving them control over their interactions (Desmet, 2007a; Hassenzahl et al., 2008). Software applications, websites, and mobile applications frequently include features that allow users to have control over their experiences, supporting users be allowing them to personalise their interactions and adjust interface elements according to their preferences and needs. By applying user control, UX designers can improve user satisfactions and foster a sense of ownership (Desmet, 2007b). Similarly, higher levels of user control can positively impact the perceived quality of an interactive design, further improving the user experience (Hassenzahl et al., 2008).

Key Principles of UX Design

In the following section, we will delve into five key principles that have significantly influenced UX design: Hick's Law, Fitts's Law, the Gestalt Principles, Progressive Disclosure, and the principle of Consistency and Standards. For each principle, we will highlight a seminal paper that explores its application in UX design, providing valuable insights into how these principles can be leveraged to create superior user experiences.

Hick's Law

Hick's Law suggests that the time it takes for a user to make a decision increases with the number and complexity of available choices. This principle has significant implications for UX design, particularly in the context of website design and this law is often used to guide the design of menus, forms plus other interface elements where users must choose from multiple options. By reducing the number of input fields and providing clear, concise labels, designers can help users complete forms more quickly and with less effort (Weinschenk, 2011). While Hick's Law provides a useful guideline, it is not an absolute rule. The optimal number of choices depends on factors such as user familiarity, choice complexity, and cognitive load (Lidwell et al., 2010). As a result, user testing and iteration based on feedback remain important for refining designs and ensuring a better user experience (D. A. Norman, 1988).

Fitts's Law

Fitts's Law describes the relationship between the size of a target, its distance from the user, and the time it takes to move to and select a target (MacKenzie, 1992). It predicts that the time required to rapidly move to a target area is a function of the distance to the target and the size of the target. The law is usually formulated as:

$$T = a + b \log_2(1 + D/W)$$

Where:

- **T** is the average time taken to complete the movement.
- **a** and **b** are constants that depend on the physical conditions.
- **D** is the distance from the starting point to the centre of the target.
- **W** is the width of the target measured along the axis of motion.
- **log2** is a logarithm to the base 2.

To summarise, larger targets are easier to hit compared to smaller ones, and targets that are closer to a user's current position are easier to reach than those that are further away. Fitts's Law has many practical applications for UX design, especially for touchscreen interface and touch screen buttons, such as smartphone keyboards and predicting a user's touch pointing performance when using a table device (Chapuis et al., 2007; Tidwell, 2010).

Gestalt Principles

The Gestalt Principles are adapted from Gestalt psychology. Gestalt Principles explain how humans naturally perceive and organise visual information, forming meaningful wholes. Gestalt principles include the principle like proximity, similarity, and closure (Lidwell et al., 2010; Todorovic, 2008). For example, the principle of proximity asserts that a user groups related elements to aid user understanding. Similarly, the principle of similarity is used to create visual hierarchies and establish consistency in the interface design. In the field of UX design, these principles are widely used to create visually cohesive and user-friendly interfaces (Krug, 2006; Paay & Kjeldskov, 2008).

Progressive Disclosure

Progressive disclosure aims to address the challenge of presenting complex or voluminous information to users without overwhelming them. The principle of progressive disclosure asserts that overwhelming users with all information and options upfront can cause cognitive overload and decision paralysis (Nielsen, 2006). Applying the principle of progressive disclosure to UX design can improve the user experience by presenting information in a manageable way, preventing information overload. This principle also empowers users by giving them control over the pace of exploration and interaction, with designers guiding users through steps while gradually revealing functionality, for a more intuitive experience (Ye, 2021).

Consistency and Standards

Consistency and Standards in UX research focuses on creating a cohesive and predictable user experience (Nielsen, 2014). By practicing visual, functional internal and external consistency, UX designers enable users to understand and predict how the system behaves and thus reduces cognitive load and improving usability (Lidwell et al., 2010; Nielsen, 1993, 2014). In this way, practicing consistency and standards play a crucial role in supporting user understanding and interaction predictability, contributing to the creation of efficient and engaging interfaces (Tullis & Albert, 2008).

Emerging Trends and Technologies in UX

The field of User Experience (UX) is continuously evolving, driven by advancements in technology and changing user expectations. UX is a constantly evolving field, adapting to technology advancements and changing user expectations. Emerging trends and technologies have the potential to transform the UX landscape, influencing how designers create user-centred experiences. We will focus on three such technologies that can be connected to the research focus of this thesis; Extended Reality (XR), Remote Research and No-code tools.

Extended Reality (XR)

Extended reality (XR) is an umbrella term that includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). These technologies offer immersive experiences by combining the digital and physical to create immersive experiences and can be applied to a wide variety of use cases, including as entertainment, engineering, and education (Alizadehsalehi et al., 2020). Despite the challenges of working with and designing for XR technologies, they present opportunities for UX researchers seeking to study user experiences at the forefront of technological innovation.

Virtual Reality (VR) creates entirely virtual environments for users to interact with via VR headsets that block out the user's view of the real world and replace it with a digital environment. This allows users to experience things that would not be possible in the real world, such as flying, shopping, exploring historical settings, or visiting different world (Saini, 2022; Selmanović et al., 2020; Trunfio et al., 2022; Wang et al., 2023). VR has been popular in entertainment and education but still presents challenge, specifically the need to wear a

headset, the reliance on a clear space for a user to safely gesture within and the tendency of some users to experience motion sickness (Linneman J, 2020; Mäkinen et al., 2020).

Augmented Reality (AR) superimposes digital information onto the real world. With AR headsets or glasses, users can view the real world through a lens that displays digital content, including text, images, or videos (Bottani & Vignali, 2019). AR augments real-world spaces and enables users to interact with digital information in a more intuitive manner, such as by pointing and clicking (Kumar, 2022). While users of AR technology do not tend to experience motion sickness, AR shares many of the challenges of VR. Cost of entry remains relatively high, as does the dependency on a specific skillset required to setup and maintain AR technologies (Xi et al., 2022).

Mixed Reality (MR) enables users to interact with digital objects while remaining aware of their surroundings, allowing for more natural and intuitive interactions (Hoppenstedt et al., 2019). Like other XR technologies, MR has various applications, including education, healthcare, retail, and architectural design. It can bring educational concepts to life, aid in surgical planning, enhance shopping experiences by allowing customers to preview products in their home, and help clients visualize architectural designs before construction (Kyriakou and Hermon, 2019). MR also enables users to manipulate and interact with virtual objects as if they were physical entities, enhancing the overall sense of presence and interactivity (Kyriakou & Hermon, 2019; Muñoz et al., 2019). The use of MR technology promises new opportunities for UX designers to create immersive and interactive experiences that go beyond the limitations of traditional screen-based interfaces (L. H. Lee et al., 2022; Rokhsaritalemi et al., 2020). However, MR also poses new challenges for UX designers, such as designing for different levels of immersion and also ensuring natural and intuitive interactions (L. H. Lee et al., 2022; Rokhsaritalemi et al., 2020).

Remote Research

Remote Research within the field of UX, refers to the practice of collecting data from users without requiring their physical presence. While remote research has been, in some form, practiced for over 25 years, the COVID-19 pandemic accelerated academic efforts to study remote research, as it provides several advantages over traditional in-person methods (Gittens, 2021). It can be significantly less expensive than in-person research, as there is no need to provide a physical location or amenities, such as food and drink (Moran K, 2022). Remote research can also provide UX researchers with greater flexibility, allowing them to respond to the needs of their participants as studies can be conducted at any time of the day and from anywhere in the world (Carter et al., 2021). Furthermore, due to the reliance on internet access, remote research can potentially reach a wider range of participants than in-person research, as there are no geographical limitations (Cuadros, 2021).

However, remote research also presents its own set of challenges. For example, remote research places a heavy reliance on technology, such as a stable internet connection, computer, and audio input devices, as well as the necessary skills to operate and maintain these systems. Likewise, researchers often do not have the same degree of control over the research environment as they might otherwise do when conducting studies in-person, with factors such as background noise, distractions and interruptions potentially impacting the quality of data (Cuadros, 2021; Martelaro, 2022). Finally, without a physical presence,

maintaining participant engagement and motivation can present a challenge, and poor video quality or no video display can restrict non-verbal cues, which can potentially affect the quality interpretation of user behaviour and emotions (Okimoto, 2022; Ratclife et al., 2021).

Despite these challenges, UX researchers have successfully applied remote research methods in various ways. One application is the use of remote research for continuous discovery, where researchers gather feedback from users on an ongoing basis. This approach allows for the identification of usability issues early in the design process and over extended time periods (Sprig, 2022; Torres, 2017). Furthermore, with its increased flexibility and reach, remote research promises to contribute to the democratisation of UX studies (Carter et al., 2021; Martelaro, 2022). By making research accessible to a wider range of participants from diverse backgrounds, remote research has the potential to improve inclusivity and representativeness. However, it remains important to ensure that participants have the necessary skills and access to technology in order to participate effectively in remote research studies (Carter et al., 2021).

No-code Tools

No-code tools allow UX researchers to quickly create interactive prototypes without extensive coding knowledge (Robinson et al., 2018). The design of these tools often incorporates pre-made components, utilises drag-and-drop interfaces and rely on visual editors (Masili, 2023). No-code tools support UX researchers and designers by allowing them to visually demonstrate and test design concepts, gather feedback from stakeholders, and develop better user interfaces while improving the user experience (Luis, 2022; Masili, 2023). These tools commonly have features for real-time collaboration, allowing multiple users to work together on a project simultaneously.

No-code tools also support commenting and sharing of prototypes, enhancing communication, and making the feedback process more efficient (Hirschfield, 2023). With these collaborative features, team members can easily collaborate, provide input, and share their perspectives, leading to more efficient and cohesive design processes (Luis, 2022; Masili, 2023; Sundberg & Holmström, 2023). No-code tools also promise to support user-centred design through their flexibility and agility. UX researchers can use these tools to rapidly iterate on a prototype and readily explore new design solutions in responses to user-feedback (Luis, 2022; Sundberg and Holmström, 2023).

UX and Digital Cultural Heritage

Digital cultural heritage adapts technologies to support cultural experiences. With an increasing number of institutions utilise the internet to create cultural heritage experiences and share cultural knowledge, any context in which a user interacts with a system can benefit from the application of UX practices (Flynn, 2022). The application of UX theory to better understand user values, concerns, and feelings about a given system serves as a crucial resource for shaping the efforts of those working with digital items within the cultural heritage sector. Each year, UX research continues to support projects and initiatives created by cultural heritage practitioners (Konstantakis and Caridakis, 2020).

Accessibility

In the context of cultural heritage, ensuring that cultural items are accessible to interested parties, both today and for future generations, remains of the utmost importance. User experience research plays a pivotal role in addressing barriers that undermine accessibility and overcoming challenges, such as language, cultural differences, digital literacy, and designing for users with physical disabilities (Konstantakis and Caridakis, 2020).

Language barriers can impede the effective communication and understanding of cultural heritage content. UX research provides valuable insights into a user's linguistic requirements and preferences, allowing designers to develop multilingual interfaces, translations, and localisation techniques (Konstantakis and Caridakis, 2020). Through considering the linguistic needs of each user, cultural heritage platforms and experiences can be made more accessible, enabling users from different backgrounds to engage with cultural content more readily (Machidon et al., 2020; Wu, 2012).

Cultural differences present a challenge to those wishing to present cultural heritage items. UX research methods assist designers in gaining a better understanding of users' cultural backgrounds, values, and expectations (C. E. Jones et al., 2019). By incorporating cultural sensitivity and appropriateness into the design process, cultural heritage experiences can be adapted to align with a variety of cultural perspectives (Häkkilä et al., 2020). This can be achieved through design decisions such as adjusting visual elements, adapting storytelling approaches, or considering the significance of specific cultural symbols or practices (Sun, 2012).

Digital literacy can pose challenges to accessibility, particularly in the digital realm. By employing UX methods such as usability studies, designers can create more intuitive interfaces and simplify complex interactions (Rizvic et al., 2017). This can potentially improve accessibility for users with varying levels of digital literacy and, consequently, users can navigate digital platforms and engage with cultural heritage content more effectively (Rizvic et al., 2019).

Understanding the needs of individuals with disabilities is essential if UX researchers are to design accessible cultural experiences. By employing user-centred research methods such as interviews, surveys, and usability testing, UX researchers can gain valuable insights into the unique challenges and requirements of individuals with disabilities. These insights can inform the design process, allowing for the development of inclusive interfaces, wheelchair accessible cultural sites, and offering tactile elements for the visually impaired (Bianco, 2020). By utilising UX methods, research, designers can gain a better understanding of the needs of those with physical disabilities and adapt the design of cultural heritage experiences to better support them (Bowen, 2017; Pisoni et al., 2021).

Emotional Connection and Engagement

To strengthen the bond between individuals and cultural heritage, UX researchers must consider how to improve emotional connection and engagement. When done effectively, cultural institutions can present to their visitors more memorable and meaningful cultural experiences (Desmet, 2007b; Falk and Dierking, 2016; Hassenzahl and Tractinsky, 2006).

Improving the emotional connection enables individuals to establish personal and deepen connections with cultural heritage, while improving engagement supports active participation and immersive experiences (Alelis et al., 2015; García Münzer, 2020; Konstantakis and Caridakis, 2020; Othman et al., 2021).

Fostering cultivating emotional connection and engagement in cultural heritage can be challenging. Factors such as limited contextual information, passive engagement, and the difficulty in evoking emotional responses can hinder users from developing strong connections with cultural heritage content (Biocca et al., 2006). These challenges can be compounded by the often-static nature of cultural heritage experiences and an overreliance on traditional modes of presentation, such as blocks of text next to cultural items providing information regarding an item's provenance (Ferraris et al., 2023).

By employing UX methods such as interviews, surveys, and observations, designers gain insights into users' preferences, emotions, and motivations. This understanding helps identify valuable aspects of the user experience and provides insights into users' emotional responses to different design elements (Dede, 2009; Kamal Othman et al., 2011). Designers can then incorporate this insight into the design of cultural experiences, UX design empowers users to engage with cultural heritage in a profound and meaningful manner (Alelis et al., 2015; Ferraris et al., 2023). To this end, designers can apply UX principles such as the use of narrative structures and enhanced interactivity. By continuously iterating upon their designs and constantly seeking to improve their understanding, those utilising UX methods can support cultural heritage institutions in improving learning experiences and more effectively communicate the value and significance of cultural items (Ardito et al., 2009; Ferraris et al., 2023).

Knowledge Sharing & Collaborations

With the evolution of the internet, researchers and CHPs have responded to a digital landscape that promises increasing interconnectedness and accessibility (Berners-Lee et al., 2001; Colace et al., 2016; Mi & Pollock, 2018). Collaboration and knowledge sharing initiatives are crucial within the cultural heritage sector, fostering the exchange of skills and information (Candela et al., 2022; Ogden, 2007). Knowledge sharing entails the dissemination and exchange of knowledge, experiences, and best practices within the cultural heritage community (Dragoni et al., 2017b). Collaboration entails active cooperation and partnerships among cultural heritage institutions, professionals, and researchers who share common goals such as preservation, research, and public engagement (Ogden, 2007).

There are numerous initiatives that have been initiated to encourage collaboration and promote knowledge sharing in the cultural heritage sector. GLAM (Galleries, Libraries, Archives, and Museums) labs have emerged as forums for fostering collaboration and innovation (Research Libraries UK, 2020). These events offer opportunities for cultural institutions to connect and collaborate with researchers, technologists, and the public while leveraging digital technologies and open access principles to advance cultural heritage projects. Meanwhile, organisations such as the Associations of the International Council of Museums (ICOM), the American Alliance of Museums (AAM), and the Museums Association provide opportunities for networking and professional development, while sharing best

practices and guidelines to CHPs (AAM, 2023; ICOM, 2023; *Museums Association*, 2023). Within the context of digital cultural items, groups such as the International Image Interoperability Framework (IIF) and the Digital Public Library of American (DPLA) support knowledge sharing, with efforts to digitise, curate, and share digital copies of analogue cultural items (DPLA, 2023; IIIF, 2023; Matusiak, 2017; Snydman, 2015).

Despite these initiatives supporting knowledge sharing and collaboration, the cultural heritage sector faces several. For example, the skill sets traditionally encouraged by cultural institutions do not encompass digitisation, preparation, or presentation of digital items, though there is some evidence to suggest that this is changing (Gradin & Matti La Mela, n.d.). However, expertise in digitisation technologies, metadata standards, content management systems, and data interoperability remain scarce (Ziegler et al., 2020). Without these essential skills, effective collaboration by institutions can be hindered, impacting the sharing of knowledge and resources among cultural heritage institutions.

In response to these challenges, UX researchers have attempted to apply UX methods to supporting institutions. Researchers have undertaken usability assessments and case studies of cultural heritage sites, both physical and online, to support both visitors and CHPS design more intuitive experiences (Konstantakis and Caridakis, 2020b). In addition, these UX methods have been applied to digital pipelines and workflows to pinpoint congestions, assisting institutions in devising more efficient procedures for such as extended reality exhibitions and collections management (Hammady et al., 2011; Mah et al., 2019; Rahaman et al., 2019).

UX to Cultural Heritage: Challenges

Theory & Practice: The Gap

Some have criticised scholarly efforts for lacking implementation of theory into 'authentic practice'. The continually evolving state of UX creates challenges for both researchers and practitioners and while they might share the have same goals of identifying, characterising and consolidating UX, their intentions can be different (C. M. Gray, 2016). This criticism is sometimes referred to as, 'the gap' (Gil-Fuentetaja and Economou, 2019a; Velt et al., 2020).

The gap can be described as the divide between theory and practice within the discipline of UX. Academia tends to focus on theoretical research, studying the cultural, psychological, and sociological impacts of technology on the presentation and preservation of cultural heritage. These studies, while invaluable, may not always translate directly into practical applications. Industry, on the other hand, is concerned with pragmatic issues like creating usable interfaces, crafting engaging experiences and maintaining technological sustainability (Conde et al., 2021; Ferraris et al., 2021). Theory then, in this context, is the governance of the academic, who seeks to explore interesting new ways to further UX understanding. Practice then, is the purview of the practitioner, the non-academic working day to day in a sector where UX promises to make improvements. This misalignment can create tension, as industry may not adopt the novel findings from academia, while academics may lack insights

into the daily challenges of practitioners (Conde et al., 2021; Ferraris et al., 2021; Gil-Fuentetaja and Economou, 2019).

Accordingly, while research involving digital items and their curation can focus on exploring and developing 'high-level' theory to better apply learnings from UX research (Campi et al., 2019; J. Forlizzi and Battarbee, 2004; Pretto et al., 2020), practitioners require practical, actionable information such as understanding how researchers locate and use cultural items or manage the data that supports them (Amato et al., 2017; Dragoni et al., 2017a; J. Forlizzi and Battarbee, 2004; Han et al., 2019; Konstantakis and Caridakis, 2020a).

Innovation & Authenticity

Applying UX practice to cultural heritage presentation of DCIs brings a tension between innovation and authenticity. Every analogue cultural item from which a DCI is built comes with its own unique aspects, nuances, and subtleties that need to be maintained and accurately conveyed. Maintaining the integrity of DCIs while simultaneously innovating and digitising them to enhance the user experience can present a unique challenge (S. Jones et al., 2018; Waters and Garrett, 1996). It's not enough to simply digitise cultural heritage, rather the aim is to ensure that users walk away with a deeper understanding of its significance.

For innovative interpretation, UX methods like co-design sessions, brainstorming, or ideation workshops can help create novel ideas and solutions that make cultural heritage engaging and accessible (Meinecke, 2022). However, translating cultural information into engaging digital experiences can sometimes undermine the authenticity of the analogue cultural item being represented by a DCI.

Finding a balance between innovation and authenticity involves combining the traditional and the new to support each other, without compromising cultural value or user engagement (Trunfio and Campana, 2020). The key is not just preserving the physical authenticity of an analogue cultural item but also presenting its contextual information and significance, with the intent of ensuring the DCI is as truthful to the analogue counterpart as possible.

UX research and practice can be applied to the challenge of innovation and authenticity in a variety of ways. User feedback can be incorporated into the design process to support iterative adjustments based on real-world usage and experiences, ensuring that the final design remains engaging and accessible to users (C. E. Jones et al., 2019; Vrettakis et al., 2019). In the realm of digital reproductions, extended reality experiences, or interactive exhibits, usability testing, cognitive walkthroughs, and heuristic evaluations can be conducted to ensure the digital experience is truthful and respectful of the DCI's cultural heritage (Konstantakis and Caridakis, 2020b; Škola et al., 2020; Wolff et al., 2018). UX research can further contribute by using user interviews, collaborative workshops with key stakeholders and ethnographic research to better understand the nuances, subtleties, and values of a given culture, and then translating these into the design of a DCI presentation (Škola et al., 2020; Were, 2015).

Technological Sustainability

Technological sustainability within the cultural heritage sector presents a significant challenge to UX researchers who aim to support cultural institutions and their efforts. The crux of the issue lies in ensuring that digital tools and resources remain functional, accessible, and effective over extended periods, despite the rapidly changing technological landscape. In this section, we will cover key areas and discuss how UX research and practice can help mitigate some of these challenges, specifically those related to obsolescence, maintenance, and adaptability.

Obsolescence

The rapid pace of technological advancements presents a significant challenge in maintaining accessibility to cultural information, including DCIs. Due to the transient nature of technology, the tools, and platforms utilised by cultural heritage institutions can quickly become outdated. This can be observed through the emergence and subsequent disappearance of various digital media types and file formats over time. Consequently, when a platform becomes outdated, there is a real risk that the associated cultural information may become more difficult or even impossible to access.

UX designers can help mitigate the risk of obsolescence by prioritising universal and timeless design principles over potentially fleeting trends. They can also design experiences that are platform-agnostic so that they function on a variety of devices and technologies. This can help ensure that, even as specific technologies become obsolete, accessibility is preserved, and the overall user experience remains intact. Additionally, UX can support cultural institutions by informing the selection of technologies that are less likely to become obsolete quickly, based on trends and research in technology and design fields.

Maintenance

Digital platforms and tools require regular updates to avoid obsolescence and ensure that cultural information remains accessible, functional, and secure. This is particularly important for cultural institutions that use specific platforms for their digital exhibitions. For instance, if a museum uses a digital platform to showcase its cultural items, it must ensure that the platform is regularly updated to remain compatible with modern devices and browsers. This requires ongoing technical support and resources, such as access to specific skills, which can be challenging for smaller institutions to sustain.

UX principles can support cultural institutions through the creation of interfaces that are easy to update and maintain. This can be achieved through modular design, where different components of the interface are designed to be independent and interchangeable, allowing for easier updates, as changes can be made to individual components without affecting the entire system.

UX practices can also help manage the user's experience during updates by providing clear communication about what is changing and why. For example, if an update is going to change the layout of a digital exhibition, users should be informed about this change in advance. Additionally, UX practices can inform the design of guides and tutorials on how to best navigate the new layout, helping ease the transition and reduce possible frustration in users.

Adaptability

As cultural heritage institutions adopt digital technologies, CHPs can find themselves under increasing pressure to digitise cultural items and provide more digital learning resources. The important decisions regarding what to digitise and to curate are best informed in response in response to what visitors value.

UX practices can support cultural heritage institutions and their CHPs overcome these challenges. Adopting a user-centred design, through employing methods such as surveys, interviews, and usability testing, can reveal what visitors value the most in their interactions with cultural heritage institutions and digital cultural information. Additionaly, by adopting an iterative design approach, cultural heritage institutions can gather feedback and then refine their digital cultural presentations to better reflect the demands of visitors. For example, if visitor feedback indicates that a digital exhibit could be more interactive or if a newly popular device is not supported, the exhibit can be updated accordingly. Finally, UX research can also help CHPs design for flexibility and scalability to create digital experiences that can easily be expanded or modified as visitor needs, technological environments, and institutional goals evolve.

Chapter 3

Study 1: What do CHPs want?

Working with any new technology presents challenges and while it has become increasingly common for cultural items to be digitized for use in cultural heritage experiences, the artistic and technical skillsets of capturing, preparing and presenting DCIs are not commonly available among the staff of cultural heritage institutions. Supporting these professionals has been the goal of many academics involved in research cited within the area of cultural heritage. However, research efforts aimed at supporting cultural heritage practitioners must consider the criticism aimed at academia revolving around the disconnect between those focusing on theory, as explored by academia, and the 'every day' practice, as performed by those working with DCIs.

In response to this criticism, it was determined that working on a real-world project would provide, 'hands on' experience of some of the challenges faced by cultural heritage practitioners working with DCIs. Such a project would serve to strengthen our connection to those cultural heritage practitioners working on similar projects through shared, relatable, experience and in so doing ensure that our future research efforts were focused on supporting their needs. To this end, working in tandem with NGSENS, a team of Swiss technical specialists, a project was undertaken for the Martin Bodmer Foundation, based in Switzerland, Geneva.

The project was titled the Mask Interactive Experience. The brief required us design and produce an interactive cultural experience which included the need to develop a portable pipeline for capturing, preparing and presenting DCIs created from a selection of hand-crafted masks crafted by the late artist, Werner Strub (Scheinman, 2004). The DCIs took the form of 'digital masks' which would be presented using augmented reality technology to create a cultural experience in which a user could 'wear' the digital masks. The pipeline required in order to create the digital masks consisted of four distinct phases: capture, preparation, integration and presentation. As with many cultural heritage projects involving DCIs, a technical skillset was required. The capture phase involved using photogrammetry to generate digital items using Agisoft's Metashape, which were then prepared using a combination of Autodesk's' Maya, Adobe's Photoshop and 3DCoat before the digital item could then be integrated into a project using the Unity game engine.

Figure 2: Capturing on location in the artist's former home, France.

Before capturing the masks, photogrammetry capture testing was performed on items that comprised of materials like those found on each mask. It was observed that patterned fabrics, wood and bone and dull plastics were captured successfully but highly reflective and transparent materials confused Metashape, producing sub-bar image alignment and meshes prone to errors. In response to this, two techniques using a sprayed substance were practiced, reducing reflectively and transparency.

The goal was to treat these surfaces so that the Metashape could generate their topography and create a digital model which an artist would manually adjust and texture. However, the sprays presented a problem in that once applied, they could only be removed through rigorous cleaning. This meant that both techniques were unsuitable for treating the material of a mask as each mask was a unique, fragile cultural item that could be damaged during the cleaning process.

While technological solutions did exist, specifically incorporating a laser scanner into our capture process was deemed too costly for the scope of the project. In response, masks with

highly reflective surfaces or significant transparencies were eliminated form capture selection.

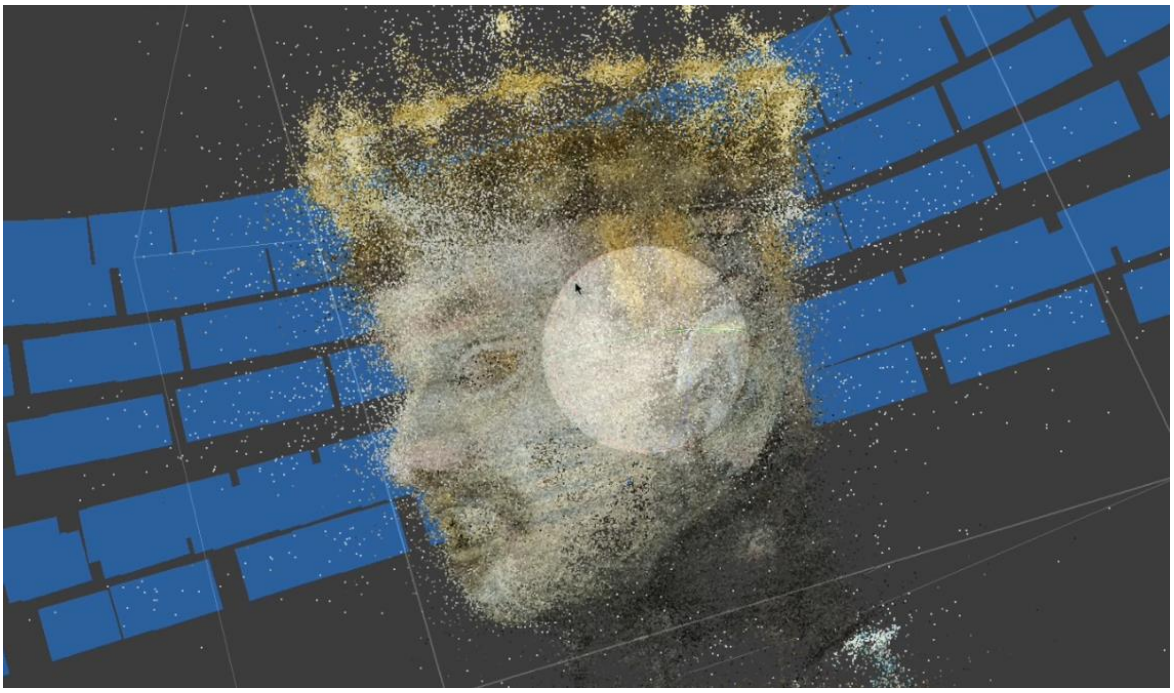

Figure 3: Point cloud generated through photogrammetry.

One of the challenges a cultural heritage practitioner faces when using photogrammetry to capture data from which to build a DCI is ensuring sufficient coverage of a subject. Areas not sufficiently captured can present as voids or graphical errors after the software has performed its calculations and due to the high level of graphic details required, the time between the original capture and the created digital item can be many hours.

The most common areas to suffer from a lack of coverage were on top of the head, under the chin and behind certain masks' ears. This required a 3D artist to carefully remove them by hand, a process which could take up to eight hours, depending on the mask. As such, ensuring sufficient coverage is critical to any DCI pipeline as corrections can prove costly, both in terms of time and also labour.

Figure 4: Early testing of the DCI pipeline.

Another challenge when capturing data from analogue cultural items is lighting as shadows cast by a given item will not remain consistent while the item rotates, causing further errors during digital item generation. To ensure sufficient coverage and even lighting, a Foldio360 rotating platform was utilised, which allowed for each mask to be presented and automatically rotated so that it could be photographed from several, carefully chosen angles with a SONY a7. This setup was lit using a professional lighting rig consisting of twelve 45W CFL bulbs, arranged using three adjustable stands around the capture area.

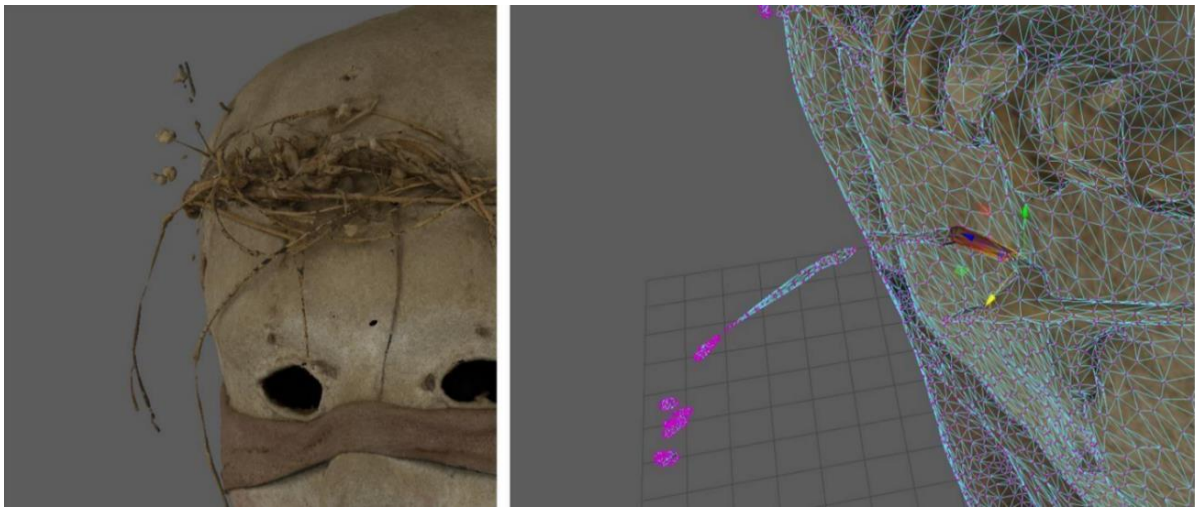

Figure 5: Digitally rebuilding details lost during capture.

After the capture of each item in the collection of images was imported into Agisoft's Metashape they were aligned and a 3D mesh was then generated before a texture applied. The process took approximately six hours per mask, longer if one or more images did not align and required additional attention. Each digital mask was then exported using the .obj file format and imported into Autodesk's Maya 2020. Within Maya, the model was aligned to fit a digital approximation of a visitor's head and checked for errors. As the digital mask would never directly interact with a visitor's shoulders the neck area of a given mask would not deform automatically.

In response to this technical limitation the neck area of each digital mask was carefully adjusted to deform in a manner that simulated its response to resting on a visitor's neck. Some masks featured long, flowing robes that would extend far beyond the neck area and, for similar reasons, these were adjusted through trimming the mesh to include only the upper neck area. Each mask was then exported as an obj. file and imported into the texture editing software 3DCoat, where a technique of cloning existing textured areas to cover texture errors was used to fix problematic areas.

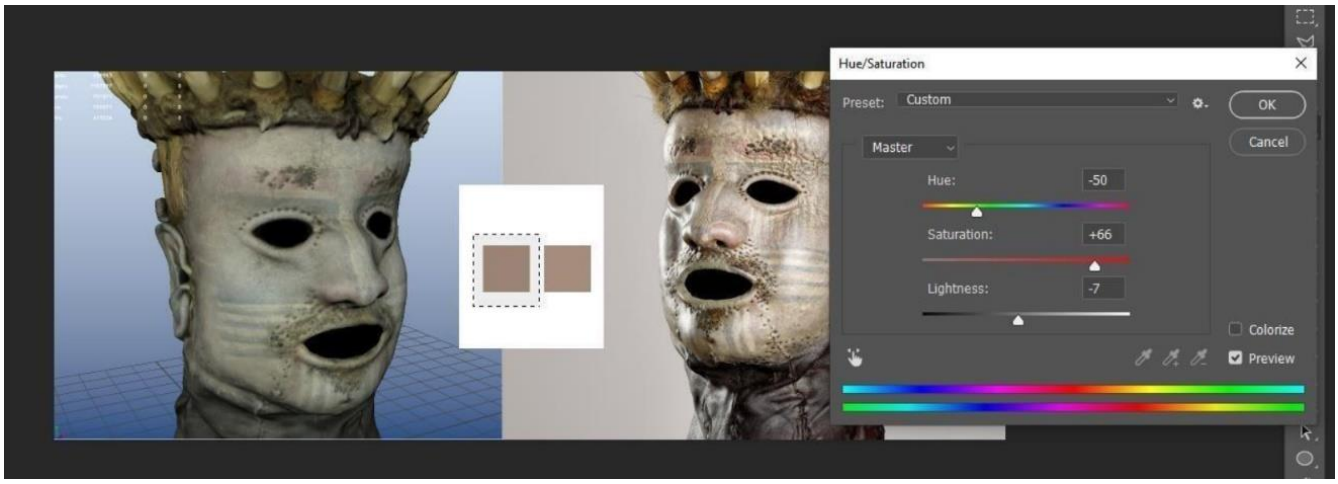

Figure 6: Manual colour management conducted to preserve fidelity between DCI and analogue counterpart.

Colour fidelity between a DCI and its analogue counterpart presents a challenge to cultural heritage practitioners tasked with building high fidelity DCIs using photogrammetry. During the capture process every effort was made to keep the digital item's colour quality as true to its analogue counterpart as possible. A Beley 8mm portable colour analyser was used during testing to improve colour matching between the analogue and digital item. After capture, a digital artist directly compared images of the digital item and its analogue counterpart before manually adjusting the colour values of each digital item's texture using a combination of Photoshop and Maya. A comparison of both digital and analogue item was then evaluated by a cultural heritage professional with the digital item then adjusted until they were satisfied with the results.

Once each digital mask was created it was then imported into a bespoke digital tool created with the Unity game engine by a supporting professional skilled in game development tools. The tool enabled the user to select between each digital mask and, using augmented reality technology, simulate 'wearing' the mask, which would move and deform in response to the user's reactions in real-time. The entire system was housed in a three-meter by three-meter booth and was originally designed for sound recording. Within was placed a Samsung QE50LS03T ‘Frame’ 4.0, 50-inch monitor for displaying the digital masks, while a Logitech StreamCam captured the user's movements.

Outcome

Creating interactive cultural experience using photogrammetry and DCIs remains a technically intensive process. The Interactive Mask Project required a digital artist with a background in both photography, digital painting and animation, a game engine specialist and also understanding of user experience practices. Extensive testing and refinement were required and in total the project took eight months to complete. While capturing technologies such as photogrammetry promise a technically accessible and relatively low-cost solution for generating DCIs from analogue cultural items, depending on the quality of the capture process and the material of the analogue item captured, the digital items generated often require extensive preparation before they can be integrated into a cultural heritage project. Both the capture and preparation as well as the software required for digital item creation require technical expertise that most cultural heritage institutions do

not have readily available in-house, requiring institutions to rely on third-party professionals.

Figure 7: Examples of final DCIs, ready for presentation in Zurich.

Figure 7: Examples of final DCIs, ready for presentation in Zurich.

Working with NGSENS and the Bodmer Foundation provided first-hand experience with some of the challenges experienced by cultural heritage practitioners working to produce DCIs. To focus our future research in order to best support these practitioners a study was designed where we would engage directly with and learn about the experiences of those creating and using DCIs in cultural heritage projects.

Figure 8: Completed DCIs, presented for selection.

Figure 9: Augmented reality testing, with a user 'wearing' a DCI.

The Interactive Mask Experience was displayed at the Martin Bodmer Foundation on the 14th of October 2020, despite the additional logistical challenges presented during the COVID-19 pandemic.

Capture, Processing and Presentation of Digital Cultural Items: Feedback from Cultural Heritage Practitioners

Digital cultural items offer many advantages, with the potential to increase accessibility, to be capable of integration in a variety of exhibitions and to provide levels of interaction not feasible with their analogue counterparts (Grau et al., 2017). While many institutions are involved in digitizing their collections, the artistic, technical and social challenges of preparing and presenting digital cultural items, as well as engaging with dynamically changing technologies that render them possible, is often the sole responsibility of individual cultural heritage practitioners (CHP) (Pedersen et al., 2017). In this study we explore how the increasing trend to digitize and the push to engage with a rapidly changing set of technologies affects the everyday experience of the CHP and the supporting professionals (SP) they work with, who help realize cultural heritage projects through skill sharing and technological support.

Methodology

The study comprised of 5 cultural heritage practitioners (CHP), each with a background in the curation of cultural items and 5 supporting professionals (SP) who collaborate with cultural heritage practitioners on projects involving digital cultural items. The CHPs and supporting professionals were selected from various institutions within the UK and included museums, universities, and private companies.

A semi-structured interview was undertaken to provide information on each participant's experiences of working with digital cultural items. The semi-structured interview technique offered the flexibility for the researcher to explore and expand on topics as they naturally arose during the interview, while also providing a focus for questioning that allowed the interview to be completed within a time better suited to the busy schedules of the professionals involved. The interview questions were designed to provide insight into CHPs and SPs perception and experience of working with digital cultural items, their role within cultural heritage curation and the challenges involved when working with them. Further questions were included to better understand the role of interactivity when applied to digital cultural items, its impact on the user experience as perceived by the CHPs and SPs, plus the challenges involved when working with interactive digital cultural items.

Participant selection criteria

Each participant was contacted either directly or through a network of professional associates working within the cultural heritage sector. The participants were each required to be curators working with digital cultural items within the cultural heritage sector or

supporting professionals with experience working with digital cultural items on cultural heritage projects.
The participants were not expected to be experts in capturing or displaying digital cultural items but were expected to have some familiarity with the processes involved. Participants were professionals based in the UK and selected for their work with digital cultural items within the cultural heritage sector. Professionals working within the cultural heritage sector were given preference over academic candidates due to the study's aim to better understand the experiences of those working 'day to day' with digital cultural heritage items.

Coordination

Over a 4-month period spanning 2020 to 2021 participants were recruited via email. Each participant was given information regarding the study's intent and after consenting, arrangements were made to conduct the interview online due to the COVID-19 rules governing social distancing in place across the UK at the time. Each interview was hosted by a video conferencing tool of the participants' choice, with all participants choosing Microsoft Teams. The individual interviews lasted between 30 to 50 minutes and were recorded using a free version of OBS Studio, and conducted at a time that best suited the professional schedule of the participant. Prior to the interview each participant was sent a copy of a video titled 'The Interactive Mask Project', which showcased a project involving digital cultural items and AR, where the use of facial recognition technology provided the user with the simulated experience of the wearing of a theatrical mask. The video demonstrating this form of interactive 'wearability' was shared to support the interview process by providing an initial 'talking point', serving as a showcase of the authors' personal experience working with cultural digital items, and creating a common ground upon which CHPs, SPs and the authors could compare and share their experiences.

Interview structure

The semi-structured interview questions were designed to elicit a participant's thoughts regarding digital cultural items and interactivity with them across three key areas, each with their own respective sub-questions. The first section of questions focused on digital cultural items and asked for each participant to provide their own definition of what a digital cultural item was before moving on to questions regarding how digital cultural items were used, the challenges they presented and how such challenges could be overcome.

The second section built upon the first, introducing interactivity into the conversation with questions designed to better understand each participant's use of interactivity and the digital cultural items they work with, plus the challenges they faced using interactive digital cultural items. The final set of questions focused on a specific form of interactivity based on the short video shown to each participant when the interview was conducted. These questions pertained to The Interactive Mask Project and the user experience created, with the participant being asked to imagine applications of such technology in future works.

As each interview progressed, the researcher was free to direct enquiry towards specific topics. Over the series of interviews, emphasis was placed on digital cultural items created

from analogue cultural items via digitization, as these involved a complete pipeline, from creation to preparation and then curation.

Data Analysis

All recordings were transcribed verbatim using an automated transcription service before being individually reviewed by the researcher. While each interview was transcribed verbatim, repetition, stuttering and broken sentences were edited for ease of comprehension. In total, the transcriptions reached 70,000 words, which were imported into qualitative analysis software (NVIVO) for codification. Thematic codification followed the inductive method, where codes arose directly from the survey responses. Throughout the process, emphasis was placed on identifying themes for their relevance to the experience of working with and making use of digital cultural items. The codes received three passes, with the first intended to identify general themes, the second to clarify and structure the identified codes before the third pass where, finally, redundant codes were eventually removed.

Thematic Analysis

Three main themes resulted from analysis: Experience, Digital Items and Interactivity. These themes are described along with their connected themes and shown in Table 1, Table 2 and Table 3.

Experience		
Sub-Theme	**Participants %**	**References**
Learning and Teaching	100%	71
Storytelling	60%	26
Considering the user	80%	40
Need to improve UX	100%	87
Improve interactivity	50%	16
Improve technology	30%	4
Improvement over analogue	90%	57
Supporting the analogue	60%	7
Replicate the analogue	30%	8
Screen-based	100%	52
Immersive Technologies	70%	19
Augmenting real-world locations	30%	4

Table 1: Experience

The theme of experience encompassed aspects relating to each participant's experience of using digital cultural items in cultural heritage projects, in what way, plus comparisons between the experiences created with digital cultural items and their analogue counterparts.
Within the theme of Experience every participant reported using digital cultural items to educate in some form or another. Of the 71 individual instances recorded, 60% of participants reported using digital cultural items to inform and educate through the means of storytelling, with 26 references.

Regarding the user experience, 80% of participants reported the importance of considering the user, with 60% of participants expressing the need to improve the user experience for users engaging with cultural digital items. 50% of participants expressed the need to improve the various methods of interaction with digital cultural items, while only 30% commented on improving specific technologies or practices, such as increasing display resolution or improving the testing of existing display systems.

When digitizing cultural heritage items for curation, comparisons to experiences offered through use of the original analogue counterparts were offered by most (90%, 57 references) participants, with the consensus being that digital cultural items provided improved experiences, replacing the analogue cultural item. There were far fewer references from fewer participants (60%, 8 references) regarding digital cultural items supporting their analogue counterparts. For example, one that can be noted is providing a digital copy of an analogue cultural item for directing a visitor's attention to details of the original analogue item. Finally, only 30% of participants referred to the digital cultural item in terms of replicating the experience a visitor might have with the analogue cultural item.

Of the participants interviewed, all referred to experiences framed by screen-based technologies, including screens used in personal computing systems as well as those found in virtual, augmented, and mixed reality experiences. Of the 33 references relating to screen-based technologies as the site of experience, 36 specifically focused on the use of the internet, under the sub-theme of 'online', while 70% of participants talked of using one or more immersive technologies, such as VR, AR and MR. Sketchfab was referred to by 50% of participants as the platform for hosting and displaying digital cultural items.

Experiences reliant on real-world cultural items were discussed by half of the participants, with 30% referring augmenting real-world cultural heritage sites and items from collections. Over the course of the interviews additional attention was placed on enquiring into experiences with virtual museums, digital environments that not only feature digital cultural items but are, themselves, entirely digital. However, only 20% of participants offered any mention or reported having had experiences of such platforms.

Digital Items

The main theme of Digital Items included the sub-themes: Definition of Digital Items, Pre-Digitization and Post-Digitization, where a digital version of the original analogue cultural item now existed and a number of connected themes, as shown on Table 2: Digital Items.

Digital Items		
Sub-Theme	**Participants %**	**References**
Defining digital items	100%	32
Accessibility	90%	122
Cost of process	80%	24
Interoperability	90%	47
Requiring specific skills	100%	122
Overcoming spatial or physical barriers	80%	43
Efforts by iiif	30%	4
Sharing	70%	14
Chosen by 3rd party	20%	3
File formats	40%	27
File sizes	50%	11
File metadata	40%	8
Acquiring funding	70%	31
Digital item manipulation	60%	23
Reliance on 3rd parties	70%	18
Priority by request	30%	9
Changing technology	70%	19
Storing digital items	50%	6
Academic efforts	20%	3

Table 2: Digital Items

In general, most (80%) participants chose to offer a definition of what they considered to be a digital item. Overall, descriptors such as ''interactive'', ''something that has been digitized'' and ''2D & 3D items'' were being commonly referred to amongst the SPs, while the CHPs had a tendency to employ more nuanced language, such as the distinction between something ''born digital'', where no analogue counterpart exists, compared to a digital item generated by digitizing an analogue cultural item.

Interview responses regarding pre-digitization were dominated by discussion relating to issues of acquiring, managing funding, and justifying funding, with 31 references from 70% of participants. Only 40% of participants talked about the decision-making process surrounding which cultural items are chosen for digitization, with sub-themes of digitizing on request, the challenges of choosing what to digitize when collections contained many cultural items and how 3rd parties influenced what was digitized when they were a key provider of funding; all together only totalling 16 references.

The use of cultural digital items overshadowed all other codes with 357 references and was coded as 'post-digitization' which included cultural digital items 'born digital' as well as digitized from analogue cultural items. To better manage such a large number of references, the theme was divided into Advantages of Digitization and Disadvantages of Digitization, each with its own sub-themes.

Under the sub-theme Advantages of Digitization, the greatest number of references at 114, reported by 90% of participants, was the sub-theme of Accessibility, with 'Overcoming spatial or physical barriers' comprising of 43 references and reported by 80% of participants. In this context, accessibility is referred to as being able to access a digital cultural item without having to travel to a specific location, typically via the internet. This sub-theme was further expanded upon to include themes such as 'Sharing', and how digitizing cultural items could be shared between institutions, visitors and researchers. The sub-theme of Accessibility did reveal the challenge of interoperability and despite many key initiatives to unify digital item creation, management and sharing from groups such as the International Image Interoperability Framework (IIIf) community, participants still commented on the tension between technologies and those working with digital cultural items and the lack of commonly agreed upon practice in regard to 3D digital items relating to file sizes, file formats and metadata.

Regarding Disadvantages of Digitization, the most frequently reported code, discussed by all participants, was the sub-theme 'Requiring Specific Skills', with 122 references. This sub-theme included the need to learn new technologies, the reliance on 3rd parties when sourcing skills and, perhaps surprisingly, the challenge of communicating the benefits of digitization to clients and institution management. Other sub-themes under Challenges of Digitization included once more the cost of the process, the difficulty of 3D scanning in terms of practice and the technological tools required plus the challenge of dealing with changing technologies, which can lead to projects becoming redundant or even no longer accessible. Likewise, storing digital items and preserving their integrity was an issue to 50% of participants, primarily the cultural heritage professionals. Only 20% of participants expressed concern with cultural heritage efforts relating to digital cultural items made by academia, with both participants echoing the need for practical solutions.

Interactivity

The majority of references as shown in Table 3: Interactivity, related to Visual, a sub-theme that was employed with participants talking about any form of interactivity that relied on visual activity. The sub-theme was further refined to include themes such as Inspection, relating to how cultural digital items allow users to study them in ways beyond what is offered by most of their analogue counterparts and included themes of Spatial Information, which primarily required cultural digital items to utilise technologies such as AR or MR to convey information regarding an item's scale and locative context.

Interactivity		
Sub-Theme	**Participants %**	**References**
Visual: Inspection	100%	123
Visual: Spatial Information	100%	60
Visual: Environmental	70%	29
Visual: Immersive technologies	40%	13
Visual: Reading	70%	17
Reading: Annotation	50%	11
Visual: Zooming, rotating & panning	60%	14
Auditory	30%	5
Connecting & linking	30%	8
Limits of interactivity	30%	5
Call for haptics	60%	9
Group interactivity	10%	1

Table 3: Interactivity

Reading was reported by 70% of participants as another form of interactivity. This theme also comprised of 40% of participants, who actively used Annotation to augment inspection of the digital cultural items they curate. Meanwhile, the sub-theme of Zooming, Rotating, Panning included 14 references from 60% of participants and complemented the theme of

Visual and the sub-theme of Inspection as the most common forms of interaction with cultural digital items.

Auditory interaction was only mentioned by 30% of participants with only one participant reported an interaction with a cultural digital item that primarily relied on sound. The same number of participants reporting on the use of Connecting and Linking, a sub-theme where information pertaining to a cultural digital item leads to the act of connecting, linking the user to other related cultural digital items.

Only 30% of participants commented on the limits of interactivity with cultural digital items, though all participants expressed a desire for augmenting interactions with haptic technologies, as recorded under the sub-theme of Interactivity, Call for Haptics. Finally, only one participant contributed to the sub-theme, 'Collective Interactivity', a theme created to record references, where participants talked about shared interactivity with digital cultural items.

Discussion

The study offered insights into the experiences of CHPs and their SPs when generating, managing, and working with digital cultural items. An overall trend is the continuing struggle between advancing technology and the expectation to find reliable returns from costly investments of both time and money, the need to improve the quality when working with commonly accessible technologies as well as cutting-edge technologies and practices and to maximise the opportunities for learning when interacting with digital cultural items.

Promises and Expectation

In what was an intriguing finding, cultural heritage practitioners seemingly still need to convince coordinators and peers of advantages of digitization. While those versed in the relevant academic literature might be aware of the various advantages, through preservation of the analogue cultural item to the increase in accessibility, those unfamiliar with this may not be aware of these benefits. The resources involved, including time, skill and technology can present a challenge to adopters of digitization or those wishing to create projects with digital cultural items.

Complicating efforts to secure support from coordinators and peers is the challenge of communicating the limits of seemingly ever-changing technologies, indicating a still present value in exploring ways of educating would-be supporters of digital cultural item creation, management and presentation practices and technologies.

The cost of skills and technology

Even before the COVID-19 pandemic, practitioners learned of the many challenges facing digital cultural heritage projects, especially the process of creating, managing and presenting digital cultural versions of analogue cultural items from their collections.

In order to create high fidelity digital cultural items from analogue cultural items, using technologies such as photogrammetry often requires specialised tools, but the process continues to become easier, faster and perhaps critically, more affordable. Likewise, when

working with digital cultural items, especially 3D digital items, the ability to manipulate digital assets is a critical skill. However, while a practitioner can invest their time and funding in learning skills for a specific technological tool or practice, this investment can often be challenged due to changes associated with the advancement of technology. Furthermore, skill sets associated with 3D digital item manipulation often take years of training to master. Ultimately, a cultural heritage practitioner wishing to engage with digital cultural curation can find themselves split between practicing the skills of curation, developing the skills required to use existing technologies and maintaining an awareness of new technologies as they arise.

In response to the CHPs requiring access to specific skill sets, the cultural heritage sector practices the strategy of promoting skill sharing through initiatives such as, 'GLAM (Galleries, Libraries, Archives and Museums) Labs', where professionals meet, network, and share knowledge about digital cultural heritage projects.

Another strategy available to institutions is to acquire access to skills and technology through 3rd party specialists. However, few institutions have the luxury of investing in technologies required for digitization or can afford to keep a 3rd party specialist, let alone a team of specialists, available for a given cultural heritage project. In relation to this, one participant mentioned:

> ''It gives people the ability to interact with objects and see them in a different context outside the museum. Good for access, but it is the Wild West in the sense that I do not think people have processes in place at the moment. I think that there are moves towards it. You know there is a lot of talk about how to do that.''

And while such networking opportunities and services might provide access to key skill sets, the ever-changing technological landscape presents the challenge of sustainability, with participants reporting concerns on issues such as file storage, file metadata, file formats and reliance on 3rd party support, together accounting for 28% of references considered as 'challenges of digitization'.

User Experience for practitioner and visitor

Nearly every participant showed their support for cultural digital items and considered them to be an improvement over their analogue counterparts. This is most likely due to the main advantage of cultural digital items, as reported by the study's participants, that of 'accessibility'. Digital items can be shared, copied, and accessed to a far greater degree than their analogue counterparts.

> ''It's worldwide, you don not have to be in the Gallery to do it, but it is obviously horrible what is going on at the moment, the brilliant thing is that we can make the items completely 3D interactive and anyone at home, anywhere in the world, can see it and interact with the same too.''

One interesting area of response was the support for haptic technologies. This seems to be an interesting extension of the interactive experience by providing the opportunity for users to touch a digital cultural item, with additional learning opportunities such as appreciating texture and weight.

> ''You can start incorporating haptic interactions. You can do 3D printing from these items for schooling, kids can come into the library, and they can actually touch what the original is like and get an idea of what how it feels.''

With this said, cultural heritage practitioners were generally focused on improving the visitor experience when engaging with experiences created using digital cultural items before improving technologies themselves. Furthermore, different participants discussed the need for 'reducing complexity' when engaging with the various technologies and practices connected to digital cultural items, as well as a need for improving interaction.

> ''And another quote from Douglas Adams is about the technology. I have to paraphrase it, but the piano, we do not call the piano technology, because it is a piano, right? Because it just works. We have not got there yet, with the internet. And all of that is kind of still technology, we must call it technology. I think where we will end up is, it will be so effortless that it might as well just be the real object. '

> *''How do we cut through this layer that we don't need them to know about? The way we did it was through telling them they don't need to know about manifest URL's because most of the time, with the IIF, the manifest URL points to a JSON file which has the details of each item. But then you need to explain what a manifest is and then explain how to use the manifest. In the end, we chose to avoid this by only presenting the most important details.''*

This suggests that practitioners prioritise enhancing their existing resources over developing new technologies and practices, especially when the latter necessitate significant investment, such as acquiring or maintaining new skills. Fortunately, numerous examples outside the digital cultural heritage sector demonstrate improvements in interactivity and underscore the critical need to reduce complexity when engaging with digital technologies.

Learning, inspection and space

In keeping with current practice and literature, the study demonstrated that nearly every effort and project involving digital cultural items involved, to some degree, education.

It can be posited that digital cultural items, due to their enhanced accessibility compared to analogue counterparts, support self-guided learning as much as they do directed learning. This is evident when we consider the most frequently reported style of interaction with a digital cultural item, specifically 'inspection'.

This is supported by the number of references regarding some form of visual inspection, with both 2D and 3D objects providing systems such as zooming, panning and rotating, allowing for a user to choose where and how they visually inspect a given item. Of interest was the discussion around annotation, which was reported as a useful teaching tool but also presented the possibility for a user to annotate an item, leaving a comment or remark, and in the process participate in a form of self-styled, visitor-centric curation available to non-cultural heritage practitioners.

When engaging with 3D digital cultural items, the various immersive technologies that are commonly the focus of contemporary academic cultural heritage study were used to facilitate inspection. One popular technology was augmented reality and with it the ability to convey spatial information such as scale, through comparison of the digital cultural item and real-world environments and items.

Meanwhile, virtual reality technologies were discussed in the context of 'immersive' experience, where the visitor was expected to interact with and within a digital environment. Both AR and VR provide additional interactivity and information to a visitor wishing to inspect a digital cultural item, especially with regards to conveying spatial information such as the relative size of a gorilla's skull compared to the user or digitally placing the user within a cultural heritage environment. On this, one participant mentioned:

> ''Why we're interested in immersive as well AR, is because we are going to look at these objects to scale. On a table top I can see how big this gorilla skull really is. We did this the other day with a bear. We searched Google for a bear, and we got a kind of a scene in AR. I put it in our living room, and I showed it to my partner, and they literally got the flight response from it. That is scary, that is dangerous, because it is so big. This thing is in my living room and it is really scary and it is really big. Try doing that on a webpage.''

However, these technologies still require systems that are unavailable to the majority of visitors through a combination of cost and the requirement of specialist technical knowledge.

Online platforms present 3D digital cultural items in a form that many visitors can access, assuming they have a personal computer and access to the internet. Of note was the popularity of digital item display sites such as Sketchfab, which provides the functionality for VR viewing. These 3rd-party managed platforms are attractive to institutions potentially because they allow for the externalisation of resource costs, such as time, technology, and training, which would otherwise need to be absorbed by the institution itself if they were to create, manage and develop their own digital item viewer. Moreover, with the discussion surrounding accessibility, one of the advantages of a 3rd-party site for sharing digital cultural items is its potential to help encourage efforts to standardize digitization efforts through only supporting selected file formats and file sizes, while encouraging best display practice through visibly recording and displaying the popularity of a given digital cultural item or curated collection.

As presented in this study, nearly every participant highlighted how spatial information enhanced visitor interaction with items and, consequently, the learning experience. However, much of this spatial information, such as scale and locative data, is lost when curators rely on platforms like Sketchfab. While many digital cultural items shared through the platform do include a reference to help users understand scale, the techniques used, and their effectiveness vary widely. As for locative information, it is typically found in scans of cultural heritage sites, likely due to the data capture process using drones, which automatically includes an area much larger than the selected cultural site. However, for most digital cultural items, particularly smaller ones, locative information is often absent. Instead, digital cultural items are displayed within the 'black or grey void' of digital space.

Curation extends beyond mere sharing and showcasing. However, while CHPs are tackling the technical challenges of digitising and sharing cultural items, certain critical aspects of curation, such as constructing and supporting a narrative through object placement and environment design, seem to have been somewhat overlooked. This is understandable if we consider that third-party digital item sharing platforms, despite their convenience, may limit curation efforts due to the specific set of tools and systems they offer.

Findings from Study 1: What to CHPs want?

With this study it attempted to provide a 'voice' through semi-structured interviews to 10 participants including both CHPs and SPs, in an effort to answer how the increasing trend to digitize and the push to engage with rapidly changing technologies affect the everyday experience of CHPs working with digital cultural items, their capture, management and curation. Overall, CHPs and SPs were positive about the digitization of cultural items with all participants reporting on the value of increased accessibility, specifically their ability to be shared and made available far more readily than their analogue counterparts. Digital cultural items were reported as being used in a variety of ways to provide educational experiences where visitors could inspect and, in some cases, approximate experiences with digital versions of analogue items that would otherwise be impossible. Furthermore, the increased level of interaction has supported new and often exciting ways of teaching and learning for both curator and visitor.

However, the resources required for digitization, specifically the investment of time, the specific skill sets, and the specialized technologies required, continue to challenge CHPs. While research efforts continue to advance digitization technologies and practices, CHPs are concerned with managing the digital cultural items they have available while ensuring that their key advantage, accessibility, is not lost because of a given technology or practice becoming no longer supported. In essence, CHPs are interested in 'using digital items better' and research that supports their day-to-day practice through making technologies easier to use, for themselves and visitors, while ensuring their efforts of digitization and curation are supported long-term and in tandem with the continuous advancement of technology.

How can we better utilize the digital void to enhance the visitor experience and provide additional learning opportunities? How can CHPs acquire additional spatial and locative tools in order to aid in forming narratives for curated collections? Finally, what might these tools look like? In our next chapter the benefits of gathering spatial and locative data are explored when integrated into the presentation of digital cultural items using commonly accessible platforms of interaction, specifically screen-based technologies.

Chapter 4

Study 2: Evaluating contextual information when presenting DCIs

We have explored the challenges experienced by Cultural Heritage Professionals (CHPs) as they endeavour to craft captivating cultural experiences through the utilisation of Digital Cultural Interfaces (DCIs). In this chapter, we aim to present a study that digs deeper into a specific aspect of employing DCIs within cultural heritage experiences, focusing on the incorporation of spatial information.

However, it is important to note that as this research work progresses, the plan is to refine the terminology from "spatial" to "contextual information". This change is because while "spatial" pertains to the quality of space, "contextual information" encompasses spatial and various other forms of information that are valued in cultural heritage presentations, such as scale, age, location, use, and provenance. Before dedicating our research efforts to this phenomenon, a study was conducted to ascertain its importance, its impact on and question how we could use contextual information to improve the user experience.

The Impact of Contextual Information on Presenting Digital Cultural Items

When encountered online, digital cultural items are often displayed in a grey void that lacks spatial information. The question thus becomes, do we need spatial context when presenting DCIs? If the intent is to simply present a digital model for inspection, it could be argued a grey void is all that is required. What might we gain however from including spatial information such as reference objects and scenery, 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 cater their 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 found supporting the efforts of cultural institutions around the world (Konstantakis and Caridakis, 2020a; Pujol-Tost, 2019). 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 (Flynn, 2022). 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 (Terras, 2015). Bespoke platforms are costly to develop and maintain plus risk becoming redundant unless continually updated, reducing their long-term survivability (Borissova, 2018; Macrì and Cristofaro, 2021; Zorich, 2003). 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 it is observed curators, often working with exhibition designers, invest considerable time and energy carefully crafting presentations for cultural items. It is via the inclusion of spatial information that learning experiences can be formed by CHPs as they utilise a combination of architectural space, contextual association and additional themed assets to shape the experiences of their visitors, forming engaging narratives through which they might learn from (Wolff and Mulholland, 2013).

The presented study investigates how context shapes user experiences with DCIs. There is, to 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 includes a description of a tool designed and developed to answer them. Following that there is a description of 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, the aim is to support CHPs, cultural heritage institutions and 3rd party developers involved with the cultural heritage sector in creating engaging, informative online experiences with DCIs.

DCI contextual information user study

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

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

To answer these questions, there was the requirement of a selection of DCIs to present to our participants. The study 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.

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 (Flynn. T, 2022). 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 the 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. The DCIs originated from a time that, combined, spanned 3500BC to 712BC.

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. 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 (Bloomer, 1990; James, 1982). Figure 1 shows the 3 DCIs and examples of the CIP tool with a selection of elements generated by the tool.

***Figure 10**: DCIs and examples of presentations using SIT with various elements.*[2]

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:

2

Sarcophagus of Taditjaina, Granite head of Amenemhat III, Predynastic bowl, taken from Sketchfab creative commons collection, available at https://sketchfab.com/3d-models/granite-head-of-amenemhat-iii-64d0b7662b59417986e9d693624de97a and https://sketchfab.com/3d-models/predynastic-c-ware-bowl-with-hippos-cddbca0ef489488398388a6831b47e1b, last accessed 21.02.25

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.

Figure 11: A DCI presented using CIP tool, with multiple layers selected.

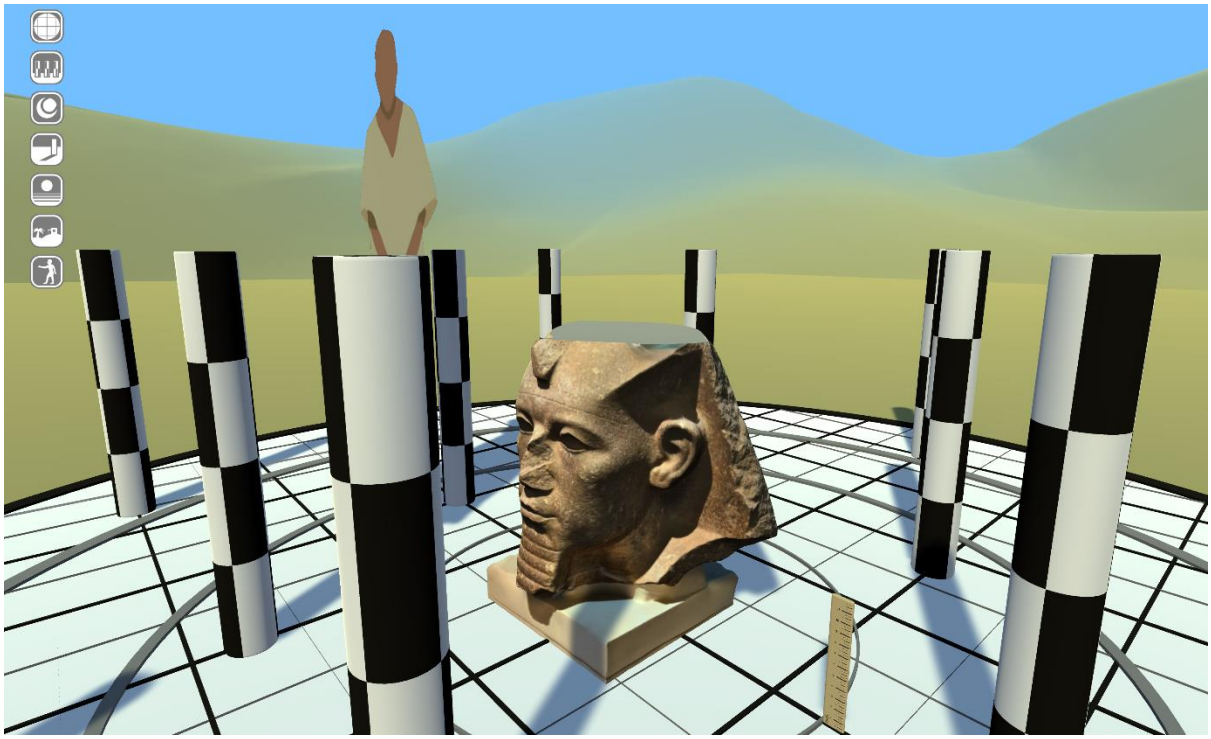

Figure 12: DCI, presented using the CIP tool, with the occlusion, context character and common item reference.

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 and 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 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.

Methodology

The 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 just after task completion which has been proven useful in eliciting participants' emotional reactions (Petrie and Precious, 2010).

Participant Selection Criteria and 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 the literature (Ando et al., 2014; Guest et al., 2006). Due to Covid-19 concerns at the time, participants were given the option of face-to-face participation or online

participation. Furthermore, the online study offered greater flexibility to participants who might find travelling difficult. Every participant opted for online participation.

Study Structure

15 participants were presented with 3 DCIs and asked to complete 5 tasks, producing 45 discrete DCI interaction data sets. Participants were encouraged to 'think aloud', verbally expressing their thoughts, feelings and experiences. While Think Aloud tasks promise 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 (Petrie and Precious, 2010). In response, semi-structured interview questions were also presented to participants upon completion of each Think Aloud task.

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 more refined coding passes. This was undertaken in an Initial Coding pass by means of Descriptive Coding, where topics, referred to as thematic codes, were assigned to blocks of text, as described by Saldaña (Saldaña, 2021).

Each code had its own criteria for inclusion which determined if a block of text would be added. The codes were divided into positive, neutral and negative blocks at the coder's discretion. The data was coded and analysed using NVIVO and 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.

Key Themes

What are the benefits of gathering spatial 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.

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 4: Greater Realism. Participants reported that the Shadows element helped 'ground' the DCI, which made the DCI 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 sensations of I am in a place, there is 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 if encountered outside of a digital environment.

Greater Realism		
Positive: Greater Realism of the DCI	**Participants %**	**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

Table 4 :Thematic Code, Greater Realism

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 to create what was described as a 'sunny' or 'summery' feel:

> "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 am not just in the middle of nowhere. There's a summery feel to it almost, the idea of the 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 uncommonly encountered 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'.

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 in Table 4: Understanding Size.

Understanding Size		
Positive: Understanding Size	**%Participants**	**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

Table 5: Thematic Code, Understanding Size

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 an improved learning experience:

> "The background definitely added in the concepts 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 at 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 is 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 '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. Potentially in response to this effort to create a realistic science, 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.

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 in Table 6: Generate Narrative

Generate Narrative		
Positive: Generate Narrative	**Participants %**	**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

Table 6: Thematic Code, Generate Narrative

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 help. I love it. I am just, I am living it, because I love being able to see these stories. And this has a whole story going on right now. There is 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 am so glad they're here.”

> “And the woman, I am assuming has something to do with it. She has obviously got something to do with the sarcophagus. And but I do not know, is that the person in the Sarcophagus? Is that the mother or the caretaker of someone for the sarcophagus? Yes, that is it.”

Largely 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. Additional criticism was made regarding the elements of participants seeking to generate narratives involving the DCI.

Reactions to nothing

Most 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 is floating in space, somehow, there is no information in the background, there is nothing to compare it to. So, it is difficult to understand how big this is. It is a feeling, it seemed like I was quite close to it. So, now this I've got no real sense of scale.”

> “And it is 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 is nothing behind it. I am not distracted by anything else in the background. So, for inspecting this particular item, I would say a plain background is good for me.”

> “So, the fact it is a dark grey makes it easier, I can see that I am 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.

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 would not 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 have 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 associates 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.

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 (Zittoun and Brinkmann, 2012).

Participants would engage with a variety of elements, adjusting the environment in accordance with their personal preference. Some focused their attention 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 spatial information, both contextual and physical, (Wolff et al., 2012), 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 (J. H. Falk, 2016).

Contextual elements

Regarding specific elements, several 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 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 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 most 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, (Seyama and Nagayama, 2007). 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.

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 does not necessarily affect me emotionally. But it piques my interest because it is 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 is just floating in the middle of a grey neutral background. It does not feel natural. I mean, naturally bowls do not float in real life. 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 (Bruner, 1991). Likewise, narrative can be said to be one of the most fundamental ways we learn (Bedford, 2001) and a powerful tool in the CHPs’ tool kit as they seek to create engaging, educational experiences (Wolff and Mulholland, 2013).

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 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 is 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 cannot 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, commonly reported as key to experiences with DCIs (Ferraris et al., 2021), interactivity akin to 'playing detective' or puzzle solving. 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. Many focus on the fundamentals of game design 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 the study shows, by providing contextual elements to participants when they engage with a DCI, participants considered the DCI as more than 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.

Findings from Study 2: Evaluating contextual information for presenting DCIs

What are the advantages 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?

With this study it has been attempted to demonstrate that by including contextual information one can improve visitor interaction with DCIs, their understanding of size and scale and increase the perception of realism with regards to the DCI. It has been explored how giving visitors the choice to customise the spatial elements supporting a DCI supports the generation of narrative, which can be used to engage and educate. It has been posited that by gathering spatial information when presenting DCIs, one might change how visitors engage with a DCI, shaping their experience towards engaging with a DCI in manner like that of the analogue cultural item from which it was created.

As it has been demonstrated through this chapter, 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. Understanding the advantages, the impact and how one might use contextual information when presenting DCIs, is another step towards supporting CHPs and forms the basis of our next chapter, where the focus will be placed on how contextual elements can be used to create informative and memorable cultural experiences.

Chapter 5

Study 3: Understanding Contextual Information in DCI presentations.

As we have explored in the previous chapters, cultural heritage practitioners (CHPs), often working with the support of third parties, have explored how to use DCIs to create engaging, entertaining and informative experiences for their visitors. While bespoke technological solutions can be used to present DCIs, the expense of creating and maintaining them can often be seen as a barrier (Borissova, 2018; Macrì & Cristofaro, 2021; Zorich, 2003). Digital model hosting platforms offer the advantage of externalising many of the costs associated with DCIs and many CHPs are already exploring online solutions to DCI presentation, such as Sketchfab and others (Flynn, 2022).

While online solutions for presenting DCIs have many advantages, it can be said that they are still too often defined by a style of virtual presentation space that is sometimes referred to as the 'grey void'. This grey void allows for the inspection of a DCI but lacks contextual information that offers to support the visitor user experience by providing additional learning opportunities, such as new forms of interaction and an understanding of a DCI's size and scale (Ferraris et al., 2021).

As with each of our studies so far, the following focuses on supporting those seeking to present DCIs through exploring the challenges of using contextual information in the presentation of DCIs and asks the following questions:

- What are the advantages, and which contextual elements are valued by those engaging with DCIs?
- What are the challenges of using contextual information in the presentation of DCIs?
- How might we better support the user experience with DCIs through the inclusion of contextual information?

Contextual Information & DCI Presentation

Principles & Assertions

To understand the challenges and value of using contextual information in the presentation of DCIs were formed in response to our previous study that investigated how contextual information affects the user experience. These principles were designed in terms of a series of defining assertions and to validate and refine these principles our method and survey are closely tied to testing these assertions:

Principle of Size & Scale

The Principle of Size & Scale asserts that the inclusion of contextual information in the form of comparable items supports a visitor’s understanding of size and scale of a DCI. Within the study, this is supported by the inclusion of selected elements, specifically, the Human Figure

Reference, the Common Item Reference, the Scenery Reference and, finally, the Abstract Human Reference. The Principle of Size & Scale is comprised of the following assertions:

- **Assertion A1** A common item supports understanding of size and scale
- **Assertion A2** A human figure supports understanding of size and scale
- **Assertion A3** When including common items with measurements, users prefer clearly visible units
- **Assertion A4** When considering the size and scale of a DCI, preference changes, depending on the relative size of the supporting item and the DCI

Principle of Valuing Provenance

The Principle of Valuing Provenance asserts that the inclusion of certain contextual elements encourages visitors to engage in meaning-making regarding the provenance of a DCI. Specifically, who is connected to the DCI, where the DCI originates from and when the DCI was used/the age of the DCI. Within the study, this is supported by the inclusion of the Human Figure Reference ('who'), the Scenery Reference ('where') plus the Timeline ('when'). The Principle of Valuing Provenance is comprised of the following assertions:

- **Assertion B1** Human figures generate interest regarding how they are connected to the DCI
- **Assertion B2** Temporal elements generate interest regarding how the DCI is connected to history/time
- **Assertion B3** Locative information generates interest regarding how it is connected to the DCI

Principle of Valuing Aesthetic Consistency

The Principle of Valuing Aesthetic Consistency asserts that visitors value a consistent aesthetic quality when engaging with presentations of DCIs. This principle was previously referred to as the principle of realism. Within the study, this principle is supported by contextual elements of different aesthetic styles, such as 2D and 3D, abstract and realistic, which were presented with the DCI. The Principle of Valuing Aesthetic Consistency is comprised of the following assertions:

- **Assertion D1** As perceived realism of a DCI presentation increases, users become more critical of contextual elements
- **Assertion D2** Users prefer contextual elements within a DC presentation to share a similar aesthetic quality

Principle of Expected Interaction

The Principle of Expected Interaction asserts that visitors form expectations regarding how to interact with a DCI based on their previous experiences with similar items. It also states that visitors engage with digital cultural heritage items in a manner supported by their experiences with analogue cultural heritage items. The Principle of Expected Interaction consists of the following assertions:

- **Assertion C1** Users expect to interact with DCIs that resemble hand-held items as if they were using their hands
- **Assertion C2** Users expect to be able to move around DCIs that resemble items considered too cumbersome to carry or move

- **Assertion C3** Cultural heritage experiences frame expected behaviour of cultural item interaction

Principle of Valuing Context

The Principle of Valuing Context asserts that contextual information, when used in the presentation of a DCI, improves the UX and is valued by visitors. This principle encompasses all of the previous principles and is used to support the inclusion of contextual information in cultural heritage projects and challenge the reliance of using the grey void, a presentation environment that has no contextual information at all. In the study, this is supported by the inclusion of specific questions targeting participant reactions to the DCI when presented within the grey void and also when presented with contextual information. The Principle of Valuing Context is based on the following assertion:

- **Assertion D1** Users value contextual information when learning about a DCI

Study Structure

To explore the impact of contextual information on the User Experience when presenting DCIs, our study was comprised of an online survey divided into 6 distinct stages. Each stage represented the DCI in virtual environment within which participants could inspect the DCI by zooming, rotating and panning, with the option of toggling on and off contextual elements, where appropriate. Each stage addressed assertions from one or more Principles, as follows:

Stage 1: Principles of Size & Scale and the Principle of Valuing Context
Stage 2: Principle of Understanding Size & Scale
Stage 3: Principle of Provenance and the Principle of Desired Realism
Stage 4: Principle of Desired Realism
Stage 5: Principle of Expected Interaction
Stage 6: Principle of Expected Interaction and the Principle of Valuing Context

For each stage, participants were then encouraged to express their thoughts, feeling and reactions regarding the presentation of the DCI, using a 'free text' box.

Figure 13 A DCI presented with no contextual elements within the virtual environment.

3.1.1 Stage 1. Stage 1 addressed assertions that aligned with both the Principle of Size & Scale and the Principle of Valuing Context. There were no contextual elements within the virtual environment (see Figure 13). The DCI was presented with a 'grey void', a style of virtual environment popular with those presenting DCIs online and commonly encountered by visitors.

3.1.2 Stage 2. Stage 2 addressed the Principle of Understanding Size & Scale. This would be the first-time participants encountered elements that provided contextual information that indicated the size and scale of the DCI. The virtual environment included elements to support the understanding of size and scale (see Figure 14).

Figure 14 A DCI presented alongside contextual elements to evaluate the principle of understanding size & scale.

Stage 2 presented the DCI in a grey void and participants were requested to 'toggle on and off' two contextual elements. The first of the two elements was the Common Item Reference, which could be 'cycled' by the participant, presenting them with 5 items that the participant was expected to be familiar with: a chair, a coke can, a laptop computer, a 30 cm ruler and a 100 cm ruler. The second element was the Human Figure Reference, a 2D render of a human figure depicting a person from the time period and culture associated with the DCI. Both the Common Item Reference and the Human Figure Reference were designed to provide contextual information regarding the size and scale of the DCI.

3.1.3 Stage 3. Stage 3 addressed assertions that aligned with the Principle of Provenance and the Principle of Desired Realism. This would be the first-time participants were presented with elements that provided contextual information regarding the origin, culture and age of the DCI.

Stage 3 presented the DCI in a grey void and participants were requested to 'toggle on and off' 4 contextual elements. These 4 elements were the Common Item Reference, Human Figure Reference, the Scenery Reference, and the Timeline. The Scenery Reference element consisted of a scene comprised of several digital elements, themed to depict a location that

may be associated with the DCI (see Figure 15). The Timeline was an abstract graphical indicator designed to communicate 'when' in the time the DCI might have existed.

3.1.4 Stage 4. Stage 4 addressed assertions that aligned with the Principle of Desired Realism. This would be the first-time participants encountered abstract contextual elements and was designed to evaluate reactions to abstraction and realism within the DCI presentation.

Stage 4 presented the DCI in grey void and participants were requested to 'toggle on and off' 4 contextual elements. These 4 elements were the Display Platform, Abstract Human Reference, Scenery Reference and Human Figure Reference. The display platform consisted of a digital 'plinth' upon which the DCI can be presented while the Abstract Human Reference consisted of a 3D model of a human figure, displayed with as a solid single colour with no texture (see Figure 13).

Figure 15 A DCI presented with contextual elements to evaluate the principles of provenance and the desired realism.

3.1.5 Stage 5*.* Stage 5 addressed assertions that aligned with the Principle of Expected Interaction. During this stage, participants were encouraged to imagine the different ways they might interact with the DCI. This stage did not present any contextual elements to the participants and was designed to challenge their expectations of interaction with the DCI.

3.1.6 Stage 6. The final stage, Stage 6, addressed assertions that aligned with the Principles of Interaction Expectation and the Principle of Valuing Context.

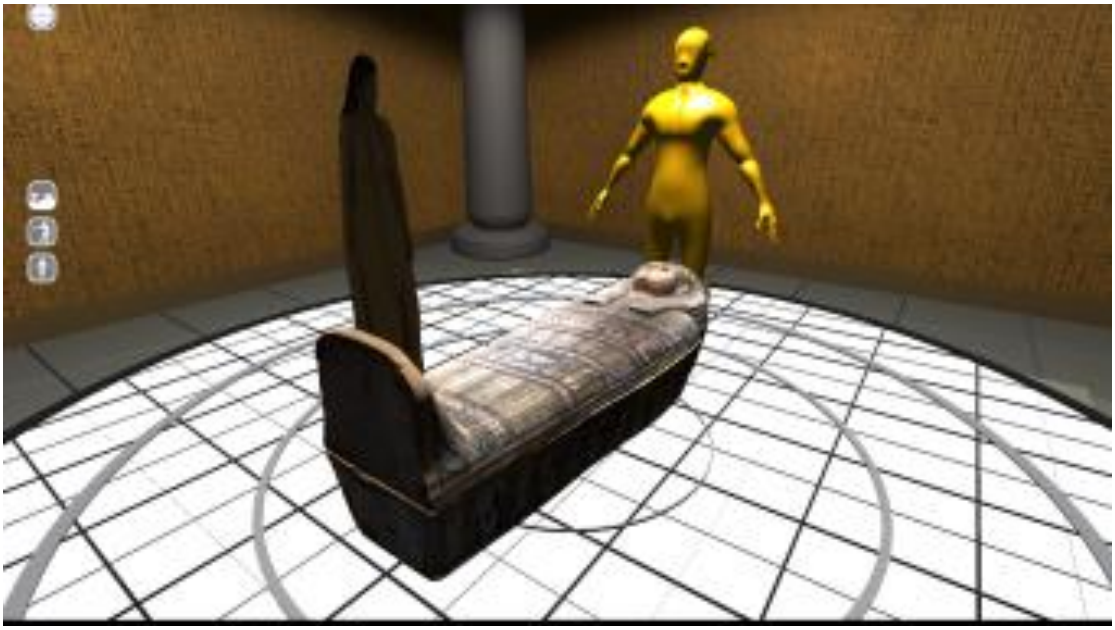

Figure 16 A DCI presented with contextual elements to evaluate the principle of desired realism.

Stage 6 presented the DCI within a grey void and included all the previous elements that were available during the previous stages of the study. The questions for this stage were designed to provide the possibility to affirm or indeed challenge responses provided in previous stages. Participants were encouraged to toggle as many elements on and off as they wished while trying to learn as much as they could about the DCI.

3.2 Participant Selection Criteria & Coordination

40 participants were recruited via word of mouth, online public forums, targeted Discord groups and private cultural heritage collaborative platforms, amounting to a combination of self-selection and convenience sampling. Participants were not required to have any cultural heritage experience or experience with DCIs. Each participant represented a cultural heritage visitor from the general public with no participant exclusion criteria. All participants were selected on a first come, first served basis.

Methodology

4.1 Study Materials

The study's stages were delivered through an online survey. Participants were assigned one of three DCIs, which were presented using CID and asked to complete the survey at their convenience. The survey consisted of 6 'free text' questions which were used to generate qualitative data, with participants encouraged to express their thoughts and feelings regarding the DCI by typing their responses in a 'free text' box.

4.2 Study Structure

Participants were presented with one of three randomly determined DCIs, each displayed in a digital environment using the contextual information display system (CID).

CID presents a digital cultural item within a 'grey void', with no supporting contextual information and has configurable layers that can be made available by the researchers. CID supported the study through providing the researchers with the ability to build several stages, each with their own contextual elements assigned to layers. Each layer could then be toggled on and off by participants, as instructed.

Analysis

Qualitative data was collected using 'free text' responses. From these written responses transcripts were encoded using exploratory methods, where the researchers conducted open-ended investigation of the data before more refined coding passes. This was undertaken in an initial coding pass by means of Descriptive Coding, where topics, referred to as thematic codes, were assigned to blocks of text, as described by Saldana [29].

Each code had its own criteria for inclusion which determined if a block of text would be added. The data was analysed using NVIVO and deductive coding, whereby blocks of text were assigned to codes organised under the 'Principles of Qualitative Information in presenting DCIs'. 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 Participant Survey Responses

5.1.1 Stage 1. Stage 1 consisted of one free text question. This stage presented the DCI to participants with no contextual information. The answers to this stage were used as a base case and, in Stage 5, in order to compare and refer to the following section.

5.1.2 Stage 2. The *Principle of Valuing Size & Scale* included three assertions. This principle asserts that various elements included within a digital presentation of a DCI supported the participant in understanding size and also scale. Coding for the free text responses suggests support for the *Principle of Size & Scale*. Again, both the Common Item Reference and Human Figure Reference were near equally effective. This also provides some insight into how participants valued each reference:

Principle of Valuing Size & Scale		
Thematic Code	**Positive %**	**References**
Valuing Size & Scale	67.5%	56
Human Figure Reference	35 %	19
Common Item Reference	32.5%	19
General Support for Size & Scale	15%	6

Table 7: Principle of valuing size and scale.

Overall, participants strongly supported the reference items as a means of augmenting their understanding of size and scale. Interestingly, the ruler common item reference was praised by only 15% of participants, who reported they valued the additional accuracy:

> "Having the human figure does add some context to the item's size, but having the ruler available helps really get a feel for how big the bowl is. For instance, I can say that this bowl is 6 inches tall." - P4

> "I was able to read the ruler, which is 12 inches. That gives me a good idea of the size of the sarcophagus." - P21

While the responses suggest that the common item reference was valued by participants, some of the common items were simultaneously criticised for seeming 'out of place' or 'strange':

> "At first I was confused because it is not the "usual" way to display an item to a visitor, but the use of unusual (common) items to comprehend the scale and size captured my attention much better than any item would have done." - P9

> "The different items placed next to the item is a weird but nice touch. This way I better grasped its size." - P34

> "The rulers give numerical values of the size of the artefact, but this feels disconnected."- P8

5.1.3 Stage 3. The responses for Stage 3 suggested an appreciation for contextual elements that inform of size and scale. The responses from Stage 6 also supported Stage 3 and included the free text response to the Principle of Valuing Provenance, indicating that participants appreciated opportunities to learn about the provenance of the item. While participants responded positively to the Human Figure Reference, Timeline and Scenery Reference the *Principle of Valuing Provenance*, the Scenery Reference provoked the most interest amongst our participants who formed conclusions regarding the cultural significance as well as the people, place and time of the DCI in response to the digital environment presented:

> "I strongly agree that it is essential to know who is associated with this cultural item as well as where it originates from." - P9

> "I picked the scenery because I think it gives an idea about the daily usage of the object." - P15

> "Era and people presentations are really good for associating this item with its purpose." - P37

Principle of Valuing Provenance		
Thematic Code	**Positive %**	**References**
Valuing Provenance	50%	78
Scenery Reference	42.5 %	22
Timeline	22.5%	21
General Support for Provenance	20.5%	31
Context Figure	10%	8

Table 8: Principle of Valuing Provenance

The Timeline, perhaps surprisingly, received the least support from participants with regards to provenance. However, this element did not receive any criticism either, with participants instead focusing on the Scenery Reference and the Human Figure Reference as well as presenting general support for the idea of understanding the provenance of the DCI:

> "I particularly like the fact that now I know from which period this sarcophagus is." - P10 "I really liked how the item is presented in a place where it originated as well as the extra information regarding the age, timeline and the origin of said item." - P12

> "It is incredibly important, as to anything's history, to explain its usage, relevance and importance to the history of its country whilst including information on said country." - P25

Overall, both the survey and the free text responses support the *Principle of Valuing Provenance* and suggest that participants, when provided with appropriate contextual information, have a keen interest in the people and place connected to a DCI.

5.1.4 Stage 4. Participant responses for Stage 4 reinforce the idea that participants valued a consistent aesthetic first at 57.5% (48 references), followed by graphical fidelity at 27.5% (14 references). Many participants reported that the abstract elements detracted from their experience with the DCI, were distracting and felt 'out of place':

> "The abstract environment is meaningless. It does not even look like an environment; it looks like a guide grid on a digital design software package." - P20
>
> "I like the scenery to fit with the digital cultural item." -P24

Many participants expressed their dislike of the Abstract Human Reference, reporting that they found it distracting, discomforting and, in some cases, 'scary':

> “I will be honest the Abstract Human Reference made me jump and completely pulled me out of the experience, therefore I much prefer the Human Figure Reference." - P18

> “I definitely prefer the context human figure. The abstract human figure made me feel alienated from the cultural item." - P29

Principle of Valuing Aesthetic Consistency		
Thematic Code	**Positive %**	**References**
Valuing Realism	72.5%	89
Contextually Appropriate Elements	57.5%	48
Graphical Fidelity	27.5%	14
Scenery Reference	22.5%	14
Human Figure Reference	20%	8
Common Item Reference	7.5%	6
Abstract Human Reference	7.5%	3

Table 9: Principle of Valuing Aesthetic Consistency.

Finally, the Common Item References also received criticism, again in keeping with the coded responses from Stage 1, further supporting the idea that the participants valued presentations of the DCI where supporting contextual elements and the DCI shared the same aesthetic and theme:

> “Human Figure Reference is much better than the common item reference because most of the common items look really alien when placed next to the objects.” - P4

> “That is why I find the items that don’t belong to that specific period very distracting and out of place.” - P15

These responses strongly support the Principle of Valuing Realism. Furthermore, the results suggest that participants value visual assets with a consistent aesthetic quality. DCIs presented alongside assets without a consistent aesthetic quality, such as a photo-realistic sky combined with hand-drawn characters, detracted from the user experience.

5.1.5 Stage 5. The *Principle of Expected Interaction* was formed based on responses from our previous study which suggested that when encountering a DCI for the first time, participants expected to be able to interact with it in a manner similar to items they had interacted with previously. For example, a participant might expect to interact with a DCI of a cup by ‘holding’ it and turning it. Likewise, we proposed that participants might be more inclined to walk or

move around a larger DCI, one which if encountered in the real world would be too large to pick up or hold. Finally, we wished to test how participants would react to the suggestion of interactions that were not typically encountered by cultural heritage institutions when interacting with items in their collections, specifically the acts of throwing/dropping plus breaking/smashing.

Principle of Expected Interaction		
Thematic Code	**Positive %**	**References**
Expectation of Interaction	87.5%	66
Support for Throwing, Breaking	40%	16
General Support for Inspection	35%	20
Against Throwing, Breaking	20%	8
Praise for the Grey Void	20%	8
Expectation from Experience	20%	8
Wanting Additional Interaction	15%	8

Table 10: Principle of Expected Interaction.

The responses for Stage 5 revealed a strong support the *Principle of Expectation of Interaction*, with many participants valuing the ability to inspect a DCI, often in ways that would not be possible with a DCI's analogue counterpart:

> "The Egyptian coffin is widely decorated on the outside. To my surprise I was able to see the inside which had no decorations. I was happy to manoeuvre the coffin." - P30 "Being able to manipulate the digital environment offers more opportunity for interaction than the real-life display would." - P6

> "Zooming in and out gives an opportunity to look closely at the details which you cannot really do in museums." - P10

Regarding interactions of throw/drop and smash/break, the coded responses suggest that participants were conflicted. While some participants expressed that they found value in the additional form of interaction, a near equal amount responded that they felt the form of interaction inappropriate for a cultural heritage experience and even that they would feel bad in performing these actions:

> "I surely don not agree that throwing and dropping the digital cultural item would be of value, as well as smashing it. This is more appropriate for a video game, not for a museum tour." - P13

> "I do not think I would want to break the artifact even if I know it is not real and it might give me more information about the durability of its material. I'd feel bad about breaking a historical cultural item." - P33

> "People will just try to break the object because they can. Instead of focusing on the details, many would just try to smash it and see if it's going to look realistic." - P37

These suggest that, while some styles of interactions with DCIs are not influenced by its size or previous experience to the extent as expected, further research focusing on cultural expectations and behaviours could provide valuable insight into understanding how best to utilise the digital nature of DCIs.

5.1.6 Stage 6. The final stage focused on the *Principle of Valuing Context*. To test the principle, we incorporated Question 1 from the start of the survey, presenting the DCI in a 'grey void' with no contextual information. Participant responses suggest a strong support for the *Principle of Valuing Context*, with 90% of participants (112 references) providing responses for Valuing Context. Of these responses, participants favoured both the Human Figure Reference (40%, 26 references) and the Common Item Reference (35%, 19 references).

Principle of Valuing Context		
Thematic Code	**Positive %**	**References**
Valuing Context	90%	112
Human Figure Reference	40%	26
General Support for Including Context	40%	23
Common Item Reference	35%	19
Scenery Reference	32.5%	19
Timeline	20%	11
Challenges of Presenting Context	15%	8
Wanting Additional Context	12.5%	6

Table 11: Principle of Valuing Context.

Responses to Valuing Context by participants included discussion regarding how background is important to learning about cultural items and how the elements within the presentation supported learning and improved their experience with the DCI:

> "Any further context makes the item more interesting, as otherwise it is just a damaged bowl that you would assume is old." - P18

> "Now the item has my full attention. This whole experience makes me more and more curious." -P3

> "Fascinating. Wish this was around when I was growing up. I think young people have such an advantage. Lucky people." -P38

In keeping with the coded response from the previous stages, coded responses for Stage 5 also emphasised the challenge of finding appropriate contextual items to include when presenting a DCI, though support for their inclusion remained strong:

> "None of the items felt particularly organic to the setting, but still served their function without being too distracting." -P3

> "Despite some of the additions being distracting, I found that overall, the additions would have helped my understanding." -P33

> "Sure, if you remove all the extra layers and just have a bowl flying in the grey void it makes you focus more on the small details, but I would prefer to see it in context". –P10

The *Principle of Valuing Context* gained considerable positive support, with participants responding to the inclusion of contextual information when presenting a DCI. While initial responses suggest participants supported the grey void when viewing the DCI, once participants had experienced and become aware of how contextual information supported the presentation of the DCI their support for the grey void ceased.

Discussion

So, what are the advantages, and which contextual elements were valued by our participant-visitors? What are the challenges of using contextual information in the presentation of DCIs? How might we better support the user experience with DCIs through the inclusion of contextual information?

To answer these questions, we defined our Key Principles, determined assertions to support them and designed our study questions in order to target these assertions.

Principle of Valuing Size & Scale

The results of our previous studies and this study strongly indicate (67.5%) that participants enjoy inspecting DCIs, rotating, panning and focusing on details as they engage in meaning-making to improve their understanding of a DCI's size and scale:

> "I want all the details, age, size, origin, etc. I can learn more about the Digital Cultural Item with the right items in place." - P22

When presenting an analogue cultural item, it is common practice to present the provenance of the item, such as the location of discovery, cultural information and age. Within a real-

world presentation of an analogue cultural item there is little need to support the analogue item with contextual information relating to size and scale as a visitor, through being physically present, can relate to themselves to an analogue item and approximate the size and scale via embodiment.

> "I think that in this case the context human figure conveys the best overall presentation reference. It also shows us from the position that the orientation of the cultural item is that of a lying down sarcophagus as opposed to one that is stood on its end." - P13

This could explain why the Human Figure Reference proved popular among participants when attempting to understand the size and scale of the DCIs (35%). While the digital human form is obviously not that of the participant, its relative familiarity supports the understanding of size and scale through embodiment, drawing upon personal experience. Likewise, the popularity of the Common Item Reference (32.5%) might be explained through the common items fulfilling a similar role to the humanoid figure, being items that we can assume each participant has had their own experience of interaction and thus a participant can, through embodiment, draw upon their familiarity with the common items to compare and contrast them with the DCI in order to provide a better understand of its size and scale.

In response to these observations, for curators working with DCIs who wish to support learning beyond just appearance and provenance the inclusion of contextual elements that support the understanding of size and scale can be said to be essential when presenting a DCI. Curators should take care to select contextual elements that are familiar to a visitor and which support understanding through embodiment, with the human form and common items promising to provide the better results.

Principle of Valuing Provenance

Exploring means to effectively communicate a cultural item's provenance underpins much of what constitutes a cultural heritage experience for a visitor. The curator, through the act of curation, carefully selects and decides what they wish to communicate about a given cultural item. In turn, the visitor engages with the act of meaning making.

Participants responded favourably to the inclusion of elements that provide information regarding the provenance of the DCI (50%). The inclusion of the Timeline element was well received (22.5%), perhaps because it is a tool that we can assume participants are familiar with, it being a device used to communicate time periods and age across the teaching spectrum. The digital model of the Context Figure, clad in clothing appropriate to the DCI, was reported to partially support participant understanding of provenance, though some participants reported confusion regarding its role and purpose. The Context Figure was presented as a 2D abstract representation of a human figure, and included less detail compared to other elements. This could be why the Context Figure, of all the contextual elements intended to support an understanding of provenance, received the least support (10%).

> "I really liked how the item is presented in a place where it originated as well as the extra information regarding the age, timeline and the origin of said item." -P7

The Scenery Reference was better received by participants than both the Human Reference Figure and the Timeline (42.5%). Within the digital scenery that comprised the Scenery Reference were geographical features, buildings and plants associated with the DCIs. Similar to the clothing and appearance depicted in the Human Figure Reference, but with enhanced detail, these elements provide clues. Participants enjoyed deciphering these clues, thereby engaging in a process of meaning-making to discern the origins of the DCIs.

Each of these contextual elements supported participant understanding of the DCIs' provenance, with the Human Reference Figure providing clues to answer, 'who' was associated with the DCI, the Timeline providing clues as to 'when' the DCI might be placed in time and the Scenery Reference providing clues for participants to determine 'where' the DCI originated from.

While a curator can offer a visitor specific information regarding a DCI's provenance through supporting text, this requires a shared language, which can exclude some visitors. Supporting text can provide specific information, though participants enjoy using contextual clues to, 'figure out' for themselves the provenance of a DCI, before having them confirmed or challenged through the provision of textual information. Our study demonstrates that provenance can be suggested to visitors through the inclusion of contextual information provided by selected elements within the presentation environment which also have the advantage of not relying on a shared language, while also improving visitor interaction with a DCI.

Principle of Valuing Aesthetic Consistency

The coded free text responses suggest that participants strongly valued a consistent aesthetic quality shared between the elements included within the presentation of a DCI (72.5%). While the Abstract Human Reference was poorly received by participants (7.5%) and the Scenery Reference scored highly (22.5%), this can be explained as the Scenery Reference sharing a similar aesthetic to the the DCI, with both being closer to a literal representation of their analogue counterparts rather than an abstraction.

This appreciation for aesthetic consistency and, importantly, the sharing of a common theme, aligns with the coded free text responses, where participants reported that they valued 'contextually appropriate' elements more so than graphical fidelity. Contextual elements that were not perceived as in keeping with presentation's theme were reported to undermine the user experience, seeming 'out of place' or 'strange':

> "The abstract human detracted from the digital display of the artefact, it created a dissociative element and took away the authenticity of the item." - P20

> "When displayed simultaneously the result is jarring, but used independently each contextual item has its own merits." - P3

When certain elements, specifically the Human Reference Figure and the Scenery Reference, were included within the DCI presentation, participants seemed to react to the DCI and the supporting elements as more than just a showcase for a high-fidelity digital model. Instead,

the study suggests the graphical 'realism' of contextual elements did not impact the user experience as much as the consistency of the aesthetic shared between the contextual elements.

This accepted aesthetic difference between DCI and contextual elements is in keeping with participant reaction to the Timeline, where an abstract element is accepted by participants as a tool for communicating information, and as a result of that does not negatively impact the user experience. Likewise, it can be said that participants recognised and accepted the use of other elements as 'tools' intended to support a DCI through the communication of contextual information, such as size, scale and provenance. The aesthetic relationship between contextual elements has a greater impact than the aesthetic relationship between contextual elements and DCI.

In response to these findings, we propose that when including contextual elements to support a DCI it is important to ensure that they all share a similar aesthetic quality, as elements that do not will detract from the user experience.

Principle of Expected Interaction

The Principle of Expected Interaction returned some interesting results„ with a strong positive response from participants (87.5%). When queried on whether they would pick up the DCI, participant responses across all DCIs were favourable (40%) and did not reflect the size of the object. Likewise, despite the depicted size of the DCI, participants did not favour walking around the DCI when trying to learn about it (15%). This challenged the expectations of the researchers and demands refinement of the *Principle of Expected Interaction*.

However, the mixed responses regarding throw/drop and smash/break interactions, especially when the coded free text responses are considered, suggest there is a tension between what is technically possible with a DCI and behaviours a participant has learnt are appropriate when interacting with a DCI's analogue counterpart or other cultural items housed in real-world cultural institutions and sites. When asked if they would throw or drop the DCI when trying to learn about it, participant responses were split. While the majority where in favour of breaking the DCI (40%), many were not (20%). When asked if they would smash of break the DCI when trying to learn about it, participants seemed conflicted, with a similar response (20%). Participants expressed differing feelings regarding breaking or throwing a DCI, with some stating that there were potential educational benefits, while others describing the style of interaction as unexpected, even 'extreme' or 'gimmicky':

> "I would like to know how durable the item was, but maybe through actions less "extreme" than throwing it (smashing it could work)." - P18

> "A science exhibition might be able to convey significant educational material through interaction, whereas the ability to smash a Ming vase might come across as gimmicky." - P35

This reaction to Questions 20 and 21 partially supports the *Principle of Expected Interaction* research efforts into DCI interaction [7], where participants generally responded positively to engaging with a 'puzzle' activity designed around rebuilding a 'broken' DCI. Our study

suggests that participants were conflicted when asked to interact with a DCI in a way that would not be supported or encouraged with its analogue counterpart. Re-building what has been broken is a behaviour that typically aligns with a visitor's education regarding the interaction with cultural items while breaking them is not.

In response, we suggest that interactions with a DCI designed to align with previous experience and education of analogue cultural items generate less conflict in visitors. Likewise, interactions that challenge visitor experience and education with analogue cultural items should be carefully designed to assure visitors and address potential concerns if they are to be readily adopted.

Principle of Valuing Context

To validate this principle, it was important to establish a baseline with which to compare participant responses. Stage 1 Question 1 presented the DCI in a virtual space with no contextual information, often called the 'grey void'. Stage 6 of the study asked participants to consider the grey void and to evaluate the role of 'things within the presentation space' with regards to learning.

Responses to Question 1 indicated that participants believed the grey void supported their understanding of the DCI (73%). However, there was a significant shift in participant responses when considering the inclusion of contextual elements over the grey void in Stage 6. In this stage, 90% of participants expressed a preference for contextual elements. This change in opinion can be explained by the timing of the questions asked; for Stage 1, participants had not experienced a presentation of a DCI with contextual information. By Stage 6, they had experienced a number of different presentations, each with their own contextual elements, supporting the DCI. In essence, participants were not aware of how contextual information could transform the presentation of a DCI until they had experienced it for themselves.

In addition to this, participants valued the Human Reference Figure (40%) and the Common Item Reference (35%). Responses coded under 'General Support for Including Context' (40%) further suggest that participants valued the inclusion of contextual elements when presenting a DCI and, in addition to this, enjoyed the experience provided by the study:

> "I believe context is vital to understanding the object in proper detail and presenting it without this crucial context limits the value of the digital aspect of the item." - P10

While there was disagreement regarding the aesthetics and application of some contextual elements, across the study, participants responded positively to contextual elements. The grey void has its role to play when presenting a digital cultural item. However, it provides a limited user experience for those engaging with DCIs. Visitors interested in cultural items, be they digital or analogue, are rarely interested in their appearance alone. Indeed, as our study supports, visitors are keen to learn as much as possible about a given cultural item and greatly enjoy the act of meaning-making made possible through the inclusion of contextual information, provided by the contextual elements within the presentation.

The study data has demonstrated how contextual information can benefit the presentation of DCIs, including additional learning opportunities and additional forms of interaction. Furthermore, our participants have reported that they greatly value contextual information and recognize the improvement that it offers to their user experience.

Findings from Study 3: Understanding Contextual Information in DCI presentations.

We asked what are the advantages and which contextual elements are valued by those interacting with DCIs? What are the challenges of using contextual information in the presentation of DCIs? And how might we better support the user experience with DCIs through the inclusion of contextual information?
The advantages of including contextual information when presenting a DCI can be summarised as the following:

- Greater information conveyed to participants, especially with regards to size, scale, and provenance of a DCI.
- Additional opportunities for interaction through meaning-making by participants.
- Increase in perceived realism of a DCI.
- Improved visitor experience.

Including contextual information when presenting DCIs offers visitors the opportunity to better understand a DCI's size and scale. When selecting contextual items to communicate size and scale and encourage meaning-making, it is important to consider the aesthetic of the DCI. Perceived realism by visitors is highly valued and contextual elements themselves better support the visitor user experience when they align with the DCI's 'reality'. For example, a human figure standing next to a sarcophagus should be styled in the manner of an Egyptian Pharaoh or archaeologist, rather than a football player or abstract figure. Meaning making is encouraged when contextual information is included, presenting an additional form of interaction. When DCIs are presented without contextual information, for example within the grey void, interaction is limited to inspection and consists of zooming, panning and rotation of the DCI. When contextual items are carefully curated, they provide additional opportunities for interaction by encouraging visitors to engage in meaning-making visitors. A human figure and a carefully selected scene can encourage visitors to connect contextual items with a DCI as they search for answers to questions such as, "Who used this item?" and also "Where did this item come from?".

It is important to recognise that while graphical fidelity within a cultural heritage presentation of a DCI is important, a consistent aesthetic of contextual items is critical. We have shown that participants value contextual elements when they align with the DCIs' visual style or historical context. However, while many DCIs are scanned and presented with a high level of graphical fidelity, supporting contextual elements do not have to meet these same graphical standards, as long as they are aesthetically consistent.

The study has shown that the user experience can be greatly improved through the inclusion of contextual information when presenting DCIs. The change in responses from the first stage, where no contextual information was present, to the last stage, where participants experienced contextual information in the presentation of a DCI, was clear and demonstrates the value of contextual information. We have also demonstrated the value of educating visitors on the different ways DCIs can be presented. The grey void has its place, providing a space that focuses the attention of a visitor on the DCI. However, as we have demonstrated, there are other ways to present a DCI, with their own distinct advantages.

Chapter 6

Thesis Conclusions

This thesis has explored contextual information and its relation to the presentation of DCIs and across the three studies conducted, contextual information has been shown to improve the user experience with DCIs in most use cases.

We began by investigating the role of DCIs themselves, as reported by CHPS and their supporting practitioners in Chapter 3, working with DCIs at cultural institutions and on cultural projects. Building on the findings from Study 1, Study 2 was designed and conducted in order to understand the value, if any, of including contextual information when presenting a DCI. Study 3 drilled down further to investigate further the role of contextual information and the impact it has when included in presentations of DCIs.

Summary

My research began with a series of face-to-face interviews with CHPs and supporting practitioners, those who work with DCIs within the cultural heritage sector on a day-to-day basis to learn, in their words, the advantages and challenges of working with DCIs. It was observed that DCIs present many considerable advantages over their original analogue counterparts, such as allowing users to interact in novel ways through improved inspection via zooming, rotating and panning. We also learnt that the digital nature of DCIs supported the preservation and sharing of cultural information through making copies and sharing via the internet. And we also learnt how DCIs can increase accessibility to cultural information by being readily available online and through overcoming the logistical challenges of storage and presentation that curators must contend with, especially when curating larger collections or collections featuring large cultural items. We also learnt of the challenges associated with DCIs. These challenges, whilst not insurmountable, do impact the day to day working practice of curators and include the challenges of storage, securing support for the use of DCIs from fellow, often non-technical, cultural practitioners and the specialist knowledge required to capture, prepare, and present DCIs.

Next, we researched a specific quality of DCIs, specifically that of contextual information, a quality that is inherently present in experiences with analogue digital items but is often absent in experiences with DCIs. Through Study 2, utilising direct interviews and the SIT tool, questions were asked what the advantages of gathering contextual information were and how contextual information can impact the user experience of DCIs. The work also investigated how we might use contextual information when presenting DCIs to support the user experience. It was learnt that the inclusion of contextual information can improve the user experience with regards to interaction with a DCI and can improve the user's understanding of the size and scale of a DCI. Another aspect was also explored on how the inclusion of contextual information can improve the perceived realism of a DCI and how, by providing users with the option to customise contextual elements within the presentation of a DCI, we can increase user engagement. So, we posited that gathering contextual information when presenting DCIs can change how visitors engage with a DCI, shaping their

experience towards engaging with a DCI in a similar manner to that of the DCI's analogue counterpart.

Finally, the work evaluated and decided to dig deeper into our findings in Study 3, where we explored the advantages of including contextual information, which contextual elements were least and most valued by users and the challenges of using contextual information with presenting DCIs. The work demonstrated that contextual information could provide greater information to presentations with DCis than without and the additional learning opportunities that it provided. Finally, we also learnt how contextual information can improve the perceived realism of a cultural presentation as well as how contextual information improves the user experience of DCIs.

Thesis contributions

This thesis has put forward several research contributions connected to UX practices and Cultural Heritage, specifically targeting contextual information and its role in presenting DCIs. The research contributions made in this thesis are presented in the following section, in accordance with their order of appearance in the thesis body. This is followed by a summary of the conclusions in response to the initial research questions.

Principles of design for the presentation of DCIs using contextual elements.

My studies have produced five design principles that can be applied by CHPs and supporting practitioners when presenting DCIs using contextual information. The principle of valuing size and scale assets that the inclusion of contextual information supports a visitor's understanding of the size and scale of a DCI. The principle of valuing provenance asserts that the inclusion of contextual elements encourages visitors to engage in meaning-making regarding the provenance of the DCI, specifically connected to who might be associated with it, where it might have been sited and when it might have been in use or originally created.

The principle of valuing aesthetic consistency asserts that visitors prefer a consistent aesthetic shared amongst contextual elements and challenges the notion that visitors prefer 'realistic' displays. Moreover, the principle of expected interaction asserts that visitors form expectations regarding how to interact with a DCI based on their previous experiences with related items and that they engage with DCIs in a manner supported by their previous experience with analogue cultural items. Finally, the principle of valuing context assets that the understanding that contextual information, when used in the presentation of a DCI, improves the visitor experience and is valued by visitors.

Data sets collected from participants regarding the use of contextual information when presenting a DCI .

These data sets were collected from face-to-face interviews and online surveys and include qualitative and quantitative data regarding which contextual elements are favoured, which are not and the challenges of using contextual information when presenting a DCI. The data sets generated from my research can be used to support secondary analysis by other researchers concerned with improving DCI presentations using contextual information.

As part of Study 2 and Study 3, the SIT tool designed for the purpose of this thesis. The SIT tool supports researchers wishing to evaluate contextual elements when presenting DCIs through providing a system where different contextual elements can be selected to appear within a presentation space. These contextual elements can be presented on their own alongside the DCI and can also be presented in combination with each other to create different contextual information displays.

Another contribution generated pertains to Chapter 3 which includes a summary of concerns of CHPs and supporting practitioners. These concerns were collected in a series of face-to-face interviews and include the various challenges related to capturing, preparing, and presenting DCIs as well as the difficulty in acquiring and relying on the specialist skill sets that are required when working with DCIs and includes the challenges of communicating their benefits to stakeholders to non-technically informed peers within the cultural heritage sector.

The research in this paper has resulted in three publications. The first is titled 'Capturing, processing and prestation of Digital Cultural Items: Feedback from cultural heritage practitioners' and was presented at the Eurographics Workshop in 2021. The paper presented the concerns and challenges, as reported by CHPs and their supporting practitioners, regarding the 'day to day' challenges of working with DCIs and the increasing efforts by the cultural heritage sector to digitise analogue cultural items.

The second paper is titled 'Digital Cultural Items in Space: The Impact of Contextual Information on Presenting Digital Cultural Items' and published by the prestigious ACM Journal of Computing and Cultural Heritage (JOCCH). The paper was generated from Study 2, as presented in this thesis and is focused on exploring and improving our understanding of the role of contextual information when presenting DCIs. The study produced the five design principles to support those using contextual information when presenting a DCI and were further refined and validated in Study 3, also presented in this thesis.

Finally, the paper titled 'RichCast - A Voice-Driven Interactive Digital Narrative Authoring System' was published and presented remotely at ICIDS 2022, which was hosted in Santa Cruz, at the University of California. The paper drew upon my experience with user experiences practices, developed during my PhD studies, and described the role of RichCast, a voice interactive authoring tool designed for the creation and sharing of interactive narrative experiences without the need for specialist technical knowledge or training, which promises to be a boon to CHPs building their own independent cultural experiences.

Answers to Research Questions

This thesis has been concerned with answering the following research question:

- How does contextual information impact the user experience when presenting digital cultural items?

To answer the research question, we conducted three studies. Study 1 served as the foundation, with Studies 2 and 3 building on this foundation and each other as we moved towards generating answers.

Study 1 aimed to identify the challenges and concerns shared by those working in the cultural heritage industry through a series of face-to-face interviews, providing a 'voice' for Cultural Heritage Professionals (CHPs). From Chapter 3, we learned that CHPs are still grappling with the technology required to generate Digital Cultural Items (DCIs) from their analogue counterparts. These challenges included issues such as skill access, storage, securing funding and the need to educate peers and superiors about the advantages of generating DCIs. With CHPs facing numerous daily challenges, the presentation of DCIs often did not receive the attention that an analogue cultural item might receive. One such aspect of presentation is that of contextual information, in part because it represents additional costs in both time and skill resources to support the presentation of a DCI through the inclusion of additional digital assets. In response to Study 1, the work identified a lack of practical advice to support CHPs with regards to presenting DCIs using contextual information.

Consequently, Study 2 was conducted to determine the value in including contextual information when presenting DCIs. Using the SIT tool, we presented participants with DCIs supported by a selection of contextual elements, including time, location, and scale. Study 2 demonstrated the value of including contextual information when presenting DCIs. To verify the findings from Study 2, Study 3 was conducted.

In response to our research question, we have identified several benefits associated with the inclusion of contextual information when presenting a Digital Cultural Item (DCI). These benefits can be summarized as follows:

1. Enhanced information conveyed to participants, specifically pertaining to the size, scale, and provenance of a DCI.
2. Increased opportunities for interaction, facilitated by self-guided meaning-making on the part of the visitor.
3. Heightened perceived realism of the DCI, resulting in a more immersive and authentic experience.
4. Improved overall visitor experience, leading to a deeper connection with the cultural heritage being presented.
5. The potential to transform how visitors engage with a DCI, shaping their experience in a way that aligns with the interaction and appreciation of the analogue cultural item from which the DCI was created from.

By incorporating contextual information into the presentation of Digital Cultural Items (DCIs), cultural heritage institutions can provide a more comprehensive and engaging experience for visitors. This approach fosters a deeper understanding and appreciation of the cultural heritage being highlighted, further enriching the visitor experience.

Integrating contextual information when presenting a DCI conveys more information to participants, enhancing their ability to interpret and connect with the cultural item. Often, DCIs are displayed in what can be described as a 'grey void' a digital space that lacks contextual clues to help visitors understand and relate to the item. By including reference objects, such as commonly encountered 'everyday' objects like chairs, beverage cans, and people, visitors can better determine the size and scale of a given DCI. This improved understanding allows for a more meaningful interaction with the cultural heritage on display, creating a more immersive and enriching experience for visitors.

Furthermore, when contextual elements are appropriately stylized, they can convey additional information, such as the individuals associated with the DCI, its location, and the culture in which it was produced. In this scenario, a curator, informed professional, or supporting text does not need to be present to communicate this additional information to a visitor. Instead, visitors can infer and engage in meaning-making for themselves, presenting a form of interaction beyond mere inspection. Participants reported enjoying 'playing detective' and piecing together a DCI's provenance and age based on contextual clues. However, they still required confirmation (or clarification) of their assumptions through supporting text or an informed professional.

The increase in perceived realism of the DCI aligns with our expectations and real-world experiences with comparable items and/or analogue cultural items. Rarely, if ever, do we encounter objects in spaces devoid of contextual information. Overall, participants reported an improved experience when engaging with DCIs that incorporated contextual information for several reasons, including additional information conveyed, increased opportunities for meaning-making, and greater perceived realism.

The potential to change how a visitor engages with a DCI through the inclusion of contextual information was observed early on during Study 2. It was noted that instead of engaging with a DCI as a digital construct, participants began to interact with the DCI in ways similar to how they might engage with its analogue counterpart. This phenomenon was further explored in Study 3, where half of the participants, despite it being impossible for them to do so, were still reluctant to 'break' the DCI. This phenomenon warrants further study and could form a solid basis for future research efforts.

Future Work

While this thesis has generated several contributions, it has also highlighted various avenues of interest for future research that are beyond the scope of this work.

Primarily, all the studies presented within this thesis were conducted remotely, with interviews and surveys administered to participants online. Although the data collected has proven valuable, it would be interesting to see variants of these studies adapted for deployment at cultural heritage institutions and sites. While many Digital Cultural Items (DCIs) are encountered online through cultural websites and bespoke digital experiences,

the intent behind this research has been to provide practical support for Cultural Heritage Professionals (CHPs) and supporting practitioners. Consequently, future studies exploring contextual information in the presentation of DCIs could be conducted in-person and on-site, promising to provide new insights for CHPs and generate data to support the use of contextual information when presenting DCIs as part of cultural heritage displays at 'real-world' locations.

Although the work has validated the design principles supporting the inclusion of contextual information when presenting various DCIs, the DCIs selected for this research were all grouped by a similar theme, specifically, that of Ancient Egypt. Moreover, these DCIs can all be described as 'cultural' items. Future research aimed at supporting CHPs in their use of contextual information when presenting DCIs could explore a broader variety of cultural items. Likewise, these studies could expand the use of digital items to include artistic digital items. How would the user experience be impacted by the inclusion of audio contextual information? Also, would the inclusion of 'artistic' digital items yield different data or further develop the design principles presented in this thesis?

While the research suggests that a DCI presentation does not need to be 'realistic' and, instead, all elements within a presentation should remain 'consistent' in aesthetic style to satisfy a visitor's expectations, an exploration into the phenomenon of how the inclusion of contextual information changes the user's relationship with a DCI could form the basis for future research efforts.

Finally, further research exploring how contextual information impacts the curation process could provide insights that directly affect CHPs in their day-to-day activities. Curation, as explored within this thesis, is strongly associated with education, and aims to be engaging, providing a positive learning experience for museum visitors. There is a wide variety of learning activities that can be produced through the manipulation of contextual information, leading one to imagine a host of entertaining and informative interactive experiences that could be made available to curators. Research examining how these learning experiences could be developed, deployed, and improved upon with the support of the research findings.

Final Thoughts

In this thesis, I have investigated the user experience and the impact of contextual information when presenting DCIs. Through interviews with CHPs and supporting practitioners, it became evident that a gap existed between academic efforts and the practical needs of CHPs, as reflected in the available literature at the time of writing. Responding to this gap, this research aimed to bridge the divide by directly engaging with CHPs and providing practical insights to support their day-to-day activities.

DCIs are often presented by CHPs who may lack the technical skills necessary for capturing and preparing them. Supporting practitioners, who provide essential services by offering access to technical skills, are typically not trained as CHPs themselves. Consequently, presenting cultural items in a manner that supports education and engagement becomes a

challenge. The prevalent "grey void" in where DCIs are often encountered online represents a practical presentation style but compromises the qualities that make real-life encounters with curated cultural items exciting, informative, and memorable.

Throughout this thesis, the role of contextual information and its impact when presenting DCIs has been explored. By collecting data from face-to-face interviews with CHPs, and members of the public engaging with DCIs, this research has presented compelling evidence of how size and scale can be better communicated, how perceived realism can be improved, and the additional opportunities for interaction generated through the inclusion of contextual information. I have investigated how engaging in meaning-making can support users in understanding the provenance of a DCI and provided insights into which contextual elements enhance the user experience. I have also discovered and evaluated the challenges associated with using contextual information in the presentation of DCIs. Finally, as in keeping with the original intent that inspired this thesis, practical advice has been offered on which contextual elements work, which do not, and why.

It is hoped that this thesis will inspire further research in this area. Researchers are encouraged to discover and validate additional principles related to the use of contextual information and its impact on the user experience when presenting DCIs. This thesis aims to increase awareness among CHPs and cultural institutions regarding the importance of including contextual information in the presentation of DCIs and I encourage research in this area to support the efforts of other academics in the cultural heritage sector. In so doing, we can contribute to bridging the gap between academic endeavours and the practical needs of CHPs. In addition to this, the practice of directly engaging directly with CHPs to provide actionable information that can improve their day-to-day practices and supporting them in offering informative and engaging cultural heritage experiences remains of crucial.

The findings and insights from this research contribute to advancing the understanding of the role of contextual information in presenting DCIs and its impact on the user experience. The practical implications of incorporating contextual information are significant, as they enhance the presentation of DCIs, improve user engagement, and promote meaningful cultural heritage experiences. With ongoing research and collaboration, we can continue to refine and expand our knowledge in this area, fostering innovative approaches to presenting DCIs and supporting the needs of Cultural Heritage Professionals in the digital era.

References

AAM. (2023). *American Alliance of Museums*. Https://Www.Aam-Us.Org/.

Abdel Latif, M. M. (2019). Using think-aloud protocols and interviews in investigating writers' composing processes: Combining concurrent and retrospective data. *International Journal of Research \& Method in Education*, *42*.

Adair, J. G. (1984). The Hawthorne Effect: A Reconsideration of the Methodological Artifact. In *Journal of Applied Psychology* (Vol. 69, Issue 2).

Alben, L. (1996). Quality of Experience: Defining the Criteria for Effective Interaction Design. *Interactions*, *3*(3), 11–15. https://doi.org/10.1145/235008.235010

Alelis, G., Bobrowicz, A., Siang Ang, C., & Author Student, C. (2015). *Comparison of engagement and emotional responses of older and younger adults interacting with 3D cultural heritage artefacts on personal devices*.

Alizadehsalehi, S., Hadavi, A., & Huang, J. C. (2020). From BIM to extended reality in AEC industry. *Automation in Construction*, *116*, 103254. https://doi.org/https://doi.org/10.1016/j.autcon.2020.103254

Als, B. S., Jensen, J. J., & Skov, M. B. (2005). *Comparison of Think-Aloud and Constructive Interaction in Usability Testing with Children*.

Amato, F., Moscato, V., Picariello, A., Colace, F., Santo, M. De, Schreiber, F. A., & Tanca, L. (2017). Big data meets digital cultural heritage: Design and implementation of scrabs, a smart context-aware browsing assistant for cultural environments. *Journal on Computing and Cultural Heritage (JOCCH)*, *10*(1), 1–23.

Ando, H., Cousins, R., & Young, C. (2014). Achieving saturation in thematic analysis: Development and refinement of a codebook. *Comprehensive Psychology*, *3*, 03–CP.

Ardito, C., Buono, P., Costabile, M. F., Lanzilotti, R., & Piccinno, A. (2009). Enabling Interactive Exploration of Cultural Heritage: An Experience of Designing Systems for Mobile Devices. *Knowledge, Technology & Policy*, *22*(1), 79–86. https://doi.org/10.1007/s12130-009-9079-7

Balagia, M. (2018). Tragic design: the impact of bad product design and how to fix it (sharlat, j. and saucier, s.) [book review]. *IEEE Transactions on Professional Communication*, *61*(2), 223–224. https://doi.org/10.1109/tpc.2018.2817998

Barcenilla, J. and B. J.-M.-C. (2009). L'acceptabilité des nouvelles technologies: quelles relations avec l'ergonomie, l'utilisabilité et l'expérience utilisateur? *Le Travail Humain*, *Vol. 72*(4), 311–331.

Bargas-Avila, J. A., & Hornbæk, K. (2011). Old wine in new bottles or novel challenges: a critical analysis of empirical studies of user experience. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2689–2698.

Bedford, L. (2001). Storytelling: The real work of museums. *Curator: The Museum Journal*, *44*(1), 27–34.

Beraldin, J.-A., Blais, F., Cournoyer, L., Rioux, M., El-Hakim, S. H., Rodella, R., Bernier, F., & Harrison, N. (1999). Digital 3D imaging system for rapid response on remote sites. *Second International Conference on 3-D Digital Imaging and Modeling (Cat. No. PR00062)*, 34–43.

Bergstrom, J. R., Schall, A. J., Y0rk, N., Oxford, *, San, P. *, & Jdiil, D. (n.d.). *Eye Tracking in User Experience Design*.

Bernardini, F., & Rushmeier, H. (2002). The 3D model acquisition pipeline. *Computer Graphics Forum*, *21*(2), 149–172.

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). *Scientific American: The Semantic Web The Semantic Web A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities*. http://www.sciam.com/print_version.cfm?articleID=00048144-10D2-1C70-84A9809EC588EF21

Bianco, L. (2020). Universal design: From design philosophy to applied science. *Journal of Accessibility and Design for All*, *10*(1), 70–97. https://doi.org/10.17411/jacces.v10i1.249

Biocca, F., Tang, A., Owen, C., & Xiao, F. (2006). *Attention funnel*. 1115–1122. https://doi.org/10.1145/1124772.1124939

Blake, J. (2000). On Defining the Cultural Heritage. *International and Comparative Law Quarterly*, *49*(1), 61–85. https://doi.org/10.1017/S002058930006396X

Bloomer, C. M. (1990). *Principles of Perception*. Herbert Press London.

Blythe, M. and O. K. and M. A. and W. P. (2003). *Funology : From usability to enjoyment*. Kluwer Academic Publishers.

Borissova, V. (2018). Cultural heritage digitization and related intellectual property issues. *Journal of Cultural Heritage*, *34*, 145–150.

Bottani, E., & Vignali, G. (2019). Augmented reality technology in the manufacturing industry: A review of the last decade. *IISE Transactions*, *51*(3), 284–310. https://doi.org/10.1080/24725854.2018.1493244

Brooke, J. (1996). *SUS-A quick and dirty usability scale*.

Bruckman, A., Luther, K., & Fiesler, C. (2015). *When Should We Use Real Names in Published Accounts of Internet Research?* http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm#46.102

Bruner, J. (1991). The narrative construction of reality. *Critical Inquiry*, *18*(1), 1–21.

Buchanan, E. A., & Hvizdak, E. E. (2009). Online survey tools: Ethical and methodological concerns of human research ethics committees. *Journal of Empirical Research on Human Research Ethics*, *4*(2), 37–48. https://doi.org/10.1525/jer.2009.4.2.37

Buhalis, D. (2000). INTEGRATED HERITAGE MANAGEMENT: PRINCIPLES AND PRACTICE by C. Michael Hall and Simon Mcarthur. The stationery office, London. No of pages: 250. Price L 45.00 (hardback). ISBN 0-1 12-90571-4. *The International Journal of Tourism Research*, *2*(2), 149.

Buxton, B. (2010). *Sketching user experiences: getting the design right and the right design*. Morgan Kaufmann.

Byrne, D. (n.d.). *Heritage as social action*.

Byrne, D. (1991). Western hegemony in archaeological heritage management. *History and Anthropology*, *5*(2), 269–276.

Caldwell B, C. M. et al. (2008). *Web Content Accessibility Guidelines (WCAG) 2.0*. W3C.

Campi, M., di Luggo, A., Palomba, D., & Palomba, R. (2019). Digital surveys and 3D reconstructions for augmented accessibility of archaeological heritage. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *42*, 205–212.

Candela, G., Escobar, P., & Marco-Such, M. (2022). Reusing digital collections from GLAM institutions. *Journal of Information Science*, *48*, 251–267. https://doi.org/10.1177/ToBeAssigned

Carrozzino, M., & Bergamasco, M. (2010). Beyond virtual museums: Experiencing immersive virtual reality in real museums. *Journal of Cultural Heritage*, *11*(4), 452–458.

Carter, S. M., Shih, P., Williams, J., Degeling, C., & Mooney-Somers, J. (2021). Conducting Qualitative Research Online: Challenges and Solutions. *Patient*, *14*(6), 711–718. https://doi.org/10.1007/s40271-021-00528-w

Chandon, P., Wansink, B., & Laurent, G. (2000). *R&D A BENEFIT CONGRUENCY FRAMEWORK OF SALES PROMOTION EFFECTIVENESS*.

Chapuis, O., Blanch, R., & Beaudouin-Lafon, M. (2007). *Fitts' law in the wild: A field study of aimed movements*. https://hal.archives-ouvertes.fr/hal-00612026

Cleere, H. (2020). Introduction: the rationale of archaeological heritage management. In *Archaeological heritage management in the modern world* (pp. 1–19). Routledge.

Clini, P., Ruggeri, L., Angeloni, R., & Sasso, M. (2018). INTERACTIVE IMMERSIVE VIRTUAL MUSEUM: DIGITAL DOCUMENTATION FOR VIRTUAL INTERACTION. *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*, *42*(2).

Colace, F., Santo, M. De, Lemma, S., Lombardi, M., Rossi, A., Santoriello, A., Terribile, A., & Vigorito, M. (2016). How to Describe Cultural Heritage Resources in the Web 2.0 Era? *Proceedings - 11th International Conference on Signal-Image Technology and Internet-Based Systems, SITIS 2015*, 809–815. https://doi.org/10.1109/SITIS.2015.50

Conde, J., López-Pernas, S., Pozo, A., Munoz-Arcentales, A., Huecas, G., & Alonso, Á. (2021). Bridging the gap between academia and industry through students' contributions to the fiware european open-source initiative: A pilot study. *Electronics (Switzerland)*, *10*(13). https://doi.org/10.3390/electronics10131523

Contrast (Minimum): Understanding SC 1.4.3. (2016). Understanding WCAG 2.0.

Costanza-Chock, S. (2020). *Design Justice: Community-Led Practices to Build the Worlds We Need*.

Cranmer, E. E., tom Dieck, M. C., & Jung, T. (2023). The role of augmented reality for sustainable development: Evidence from cultural heritage tourism. *Tourism Management Perspectives*, *49*. https://doi.org/10.1016/j.tmp.2023.101196

Cuadros, J. S. V. G.-Z. J. and H.-J. U. (2021). Design and Evaluation of a User Experience Questionnaire for Remote Labs. *IEEE Access*, *9*.

David, B. R. J. D. (2015). *What is ethics in research & why is it important?* National Institute of Environmental Health Science.

Dede, C. (2009). Immersive interfaces for engagement and learning. In *Science* (Vol. 323, Issue 5910, pp. 66–69). https://doi.org/10.1126/science.1167311

Desmet, P. and H. P. (2007a). Framework of product experience. *International Journal of Design*, 57–66.

Desmet, P. and H. P. (2007b). Framework of product experience. *International Journal of Design*, 57–66.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. DC Heath.

Di Franco, P. D. G., Camporesi, C., Galeazzi, F., & Kallmann, M. (2015). 3D printing and immersive visualization for improved perception of ancient artifacts. *Presence: Teleoperators and Virtual Environments*, *24*(3), 243–264.

D'lgnazio C, K. L. (2023, April 23). *Principle: Examine Power, Data feminism begins by analyzing how power operates in the world.*

DPLA. (2023). *Digital Public Library of America*. Https://Dp.La/.

Dragoni, M., Tonelli, S., & Moretti, G. (2017a). A knowledge management architecture for digital cultural heritage. *Journal on Computing and Cultural Heritage (JOCCH)*, *10*(3), 1–18.

Dragoni, M., Tonelli, S., & Moretti, G. (2017b). A knowledge management architecture for digital cultural heritage. *Journal on Computing and Cultural Heritage*, *10*(3). https://doi.org/10.1145/3012289

Dumas, J. S. and R. J. (1999). *A practical guide to usability testing*. Intellect books.

Falk, J. H. (2016). *Identity and the museum visitor experience*. Routledge.

Falk, J. H. and D. L. D. (2016). *The museum experience revisited*. Routledge.

Falk, J. H., Falk, J. H., Dierking, L. D., & Foutz, S. (2007). *In principle, in practice: Museums as learning institutions*. Rowman Altamira.

Fan, M., Lin, J., Chung, C., & Truong, K. N. (2019). Concurrent think-aloud verbalizations and usability problems. *ACM Transactions on Computer-Human Interaction*, *26*(5). https://doi.org/10.1145/3325281

Fan, M., Yang, X., Yu, T. T., Liao, Q. V., & Zhao, J. (2022). Human-AI Collaboration for UX Evaluation: Effects of Explanation and Synchronization. *Proceedings of the ACM on Human-Computer Interaction*, *6*(CSCW1). https://doi.org/10.1145/3512943

Feng, K. J. K., Li, T. W., & Zhang, A. X. (2023). Understanding Collaborative Practices and Tools of Professional UX Practitioners in Software Organizations. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–20. https://doi.org/10.1145/3544548.3581273

Ferraris, C., Davis, T., Gatzidis, C., & Hargood, C. (2023). Digital Cultural Items in Space: The Impact of Contextual Information on Presenting Digital Cultural Items. *Journal on Computing and Cultural Heritage*. https://doi.org/10.1145/3594725

Ferraris, C., Gatzidis, C., Tom, D., & Hargood, C. (2021). *Capture, Processing and Presentation of Digital Cultural Items: Feedback from cultural heritage practitioners*.

Fiesler, C., & Proferes, N. (2018). "Participant" Perceptions of Twitter Research Ethics. *Social Media and Society*, *4*(1). https://doi.org/10.1177/2056305118763366

Flynn, T. (2022). *Sketchfab museum signups per month.* .

Forlizzi, J. and F. S. (n.d.). *The building blocks of experience An early framework for interaction designers.*

Forlizzi, J., & Battarbee, K. (2004). Understanding experience in interactive systems. *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*, 261–268.

Friedman, B. and H. D. G. (2019). *Value sensitive design: Shaping technology with moral imagination*. Mit Press.

Friedman, B., Kahn, P. H., & Borning, A. (2013). *Value Sensitive Design and Information Systems*.

García Münzer, M. (2020). How can augmented reality improve the user experience of digital products and engagement with cultural heritage outside the museum space? *IOP Conference Series: Materials Science and Engineering*, *949*(1). https://doi.org/10.1088/1757-899X/949/1/012040

Gerjets, P., Kammerer, Y., & Werner, B. (n.d.). *Measuring spontaneous and instructed evaluation processes during Web search: Integrating concurrent thinking-aloud protocols and eye-tracking data*.

Gilbert, R. M. (2019). *Inclusive design for a digital world: Designing with accessibility in mind*. Apress.

Gil-Fuentetaja, I., & Economou, M. (2019a). Communicating Museum Collections Information Online: Analysis of the Philosophy of Communication Extending the Constructivist Approach. *J. Comput. Cult. Herit.*, *12*(1). https://doi.org/10.1145/3283253

Gil-Fuentetaja, I., & Economou, M. (2019b). Communicating museum collections information online: Analysis of the philosophy of communication extending the constructivist approach. *Journal on Computing and Cultural Heritage (JOCCH)*, *12*(1), 1–16.

Gittens, C. L. (2021). Remote HRI: a Methodology for Maintaining COVID-19 Physical Distancing and Human Interaction Requirements in HRI Studies. *Information Systems Frontiers*. https://doi.org/10.1007/s10796-021-10162-4

Gove, W. R., & Geerken, M. R. (n.d.). *Response Bias in Surveys of Mental Health: An Empirical Investigation'*. http://about.jstor.org/terms

Gradin, A., & Matti La Mela, S. (n.d.). *Digital Skills and Education in the Cultural Heritage Sector Post-COVID Digital Transformation of Galleries, Libraries, Archives and Museums*.

Graham, B., Ashworth, G., & Tunbridge, J. (2016). *A geography of heritage*. Routledge.

Grau, O., Coones, W., & Rühse, V. (2017). Museum and Archive on the Move: Changing Cultural Institutions in the Digital Era. In *Museum and Archive on the Move: Changing Cultural Institutions in the Digital Era*. https://doi.org/10.1515/9783110529630

Gray, C. M. (2016). " It's More of a Mindset Than a Method" UX Practitioners' Conception of Design Methods. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 4044–4055.

Gray, W. D., & Fu, W. T. (2004). Soft constraints in interactive behavior: The case of ignoring perfect knowledge in-the-world for imperfect knowledge in-the-head. *Cognitive Science*, *28*(3), 359–382. https://doi.org/10.1016/j.cogsci.2003.12.001

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, *18*(1), 59–82.

Häkkilä, J., Wiberg, M., Eira, N. J., Seppänen, T., Juuso, I., Mäkikalli, M., & Wolf, K. (2020, October 25). Design Sensibilities - Designing for Cultural Sensitivity. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3419249.3420100

Hamid, N. A. A. (2021). The User Experience (UX) Analysis of Self-Service Kiosk (SSK) in Waiting Time at Fast Food Restaurant Using User Experience (UX) Model. *Journal of Social Transformation and Regional Development*, *3*(2), 85–98.

Hammady, R., Ma, M., & Powell, A. (2011). *User Experience of Markerless Augmented Reality Applications in Cultural Heritage Museums: "MuseumEye" as a Case Study*.

Han, D.-I. D., Weber, J., Bastiaansen, M., Mitas, O., & Lub, X. (2019). Virtual and augmented reality technologies to enhance the visitor experience in cultural tourism. In *Augmented reality and virtual reality* (pp. 113–128). Springer.

Harrison, R. (2008). *The politics of the past: conflict in the use of heritage in the modern world*.

Harvey, D. C. (2001). Heritage pasts and heritage presents: Temporality, meaning and the scope of heritage studies. *International Journal of Heritage Studies*, *7*(4), 319–338.

Hassenzahl, M. (2010). Experience design: Technology for all the right reasons. *Synthesis Lectures on Human-Centered Informatics*, *3*(1).

Hassenzahl, M. (2018). The thing and I: understanding the relationship between user and product. *Funology 2: From Usability to Enjoyment*, 301--313.

Hassenzahl, M., Schöbel, M., & Trautmann, T. (2008). How motivational orientation influences the evaluation and choice of hedonic and pragmatic interactive products: The role of regulatory focus. *Interacting with Computers*, *20*(4–5), 473–479. https://doi.org/10.1016/j.intcom.2008.05.001

Hassenzahl, M., & Tractinsky, N. (2006). User experience-a research agenda. *Behaviour & Information Technology*, *25*(2), 91–97.

Hertzum, M., & Jacobsen, N. E. (2001). The Evaluator Effect: A Chilling Fact About Usability Evaluation Methods. In *INTERNATIONAL JOURNAL OF HUMAN-COMPUTER INTERACTION* (Vol. 13, Issue 4). http://www.dialogdesign.dk/cue.html

Hewison, R. (1987). *The heritage industry: Britain in a climate ofdecline*. London: Methuen.

Hirschfield, R. (2023). *How a No Code Platform Fostered Collaboration When Developing NLP Models*.

Hooper-Greenhill, E. (2007). *Museums and education: Purpose, pedagogy, performance*. Routledge.

Hooper-Greenhill, E. (2020). *Museums and the interpretation of visual culture*. Routledge.

Hoppenstedt, B., Probst, T., Reichert, M., Schlee, W., Kammerer, K., Spiliopoulou, M., Schobel, J., Winter, M., Felnhofer, A., Kothgassner, O. D., & Pryss, R. (2019). Applicability of Immersive Analytics in Mixed Reality: Usability Study. *IEEE Access*, *7*, 71921–71932. https://doi.org/10.1109/ACCESS.2019.2919162

ICOM. (2023). *International Council of Museums* . Https://Icom.Museum/En/.

iiif. (2023). *International Image Interoperability Framework*. Https://Iiif.Io/.

James, C. M. and J. K. (1982). Sensation and Perception. In *Leonardo* (Vol. 15). The MIT Press.

Jones, C. E., Theodosis, S., & Lykourentzou, I. (2019). The enthusiast, the interested, the sceptic, and the cynic: Understanding user experience and perceived value in location-based cultural heritage games through qualitative and sentiment analysis. *Journal on Computing and Cultural Heritage*, *12*(1). https://doi.org/10.1145/3297716

Jones, J., & Smith, J. (2017). Ethnography: Challenges and opportunities. *Evidence-Based Nursing*, *20*(4), 98–100. https://doi.org/10.1136/eb-2017-102786

Jones, S., Jeffrey, S., Maxwell, M., Associate, R., Hale, A., Environment Scotland, H., Sinclair House, J., & Jones, C. (2018). 3D heritage visualisation and the negotiation of authenticity: the ACCORD project. *International Journal of Heritage Studies*, *24*, 333–353. https://doi.org/10.5284/1042733

Kamal Othman, M., Petrie, H., & Power, C. (2011). *Engaging Visitors in Museums with Technology: Scales for the Measurement of Visitor and Multimedia Guide Experience Engaging Visitors in Museums with Tech-nology: Scales for the Measurement of Visitor and Multimedia Guide Experience Engaging Visitors in Museums with technology: scales for the measurement of visitor and multimedia guide experience*. 92–99. https://doi.org/10.1007/978-3-642-23768-3_8ï

Kim, S., Whitford, M., & Arcodia, C. (2019). Development of intangible cultural heritage as a sustainable tourism resource: the intangible cultural heritage practitioners' perspectives. *Journal of Heritage Tourism*, *14*(5–6), 422–435. https://doi.org/10.1080/1743873X.2018.1561703

Konstantakis, M., & Caridakis, G. (2020a). Adding culture to UX: UX research methodologies and applications in cultural heritage. *Journal on Computing and Cultural Heritage (JOCCH)*, *13*(1), 1–17.

Konstantakis, M., & Caridakis, G. (2020b). Adding culture to UX: UX research methodologies and applications in cultural heritage. *Journal on Computing and Cultural Heritage*, *13*(1). https://doi.org/10.1145/3354002

Krug, S. (2006). *Don't make me think! : a common sense approach to Web usability*. New Riders Pub.

Kujala, S., Roto, V., Väänänen-Vainio-Mattila, K., Karapanos, E., & Sinnelä, A. (2011). UX Curve: A method for evaluating long-term user experience. *Interacting with Computers*, *23*(5), 473–483. https://doi.org/10.1016/j.intcom.2011.06.005

Kumar, H. (2022). Augmented reality in online retailing: a systematic review and research agenda. *International Journal of Retail and Distribution Management*, *50*(4), 537–559. https://doi.org/10.1108/IJRDM-06-2021-0287

Kuniavsky, M. (2003). *Observing the user experience: a practitioner's guide to user research*. Elsevier.
Kushniruk, A., & Nøhr, C. (2016). Participatory design, user involvement and health IT evaluation. In *Evidence-Based Health Informatics: Promoting Safety and Efficiency through Scientific Methods and Ethical Policy* (Vol. 222, pp. 139–151). IOS Press. https://doi.org/10.3233/978-1-61499-635-4-139
Kyriakou, P., & Hermon, S. (2019). Can I touch this? Using Natural Interaction in a Museum Augmented Reality System. *Digital Applications in Archaeology and Cultural Heritage*, *12*. https://doi.org/10.1016/j.daach.2018.e00088
Lai-Chong Law, E., van Schaik, P., & Roto, V. (2014). *Attitudes towards User Experience (UX) Measurement*.
Lallemand, C., Gronier, G., & Koenig, V. (2015). User experience: A concept without consensus? Exploring practitioners' perspectives through an international survey. *Computers in Human Behavior*, *43*, 35–48. https://doi.org/10.1016/j.chb.2014.10.048
Laugwitz, B., Held, T., & Schrepp, M. (2008). Construction and Evaluation of a User Experience Questionnaire. In *LNCS* (Vol. 5298).
Law, E. L.-C., Roto, V., Hassenzahl, M., Vermeeren, A. P. O. S., & Kort, J. (2009). Understanding, scoping and defining user experience: a survey approach. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 719–728.
Law, E., Roto, V., Vermeeren, A. P. O. S., Kort, J., & Hassenzahl, M. (2008). Towards a shared definition of user experience. In *CHI'08 extended abstracts on Human factors in computing systems* (pp. 2395–2398).
Leask, A., & Yeoman, I. (1999). *Heritage visitor attractions: an operations management perspective*. Cengage Learning EMEA.
Lee, A. S., Wilson, W., Tibbetts, J., Gawboy, C., Meyer, A., Buck, W., Knutson-Kolodzne, J., & Pantalony, D. (2019). Celestial calendar-paintings and culture-based digital storytelling: cross-cultural, interdisciplinary, STEM/STEAM resources for authentic astronomy education engagement. *EPJ Web of Conferences*, *200*, 01002. https://doi.org/10.1051/epjconf/201920001002
Lee, L. H., Braud, T., Hosio, S., & Hui, P. (2022). Towards Augmented Reality Driven Human-City Interaction: Current Research on Mobile Headsets and Future Challenges. In *ACM Computing Surveys* (Vol. 54, Issue 8). Association for Computing Machinery. https://doi.org/10.1145/3467963
Lesselroth, B. J., Monkman, H., Adams, K., Wood, S., Corbett, A., Homco, J., Borycki, E. M., Spier, R., & Kushniruk, A. W. (2020). User Experience Theories, Models, and Frameworks: A Focused Review of the Healthcare Literature. *MIE*, 1076–1080.
Levoy, M., Pulli, K., Curless, B., Rusinkiewicz, S., Koller, D., Pereira, L., Ginzton, M., Anderson, S., Davis, J., Ginsberg, J., & others. (2000). The digital Michelangelo project: 3D scanning of large statues. *Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, 131–144.
Lewis, C. (1982). *Using the" thinking-aloud" method in cognitive interface design*. IBM TJ Watson Research Center Yorktown Heights, NY.
Lewis Senior HF Engineer, J. R., & Sauro, J. (2017). Revisiting the Factor Structure of the System Usability Scale. In *Journal of Usability Studies* (Vol. 12).
Li, A. C., Kannry, J. L., Kushniruk, A., Chrimes, D., McGinn, T. G., Edonyabo, D., & Mann, D. M. (2012). Integrating usability testing and think-aloud protocol analysis with "near-live" clinical simulations in evaluating clinical decision support. *International Journal of Medical Informatics*, *81*(11), 761–772. https://doi.org/10.1016/j.ijmedinf.2012.02.009
Lidwell, W., Holden, K., & Butler, J. (2010). *Universal Principles of Design*.
Linneman J. (2020). Half-Life: Alyx tech analysis - a VR masterpiece that must be experienced . *Eurogamer*.
Luis. (2022). *No-Code tools: Allowing everyone to be a digital product builder*. UX Collective.

Machidon, O. M., Tavčar, A., Gams, M., & Duguleană, M. (2020). CulturalERICA: A conversational agent improving the exploration of European cultural heritage. *Journal of Cultural Heritage*, *41*, 152–165. https://doi.org/10.1016/j.culher.2019.07.010

MacKenzie, I. S. (1992). Fitts' Law as a Research and Design Tool in Human-Computer Interaction. *Hum.-Comput. Interact*, 91–139.

Macrì, E., & Cristofaro, C. L. (2021). The Digitalisation of Cultural Heritage for Sustainable Development: The Impact of Europeana. In *Cultural Initiatives for Sustainable Development* (pp. 373–400). Springer.

Maeda, J. (2006). *The laws of simplicity*. MIT press.

Mah, O. B. P., Yan, Y., Tan, J. S. Y., Tan, Y. X., Tay, G. Q. Y., Chiam, D. J., Wang, Y. C., Dean, K., & Feng, C. C. (2019). Generating a virtual tour for the preservation of the (in)tangible cultural heritage of Tampines Chinese Temple in Singapore. *Journal of Cultural Heritage*, *39*, 202–211. https://doi.org/10.1016/j.culher.2019.04.004

Mäkinen, H., Haavisto, E., Havola, S., & Koivisto, J. M. (2020). User experiences of virtual reality technologies for healthcare in learning: an integrative review. *Behaviour and Information Technology*, 1–17. https://doi.org/10.1080/0144929X.2020.1788162

Malraux, A. (1947). *Le musée imaginaire*.

Mark, D., & Douglas, C. (n.d.). *Understanding and supporting web developers: : design and evaluation of a web accessibility information resource (WebAIR)*. https://www.w3.org/WAI/EO/

Martelaro, N. (2022). *Exploring the Future of Remote User Research*. http://arxiv.org/abs/2208.03349

Masili, G. (2023). NO-CODE DEVELOPMENT PLATFORMS: BREAKING THE BOUNDARIES BETWEEN IT AND BUSINESS EXPERTS. *International Journal of Economic Behavior (IJEB)*, *13*, 33–49. https://doi.org/10.14276/2285-0430.3705

Matusiak, K. K. (2017). User Navigation in Large-Scale Distributed Digital Libraries: The Case of the Digital Public Library of America. *Journal of Web Librarianship*, *11*(3–4), 157–171. https://doi.org/10.1080/19322909.2017.1356257

McArthur, V. (2017). The UX of avatar customization. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 5029–5033.

McNamara, N., & Kirakowski, J. (2006). Functionality, Usability, and User Experience: Three Areas of Concern. *Interactions*, *13*(6), 26–28. https://doi.org/10.1145/1167948.1167972

Meinecke, C. (2022). *Labeling of Cultural Heritage Collections on the Intersection of Visual Analytics and Digital Humanities*. http://arxiv.org/abs/2208.13512

Mi, X., & Pollock, B. M. (2018). Metadata schema to facilitate linked data for 3D digital models of cultural heritage collections: A university of south florida libraries case study. *Cataloging and Classification Quarterly*, *56*(2–3), 273–286. https://doi.org/10.1080/01639374.2017.1388894

Monk, A., Hassenzahl, M., Blythe, M., & Reed, D. (n.d.). *Workshop CHI changing the world, changing ourselves Funology: designing enjoyment*. http://www.idea.unimas.my/cahd2001/index.htm

Moran K. (2022). *Remote Usability Testing Costs*. Nielsen Norman Group.

Mundy, J., & Burton, J. (2013). Online exhibitions. *Museums and the Web*, 17–20.

Muñoz, A., Mahiques, X., Solanes, J. E., Martí, A., Gracia, L., & Tornero, J. (2019). *Mixed reality-based user interface for quality control inspection of car body surfaces*.

Munteanu, C., Molyneaux, H., Moncur, W., Romero, M., O'Donnell, S., & Vines, J. (2015). Situational ethics: Re-thinking approaches to formal ethics requirements for human-computer interaction. *Conference on Human Factors in Computing Systems - Proceedings*, *2015-April*, 105–114. https://doi.org/10.1145/2702123.2702481

Museums Association. (2023). Https://Www.Museumsassociation.Org/.

Navarrete, T. (2013). Digital cultural heritage. In *Handbook on the economics of cultural heritage*. Edward Elgar Publishing.

Niccolucci, F., Felicetti, A., & Hermon, S. (2022). *Populating the Digital Space for Cultural Heritage with Herit-age Digital Twins*. *7*. https://doi.org/10.3390/xxxxx

Nielsen, J. (1994). *Usability Inspection Methods*.

Nielsen, J. (1993). *Usability engineering*. Academic Press.
Nielsen, J. (2006). *Progressive Disclosure*. Nielsen Norman Group.
Nielsen, J. (2014). *10 Usability Heuristics for User Interface Design*. Nielsen Norman Group.
Nielsen, J., Molich, R., & Bitnet Denmark, J. (1990). *CHI 90 Procee&qs HEURISTIC EVALUATION OF USER INTERFACES*.
Norman, D. (2002). Emotion & design. *Interactions*, *9*(4), 36–42. https://doi.org/10.1145/543434.543435
Norman, D. A. (1988). *The psychology of everyday things*. Basic books.
Oberlander, J., Karakatsiotis, G., Isard, A., Androutsopoulos, I., & others. (2008). Building an adaptive museum gallery in Second Life. *Proceedings of Museums and the Web, Montreal, Quebec, Canada*.
of Museums, I. C. (2007). *Development of the Museum Definition according to ICOM Statutes (2007–1946)*. International Council of Museums (ICOM) Paris, France.
Ogden, S. (2007). Understanding, respect, and collaboration in cultural heritage preservation: a conservator's developing perspective. *Library Trends*, *56*(1), 275–287.
Okimoto, M. (2022). *User Experience in Remote Context* (1st Edition). CRC Press.
Othman, M. K., Aman, S., Anuar, N. N., & Ahmad, I. (2021). Improving Children's Cultural Heritage Experience Using Game-based Learning at a Living Museum. *Journal on Computing and Cultural Heritage*, *14*(3). https://doi.org/10.1145/3453073
Paay, J., & Kjeldskov, J. (2008). Understanding the user experience of location-based services: Five principles of perceptual organisation applied. *Journal of Location Based Services*, *2*(4), 267–286. https://doi.org/10.1080/17489720802609328
Paliokas, I., & Sylaiou, S. (2016). The use of serious games in museum visits and exhibitions: A systematic mapping study. *2016 8th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)*, 1–8.
Pannucci, C. J., & Wilkins, E. G. (2010). Identifying and avoiding bias in research. *Plastic and Reconstructive Surgery*, *126*(2), 619–625. https://doi.org/10.1097/PRS.0b013e3181de24bc
Pedersen, I., Gale, N., Mirza-Babaei, P., & Reid, S. (2017). More than Meets the Eye: The Benefits of Augmented Reality and Holographic Displays for Digital Cultural Heritage. *J. Comput. Cult. Herit.*, *10*(2). https://doi.org/10.1145/3051480
Pessoa, J., Deloumeaux, L., & Ellis, S. (2009). UNESCO framework for cultural statistics. *Journal of Cultural Economics*, *5*. http://uis.unesco.org/en/glossary-term/cultural-heritage
Petrie, H., & Precious, J. (2010). Measuring User Experience of websites: Think aloud protocols and an emotion word prompt list. In *CHI'10 Extended Abstracts on Human Factors in Computing Systems* (pp. 3673–3678).
Pettersson, I. (2018). *Eliciting user experience information in early design phases : the CARE approach to in-vehicle UX*.
Pettersson, I., Lachner, F., Frison, A.-K., Riener, A., & Butz, A. (2018). A Bermuda triangle? A Review of method application and triangulation in user experience evaluation. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–16.
Pisoni, G., Díaz-Rodríguez, N., Gijlers, H., & Tonolli, L. (2021). Human-centred artificial intelligence for designing accessible cultural heritage. *Applied Sciences (Switzerland)*, *11*(2), 1–30. https://doi.org/10.3390/app11020870
Portalés, C., Lerma, J. L., & Pérez, C. (2009). Photogrammetry and augmented reality for cultural heritage applications. *The Photogrammetric Record*, *24*(128), 316–331.
Preece, J. and S. H. and R. Y. (2015). *Interaction design: beyond human-computer interaction*. John Wiley & Sons.
Pretto, N., Micheloni, E., Gasparotto, S., Fantozzi, C., Poli, G. De, & Canazza, S. (2020). Technology-enhanced interaction with cultural heritage: an antique pan flute from Egypt. *Journal on Computing and Cultural Heritage (JOCCH)*, *13*(2), 1–20.
Prott, L. V, & O'Keefe, P. J. (1984). *Law and the cultural heritage. Volume 1*. Professional Books.

Pujol-Tost, L. (2019). Did we just travel to the past? Building and evaluating with cultural presence different modes of VR-mediated experiences in virtual archaeology. *Journal on Computing and Cultural Heritage (JOCCH)*, *12*(1), 1–20.

Rahaman, H., Champion, E., & Bekele, M. (2019). *From Photo to 3D to Mixed Reality: A Complete Workflow for Cultural Heritage Visualisation and Experience*.

Ratclife, J., Soave, F., Bryan-Kinns, N., Tokarchuk, L., & Farkhatdinov, I. (2021, May 6). Extended reality (xr) remote research: A survey of drawbacks and opportunities. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3411764.3445170

Research Libraries UK. (2020). *A manifesto for the digital shift in research libraries*. Https://Www.Rluk.Ac.Uk/Digital-Shift-Manifesto/.

Rizvic, S., Boskovic, D., Okanovic, V., Sljivo, S., & Zukic, M. (2019). *Interactive digital storytelling: bringing cultural heritage in a classroom*.

Rizvic, S., Djapo, N., Alispahic, F., Hadzihalilovic, B., Cengic, F. F., Imamovic, A., Okanovic, V., & Boskovic, D. (2017). Guidelines for interactive digital storytelling presentations of cultural heritage. *2017 9th International Conference on Virtual Worlds and Games for Serious Applications, VS-Games 2017 - Proceedings*, 253–259. https://doi.org/10.1109/VS-GAMES.2017.8056610

Robinson, J., Lanius, C., & Weber, R. (2018). The past, present, and future of UX empirical research. *Communication Design Quarterly Review*, *5*(3), 10–23.

Rodriguez Echavarria, K., Samaroudi, M., Lloyd, J., & Weyrich, T. (2021). *Interactive 3D Artefact Puzzles to Support Engagement Beyond the Museum Environment*. https://doi.org/10.2312/gch.20211403

Rokhsaritalemi, S., Sadeghi-Niaraki, A., & Choi, S. M. (2020). A review on mixed reality: Current trends, challenges and prospects. In *Applied Sciences (Switzerland)* (Vol. 10, Issue 2). MDPI AG. https://doi.org/10.3390/app10020636

Rongqian Ma. (2022). Curating China's Cultural Revolution. *Information & Culture*, *57*, 27–45.

Roto, V., Law, E., Vermeeren, A., & Hoonhout, J. (2011). *Demarcating User Experience Dagstuhl Seminar*. http://www.allaboutux.org.

Roto, V., Väätäjä, H., Law, E., & Powers, R. (2016). Experience design for multiple customer touchpoints. *ACM International Conference Proceeding Series*, *23-27-October-2016*. https://doi.org/10.1145/2971485.2987685

Rousi, R. (2023). *AI Design, Design AI, Human-Centred AI and the Theatre of the Absurd-the language, life and times of a UX designer*. https://theblog.adobe.com/what-does-a-ux-designer-

Rubin, H. J., & Rubin, I. (2011). *Qualitative interviewing : the art of hearing data*.

Rusu, C., & Rusu, V. (2007). Teaching HCI: a challenging intercultural, interdisciplinary, cross-field experience. *International Workshop on Intercultural Collaboration*, 344–354.

Saini, S. S. and M. S. S. et al. (2022). Virtual Reality: A Survey of Enabling Technologies and its Applications in IoT. *International Conference on Electronics and Renewable Systems* .

Saldaña, J. (2021). *The coding manual for qualitative researchers*. SAGE publications Ltd.

Scheinman, P. (2004). *Werner Strub: Ghostly heads of thread*.

Scherling, L. and D. A. (2020). *Ethics in design and communication: Critical perspectives*. Bloomsbury Publishing.

Schlesinger, A., Edwards, W. K., & Grinter, R. E. (2017). Intersectional HCI: Engaging identity through gender, race, and class. *Conference on Human Factors in Computing Systems - Proceedings*, *2017-May*, 5412–5427. https://doi.org/10.1145/3025453.3025766

Schmutz, V., & Elliott, M. A. (2016). *Tourism and Sustainability in the Evaluation of World Heritage Sites, 1980-2010*. https://doi.org/10.3390/su8030261

Schweibenz, W. (1998). The" Virtual Museum": New Perspectives For Museums to Present Objects and Information Using the Internet as a Knowledge Base and Communication System. *Isi*, *34*, 185–200.

Second International Peace Conference, T. H. (1910). *Hague Convention (IV) Respecting the Laws and Customs of War on Land and Its Annex: Regulations Concerning the Laws and Customs of War on Land*.

Selmanović, E., Rizvic, S., Harvey, C., Boskovic, D., Hulusic, V., Chahin, M., & Sljivo, S. (2020). Improving Accessibility to Intangible Cultural Heritage Preservation Using Virtual Reality. *Journal on Computing and Cultural Heritage*, *13*(2). https://doi.org/10.1145/3377143

Seyama, J., & Nagayama, R. S. (2007). The Uncanny Valley: Effect of Realism on the Impression of Artificial Human Faces. *Presence*, *16*(4), 337–351. https://doi.org/10.1162/pres.16.4.337

Shneiderman, B. and P. C. and C. M. S. and J. S. and E. N. and D. N. (2016). *Designing the user interface: strategies for effective human-computer interaction*. Pearson.

Shore, N. (2006). Re-conceptualizing the Belmont Report: A community-based participatory research perspective. *Journal of Community Practice*, *14*(4), 5–26.

Showcase, R., Forlizzi, J., Batarbee, K., & Battarbee, K. (2004). *Understanding Experience in Interactive Systems*.

Škola, F., Rizvić, S., Cozza, M., Barbieri, L., Bruno, F., Skarlatos, D., & Liarokapis, F. (2020). Virtual reality with 360-video storytelling in cultural heritage: Study of presence, engagement, and immersion. *Sensors (Switzerland)*, *20*(20), 1–17. https://doi.org/10.3390/s20205851

Smith, L., & Waterton, E. (2013). *Heritage, communities and archaeology*. A&C Black.

Snydman, S. (2015). *The International Image Interoperability Framework (IIIF): A community & technology approach for web-based images*. http://iiif.io/community.html

Song, J. W., & Chung, K. C. (2010). Observational studies: Cohort and case-control studies. *Plastic and Reconstructive Surgery*, *126*(6), 2234–2242. https://doi.org/10.1097/PRS.0b013e3181f44abc

Spi Ekermann, S. (n.d.). *Technology Paternalism-Wider Implications of Ubiquitous Computing*.

Sprig. (2022). *Top 2023 UX Research Trends Enable Customer Focus*.

Sun, H. (2012). Cross-Cultural Technology Design: Creating Culture-Sensitive Technology for Local Users. In *Cross-Cultural Technology Design: Creating Culture-Sensitive Technology for Local Users*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199744763.001.0001

Sundberg, L., & Holmström, J. (2023). Democratizing artificial intelligence: How no-code AI can leverage machine learning operations. *Business Horizons*. https://doi.org/10.1016/j.bushor.2023.04.003

Sutcliffe, A. (2009). Designing for user engagement: Aesthetic and attractive user interfaces. *Synthesis Lectures on Human-Centered Informatics*, *2*(1), 1–55.

Swarbrooke, J. (2012). *The development and management of visitor attractions*. Routledge.

Sylaiou, S., Mania, K., Paliokas, I., Pujol-Tost, L., Killintzis, V., & Liarokapis, F. (2017). Exploring the educational impact of diverse technologies in online virtual museums. *International Journal of Arts and Technology*, *10*(1), 58–84.

Szwillus, G., & Ziegler (hrsg, J. (2003). *AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität 1*. www.attrakdiff.de.

Tan, D. S., Begole, Bo., Kellogg, Wendy., & SIGCHI (Group : U.S.). (2011). *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems : 2011 proceeding, Vancouver, BC, Canada - May 07-12, 2011*. ACM Press.

Waters, D., & Garrett, J. (1996). *Preserving digital information : report of the Task Force on Archiving of Digital Information*. Commission on Preservation and Access.

Terras, M. (2015). Cultural heritage information: Artefacts and digitization technologies. *Cultural Heritage Information*, 63–88.

Tidwell, J. (2010). *Designing interfaces: Patterns for effective interaction design*. O'Reilly Media, Inc.

Tilden, F. (2009). *Interpreting our heritage*. Univ of North Carolina Press.

Todorovic, D. (2008). *Gestalt principles*. Scholarpedia.

Torres, T. (2017). *3 Best Practices for Adopting Continuous Product Discovery*.

Tractinsky, N. (2004). *TOWARD THE STUDY OF AESTHETICS IN INFORMATION TECHNOLOGY*.

Tractinsky, N., Katz, A. S., & Ikar, D. (2000). *What is beautiful is usable*. www.elsevier.com/locate/intcom

Trischler, J., & Zehrer, A. (2012). Service design: Suggesting a qualitative multistep approach for analyzing and examining theme park experiences. *Journal of Vacation Marketing*, *18*(1), 57–71. https://doi.org/10.1177/1356766711430944

Trunfio, M., & Campana, S. (2020). A visitors' experience model for mixed reality in the museum. In *Current Issues in Tourism* (Vol. 23, Issue 9, pp. 1053–1058). Routledge. https://doi.org/10.1080/13683500.2019.1586847

Trunfio, M., Lucia, M. Della, Campana, S., & Magnelli, A. (2022). Innovating the cultural heritage museum service model through virtual reality and augmented reality: the effects on the overall visitor experience and satisfaction. *Journal of Heritage Tourism*, *17*(1), 1–19. https://doi.org/10.1080/1743873X.2020.1850742

Tuch, A. N., Roth, S. P., Hornbæk, K., Opwis, K., & Bargas-Avila, J. A. (2012). Is beautiful really usable? Toward understanding the relation between usability, aesthetics, and affect in HCI. *Computers in Human Behavior*, *28*(5), 1596–1607. https://doi.org/10.1016/j.chb.2012.03.024

Tullis, T. (Thomas), & Albert, B. (William). (2008). *Measuring the user experience : collecting, analyzing, and presenting usability metrics*. Elsevier/Morgan Kaufmann.

Tunbridge, J. E., & others. (1984). Whose heritage to conserve? Cross-cultural reflections on political dominance and urban heritage conservation. *Canadian Geographer*, *28*(2), 170–180.

Ubisoft. (2007). *Assassin's Creed*.

UNESCO. (2023). *Involvement of tradition bearers and practitioners*. UNESCO Intangible Cultural Heritage .

van Wynsberghe, A., & Robbins, S. (2019). Critiquing the Reasons for Making Artificial Moral Agents. *Science and Engineering Ethics*, *25*(3), 719–735. https://doi.org/10.1007/s11948-018-0030-8

Vecco, M. (2010). A definition of cultural heritage: From the tangible to the intangible. *Journal of Cultural Heritage*, *11*(3), 321–324.

Velt, R., Benford, S., & Reeves, S. (2020). Translations and boundaries in the gap between HCI theory and design practice. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *27*(4), 1–28.

Vergo, P. (1997). *New museology*. Reaktion books.

Verma, S. (2019). Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy. *Vikalpa: The Journal for Decision Makers*, *44*(2), 97–98. https://doi.org/10.1177/0256090919853933

Vrettakis, E., Kourtis, V., Katifori, A., Karvounis, M., Lougiakis, C., & Ioannidis, Y. (2019). *Narralive-creating and experiencing mobile digital storytelling in cultural heritage*.

Wachowiak, M. J., & Karas, B. V. (2009). 3D scanning and replication for museum and cultural heritage applications. *Journal of the American Institute for Conservation*, *48*(2), 141–158.

Walker, K. (2008). Structuring visitor participation. *Digital Technologies and the Museum Experience: Handheld Guides and Other Media*, 109–124.

Wang, B., Dai, L., & Liao, B. (2023). System Architecture Design of a Multimedia Platform to Increase Awareness of Cultural Heritage: A Case Study of Sustainable Cultural Heritage. *Sustainability (Switzerland)*, *15*(3). https://doi.org/10.3390/su15032504

Bowen, J. P. (2017). Web access to cultural heritage for the disabled. *Digital Applications for Cultural and Heritage Institutions*, 243–254.

WebAim. (2021). *WebAIM. (n.d.). Alternative Tex*.

Weinschenk, S. (2011). *100 things every designer needs to know about people*.

Were, G. (2015). Digital heritage in a Melanesian context: Authenticity, integrity and ancestrality from the other side of the digital divide. *International Journal of Heritage Studies*, *21*(2), 153–165. https://doi.org/10.1080/13527258.2013.842607

Wharton, C. (1994). The cognitive walkthrough method: A practitioner's guide. *Usability Inspection Methods, New York*, 105--140.

Wilson, C. (n.d.). *Interview Techniques for UX Practitioners A User-Centered Design Method*.

Wolff, A., & Mulholland, P. (2013). Curation, curation, curation. *Proceedings of the 3rd Narrative and Hypertext Workshop*, 1–5.

Wolff, A., Mulholland, P., & Collins, T. (2012). Storyspace: a story-driven approach for creating museum narratives. *Proceedings of the 23rd ACM Conference on Hypertext and Social Media*, 89–98.

Wolff, A., Torres, J., & Thi My, H. (2018). Usability Evaluation of The Interactive 3D Virtual Reality Cultural Heritage Museum Display: Fountain of The Lions Software Application. In *International Journal of Engineering & Technology* (Vol. 7, Issue 2). www.sciencepubco.com/index.php/IJET

Wright, P. (2009). *On living in an old country: The national past in contemporary Britain*. OUP Oxford.

Wu, D. and H. D. and L. B. (2012). Multilingual needs and expectations in digital libraries: A survey of academic users with different languages. *The Electronic Library*.

Xi, N., Chen, J., Gama, F., Riar, M., & Hamari, J. (2022). The challenges of entering the metaverse: An experiment on the effect of extended reality on workload. *Information Systems Frontiers*. https://doi.org/10.1007/s10796-022-10244-x

Xu, W. (2023). User-Centered Design（IX）：A “User Experience 3.0” Paradigm Framework in the Intelligence Era. *Chinese Journal of Applied Psychology*. https://doi.org/10.48550/arXiv.2302.0668

Ye, Z. and X. C. and L. Y. (2021). Visual perception based on gestalt theory. *Intelligent Human Systems Integration 2021*.

Zandi, S. (n.d.). *Revival of the Silk Road using the applications of AR/VR and its role on cultural tourism*.

Ziegler, M. M., Se, D., & Arte, H. (2020). *The time of Digital Humanities: Between Art History, Cultural Heritage, Global Citizenship and Education in Digital Skills.* https://www.researchgate.net/publication/366977152

Zittoun, T., & Brinkmann, S. (2012). Learning as meaning making. *Encyclopedia of the Sciences of Learning*, 1809–1811.

Zorich, D. M. (2003). *A Survey of Digital Cultural Heritage Initiatives and Their Sustainability Concerns. Managing Economic Challenges.* ERIC.

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, *38*(9), 25–32.

为许. (2023). 九论以用户为中心的设计: 智能时代的"用户体验 3.0"范式. *Chinese Journal of Applied Psychology*. https://doi.org/10.48550/arXiv.2302.0668

END OF DOCUMENT