Towards a Digital Dream Space: How can the use of digital 3D scanning, editing and print technologies foster new forms of creative engagement with museum artefacts?

by

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This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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To my family,

for showing me that the first answer is not always the right one

and to Dave,

for sharing his home.

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Abstract

This thesis describes research into the creative use of digital three-dimensional (3D) technologies in museums. It examines how digital 3D reproductions of museum artefacts support creative engagement and enhance museum experience. Digital 3D models of museum artefacts are malleable; they allow users to create new artworks through digital manipulation and transformation. 3D printing technologies enable users to translate digital 3D models directly into physical forms. This research investigates how these technologies can impact on museum engagement and makes recommendations for museums exploring the possible uses of digital 3D technologies.

A contextual review, informed by ongoing developments in the field of digital heritage and a critical review of published literature, identifies key issues examined in the research. These include the ways in which reproductive digital 3D technologies can foster unprecedented audience access to museum collections, democratise art interventions in museums and engage with the museum 'dream space'. The rationale for the use of qualitative research methods in the study is explained and the case studies undertaken during the research are described. The investigation of artworks created by participants in the case studies; data from interviews with artists, museum staff and museum visitors, provide insights into how digital 3D reproductions foster new experiences with museum artefacts.

In this research, reproductive digital 3D technologies are shown to support creative forms of museum engagement, to democratise museum interventions and increase public access to museum collections. They engage users with personal and subrational forms of museum experience. Furthermore, the use of digital technologies in museums has been shown, in this research, to trigger learning experiences and increase historical awareness and digital literacy. Recommendations are made for institutional approaches to the use of digital 3D technologies and for future research in the area of creative engagement with digital heritage.

1. Introduction

This PhD research investigates how digital three-dimensional (3D) scanning and 3D printing technologies can foster new forms of artist engagement with museum objects. In this research, a series of practical experiments and case studies were undertaken in order to experiment with digital 3D models of museum artefacts and to explore their potential creative uses and impact. The principal case study was undertaken in collaboration with the National Museum Cardiff[1], a museum with a rich history of artistic collaboration and experimentation[2]. This case study, the *(Im)material Artefacts* project, encompassed an exhibition at the National Museum Cardiff and a symposium, organised in collaboration with Axisweb[3].

Digital media have become an important component of our social and professional lives (Lister, 2008). They are no longer solely a means of communicating information, but play an intimate role in the way we construct and navigate both personal and cultural identities (Cutting Edge Group, 2000). Ubiquitous digital media can be used to record any object or event in a range of different formats, they are increasingly being used as repositories of personal memories (Keightley and Schlesinger, 2014). Developments in 3D imaging technologies look set to bring about new forms of engagement with heritage artefacts (Callaway, 2014). The use of 3D computer graphics is becoming commonplace in everyday culture[4].

The form of real objects can be captured and stored as digital files using digital 3D scanning technologies. These technologies are inherently suited to the re-production of historical artefacts; they allow the production of copies without

[1] Andrew Renton, Keeper of Art at the National Museum Cardiff, is one of the supervisors of this research. He provided the researcher with valuable support and access to the museum's collections.
[2] See for example The artist Carwyn Evans' thoughts on his work *Unlliw*, an installation of 6,500 bird boxes made from cardboard, installed as an intervention in the Landscape Gallery at the National Museum Cardiff in 2011: https://vimeo.com/28661955, accessed 10.10.2015.
[3] See http://www.axisweb.org/features/news-and-views/our-news-and-stories/behind-the-scenes-of-the-museum-artists-in-collections/, accessed 10.09.2015.
[4] Video games, movies, websites, commercials and other digital media increasingly feature 3D content.

physical risk to valuable objects (see Section 2.2.1. 3D scanning). Developments in 3D print (see Section 2.2.3. 3D print) are swiftly bridging the gap between digital and physical objects; it is now possible to print physical objects directly from digital files. In addition, digital 3D models make it possible to study heritage artefacts on the computer. Some research can be undertaken through the study of digital 3D models, without the need to physically visit museum collections (Flaten and Gill, 2009, see also Section 2.3.1. Knowledge-based strategies). More and more historical artefacts and sites are documented in 3D; digital 3D models are increasingly used to aid preservation and restoration in museums (Callaway, 2014) and to assist the exchange of ideas and information.

A growing number of museums are creating digital 3D models of artefacts from their collections (Koller *et al.*, 2010). It is now commonplace for museums and other heritage institutions to create and deliver digital representations of cultural and historical documents, artefacts and images to foster greater understanding and to improve access to the collections they hold (Callaway, 2014, Gomes *et al.*, 2014, Remondino, 2011). In response, researchers, academic institutions and heritage organizations are engaged in contextualizing the creation, distribution and use of these models (see Abate *et al.*, 2011, De Luca *et al.*, 2011, Felicetti and Lorenzini, 2011, Yu and Hunter, 2013). Easier and cheaper digitisation and editing tools and faster, more affordable 3D printing in a greater range of materials are imminent (see Gordon, 2013, Hastings, 2001, Kirchhöfer *et al*., 2011, Lipson and Kurman, 2013, Straub and Kerlin, 2014). In museums the use of these technologies is an area of on-going developments and research. Researchers and museums are working towards developing legislative approaches, building shared platforms for digital heritage content, and developing museum policies and best practice standards concerning digital 3D models (see Koller *et al.*, 2010, Ning *et al.*, 2011, Santos Junior *et al.*, 2012).

However, digital 3D models of museum artefacts also possess great potential for creative use, which has not yet been fully explored. The 3D scanning of physical artefacts translates the form of physical objects into digital models ‘open to further amendment or reconstitution’ (Parry, 2007:102). Unlike the original artefacts from which they derive, digital 3D models of museum artefacts are malleable and can be transformed through further derivation (Neely and Langer, 2013). They permit creative experimentation and play. Museums, primarily in the United States but increasingly also in the UK and across Europe, are beginning to embrace and foster creative digital engagement with their collections (see Brunckhorst, 2012, Hurst, 2012, Monaghan, 2013, Terrassa, 2012). Some museums, for example the Metropolitan Museum, New York, have begun to make digital 3D models of objects from their collections available online[5]. This increased availability of reproductions is conducive to the creation of remixed (see Glossary) art that builds on previous works (Dyer, 2007).

Affordable 3D scanners and photogrammetry[6] software enable non-experts to digitise real-life artefacts. Photogrammetric 3D imaging software can be found for free online[7] and has enabled museum visitors to create digital 3D models from museum artefacts outside the scope of the museum. The emergence of inexpensive and flexible 3D digitisation technologies, increasingly easy to use and intuitive 3D editing software, as well as affordable and accessible 3D printing, has both lowered the bar for entry into digital 3D editing and led to an increase in the number of people engaging with museum collections through digital activities. These technologies hold the potential to break the 'interpretative monopoly' of scholars (Callaway, 201:320). While original museum artefacts rest within the museum, digital 3D models can cross the threshold into the private sphere of individuals. 3D models of museum artefacts appear to hold a strong popular appeal; a vast number of 3D digital models of museum artefacts can be found across various file sharing websites, where they are added as user generated (UG) content[8].

[5] See https://www.thingiverse.com/met/about, accessed 24.04.2015.
[6] The term photogrammetry describes the practice of determining the geometric properties of objects from photographic images. Due to increasingly user-friendly, freely available photogrammetric software physical access and technological insight are no longer required to create digital three-dimensional copies from photographs. Photogrammetry is used in surveying and mapping and to obtain reliable information about the measurements of physical objects.
[7] For example *Smoothie 3D* and *123D Catch*. These applications let users create 3D models from digital photographs online. See http://www.smoothie-3d.com/site/page_index.php, http://www.123dapp.com/catch, accessed 21.01.2015.
[8] See for example this UG collection of 3D models from the American Museum of Natural History; http://www.thingiverse.com/thing:25369, accessed 04.06.2015.

Museum artefacts are capable of taking on diverse and sometimes contradictory meanings (Preziosi and Farago, 2004, Smith, 1989); they possess little fixed content without the contextualising framework of metadata and contextual material (Parry, 2007, Smith, 1989). Sheldon Annis (1986) argues, that museum exhibitions and artefacts do not have a meaning in themselves but reflect the meanings, thoughts, memories and emotions visitors bring with them. Annis identifies a personal and subrational level of viewer interaction with museum collections, which he terms the 'museum dream space'. In her book *Dream Spaces: Memory and the Museum* (2000) Gaynor Kavanagh describes the dream space as an experiential realm beyond the rational and knowledge-based fields of museum experience, where 'our inner experiences find a mesh with the outer experiences which museums provide' (Kavanagh, 2000:175).

3D models of museum artefacts hold a mercurial position in between the historically and materially grounded sphere of the museum and the volatile realm of digital media. They present a new medium through which museum collections can be explored and which offers new creative and artistic ways of engaging with the museum. The fluidity and availability of digital 3D models invites reflection on the boundary between culture and personal agency. It challenges notions of originality, authenticity and ownership, and calls into question established methods of curating and collections management in museums (Parry, 2007). Creative digital engagement with museum artefacts follows in the footsteps of previous artistic forms of museum engagement. Since the late 1980s artists have undertaken projects in museums, termed 'artist interventions', to question the institutional setting of cultural heritage objects within museums, and to offer alternative viewpoints to the historical narratives presented in museums (Putnam, 2012). These interventions enable museums to experiment with new approaches, to integrate different views, and to attract new audiences (Putnam, 2012). Artist engagement with museums is restricted by museum guidelines and policies and the valuable and often fragile nature of artefacts in museum collections. Video installations, photography and digital forms of engagement with museum artefacts can move beyond these restrictions and explore new pathways of museum intervention. However, they frequently engage with museum artefacts only as 2D representations. Digital 3D models of museum artefacts now enable digital interventions that engage with the 3D form of objects in museum collections.

Little academic attention has so far been paid to the question of what the impact of the creative use of 3D replicas of museum artefacts might be. Digitally 'remixed' artworks (see Glossary) can engage with museum collections, theory and history and engage museums with digital culture, metamorphosed objects (see Glossary) and transformed realities (examples will be given further in the thesis). Potentially, these technologies can transform the way audiences engage with museum collections (Jewitt, 2014). At a time when these technologies are beginning to have an increasing impact on museums, this research is both timely and relevant, as it investigates the potential of digital 3D technologies to foster creativity and novel experiences with museum collections. It explores connections between digital forms of museum intervention and the museum dream space and investigates how audiences engage creatively with 'digital heritage' (see Glossary).

The following sections give an introduction and overview of the research. Section 1.1. explains the rationale and scope of the research. Section 1.2. presents the aims and objectives of the research.

1.1. Rationale and scope of the research

Digital 3D technologies are becoming increasingly available and easy to use, in the context of the museum their creative use can promote new forms of engagement and bring about new cultural products. Institutional uses of digital 3D technologies are currently being explored in museums and other heritage institutions. However, the creative use of these tools bears scope for wider academic investigation. This research contributes new knowledge to the field by moving beyond knowledge-based and institutional uses of 3D technologies to explore their impact on the creative, personalised and subrational realms of museum experience.

Across the museum sector, the focus of considerable exploration and research is on the use of digital 3D technologies in support of core museum duties, including collection management, conservation, research and the interpretation of collections for the public (Parry, 2010). This focus on established museum practices risks ignoring more personal and subjective forms of museum experience, which can be explored through the use of digital technologies, such as museum dream space experience. Museum artefacts can trigger internal associations of 'fantasy, desire and anxiety in the mind of the viewer' (Annis, 1986:169). Erik Davis argues, that digital media can open up similar fields of experience; 'novel and protean spaces of possibility within social reality' (Davis, 2004:216). This research investigates artistic engagement with digital 3D models of museum artefacts and gives insight into the ways digital scanning, editing and 3D printing technologies are fostering new forms of creative engagement and new experiences with museum collections.

The creative engagement of artists and the wider public with digital 3D models can open up new ways of interacting with and understanding museum collections. This thesis examines how artists and others can make use of digital 3D models of museum artefacts, and how the works they produce from these digital 3D reproductions engage with the context of museums, contemporary culture, art and the museum dream space. It also considers the impact of these forms of engagement on curatorial practice and institutional policies.

Through a contextual and literature review, this thesis presents the creative engagement with digital 3D models of museum artefacts in context with the wider field of museum engagement, reproductive technologies and digital media. The Internet enables a global audience to access digital museum materials and 'the web is increasingly seen as a means to transform (…) the ways in which online visitors engage with object-based information' (Hogsden and Poulter, 2012:274). Museums are exploring the use of digital 3D technologies within an international context and digital heritage can have significance beyond national boundaries, as it can potentially be disseminated internationally (Bertacchini and Morando, 2013). Although the examples presented in this review mostly come from American and UK-based museums, this research should not be seen as limited to any given geographical location.

This thesis includes material sourced from the Internet, such as blogs, museum websites and online journalism. Since the use of digital 3D technologies in museums is developing at a rapid pace, online materials were included in this research as an essential way of keeping abreast the rapidly expanding field of digital museum engagement and digital heritage. Blogs and online journalism can provide a rich source of up to date material because they do not undergo lengthy processes of peer review. However, in the age of search engines and Wikipedia it is important to distinguish between well-grounded online articles and lifestyle blogs. In the choice of online sources discrimination was made between primary and secondary online materials; only blogs written by academics and museum staff, as well as first-hand participant accounts of digital engagement with museum collections were referenced in this thesis.

In this study, theoretical insights from the literature review are supplemented with experimental data. This study was undertaken using mixed methods of research. Digital processes of 3D replication and manufacture were employed as investigative tools and case study research was undertaken in collaboration with the National Museum Cardiff. The case study was practise-led; participating artists engaged creatively with digital 3D models of museum artefacts, and data on their work and experiences were collected. The thesis brings together theories on the nature of creative and digital engagement with museums, and experiential accounts of people creatively experimenting with digital 3D models and technologies in the context of the museum.

1.2. Aims and objectives

The aim of this research is:

- To gain qualitative insight into creative engagement with digital 3D models of museum artefacts.

Objectives of the research are:

- To explore the context and implications of museum engagement through digital 3D technologies in the heritage sector in the UK and abroad, and to create a conclusive overview through a literature and contextual review.

- To gain empirical understanding through a collaborative case study at the National Museum Cardiff, and to compare the outcomes of this case study with similar projects.

- To explore the creative use of digital 3D technologies as a new form of museum intervention, and to investigate its connection to museum dream space experience.

- To gain insight into the audience perception of creative digital 3D projects in museums and into their effect on the museum itself.

- To propose new theories on the future of creative digital engagement with museum collections through the use of 3D model

2. Literature and Contextual Review

2.1. Introduction

This chapter presents a literature and contextual review of areas relevant to the creative use of digital 3D technologies in museums. The review brings together theories from key authors on the interpretation of museum artefacts and on the use of reproductive technologies within the museum context. It investigates how digital 3D technologies are gaining relevance in the museum sector and presents examples of digital and artistic museum projects through a contextual review of the field.

Theories are presented from key authors and literature that inform the area of study. The sections of this chapter look into different contexts that are relevant for the research. Section 2.2. presents the tools that were used in this study. Section 2.3. reviews current digital museum strategies. Section 2.4. investigates the meaning of artefacts in museum collections. Section 2.5. presents an overview of types of artists' interventions in museum collections. Section 2.6. discusses the review and presents the research plan of this study.

2.2. Technical Review

Much of the published literature on digital 3D technologies is of a technical nature. However, since the focus of this research is on the cultural implications of the use of 3D technologies in the museum realm, an exhaustive technical review of digital 3D imaging, scanning, editing and printing[9] tools was

[9] In industry and research the terms 'rapid prototyping' and 'additive manufacturing', or 'computer aided manufacturing' are often used instead of the more colloquial term '3D printing'. Instead of '3D editing' the term 'computer aided design' is sometimes used. However, the average museums and their audiences are non-specialist users of these digital 3D technologies. Hobbyists

considered beyond the scope of the study. Instead, this section gives a review of the tools used in the course of this study.

3D scanners are now being marketed towards the hobbyist consumer[10] and free and premium photogrammetry software such as *Autodesk's 123D Catch*[11] enable users to create digital 3D models from physical objects without the need for specialised equipment. A range of free and commercially available 3D editing programmes are available online and in stores. These programmes are becoming increasingly easy to operate and find use in a vast number of fields, including product design, game design, animation, advertising, art and architecture. Tabletop 3D printers have also made their way into the domestic market at prices that are affordable to private users (Walmsley, 2011). These developments lead to new pathways of content production and use (Fig.1) and make it possible for a wider audience to engage with digital 3D content.

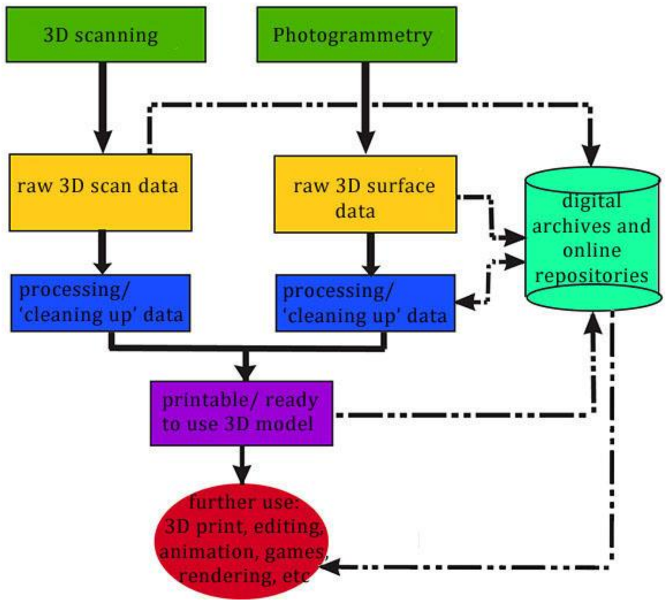

Fig.1 Typical production and distribution pathway of 3D content © Sarah Younan

and other non-specialist users of digital 3D technologies frequently use the more colloquial terms '3D printing' and '3D editing'. These more colloquial terms are also used in this thesis.

[10] See for example the *Makerbot Digitizier* https://store.makerbot.com/digitizer , a 3D tabletop scanner developed by 3D printer company Makerbot. Accessed 04.11.2014.
[11] *123D Catch* is a free photogrammetry tool provided online by *Autodesk* see http://www.123dapp.com/catch , accessed 04.1..2014.

Beyond this domestic market, digital 3D technologies are also evolving on the industrial level. 3D editing programmes are regularly used in a diverse range of fields, such as product design, video game and movie production, and marketing. 3D printers are being developed to print in a vast range of materials (Bredt, 2012) and on an increasingly flexible scale. 3D printing technologies evolved from manufacturing design processes and are now widely used in many manufacturing industries, from aerospace design to health care. Professional 3D scanning has become a marketable service[12].

The possibilities and restrictions afforded by digital technologies influence the cultural practices that form around their use and shape the products, which emerge from them. Digital 3D scanning, 3D editing and 3D printing technologies offer particular affordances and constraints, which will be discussed in the following sections. Technologies are presented in sections corresponding to the order in which they were deployed during the research; Section 2.2.1. 3D scanning, Section 2.2.2. 3D editing and Section 2.2.3. 3D print.

2.2.1. 3D scanning

Digital scanning allows the measurement of the surface geometry, texture and volume of objects, without surface contact. In this research a Next Engine laser scanner[13] was used to create 3D models of artefacts from the ceramics collections at the National Museum Cardiff (Fig.2). This piece of equipment was available through Cardiff Metropolitan University. The Next Engine laser scanner is an affordable model, which 'meets many requirements for the purposes of museum conservation' (Kuzminsky and Gardiner, 2012:2745) and for other applications of digital heritage. While some scanners can be used to create 3D models, which capture the material composition and internal structure of

[12] See for example the UK service provider *Sample and Hold*, who offer a range of 3D scanning and editing service; http://www.sampleandhold.co.uk, accessed 10.06.2015.
[13] See http://www.nextengine.com/ , accessed 24.7.2013.

objects[14] the Next Engine laser scanner only records the shape of the scanned object.

To create digital 3D models of artefacts for this research the artefacts were placed on the turntable of the scanner, one at a time. The inbuilt camera collected photographic surface data of the object. Then, four laser beams moved across the surface of the objects, capturing their geometric structure as X, Y and Z coordinates. Once a single surface scan was complete, the turntable rotated by 45 degrees and the process began again until the desired number of scans was achieved. The separate scan faces were then fused together to compose 3D models. In this way 3D models of the original artefacts, composed of thousands of coordinate points, were created. Scan Studio HD editing software[15] included in the Next Engine package was used to manage the scanner hardware and to assemble scan data into 3D mesh models. The resulting digital models can be exported in various file formats.

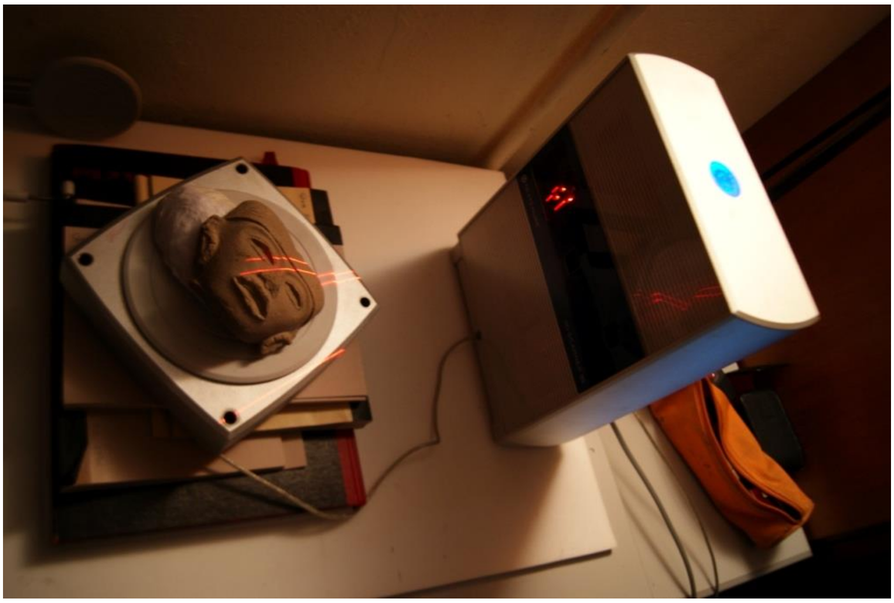

Fig.2 3D scanning of a Mexican artefact at the National Museum Cardiff, using the Next Engine laser scanner; 2013 © Sarah Younan

[14] For example, mummies from Medelhavsmuseet in Stockholm are digitised using photographs and X-ray scans to create 3D models. Source: BBC News http://www.bbc.co.uk/news/science-environment-23045904 , accessed 09.06.2014.
[15] See http://www.nextengine.com/products/scanstudio-hd/specs/overview accessed 08.03.2014.

For this research digital 3D scans were saved as stereo lithography files (.STL files, see Glossary), a common file format for 3D printing. After the scanning process was complete, unwanted parts of the scans were trimmed, the individual scans of different angles of the objects were fused together, and missing parts of the digital models were edited in, to prepare them for further use. Scan Studio HD editing software, which is included with the Next Engine scanner was used for these processes.

The accuracy of digital scan models depends on the settings of the 3D scanner, the software and the expertise of the person using the scanner. Reflective surfaces can be difficult to scan and the laser only travels in a straight line, thus some areas of the ceramic artefacts that were used in this research were impossible to scan, due to undercuts and surface reflections. Although 3D scanning is often seen as an unbiased method of documentation, 3D models should not be seen as truly objective records. 3D scan data is usually edited to prepare it for further use. Editing software comes with a set of predetermined parameters that inform the possibilities and limitations of editing. While editing the author can only venture his or her best guess concerning the parts of an object. The resulting digital copies are based on partial evidence and can give a misleading sense of accuracy (Styliani *et al.*, 2009).

2.2.2. 3D editing

3D data is used in a range of fields, such as medicine, engineering, architecture, the military, cultural heritage, art and design. 3D editing software programs can be used to view, edit, import and export 3D files, to build 3D models, animate them, and render (see Glossary) 3D content with various settings. Digital 3D editing programs can also be used to simulate physical processes, such as the flow of liquids, in order to test industrial designs prior to manufacture, or to add realistic features to virtual environments.

Digital 3D files are based on mathematical modelling and their appearance can be changed. Physical artefacts have intrinsic qualities; digital 3D models do not (see Section 2.4.3. Digital copies). They can be animated, distorted, or rendered to appear like a photograph. The qualities of digital 3D models can be grouped under three categories; geometry, surface appearance and scene information. The geometry of a digital model is stored as a set of 3D points, called 'vertices' (see Glossary). The surface of the model is composed of a series of polygons, known as 'faces' (see Glossary). These faces are composed of connected vertices on a plane. Triangular faces with three vertices are most common (McHenry and Bajcsy, 2008).

The surface appearance of digital 3D models can be altered using digital editing software. Textures, also known as texture maps, can be applied to the surface of 3D models. This is achieved by allocating vertice points to a corresponding point within a two dimensional image and 'wrapping' the image around a 3D model. This process is called texture mapping. Many 3D editing programmes also offer pre-set properties, which can be assigned to the surface of a 3D model, such as colour, reflectivity and transparency, amongst others.

3D models can be placed within a digital environment or scene, which can contain light sources and other 3D models. When animating digital 3D models the editor can choose a viewpoint, or camera angle, within the scene. Different software programmes have different settings for visualising digital 3D models; some offer a choice of different perspective settings. As a result 3D models might appear differently every time they are viewed in different software programs (Keene, 2006:7).

Digital editing software has made it possible to create virtual worlds and to set rules by which these worlds operate. Video games, for example, include settings, known as game physics, which determine how digital models and characters in the game respond to each other, how far they can jump, how fast the fall, etc. Digital 3D models can be animated and are widely used in the film industry to create animated movies, special effects and to change the appearance of real environments and even actors[16]. Virtual reality (VR, see Glossary) technologies, like the *Oculus Rift*[17] headset, allow users to have the impression of entering into 3D virtual worlds and emerging augmented reality (AR, see Glossary) technologies like Microsoft's *Hololens*[18] layer digital content over the viewer's environment by projecting digital images and 3D models into the user's field of vision. Video game graphics, special effects in films, VR and AR technologies all make extensive use of digital 3D models. These technologies are developing rapidly and look set to become ever more pervasive in our daily lives. It will be important for museums to negotiate if and how their collections will play a role in these developments.

2.2.3. 3D print

3D printing, also known as additive manufacturing or rapid prototyping[19], describes the process of producing a physical 3D object of virtually any shape from a digital 3D model. 3D printing is an additive process; objects are constructed by laying down successive layers of material and prototypes of digital models are printed layer by layer straight from digital files. 3D print is used across a vast range of disciplines, from fashion to architecture and medicine. Currently, 3D printing technologies are developing fast, the quality of 3D prints is improving rapidly, the choice of materials is expanding and 3D printers are becoming more affordable (Lipson and Kurman, 2013). 3D printing technologies are capturing the public imagination. At present, 3D print is receiving widespread attention in the news media and online, via blogs and community pages[20]. For this research, tabletop 3D printers were initially considered for in-situ 3D printing in the applied arts galleries at the National

[16] For Disney's *Maleficent,* for example the faces of real actors were mapped on to digital models and they were given digital hair and clothes to create fairy creatures.
[17] See https://www.oculus.com/rift/, accessed 24.02.2015.
[18] See http://www.microsoft.com/microsoft-hololens/en-us, accessed 24.02.2015.
[19] Although additive manufacturing and rapid prototyping can be considered as more scientific terms the term most popular term used in the media and by non-experts is '3D printing'. In this thesis '3D printing' is consistently used to describe this method of manufacturing.
[20] See for example http://3dprint.com/, and news features such as http://www.bbc.co.uk/news/technology-32780674, both accessed 19.08.2015.

Museum Cardiff. However, this plan had to be abandoned due to health and safety concerns raised by the National Museum Cardiff. Instead, 3D prints were commissioned from the International Centre for Product Design and Research in Cardiff[21].

Different additive processes have been developed and used in 3D print. The most common form of 3D printing is Fused Deposition Modelling (FDM) (Bredt, 2012). FDM 3D printers lay down material in layers; a plastic filament or metal wire is unwound from a coil and passes through a heated nozzle. This heated nozzle moves around to deposit the build material on a platform[22], as new layers are added the platform is lowered, the layers fuse together and form the object[23]. FDM has been popularized through tabletop size 3D printers, targeted at the domestic market[24]. Thermoplastics are mostly used in FDM 3D print, but there are many cases of creative experimentation with a variety of materials. Hobbyists and researchers are experimenting with a number of unusual FDM materials, including cake icing, wax, chocolate, ceramic slip and many more. Aside from readymade 3D printers some companies now offer DIY self-assembly kits[25] and open source projects like RepRap[26] offer crowd sourced software and building instructions for 3D printers. These self-assembly and open source printers are usually FDM models.

In industry and research another commonly used form of 3D print is Selective Laser Sintering (SLS). SLS printers use a laser to heat and fuse together the 3D printing material. The material is in powdered form; the laser heats a thin layer of the material and causes it to fuse. After a layer of the object has been fused the platform lowers, so that another thin layer of 3D printing material is exposed to

[21] See http://pdronline.co.uk, accessed 04.06.2015.
[22] Occasionally it is the plattform, which moves, and the nozzle which stays still. In other 3D printer designs both plattform and nozzle are designed to move on opposite axes.
[23] This youtube video is one of many which document and describe this process; http://www.youtube.com/watch?v=WHO6G67GJbM , accessed 15.05.2014.
[24] See for example https://www.ultimaker.com/ , https://www.makerbot.com/ , http://www.maplin.co.uk/3d-printer , all accessed 15.05.2014.
[25] See for example the *bvuildabot* http://www.york3dprinters.com/3d-printer-kit-buildabot, accessed 02.10.2014.
[26] See http://reprap.org, accessed 02.10.2014.

the laser[27]. Materials, which are currently used in SLS print are gold, silver and other metals, as well as a number of plastics and other synthetic materials.

Another 3D printing method that uses powdered materials is powder bed 3D printing. This technology uses an inkjet print head, which moves across a bed of powder and deposits a liquid binding material. Starch and gypsum plaster are materials commonly used for powder bed 3D printing. At the time of this research, Researchers at the Centre for Fine Print Research, at the University of the West of England in Bristol were developing a powder bed method for 3D printing with ceramic materials (Huson, 2010). Ceramic 3D printed objects are very delicate prior to being fired and glazed and delicate forms are as yet difficult to manufacture using ceramic powder bed printing[28].

Stereo lithography (SLA) is another 3D printing technology. SLA 3D printers build successive layers of an object by curing a photo-reactive resin with a UV laser. The SLA process utilizes ultraviolet laser to cure an object layer by layer from a vat of liquid photopolymer resin[29]. During SLA printing a ultraviolet (UV) light is beam focused onto the surface of a vat of liquid photopolymer. The light beam draws the successive layers of the object onto the surface of the liquid. Exposure to the ultraviolet laser light cures and solidifies the resin and joins it to the layer below. After each layer the platform on which the object rests descends by a measure equal to the thickness of the layer, and the process repeats. After completion of the printing process, the object is cleaned of excess resin and then cured in an ultraviolet oven. The amount of time needed for SLA printing depends on the size of the 3D model and can vary from a few hours to longer than a day. One disadvantage of SLA printing is that the resin remains slightly photo reactive and can discolour and become brittle when exposed to direct

[27] Many videos which document and explain this process are now available on youtube, see for example http://www.youtube.com/watch?v=wD9-QEo-qDk , accessed 15.05.2014.
[28] A collaboration with the Centre for Fine Print Research was considered during this research, however many of the 3D models artists created during the case study research were too thin to be manufactured using ceramic powder bed printing.
[29] See for example http://www.youtube.com/watch?v=4y-m1URlh00 , accessed 15.05.2014.

sunlight[30]. SLA 3D prints are strong enough to be used as prototypes for injection moulding, thermoforming and other casting processes. At the National Centre for Product Design and Development Research, where printing for this research was undertaken, SLA printing is regularly used to produce prototypes for medical implants and prosthetics[31]. SLA resins are available in multiple colours. During this research, SLA 3D printing technologies were used to print digital 3D models at the National Centre for Product Design and Development Research[32], a transparent resin was used (Fig.3).

Fig.3 *Teapot Trainfortress*, Ian Cooke Tapia, this piece was manufactured in photoreactive transparent resin using SLA printing, 14.7cm x 23cm x 10.8cm; 2014 © Sarah Younan

[30] During her PhD studies, the researcher participated in a knowledge exchange project funded by the Arts and Humanities Research Council (AHRC). During this collaboration between the Bartlett Faculty of Built Environment, University College London and the Victoria & Albert Museum she investigated the degradation of 3D printed objects. See http://www.designwithheritage.org/materials-migrations-3d-scanning/, accessed 10.10.2015.
[31] For more information see http://pdronline.info/en/research/research-strategy/medical-applications-group/ , accessed 02.10.2014.
[32] See http://pdronline.info/, accessed 07.06.2014.

2.3. Digital museum strategies

3D technologies have become a reality for many museums and other heritage institutions.

> *'3D cultural heritage, or "virtual heritage", is the relatively new branch of knowledge that utilizes information technology to capture or represent the data studied by archaeologists and historians'* (Koller *et al.*, 2010:2).

Today, 'an increasing number of commercial systems are being tailored and marketed for heritage applications' (Wachowiak and Karas, 2009:141) and some 3D digitising service providers actively target heritage institutions[33]. In the UK *JISC*, a registered charity with focus on developing the use of digital technologies in research and education, provides info kits and best-practice guides to encourage the systematic creation of digital models by heritage institutions[34].

Digital media are increasingly incorporated in museum exhibitions; 'exhibitions now inhabit both real and virtual architectures' (Lovejoy, 2004:307). In exhibitions, 3D models 'augment the museum viewing experience by giving visitors greater control over what they look at', such as 'the ability to turn fragile objects upside down and to see them in high magnification and other privileges normally reserved for curators and conservators' (Robson *et al.*, 2012:97). Whereas museum artefacts are perceived as a part of the past, 'digital historical objects are usually conceived as *tools* for understanding the past' (Newell *et al.*, 2012:291). Museums and other heritage institutions commonly undertake digitisation of their collections to support the collection, preservation and display of artefacts; 'collecting and creating digital objects themselves is seldom a goal in its own right, but rather a consequence of other institutional activity' (Newell *et al.*, 2012:291). Digital 3D models are used in a 'continuation of the

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[33] For example the scanning service company *Sample and Hold*; http://www.sampleandhold.co.uk/collections.html and the Dutch 3D scanning and 'story building' company *Museum Solutions* http://museumsolutions.com/company/ , both accessed 17.6.2013.

[34] See http://www.jiscdigitalmedia.ac.uk/infokits/3D-digitisation/, accessed 19.06.2013.

traditional activities which scholars and scientists active in the area of cultural heritage studies have been pursuing for several centuries' (Koller *et al.*, 2010:2). However, some museums are beginning to embrace projects, which focus on digital 3D as a creative medium.

The following sections explore digital strategies implemented by museums. Section 2.3.1. gives examples of digital museum strategies that promote knowledge-based engagement, such as learning and research. Section 2.3.2. presents forms of digital engagement that emphasize social interaction and content. Section 2.3.3. investigates how digital 3D models of museum artefacts can be accessed online. Section 2.3.4. presents examples of museum strategies that emphasize an open and creative approach.

2.3.1. Knowledge-based strategies

Museums are centres of historical, cultural and scientific information and learning. In this context, the digitisation of museum objects can facilitate enquiry, make it easier to browse historical materials and to bring together different sources from repositories around the world (De Oliveira *et al.*, 2012). Cross-institutional databases such as *Digitised Diseases*[35] at the University of Bradford allow researchers unprecedented access to a range of collections in order to compare digital material (Newell *et al.*, 2012). Digital 3D representations are well suited for research purposes, as they preserve more information than other forms of digitisation, for example photography. Despite their obvious inauthenticity digital models of historical objects can support researcher. Instead of working through artefact collections, it is 'possible to start forming research conclusions in front of a computer by engaging purely with digital representations' (Newell *et al.*, 2012:289). Digital 3D scans can at times reveal details, such as fine surface details, which are not visible to the naked eye (Hess *et al.*, 2008).

[35] See http://www.digitiseddiseases.org/alpha/, accessed 10.06.2015.

Digital models of physical artefacts can also be used to simulate real-world scenarios and to test restoration and hypothetical reconstructions (Sablatinig, 2010). Furthermore, digital reconstruction from photographic data can 'restore' heritage objects for which no physical examples exist today (Guidi *et al.*, 2014). The Buddhas of Bamiyan, for example, were reconstructed digitally from photographic images following their destruction in 2001 (Gruen *et al.*, 2004). 3D digitisation can be used to preserve museum displays when museums rearrange their collections. For example, the Science Museum in London used 3D scanners to preserve its entire shipping gallery prior to dismantling the display in 2012[36]. Digital 3D technologies are also increasingly used in the documentation of heritage sites. The organisation CyArk, for example, is engaged in the creation of a digital 3D library of the world's cultural heritage sites, which can be accessed and studied online[37]. Via the Internet digital 3D models can be distributed to a wide public and objects from different locations can be assembled digitally and studied in context with each other.

2.3.2. Social engagement

People frequently visit museums in groups, and social interaction can play an important role in museum experience (Coffee, 2007). The rise of social media has led many museums to see the Internet as a new space for social engagement. In recent years, museums have begun to seek out social media as a way of engaging and connecting with visitors. While some writers criticize the rush of museums towards social media as lacking a clear end goal (Kidd, 2011) others suggest that museums should go so far as to dedicate staff to social media (Davidoff, 2012).

When museum collections are digitized the dynamics of access, ownership and meaning change (Hogsden and Poulter, 2012). Through social media people can potentially contribute as many points of view to the interpretation of museum artefacts as there are human communities (Levy, 2010:109-10). Some museums

[36] http://www.sciencemuseum.org.uk/about_us/history/shipping.aspx , accessed 25.8.2013 .
[37] see http://archive.cyark.org , accessed 06.10.2014.

now offer personal digital collections systems[38] on their websites, where visitors are encouraged to create personal online collections of digital images of museum artefacts (Marty, 2011). Projects such as *Qrator*[39], and the Imperial War Museum's *Social Interpretation Blog*[40] allow audiences to act as co-curators and to add their own interpretations to museum objects. Systems that allow users to add descriptions, or tags, are known as 'folksonomy'. Proponents of folksonomy hope that it can make content more meaningful to audiences (Suster, 2006). However, user-curated online content can also be seen as non-instructive and at times misleading; some fear that 'folksonomy opens the door to idiosyncratic, inconsistent, irrelevant or simply incorrect subject terms, undermining the usefulness of any index that is created' (MacArthur, 2007:58).

Folksonomy projects engage with museum collections at the level of the archive, by adding additional contextual information to museum artefacts, which can question established interpretations. While folksonomy projects take advantage of the potential of digital technologies and the Internet for open communication, crowd sourcing and exchange, they do not engage with the essentially fluid and editable qualities of digital heritage materials. They add new meaning and interpretations to artefacts, but stop short of transforming the form of the digital heritage materials themselves.

2.3.3. Digital 3D repositories of museum artefacts online

Some museums now see making high-quality digital content from their collections available to the public as part of their museum mission (see Kelly, 2013). The *Rijksstudio*, an initiative by the Rijksmuseum in Amsterdam, for example, makes high-resolution 2D images from its collections available online. The *Rijksstudio* website also provides tools for manipulating, changing or

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[38] For example the Royal Albert Memorial Museum's *Bigbox,* an online 'game' designed for children, allows users to build their own digital collections and share with other players. http://bigbox.rammuseum.org.uk/ , accessed 1.7.2013.
[39] http://www.qrator.org/ , accessed 24.7.2013
[40] http://blogs.iwm.org.uk/social-interpretation/ , accessed 13.6.2013.

clipping the images[41]. In an effort to pool digital content from different museums, online platforms like *Europeana*[42], bring together digital content from multiple museum websites and offer a centralised way of searching and accessing museum collections.

Increasingly, digital 3D models of museum artefacts can also be found online. The *Digital Michelangelo Project*[43] at Stanford University, for example, offers a digital 3D archive of Michelangelo sculptures. The models, as well as the raw range scans and metadata, are available via the project website. However, the 3D models and raw data are only obtainable to established scholars, after submitting an application to the project director. For the general public, access is limited to the examination of the digital 3D models via a remote rendering system, which allows users to view 3D models and to turn them in different directions using mouse and keyboard commands. In the same vein, the Stanford University's *Digital Forma Urbis Romae*[44] and the *3D Petrie Museum*[45] project also allows viewing of, but not direct access to, digital 3D models of museum artefacts. In general, museum-led online repositories of digital 3D models allow interactive viewing, but frequently bar the download and creative use of digital 3D models.

Museums can face considerable expenses in order to create realistic high-resolution digital models of items held in their collection. Furthermore museum artefacts are regarded as valuable property by museums, representing cultural heritage and historical fact. Consequently, museum managers are often reluctant to allow unrestricted use of digital 3D models of their collections, since it could lead to a loss of control of the digital representations arising from their collections.

> *'Many cultural heritage scholars and content developers would be unwilling to participate in a centralized digital archiving effort that does not offer*

[41] See https://www.rijksmuseum.nl/en/rijksstudio, accessed 23.02.2015.
[42] http://www.europeana.eu, accessed 23.02.2015.
[43] http://graphics.stanford.edu/projects/mich/ accessed 06.10.2014.
[44] See http://formaurbis.stanford.edu accessed 06.10.2014.
[45] an interactive online 3D object library by the Petrie Museum of Egyptian Archaeology in London. See http://www.ucl.ac.uk/3dpetriemuseum, accessed 12.06.2015.

> *some guarantees about the security and trustworthy dissemination of their intellectual property.'* (Koller *et al.*, 2010:7)

Nonetheless, there are examples of heritage institutions taking a more open approach to the distribution of digital 3D models created from their collections. The Smithsonian *X3D Explorer,* for example, was designed to allow users of the website to 'explore and manipulate museum objects like never before'[46]. Users can download 3D models of museum objects from the Smithsonian website for creative, educational, non-commercial or personal use.

Similar projects are emerging across Europe and the US; the online 3D Archeo Lab[47] for example brings together downloadable 3D models of Italian heritage artefacts. *Scan the World*, an initiative funded by MyMiniFactory[48] and iMakr[49], also brings together digital 3D models of public monuments, museum and heritage artefacts[50]. *Scan the World* sources digital 3D models through collaborations with museums as well as from user-generated content. Sketchfab[51], MyMiniFactory and Thingiverse[52] are among a number of websites dedicated to the sharing of user-created digital 3D files. On these websites users can create profiles and upload digital 3D models. Due to the growing interest in 3D technologies a number of 3D file repositories have emerged online. These online repositories allow users to view and download free and premium 3D models for further use. Some websites also offer software tools and cloud services. For example, the software corporation Autodesk offers a suite of free 3D tools, called Autodesk 123D, including the free photogrammetry software 123D Catch[53]. The Autodesk 123D app website also includes a 'gallery', where users can upload and share digital 3D models. While some online 3D

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[46] See http://3d.si.edu accessed 06.10.2014.
[47] See http://www.3d-archeolab.it/3d-virtual-museum/, accessed 06.04.2015.
[48] MyMiniFactory is an online plattform, dedicated to the sharing of free, print-ready digital 3D models. Unlike other online repositories, MyMiniFactory is 'curated'; all 3D files are test printed and optimised by in-house designers prior to sharing. See https://www.myminifactory.com, accessed 15.05.2015.
[49] iMakr is the largest international re-seller of 3D printers and 3D printing products. See http://www.imakr.com, accessed 15.05.2015.
[50] See https://www.myminifactory.com/users/Scan%20The%20World, accessed 15.05.2015.
[51] See https://sketchfab.com/, accessed 01.08.2014.
[52] See http://www.thingiverse.com/, accessed 01.08.2014.
[53] See http://www.123dapp.com/ , accessed 01.08.2014.

repositories, such as Autodesk, only host non-commercial 3D models the 3D files on other repositories, such as Threeding[54] and Thingiverse, can be bought and sold as well as shared for free. In addition some repositories, like Autodesk and Thingiverse, feature a 'remix' option, which allows users to share their remixes of 3D models from the sites. When uploading 3D models to online 3D repositories, users are usually requested to 'tag' their 3D files. Tags are used to describe items online and to increase searchability. Tags enable an online item to be found by browsing or searching for the term or category it is 'tagged' with. In addition, many of these online repositories contain social features, such as messaging services, which allow users to connect with each other. These online repository play host to user-generated (UG, see Glossary) digital 3D models of museum artefacts created outside the scope of museum institutions. Hundreds of 3D models with the tag 'museum' can now be found online[55].

Museums are beginning to explore the use of established online 3D model repositories. The Metropolitan Museum of Art, for example, shares some digital 3D models from its collection via the online digital 3D file repository Thingiverse, to encourage use of their content, 'which represents the world's cultural heritage, to create their own creative works'[56]. In a similar vein, the British Museum has made digital 3D models of artefacts from its collections available online via the Sketchfab online repository[57]. The pioneering Medialab at the Metropolitan Museum in New York has published a 3D printing booklet for beginners online[58], to encourage more of their visitors to take up photogrammetry in the Metropolitan Museum's collections. In 2013 seven of the largest museums in Utrecht, The Netherlands, organized the *De Digitale Kunstroof* event[59], to promote the use of photogrammetry, and other forms of creative engagement with their collections through digital 3D technologies.

[54] See https://www.threeding.com/ accessed 01.08.2014.
[55] The search term 'museum' was entered in to the search bar on all three 3D repository websites discussed above on the 2nd of June 2014.
[56] These models include photogrammetric models created during the Metropolitan Museum's 3D Hackathon. See http://www.thingiverse.com/met/about , accessed 01.08.2014.
[57] See https://sketchfab.com/britishmuseum/models , accessed 06.04.2015.
[58] See http://www.metmuseum.org/about-the-museum/museum-departments/office-of-the-director/digital-media-department/digital-underground/2014/3d-printing-booklet, accessed 04.04.2015.
[59] See http://kunstroof.setup.nl , accessed 04.04.2015.

In most museums photogrammetric activities are however still a novelty and are frequently met with suspicion by invigilating staff (Younan and Gill, 2013). Nonetheless, 'visitors are increasingly beginning to discover digital ways of accessing and interacting with museum collections beyond the reach of museum authority' (Younan and Gill, 2013:2). An increasing number of artists and hobbyists are now experimenting with the creation and re-contextualization of digital models of museum objects[60], with and without institutional approval.

2.3.4. Museum hackathons

Digital 3D imaging and 3D printing technologies, especially DIY and open source tools, are strongly tied into digital maker culture and the free culture movement. 3D scanning, editing and printing tools and the knowledge of how to use them are part of a set of digital tools and skills which are described as 'digital craft' by Malcolm McCullough in his seminal book *Abstracting Craft: The Practiced Digital Hand* (1996). Today, notions of craft have expanded to include interaction with computers and other digital devices, the manipulation of digital data and interaction with physical as well as digital materials; tools and technologies are now seen to support novel forms of crafting.

The digital maker movement is a digital technology oriented extension of DIY culture and has roots in the Arts and Crafts movement of the late nineteenth and early twentieth century (Gonzalez, 2015). The free culture movement is a social movement that promotes the free distribution of cultural content, such as visual material and data, for open use (Lessig, 2004). The free culture movement

[60] See for example GIFs by Zack Dougherty http://hateplow.tumblr.com/post/55517788014 , or Cosmo Wennman's work with museum artefacts http://www.youtube.com/watch?v=blKcIsEEoag&list=TLn7w6HXs8Spo , both accessed 1.8.2013.

encompasses a number of interest groups, including supporters of open access[61], various hacker groups and the access to knowledge movement[62].

Recognising the cultural importance of these movements, some museums now host maker spaces or 'FabLabs'[63]: small-scale workshops that provide digital fabrication tools to the public. Museums across Europe and the United States have also begun to organise hackathon events, which embrace digital maker culture. Hackathons (also referred to as hack days, hackfests or codefests, see Glossary) are events in which computer programmers, graphic designers, hackers, media artists and others involved in digital media develop intensive software collaborations, often in a short period of time;

> *'In its most basic form, a hackathon is an intense, multiday event devoted to rapid software production. Hackathon organizers invite programmers, designers, and others with relevant skills to spend one to three days addressing an issue by programming and creating prototypes. Organizers offer a space, power, wireless Internet, and often food. Participants bring their computers, their production skills, and their undivided attention. (…) In recent years, companies, NGOs, universities, and even government agencies have taken up hackathons as a means to recruit volunteer labour, generate interest in social or technological platforms, and use participants to explore possible futures for a host organization*.' (Irani, 2015:5-6)

Hackathons have become a popular method for organizations to experiment with digital media. Some hackathons are intended for educational or social purposes. At other times, the goal is to create solutions such as websites, applications or usable software, to a broader challenge or goal outlined by the host (see Callahan and Goodlander, 2014, Leckart, 2012).

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[61] Supporters of open access (OA) demand unrestricted online access to peer-reviewed scholarly literature and similar research materials.
[62] A2K is an umbrella term for a loose collection of civil groups and individuals who aim to make educational and cultural works accessible to all
[63] See for example the Newark Museum, Washington; http://www.newarkmuseum.org/makerspace.html , accessed 23.07.2013.

In 2012 the Metropolitan Museum of Art[64] staged a museum hackathon in collaboration with MakerBot Industries[65], which utilized digital 3D scanning, editing and 3D printing technologies to digitize, remix and reproduce museum artefacts on-site. Invited artists were guided through the collections and given the opportunity to create photogrammetric[66] models of museum objects. These models were edited and 3D printed (see Mullaney, 2012, Terrassa, 2012). All digital 3D models created from the Met's were uploaded to Thingiverse (see section 1.4.3. Digital 3D repositories of museum artefacts online).

Museums in London, such as the British Museum, the Victoria & Albert Museum, the Science Museum, the Natural History Museum, and Tate Britain as well as institutions across the UK, for example the historic Lunt Roman Fort in Baginton, the People's History Museum in Manchester and the Horniman Museum and Gardens have hosted hackathons. The aims of these events are often shaped by the identity of the host museum; the Fort Lunt hackathon was aimed at helping to re-establish the Lunt as a Roman visitor attraction[67] the People's History Museum hackathon aspired to develop new forms of protest[68] and the Horniman Museum and Gardens hackathon's aim was to develop a control system for coral research[69].

Hackathons allow museums to engage with digital creativity, however they are restricted and exclusive in scope; attendant numbers are generally limited and hackathons tend to be short and intensive events, no longer than a couple of days. Furthermore these events usually take place inside the museum space and are supervised by museum staff. The cumulated potential of online communities

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[64] The Metropolitan Museum of Art is a pioneering institution in terms of working with 3D technologies. Since its first Museum Hackathon the Metropolitan Museum of Art's Media Lab has continued to foster educational and creative 3D projects. As well as keeping in touch with Hackathon participants the Metropolitan Museum's Media Lab has been focusing on the promotion of 3D tools and activities accessible to a wide range of people, such as 123D Catch photogrammetry software and the free 3D editing software Meshmixer. However, the Media Lab is not involved in the curating or acquisition of work at the Metropolitan Museum.
[65] http://www.makerbot.com/ , accessed 28.6.2013.
[66] Digital 3D models created using photogrammetry software.
[67] see http://www.ludilunt.co.uk/?page_id=206 , accessed 03.11.2014.
[68] see http://www.phm.org.uk/whatson/hacktivism-the-unlocking-ideas-hackathon/ , accessed 03.11.2014.
[69] see http://hornimanhackathon.s3-website-eu-west-1.amazonaws.com , accessed 03.11.2014 .

and the maker movement to generate new premises for engaging with digital heritage as creators of UG content remains largely untapped by these projects (Proctor, 2015).

2.4. The museum object and its reproductions

Digital 3D models can only be understood in connection to the original artefacts from which they derive. Original museum objects can be read in a variety of ways; 'the object is inexhaustible' (Pearce, 1992:219).

> *'The way meaning or signification is formed in and by an exhibited object in a museum is dependent on a complicated connection between the object and its physical shape and condition, its original context, its museum context, (…) and finally its dialogue with the museum's visitors.'* (Christensen, 2010:8)

To understand digital heritage artefacts we firstly have to look into the context of museums and the physical artefacts they hold. This section investigates how meaning is created around museum objects and their reproductions. Section 2.4.1. investigates how meaning is created around museum objects; how they are interpreted and read. Section 2.4.2. examines the interplay between museum objects and their reproductions. Section 2.4.3. looks into the qualities of digital copies of heritage artefacts. Section 2.4.4. explores how digital reproductions can be appropriated, opening up new meanings and trajectories. Section 2.4.5. investigates the relevance of the museum dream space in the context of digital reproductions of museum artefacts.

2.4.1. The museum object

Museums are institutions in the service of society and its development, which are open to the public; their role is to acquire, conserve, research, communicate and exhibit the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment. (Museum Definition by the International Council of Museums, ICOM, 2007). Though the definition of museums is broad, they share a common purpose - the collection, preservation and display of physical objects. However, the role these objects play remains ambiguous. When objects enter the museum, they are taken out of their previous context; artefacts, which previously were one of many become unique, formerly useful items become inactive and objects previously in private collections enter into public possession (Branham, 1994). They are removed from primary use and embedded in museum narrative; their practical or cultic use or is reframed and they gain a new 'display value' (Benjamin, 2008:12). Museums recontextualize objects and generate a cult of authenticity, wherein auratic[70] museum objects hold a higher status than objects of everyday use. Walter Benjamin's formulation of aura arises from a interplay of proximity and distance (Dorrian, 2014). Museums provide the perfect conditions for auratic experiences; in museum galleries artefacts are accessible to the public and yet remain distant and untouchable.

In the eighteenth century, definitive meaning of museum objects was believed to lie within their physical form, and descriptive data was seen as objective fact (Lewis, 2013). Objects were thought to communicate perfectly by being what they are. This model came under critique at the end of the 18th century (Lewis, 2013) and a climate of institutional reflexivity has reshaped understandings about museums and the objects they contain since the 1970s (Ross, 2004). Today, museum artefacts are no longer understood as complete educational experiences; they are now seen to benefit from forms of display and use, which foster discussion and enable viewers to respond actively (Smith, 1989).

Some theorists still hold that objects can communicate; Gibson maintains that 'in some sense memories through objects are already there and, like photograph

[70] 'Aura' describes an air of significance and mystery, which can surround museum objects. Original and rare objects are seen to possess greater auratic value than unoriginal and readily available artefacts. In museum practice perception of the 'aura' is heightened through display design and social conditioning.

negatives, are just waiting to be printed out' (Gibson, 2008:24). However, most theorists reject the notion of 'eloquent' artefacts;

> *'They are not eloquent as some thinkers in the art museums claim. They are dumb. And if by some ventriloquism they seem to speak, they lie.'* (Crew and Sims, 1991:159)

Today, 'few people still believe that physical objects "speak for themselves", but neither are they mute' (Hein, 2000:31); their meaning is informed by the context of the museum and their interpretation is a 'highly fluid and complex activity' (Smith, 1989:19). Kavanagh (2000) contends, that objects have no personality, life, or story except that which viewers bring to bear on them from their own emotional and cultural background. As understandings of history change so do the narratives told through museum objects. The original contexts and meaning of the museum artefacts can never be truly known or understood. The historical, or 'mnemonic', imagination of viewers supplements and fills in gaps in knowledge and understanding with personal associations, memories and desires (Keightley and Pickering, 2012). There have been a number of calls by heritage experts to acknowledge the illusory and constructed nature of historical 'facts' and representations:

> *'For a truer understanding of the significance and causality of the past we should reckon more with memory, embracing all its subjective viewpoints.'* (Kwint *et al.*, 1999:1)

> *'History must abandon its absolutes, and instead of finding generalisations and unities, should look for differences, for change, and rupture.'* (Hooper-Greenhill, 1992:10)

> *'It is far better to realize the past has always been altered than to pretend it has always been the same.'* (Lowenthal, 1985:412)

Nonetheless, museum artefacts remain a source, as well as an important vehicle for information. The information they provide 'may be intellectual, aesthetic, sensory, spiritual or emotional in character; or, more likely, an experience involving some combination of these' (MacDonald and Alsford, 2010:75). The perception of museum artefacts is informed by the artefacts' original context, that created by the curator, and that brought to bear by the visitor, according to his place within history and culture (Taborsky, 1990). Personal meanings can be multiple, produced from a range of starting points 'diverse in history and culture (…) through factual information or (…) emotional significance' (Hooper-Greenhill, 2000). Audience readings of museum collections are not necessarily coherent with interpretations provided by the museum. This merging of personality, situation and object gives rise to the manifold nature of museum objects and engages our imagination; drawing on Iser (1978), Pearce describes this dynamic nature of objects as 'virtuality'[71] (Pearce, 1992:219). Discussing ceramic objects from the Fitzwilliam Museum, Cambridge, Pearce writes:

> *'As we stand in front of the show-case (…) our creative urges are set in motion, our imagination is engaged, and the dynamic process of interpretation and reinterpretation begins, which extends far beyond the mere perception that the things are vessels for holding liquid.'* (Pearce, 1992:219)

However, museum objects do not necessarily trigger such experiences; it is only when interest in an object is triggered, that 'every user completes the museum (…) in a different way' (Carr, 2001:180).

Museum objects can be displayed as works of art, as scientific evidence of a different time, or, commonly, 'some combination of both' (Preziosi and Farago, 2004:4). Barbara Kirshenblatt-Gimblett distinguishes between 'in situ displays', objects displayed within a staged setting, and 'in-context displays', objects

[71] Pearce, uses the term 'virtuality' to describe the dynamism of objects, which take on meaning only as viewers make sense of them, the viewer is "forced to reveal aspects of himself in order to experience a reality which is different from his own" (Pearce, 1992:219).

grouped into categories (Kirshenblatt-Gimblett, 1998:388).

By contrast, in our private lives, ceramic artefacts are often tied into family histories. Objects are sometimes described as leading a 'social life' of their own. Theorists, like the psychologist Mihalyi Csikszentmihalyi, believe that man-made objects evolve and reproduce in symbiosis with human beings. Csikszentmihalyi argues that as artefacts are used and passed on, emotional attachments form (Csikszentmihalyi and Rochberg-Halton, 1981). He attributes this to 'the psychological value of china';

> *'To preserve a fragile object from its destiny one must pay at least some attention to it, care for it, buffet it from the long arm of chance. Thus a china cup preserved over a generation is a victory of human purpose over chaos'* (Csikszentmihalyi and Rochberg-Halton, 1981:83)

This 'will to preserve' is further emphasized by the museum, and has been criticized as a 'culturally engendered desire for immortality' (Brown, 2012:2). The presentation of historic or cultural artefacts inside museum galleries 'envelops them with a patina of authority and a particular affective potency' (Newell *et al.*, 2012:296). This can lead audiences to accept museum displays unquestioningly. Today, it is commonly accepted, that:

> *'Museums are not neutral. While they collect and conserve, classify and display, research and educate, they also deliver messages and make arguments.'* (Starn, 2005:70-71)

It is now the priority of many museums to respect cultural and ideological differences, and to offer 'alternative' interpretations of their collections. In the case of museum objects from different cultures, museums have begun to take into account the interpretations of indigenous communities. Objects from outside the museum's cultural sphere can be the subjects of intense debate; communities might object to their display in museums, or voice demands for repatriation[72]. The history of museum objects can be problematic, especially when they were taken in times of colonial occupation. The artefacts and monumental works that were acquired in past decades by museums throughout Europe and America were frequently obtained under conditions that would not be considered ethical today (Barringer *et al.*, 1998). This raises important questions regarding ownership, access and interpretation. Repatriation has become an important issue for museums (Curtis, 2006).

> '*The issues surrounding indigenous collections in museums are prompting a re-examination of the museum as a public trust. Overall, the result is a posture that is less authoritarian and more deferential, one in which the public is seen not as a monolithic mass but as a collective of individuals with differing needs, expectations, interests, and rights.'* (Harth, 1999:7)

Nonetheless, museums play an important role in the diffusion of cultural content and ideas; many ancient civilisations would not be as universally admired today, had their cultural artefacts not been procured and displayed in museums;

> *'The sculpture of classical Greece (…) is an excellent illustration of this point (…) The centuries-long history of appreciation of Greek art began in antiquity, was renewed in Renaissance Italy, and subsequently spread through the rest of Europe and to the Americas. Its accession into the collections of public museums throughout the world marked the significance of Greek sculpture for mankind as a whole and its enduring value for the contemporary world.'* (Curtis, 2006:126)

Museums fulfill the important task of preserving cultural objects for the future, and mediating them to the public, thus ensuring their continued relevance.

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[72] Much of the discussions concerning removal from display and repatriation began with a focus on human remains and ontologically charged artefacts; indigenous people have voiced requests for the return of the remains of their ancestors and sacred items.

2.4.2. Originals and copies

In museums authenticity is essential; it validates physical artefacts as exemplary cultural objects. An artefact's authenticity determines its worth, its historical importance, and its exhibition value. If an item is proven to be inauthentic, it loses its value as a research source, or an exemplary exhibition item worth collecting.

In its primary sense, authenticity is the verifiable premise that an object is what it claims to be. In his seminal essay *The work of art in the age of mechanical reproduction* Walter Benjamin argues that the authenticity of an art object is composed of its unique identity, its context and history (Benjamin, 2008). In Benjamin's account of the relationship between authenticity and art objects, 'the aura of the original defies reproducibility' (MacNeil and Mak, 2007).

The authenticity of an art object is composed of its unique identity, its context and history. This definition of authenticity includes changes to an object, through accidental damage or deterioration over time. This creates a problematic situation for museums when undertaking cleaning or restoration of artefacts. Restoration, as opposed to conservation, encompasses repairs that seek to restore an artefact to a previous state. Conservation practices, on the other hand, seek to halt the deterioration of objects over time. Restoration of an artefact to its original condition wipes out the evidence of the passage of time, whereas conservation seeks to prevent further changes in an object. Conservation of a work of art can interfere with qualities deemed crucial to its authenticity[73]. Martha Buskirk writes in her seminal book *The Contingent Object of Contemporary* Art, that 'questions about display and preservation require an interpretation of exactly what constitutes the work' (MacNeil and Mak, 2007:24). This implies, that the concept of authenticity is negotiable; 'authenticity itself is a creature of circumstance', and provides only 'a semblance of stability' (Buskirk,

[73] A good example of 'conservation' efforts damaging the authentic qualities of historical artefacts is the scandal of the 'cleaning' of the Elgin marbles in the 1930s. During cleaning and conservation efforts at the British museum the Elgin marbles were irrevocably damaged, see http://www.britishmuseum.org/about_us/news_and_press/statements/parthenon_sculptures/1930s_cleaning.aspx, accessed 29.10.2013.

2003:44). The way historic or cultural objects are displayed in museum galleries 'literally or figuratively on a pedestal' (MacNeil and Mak, 2007:295) bestows an air of authority on them. This sense of 'museum authority' is not necessarily based on qualities of the artefact in question. Unidentified fakes within museum collections can be perceived as just as authentic as veritable items. Anthropologist Jane Walsh confirms that fakes are ubiquitous in museum collections; unrecognized forgeries, copies and genuine historical artefacts can all form part of museum collections (Newell *et al.*, 2012).

Nonetheless, despite their lack of authenticity, copies have long held a place in museums; in the 19th century museums acquired reproductions of important monuments and works of art to complement their collections[74]. Art schools also frequently formed collections of plaster casts to act as a source of learning and inspiration to their pupils[75]. However, by the late 19th century plaster casts were falling from grace; doubts had arisen about the detrimental effects of the casting process on the originals and casts were playing less of an essential role in art schools (Bilbey and Cribb, 2007). By the 1920s the modern movement in painting and sculpture further reduced the importance of plaster copies[76].

With the rise of new reproductive technologies, such as photography, other forms of reproduction gained importance. Photography allowed work to be seen in many different contexts, such as on greeting cards or in newspapers. As a result the photographed work began to take on new meanings, and to fragment into new sets of fresh associations (Lovejoy, 2004).

> *'Art that is enlarged, reduced, printed as postcards or posters, and widely disseminated for enjoyment of the public at large, reaches a broader audience, an expanded one beyond the confines of art institutions and the gallery system. As a consequence, the cultural sphere is broadened, enriched, and democratized.'* (Lovejoy, 2004:24)

[74] Such as, for example, the V&A collection of plaster casts, see http://www.vam.ac.uk/content/articles/t/the-vanda-cast-collection/, accessed 04.07.2014.
[75] This allowed students to study and emulate classical works without having to travel across Europe.
[76] Since the 19th century plaster casts have acquired a new significance. In a few cases, where the original has been destroyed they provide a unique record of a lost work. However, due to the damage plaster casting can cause to originals, few new plaster casts are produced today.

In museums, initially photography was employed to aid in the primary functions of the museum; 'first experiments with photography were connected (…) with scholarly and documentary purposes and not with indulging a taste for enhanced memoralising' (Mack, 2003:145). However, artists soon discovered, that they could alter photographs. Duchamp famously drew a moustache and beard on a colour reproduction of Leonardo's Mona Lisa in a bid to desanctify the famous painting:

> *'…Duchamp desanctifies the object, allowing us a mental proximity to it that we would not otherwise have even in the Louvre, standing before the painting itself. The reproduction is that much closer to our lives.'* (McShine and Art, 1999:15)

Today, reproductions of Greek and Roman marbles in various scales and materials can be found in gift shops and garden centres. Museum gift shops frequently offer small-scale reproductions of memorable historical objects to visitors. Such reproductions are widely regarded as kitsch; a 'debasement of the essential value residing in the ideal original' (Ranfft and Hughes, 1997:156). Work that imitates a style, replicates the content of another work, or mixes and reuses the content of other works, whole or in part, is often seen as unoriginal. However, postmodern thought has led to a revaluation of reproductions and 'pastiche' art (Rose, 1991). In her book-length study of the pastiche, Ingeborg Hoesterey argues that the pastiche plays 'the important role of the Other of authentic art' (Hoesterey, 2001:16); her definition of the term 'pastiche' includes homage, parody, collage, assemblage, montage, appropriation and other forms of engagement that take historical artworks, artefacts, and rituals as the starting point for new work (Hoesterey 2001).

James Elkins proposes that any work of art is always to some degree derived from earlier originals; he argues that originals 'must be redefined as works related to and derived from copies', and that copies are original artworks in the course of being formed (Elkins, 1993:118). This view positions copies and pastiche art as essential steps in the creation of new artworks and artefacts.

In the essay *Travels in Hyperreality* (Eco, 1990) Umberto Eco describes imitation and reproductiosn intended to be better than real, he warns that these more accessible and more exciting reproductions hide a financial interest in the marketing of culture. Other writers have since argued, that the engagement with original museum artefacts and artworks through reproduction and pastiche presents a way of paying homage to the past and connecting it to the present (Hoesterey, 2001:85). Dyer suggests that, in certain historical periods 'in which new media suddenly make available a huge range of hitherto inaccessible works' forms of pastiche can become more frequent and characteristic of those periods in time (Dyer 2007: 131). Greater access to artefacts and artworks brought about by new media technologies can bring about an increased 'sense of the variability of ways of doing things' (Dyer, 2007:131) and encourage experimentation. In the context of the museum, digital 3D imaging technologies follow in the footsteps of previous methods of reproduction, such as plaster casting and photography; they have the potential to increase access to previously unavailable forms, to inspire new works of art and to inform new cultural processes and products.

2.4.3. Digital copies

While mechanical reproduction can increase public access to works of art, Walter Benjamin feared that it would also wither the aura of the work of art. In his seminal piece *The Work of Art in the Age of Mechanical Reproduction* (first published 1936) he foresaw a depletion of the 'aura' of original objects through their photographic reproduction and distribution (Benjamin, 2008). Baudrillard suggested that the shift from perceiving real objects to perceiving copies and simulations would result in a loss of reality, which would lead to subsequent compensation through 'hyperreality'[77] (Baudrillard and Glaser, 1994). These views identify copies and digital models as a threat to museum culture and practise, based on a 'deeper fear' in museums 'that increased availability of 3D models will be likely to deter or occlude study of the object itself' (Robson *et al.*

[77] Hyperreality is generally defined as a condition in which reality and fiction are blend together and clear distinctions between the two are lost.

2012:98). However ‘multiplication of an icon, far from diluting its cultic power, rather increases its fame’ (Ranfft and Hughes, 1997:38). Distribution of copies, reproductions and images of an artwork can lead to increased awareness and interest in the original item itself. Research in museums and heritage institutions suggest that neither photography, nor digitisation and mass media have diminished the fascination of the real (Cameron and Kenderdine, 2007). On the contrary, reproduction can be seen to generate the ‘original’;

> *‘Benjamin has the aura of art exactly the wrong way around. It is the mechanical reproduction – the photograph – that created the aura of the original, much as it was the machine that created the “handmade”, the negative that created the “positive”, and the digital that gave retroactive birth to its latent opposite, the “analogue”.’* (Walsh, 2007:29)

Digital actions do not affect any direct changes to the original; digitisation of historical artefacts does not deteriorate the value of original artefacts or their aura. On the contrary, in some cases digitisation can enhance the original objects; ‘the copying and wide distribution of an art work not only increases its currency in the public consciousness (…) the cultural sphere is broadened, enriched, and democratized’ (Lovejoy, 2004:57).

Digital 3D scanning ‘reduces the complexity of spatial experience down to an XYZ grid of mathematical absolutes’ (Cameron and Kenderdine, 2007:350); qualities of an artefact that are ‘intrinsic to its physical presence’ are not recorded (Smith, 2003:179). Alterations can be made to digital objects without leaving discernible traces; digital editing ‘has destroyed the faith in the truthfulness in representation’ (Lovejoy,2004:275). However, while digital copies are not necessarily ‘truthful’ to the original objects, they can be seen to posses a different kind of authenticity. In *Languages of Art* (Goodman, 1969) Goodman argues that any performance of a piece of art, which corresponds suitably to its notation, can be counted as authentic. Digital data are stored in bits, as ones and zeros. Bits lack intrinsic meaning until they are read and performed as, for example, a visual image or a physical print. Such performances exist as entry points to different perceptual planes, or interfaces, that render data into recognizable representations.

> *'In the world of digitalized images, we are dealing only with originals - only with original presentations of the absent, invisible digital original'* (Groys, 2008:91)

Lovejoy contends, that, 'there is no point in regarding digital information models as simple fakes or reproductions' (Lovejoy, 2004:153), since digital models replicate real objects through mathematically modelling rather than a copying process.

Different interfaces might present different versions of the same work (Manovich, 2010:69). Artefacts were historically made within a particular medium[78]; the level of the interface did not exist (Manovich, 2010:69). With digital media the content of the work and the interface become separate, 'any medium can be translated into any other' (Kittler, 1986:2). Interaction with digital 3D models takes place at the level of the interface; the data itself remains, more or less invisible (Witcomb, 2007).

The 'materiality' of digital objects has been the source of discourse. Existing debates are often based on a supposed opposition between the virtual and the material world (Witcomb, 2007) but there has been a move towards framing digital media within a new understanding of materiality (Blanchette, 2011, Ekbia, 2009, Gross *et al.*, 2014, Manoff, 2006,). Digital media has always been embedded in and structured by material objects, networks, and practices that determine its uses and meanings. Digital artefacts bear traces of the conditions of their production, and digital data is stored on physical devices, they can be perceived and experienced only through material tools, and 'they do leave traces of their creation, use, and transmission' (Smith, 2003:179).

Like physical artefacts, digital 3D models can become invested with emotional

[78] For instance artefacts from the ceramics collections at the National Museum of Wales; during scanning the original ceramic pieces are dematerialised and noted as data and 3D prints can be executed in a range of materials.

and cultural meaning. Their likeness to original artefacts can lead viewers to experience them as connected to the originals. The idea that reproductions can connect viewers to the 'real thing' has roots in pre-Renaissance western art. Through the similarities which digital 3D reproductions bear to physical artefacts they can possess experiential and affective authenticity (Smith, 2003). In some cultures, digital reproductions are seen to share the ontological qualities of original artefacts. Research on digital 3D reproductions of Māori artefacts by Deidre Brown (2008) suggests that some Māori people consider digital 3D reproductions as potent artefacts, imbued with ancestral power. Digital 3D models are perceived in what Foucault (1986) describes as 'a placeless place'; 'an unreal, virtual space that opens up behind the surface' of the mirror, or, in this case, the computer screen (Foucault, 1986:24). However, they remain embedded in the physical world, through their meaningful relationships to physical objects.

The relation between digital 3D models and physical objects is not a duality between virtual and real, as human activity takes part in both virtual and real spaces (Dziekian, 2011:20). However, digitisation can disconnect data from its source; through 3D digitisation shape and form is displaced from its origin and stored as digital data, which can be 'changed, and manipulated by a viewer interactively through software commands' (Lovejoy, 2004:8). To see a digital 3D object, information about its shape must be called up for display. Even when the digital 3D object is not actively interfered with, it 'changes with each instantiation due to varying processing speeds, screen size and resolution, and other hardware specifications' (Smith, 2003:179).

Digital 3D models are liminal objects located on the threshold between external reality and our own minds. Victor Turner (1969) defined the liminal condition as 'the state and process of mid-transition in a rite of passage'; a 'moment in and out of time' (Turner, 1969:96), the liminal phase of a transition represents an instance of incompleteness, when the liminal subjects 'elude or slip through the network of classifications that normally locate states and positions in cultural space' (Turner, 1969:95). Although Turner locates liminality within ritual action the concept of liminality can be applied more broadly. The liminal object has its origins in Winicott's notion of the transitional object (Winnicott, 1971), and appears in discussions of technology and virtuality by Lévy (1998). A liminal object can combine seemingly irreconcilable binary oppositions, such as subject and object, mind and body, digital and physical. Digital 3D scans are such liminal objects; they exist on the threshold of reality and imagination. Interaction with digital 3D can also be considered to be liminal; when a user operates a conventional mouse and keypad to edit 3D files, pushing a button can be regarded as a metaphor for sculpting an artefact, which exists in a removed space (see Woo *et al.*, 2011). Liminal objects are the 'basis of symbolism and creativity' (Turkle, 2011:228). They exist midway between two identifiable states, in 'a realm of pure possibility whence novel configurations of ideas and relations may arise' (Turner, 1967: 97). Computers can give access to emotions and thoughts that are inhibited in real life, and editing software enables the competent user to control and manipulate any form of data. In the digital realm spectators no longer need the powers of hallucination; what can be imagined can be rendered visible through digital editing; 'we are carelessly thrown into a realm of imagination – a realm that for centuries was only accessed through fantasy, dreams and art' (Campanelli, 2010:60).

2.4.4. Digital poaching

Freely available photogrammetry software has enabled museum visitors to create 3D models of museum artefacts using their digital cameras or mobile phones; 'access to cheap, flexible tools removes many of the barriers to trying new things' (Shirky, 2010:17). While 'technology may provide a bridge to both physical and virtual access and eventually to a culture of social inclusion' (Leighton, 2007:311), the mobility of digital tools of reprudiction, such as camera phones also 'increases the likelihood that it will be used for controversial purposes' (Nightingale, 2007:291). In recent years, museums have liberalized their photo policies, photogrammetry software now extends this mobility to the creation and manipulation of digital 3D models. It thus creates a possibility for museum artefacts to be digitally appropriated in ways that might be considered inappropriate or offensive. At the same time, it brings new opportunities to the engagement with museum artefacts.

Through forms of digital reproduction, exchange and creativity, images and cultural content can be appropriated and recontextualised. In his seminal work *The Practise of Everyday Life* (first published 1984), Michel de Certeau compares the creative appropriation of cultural artefacts to poaching; illegally hunting or catching game or fish on land that is not one's territory (Certeau and Rendall, 2002). De Certeau proposes, that human consumption is itself a creative act. During consumption, he argues, users recontextualise products, alter them and find unexpected uses for them. According to De Certeau, ‘assimilating’ does not necessarily mean ‘to become similar to’; he argues instead that by assimilating something the consumer appropriates or reappropriates it (Certeau and Rendall, 2002). Poaching can recontextualise cultural materials in ways that move beyond institutional initiatives and control. Unlike the poaching of wild animals[79], cultural poaching does not necessarily carry negative conotations; John Fiske describes it as a playful, ‘creative, nimble, and flexible’ strategy, through which the individual can overcome the power imbalance between himself and the dominant culture industries, which ‘control the places and the commodities that constitute the parameters of everyday life’ (Fiske, 1998:29).

There are now a number of online repositories, many of which pay host to UG models of museum artefacts (see Section 2.3.3. Digital 3D repositories of museum artefacts online). They ‘spur new ways of engagement with cultural heritage driven by members’ interests and passion, and closely associated with their making practice’ (Sabiescu *et al.*, 2015). The time and effort that goes into digital creativity and exchange online has been termed the ‘cognitive surplus’ by technical writer Clay Shirky (2010) and ‘fan labour’ by Trebor Scholz, the author of *Digital Labour: the Internet as playground and factory* (2012). Shirky argues that the Internet has transformed the public from consumers to users and producers who actively participate in online culture. According to Scholz, their

[79] There is however one interesting parallel between cultural poaching and hunting; during 3D digitisation the ‘skin’ or surface information of objects is reproduced and mounted on a digital wireframe, much like the skin of hunted animals is sometimes mounted on a taxidermy model.

'labour is willingly given in exchange for the opportunity to enjoy and play' (Scholz, 2012:107).

Digital forms of cultural poaching 'harness the participatory potential of the Internet and typify modern popular culture' (Marwick, 2013:13). The creative engagement with digital heritage materials can be understood as a form of cultural poaching. Cultural institutions are mostly absent from these practices (Sabiescu *et al.*, 2015) and may even be unaware that they are a source of material for poachers. These poached artefacts can take on new meanings, thus challenging institutional control and mediation of historical cultural materials.

2.4.5. Digital media and the museum dream space

> *'While we may encounter, in museum objects and their surroundings, a complex public documentation of eras, patterns, details, and makers, we also encounter simultaneous and more complex private dimensions of our own memories, resonances, and mysteries.'* (Carr, 2001:176)

To employ a somewhat worn metaphor, museum objects can act as palimpsests; they can be scraped clean and rewritten with new meanings. Viewers at times respond to this in contradictory ways (Carr, 2001); while museums can impart knowledge and provide informational experiences, they also nurture experiential events and trigger creativity and free association in the minds of their visitors (Carr 2001:178-9). These affective events take place within the realm of the museum dream space.

The term 'dream space' describes a field of subrational thought in which museum artefacts interact with viewers' memories, imaginations and emotions (Annis, 1987, Kavanagh, 2000). Annis (1987) defines three forms of engagement, or 'symbolic spaces', in the museum; cognitive space, pragmatic space, and dream space. In her book *Dream Spaces: Memory and the Museum* (2000), Kavanagh expands Annis' theory of the dream space. She adopts Annis' terminology, but uses the term 'social space' in place of 'pragmatic space'. The cognitive space describes the rational contemplation of the museum. This space is informed by signage and display design; meaning is assigned to objects through curatorial choices. The pragmatic, or social space is the field in which the viewer moves and interacts with other people, and in which we act out our social roles in the museum. The dream space is the point at which inner and outer experiences blend together (Kavanagh, 2000). 3D space and the possibility to negotiate the museum environment assist dream space experience:

> *'The symbolic landscape of the museum (…) is three- rather than two-dimensional. The visitor can move into, through and past. He can slow down images, speed them up (…) In museum dream space there is a flow of images and meanings.'* (Annis, 1986:169).

Museums were conceived under the assumption that general knowledge and perceptions could be influenced and moulded by public displays, and that the public could be educated through museum exhibitions (Hooper-Greenhill, 1992, Starn, 2005). However, since the 1970s, a climate of increasing reflexivity has led museum professionals to shift their attention from their collections towards visitors. Within the profession this shift is identified as a 'new museology' (Ross, 2004, Vergo, 1989). Today, it is commonly understood that museum audiences do not passively absorb displays. Instead, they form their own connections and produce an eclectic range of interpretations, thus appropriating or re-appropriating museum displays.

According to dream space theory, people make sense of the museum experience by constructing personal narratives using stories and memories that are already familiar to them. This sense-making is a form of cultural poaching as defined by De Certeau (Boon, 2011, Certeau and Rendall, 2002). During the museum visit, memory and the present fuse into one singular experience; 'memories enter the museum as product' (Kavanagh, 2000:3) they can be collected, stored and employed. However, 'the successor generation cannot share its grandparents' memory of a reality of which it has no direct recollection' (Hein, 2000:82). Even so, successor generations carry their own set of associations; mass media has become a source, which feeds into our historical imagination (Wallace, 1995:112) and blurs fantasy with historical fact[80].

Not only does digital media influence popular historical imagination, it also enables new forms of cultural poaching and can lead to creative engagement with the museum dream space. Digital 3D models are not fixed; they remain open to exploration and transformation. They can exist in multiple locations and states at the same time[81]. In the context of the museum digital 3D technologies create a liminal space, a space somewhere between the tangible and the imaginary. In this space it becomes possible for heritage content to change and to take on new forms and meanings. Through digital editing users' associations, imagination and memories can be integrated in the digital 3D models themselves. With the necessary editing skill, users are able to transform digital 3D models of heritage artefacts into metamorphosed digital objects. In the museum dream space we make sense of our museum experiences by constructing personal narratives, which draw on stories and memories that are already familiar to us. With the help of digital technologies museum dream space experiences can be manufactured as physical objects.

This form of engagement can question established ways of reading and engaging with museum artefacts and go against the notion that there are appropriate and inappropriate ways of understanding and engaging with digital historical materials. Digital creativity in the context of the museum follows in the footsteps of artistic museum projects known as 'artist interventions' (see Glossary).

[80] For example, a shabti figure from the Manchester Museum recently caught the imagination of the public, after a time-lapse video of the mysteriously rotating figurine went viral on the internet. The BBC hosted a video of the spinning statue; https://www.youtube.com/watch?v=qnyZNf0vU_8, accessed 12.08.2013.
[81] For example, they can be shared online and downloaded from anywhere across the world.

2.5. Artist museum engagement

In the twentieth century museums have increasingly begun working with artists and other creative people to make new work inspired by their collections, or as guest curators (Brown, 2012, McShine and Art, 1999, Putnam, 2012, von Zinnenburg Carroll, 2012). Science and history museums, as well as other heritage institutions from a non-art background have now taken up collaborations with artists. Artists have been invited to interact with specialized collections such as archaeology, ethnography or natural history. Such projects, known as artist interventions, have helped museums to cast off their conventional image. Artist interventions in museums can question the institutional framing of objects, attract new audiences, experiment with alternative perspectives, examine the museum's relationship with visitors and question practices traditionally associated with curatorship and exhibition design (McShine, 1999). This section examines forms of creative artist engagement with museum collections, in order to better understand forms of creative interaction with digital materials derived from museum collections.

Artists, makers and other creative parties have a particular relationship with museums and the artefacts they hold. They, and their artistic forbearers, are audiences as well as potential contributors to museum collections. Artists turn to museums to find inspiration, but museums are also institutions that collect and display artistic creations; museums play a role both in stimulating ideas and in displaying and acquiring the fruits of artistic inspiration. As a result 'artists are constantly negotiating a delicate balance within the museum between being the observer and the observed' (McShine, 1999:6). Museums stimulate creativity, and at the same time distinguish between the creative responses they inspire, acquiring some while rejecting others. This dual role of the museum can elicit varied responses from artists. To some, inclusion of their work in a museum might signify professional success and public recognition. Other artists may 'question whether their work should be in a museum at all' (McShine, 1999:11). To them inclusion of their work in institutional museums might represent an act of selling out and yielding to the establishment, or allowing their work to become inactive and removed from real life interaction. As a result, artistic engagement with museum collections can be supportive and explorative, but also critical and with little sympathy for the role and function of museums. Museums can benefit from both approaches; artistic engagement provides museums with the opportunity to rediscover their collections and to engage in a dialogue.

Since the late 1980s politically engaged artists have used intervention as a tool to critique the institutional nature of museums (McShine, 1999), and to question the supposedly unbiased facts, which they represent. Such forms of artistic engagement are interventions in the truest sense, as they are an effective tool of deconstruction, a means of destabilising the 'homogeneity' of museums (McShine, 1999). However, museum intervention has been described as a fading tool for institutional critique;

> *'Once it had achieved its objective of exposing underlying dynamics of power in the apparently neutral spaces of preservation and display, it seemed destined to die out.'* (Brown, 2012)

However, museum interventions continue to be more than a fashionable way for museums to 'demonstrate their open-mindedness and resilience' (McClellan, 2007:567). Even though artist interventions have become relatively well established, they continue to present challenges to museum practice; creative art projects 'counterbalance the sense of permanence and order associated with the museum in a constructive dialogue' (Putnam, 2012). This shift from critique to constructive dialogue can be seen as an evolution of artist engagement with museums, rather than as an end to the artistic museum intervention;

> '*When contemporary artists intervene in museum exhibitions they intervene between past and future ways of seeing, thereby turning the museum objects into projects. The word "intervention" is derived from the Latin intervenire, "to come between".'* (von Zinnenburg Carroll, 2012:11)

Therefore, the focus of contemporary artist intervention in museums is not necessarily on institutional critique, but rather on ways of opening up different paths of interpretation and understanding.

2.5.1. Forms of artistic museum engagement

Museums are complex institutions; they collect, conserve and display artefacts. These artefacts can come from a range of sources, and posses a range of different histories, qualities and trajectories. Museums construct historical narratives, at the same time they possess their own histories and are cultural artefacts themselves. They are also social, political and architectural spaces. It follows, that art interventions can engage with a vast number of different aspects of museums. Nonetheless it is possible to identify some reoccurring approaches.

> *'Interventions often tend to address museological policies of acquisition, interpretation and display or other provocative topical issues, thus challenging the traditional impartiality of the institutional context. Alternatively, a museum's architecture or artefacts can add a unique spatial, conceptual or aesthetic dimension to the installation of an artist's work, whether existing or specially made for the occasion.'* (Putnam, 2012)

The following sections present an overview of types of artist engagement with museums. Section 2.5.1.1. lays out examples of artist interventions that engage with stored museum collections. Section 2.5.1.2. presents artist-made mock museums. Section 2.5.1.3. investigates how artist interventions can engage with museum archives. Section 2.5.1.4. gives examples of artists intervening at the level of the museum display. Section 2.5.1.5. discusses how artists take on the role of museum guides. Section 2.5.1.6. discusses site-specific interventions in museums. Section 2.5.1.7. looks into un-authorised forms of museum intervention. Section 2.5.1.8. presents digital examples of museum intervention.

These artistic approaches are not necessarily mutually exclusive; often artists choose to apply undertake museum interventions, which combine two or more of the presented categories.

2.5.1.1. Mining the museum

Only a small proportion of museum artefacts are displayed, most are held in museum storage; they lie in store for the future 'in a state of moribund exaltation, unredeemed until and unless a hand or eye from the real world touches them with the enchantment of new meaning' (Hein, 2000:60). Artists undertaking museum collaborations frequently work with unseen objects held in museum storage. An early precedent for this was Andy Warhol's *Raid the Icebox*. In 1970 the Rhode Island School of Design invited Andy Warhol to curate a selection of works from their collection (Putnam, 2012). Warhol chose to exhibit the complete storage collections. The artist Fred Wilson also explored stored museum collections for his exhibition 'Mining the Museum' at the Maryland Historical Society, Baltimore, USA (1992). Wilson created new museum displays using previously undisplayed museum objects, such as Ku-Klux Clan hoods and slave shackles. He challenged the lack of black American history represented through museum displays (Correia, 2011) and laid bare the social and political bias, which can still exist underneath the museum's veneer of neutrality.

2.5.1.2. Mock museums

Some artists choose to create museums of their own. For example, Marcel Broodthaers's *Museum of Modern Art, Department of Eagles* was a conceptual museum created in Brussels in 1968. This 'museum' had no permanent collection or location, and sections of the museum appeared at various locations between 1968 and 1971. At the 1972 Documenta in Kassel, Germany, the artist Claes Oldenburg displayed mass produced objects and found and altered everyday artefacts in a 'museum' built specifically for this purpose in the shape of Mickey Mouse's head (Rose, 1972). Mock museums, such as this *Mouse Museum*, poke fun at the concept of collecting and displaying artefacts.
Other artists produced portable museums; Duchamp famously created multiple boxed museums, which he called 'boites en valise', that housed miniature collections of his most famous works. Herbert Distel, inspired by Duchamp's

boites en valise, began assembling a *Museum of Drawers* in 1970. This museum now houses an original work of art in each of its 500 compartments. Other artists created virtual museums, such as Andre Malraux's photographic *museum without walls*, an early forbearer of today's digital online collections (Didi-Huberman, 2012, Malraux, 1978).

2.5.1.3. Opening the archive

Museum archives hold descriptions of artefacts and other associated information. Through their archives museums keep track of acquisitions and de-acquisitions as well as the provenance and condition of the objects they hold. Despite their impartial appearance archives can be highly controversial. Artefacts can hold completely different meanings if they are filed, for example, as artworks or as social history. In addition uncomfortable facts can lie hidden in museum archives. The artist Hans Haacke addressed such an uncomfortable truth in his piece *Manet-PROJEKT '74*. *PROJEKT '74 Kunst bleibt Kunst* (art remains art) was an exhibition organized by the Wallraf-Richartz-Museum for its 150th anniversary. Haacke chose to create a series of printed panels in relation to a painting held by the museum; Manet's *Bunch of Aspargus* (1880). Haacke's ten-panel work details the provenance of the *Bunch of Aspargus*. The list of previous owners of the Manet includes the German Banker Hermann J. Abs, an influential supporter of the Nazi party. Most of the painting's previous owners were German Jews. This type of revelatory and disquieting detail tended to be omitted in post-war Germany, and (perhaps under pressure from Abs, who was still influential as the chairman of the Deutsche Bank) the piece was omitted from PROJEKT 74 (Grasskamp *et al.*, 2004). Baldessari's *Painting That Is It's Own Documentation* (1968) also investigates the idea of the archive. Baldessari hired a sign painter to write on canvas the dates of the conception, creation, and first exhibition of *Painting That Is It's Own Documentation*, as well as written instruction to add subsequent exhibitions onto the canvas, and continue on further canvasses if necessary. Since its initial exhibition at the Molly Barnes Gallery the painting has been exhibited internationally and now includes four additional canvasses with a listing of venues where it has been displayed. The painting thus acts as an archive of itself.

2.5.1.4. Museum displays

Artists are sometimes given the opportunity to undertake a temporary rearrangement of galleries and to provide a more personal commentary on permanent exhibits (Putnam, 2012). When given the opportunity to curate museum displays, 'artists have the tendency to select very different objects from those chosen by the museum curators' (Putnam, 2012). Their choice of objects is not restricted by scholarly interpretation and they frequently create unconventional groupings and juxtapositions. Often artists introduce found objects or pieces of their own work into museum galleries. Artist Mark Dion, for example, led a pseudo-archaeological dig along the Thames riverbank; the debris uncovered during the dig was subsequently cleaned and exhibited at the Tate museum[82]. Artists can also engage with the concept of the museum display and it's effects. When artefacts enter into museum collections they lose their practical function and become objects of display.

David Cushway's performance piece *Teatime at the Museum*[83] (Fig.4), undertaken at the National Museum Cardiff in 2012, engages with the loss of functionality through display. In the filmed performance Cushway, together with Andrew Renton, Keeper of Art at the National Museum Cardiff, uses a historic tea service to drink tea in the Museum's principal ceramics gallery.

[82] See http://www.tate.org.uk/learn/online-resources/mark-dion-tate-thames-dig, accessed 04.09.2014.
[83] See http://www.davidcushway.co.uk/2012/Teatime_at_the_Museum.html , accessed 29.10.2014.

Fig.4 *Teatime at the Museum*, David Cushway, Still image from film, featuring Andrew Renton and David Cushway drinking tea in the ceramics galleries of the National Museum of Cardiff; 2012 © David Cushway

Cecile Johnson Soliz's exhibition *Regarding the Function of Objects*, also held at the National Museum Cardiff in 1999, reflected on the loss of function which ceramic artefacts undergo upon their inclusion in museum collections (Soliz and Carey, 1999).

2.5.1.5. Guiding the viewer

Artistic engagement with museums can also mimic the ways in which museums narrate and contextualize their displays. Such projects can explore museum signage and other forms in which museums communicate meaning to their audiences, including the role of the museum guide. For the Tate *Britain's RE-CREATE*[84] series the comedian Adam Buxton created a short film inside the Tate galleries. In character as Monty Buggershop-Hooty, Buxton purposefully strides

[84] See https://www.google.com/culturalinstitute/exhibit/re-create-with-tate-britain-comedy/gQV-41Rt, accessed 03.04.2014.

Fig.5 *Arcanum*, Edmund De Waal, installation detail of the work as displayed at National Museum of Cardiff; 2005 © Michael Tooby

through the galleries, re-narrating the art on display[85]. In this short sketch Buxton pokes fun at the idea of the connoisseur, his whimsical claims about the art on display undermine the interpretative monopoly of the museum.

Artists can also ‘guide’ the viewer by creating artworks, which point towards certain features of an artefact or artwork, or suggest different ways of viewing a museum collection. In 2005 artist Edmund De Waal curated *Arcanum* in the ceramics galleries at the National Museum Cardiff (see Tooby, 2012). De Waal presented ceramics from the De Winton collections on an open table, outside their glass cases and some objects were displayed in an unusual manner, for example upside-down (Fig.5). This form of display references the collector’s way of viewing ceramic collections; to a collector the markings on the base of ceramic objects provide the most information; yet this viewpoint is rarely offered in ceramic museum displays.

[85] See http://www.youtube.com/watch?v=ftxcjC5gh98 accessed 03.04.2014.

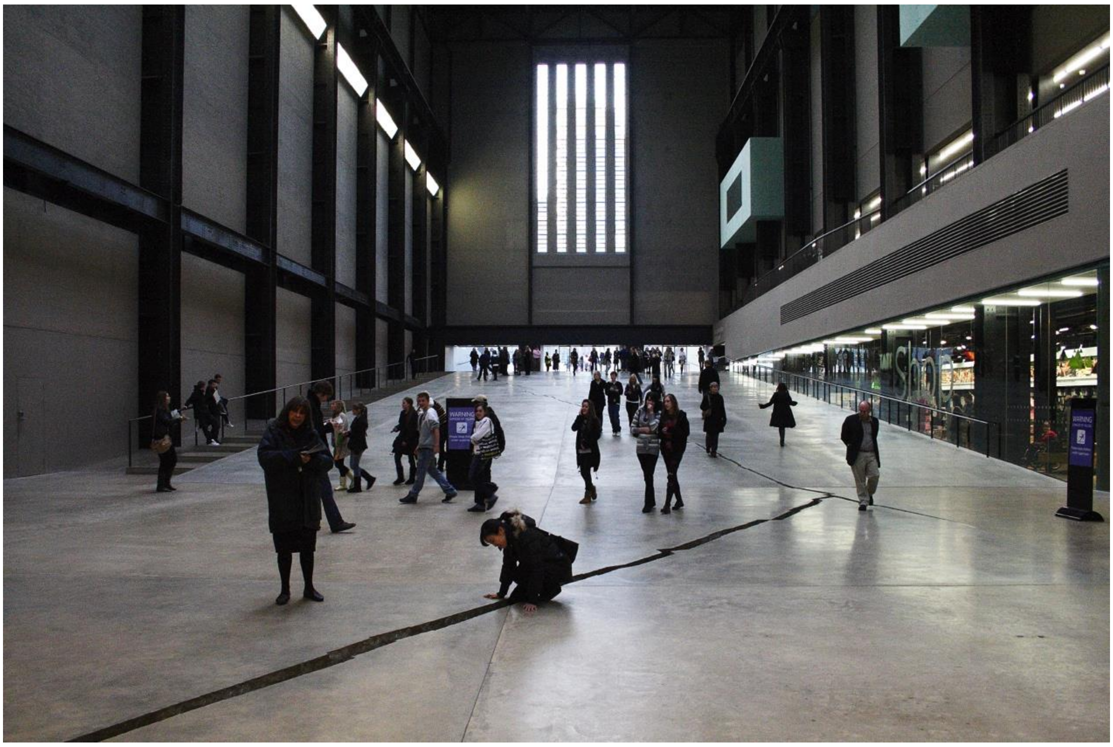

Fig.6 *Shiboleth*, Doris Salcedo, Tate Modern Turbine Hall; 2008 © Ted and Jen Photography

2.5.1.6. The Museum as place

For some artists the spatial/architectural site of the museum has been a point of investigation. They have responded to the museum itself as an artefact, creating work, which merges or interferes in some way with the museum site. In 2007 Colombian artist Doris Salcedo broke open the floor of the turbine hall at the Tate museum. Salcedo's piece *Shibboleth* questions the way in which museums can still act as exclusive institutions[86]. This highly symbolic and evocative piece questioned the idea of the museum itself, down to its physical foundation (Fig.6).

The physical location of an object in the museum can influence its meaning. For example an object displayed in an art gallery will be received differently when it is place in an ethnographic display. Michael Asher's intervention at the Art

[86] See http://www.tate.org.uk/whats-on/tate-modern/exhibition/unilever-series-doris-salcedo-shibboleth, accessed 07.09.2014.

Institute of Chicago in 1979 investigated the relationship between a piece of art and the politics of display. Asher moved a 20th-century bronze cast of Houdon's marble George Washington (1785–91) from the museum's front steps into its art galleries. By situating the work in a new context, Asher explored how placement can influence the aesthetic reading of an artwork.

Museum architecture can also provide a unique space in which an artist's work can be installed or performed. For example, a sequence from Barney Mathews *Cremaster III*, was shot in the Guggenheim museum. In the filmed piece a mythical quest takes place across five levels of the Guggenheim's spiralling ramps, weaving the museum itself into Barney's fictional narrative[87].

2.5.1.7. Invading the museum

Some artists choose to conduct museum interventions outside the scope of the institution, by invading or infiltrating its displays. Such interventions are often performative; the artist enters the museum 'disguised' as a member of the audience. Graffiti artist Banksy famously placed his own works in museums. His humorous pieces often hung unnoticed among museum displays for several days[88]. The artist has since gone on to undertake institutionally sanctioned museum projects. However, interventions that take place without having been sanctioned beforehand are rarely tolerated and can constitute criminal acts. Duchamp's urinal, for example, has been the target of several unlicensed interventions; it has been urinated into and struck with a hammer[89]. Cases like this, where original work is damaged, or social boundaries are crossed, are widely regarded as vandalism, rather than art.

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[87] See http://www.cremaster.net/crem3.htm, accessed 07.09.2014.

[88] See http://news.bbc.co.uk/1/hi/entertainment/4563751.stm, accessed 07.09.2014.

[89] Interestingly, Brian Eno, who vandalised the piece, was protesting the fact that a replica is today used to show the *fountain*, see http://www.tate.org.uk/art/artists/marcel-duchamp-1036, accessed 21.10.2015.

Fig.7 *Ben Franklinstein*, WeTheBuilders, crowdsourced, 3D printed and assembled sculpture, dimensions not known; 2013 © Todd Blatt

2.5.1.8. Going digital

Museum interventions usually employ objects from museum collections and original pieces created or found by artists. In a recent trend, digital copies are increasingly beginning to be used in artistic museum projects. The *We the Builders* project[90], for example, was conceived during the 2013 ArtBytes Hackathon at the Walters Art Museum, Baltimore. A bust from the museum's collections was scanned and sliced into 110 four-inch cubes, which were made available for download online. The slices were then printed by volunteers and sent back for assembly (Fig.7). Through crowd sourcing 3D prints this project engaged multiple individuals as authors of the assembled 3D printed bust. Hackathons (see Section 2.3.4.) can be seen as a form of creative museum

[90] See http://www.wethebuilders.com/, accessed 09.09.2014.

engagement, however they are not generally described as art. Nonetheless, some artists have begun to use digital 3D models to engage with museums.

For the 2011 London Design Festival, milliner Stephen Jones employed 3D scanning and 3D printing technologies to re-imagine a bust of Lady Belhaven, created in 1827 by Samuel Joseph. Jones reprinted the original bust with the addition of an elaborate hat. Other examples of digital tools being employed to experiment with museum collections are the British artist Simon Starling's work Drop Sculpture, at the Rijksmuseum Amsterdam (Starling, 2012), the National Palace Museum's 3D animated film Adventures in the NPM[91] (Lin and Din 2008), Oliver *Laric's Lincoln 3D Scans*[92] (2012), Tom Burtonwood's *New Museum*[93] (2014).

Lincoln 3D Scans, a project by the artist Oliver Laric, involved the creation of 3D scan models of the holdings of the Usher Gallery and The Collection in Lincoln. A number of items were 3D scanned, and the resulting 3D models were made available for download and further use without copyright restrictions. The 3D models are available online, to be used by the public 'for free, and for any reason– whether advertising, garden decoration, scholarly research or design' (Larios, 2014:108). The *Lincoln 3D Scans* project aims to make digital 3D models of the collections of the Usher Gallery and The Collection in Lincoln available online. *Lincoln 3D Scans* is presented as an online artwork. Through the promotion of third-party creative engagement Laric's *Lincoln 3D Scans* project seeks to 'parse the productive potential of the copy, the bootleg, and the remix, and examine their role in the formation of both historic and contemporary image cultures', a frequent theme in the artists' work (Crilly, 2012). This project echoes the creative engagement of 3D enthusiasts and hobbyists, who create and share UCG online for open use (see section 1.4.3. Digital 3D repositories of museum artefacts online).

91 A preview to the film is available at http://www.youtube.com/watch?v=3x_sO1S3Ajk , accessed 1.8.2013.
92 See http://lincoln3dscans.co.uk/info/, accessed 04.11.2014.
93 See http://tomburtonwood.com/2014/01/new-museum/, accessed 03.11.2014.

The artists' projects discussed in this section use digital 3D models of museum artefacts and employ strategies of digital reproduction, transformation and co-creation to pose questions concerning originality and authorship. While the traditional artist intervention in museums is frequently the project of a singular artist, digital intervention can make use of the potential of digital media for collaboration and enable audiences to partake in new forms of collaborative museum interventions.

2.6. Discussion and research plan

Museums are increasingly making use of an ever-widening range of digital resources, including digital 3D technologies (see Section 2.3. Digital museum strategies). 3D scanning technologies offer an effective way of producing highly accurate digital reproductions of heritage artefacts (Wachowiak and Karas, 2009). At the same time, a certain amount of objectivity is unavoidable in the creation of digital 3D models (Lapp and Nicoli, 2014). In the museum and heritage context, digital 3D scanning is predominantly used to support 'traditional activities which scholars and scientists active in the area of cultural heritage studies have been pursuing for several centuries' (Koller *et al.*, 2010:2). Research on virtual heritage tends to focus on these 'traditional activities', such as documentation, preservation, examination and restoration. However, digital 3D scanning technologies afford new opportunities for creative digital and online engagement with arts and culture (Bertacchini and Morando, 2013). Digital technologies can 'help art ideas to penetrate more effortlessly into visitor's lives' (Samis, 2008:13); they can reveal the multiplicity of meanings museum collections can trigger in viewers.

Museum exhibitions carry an abundance of possible meanings (see Section 2.4. The museum object). Audiences and their reading of museum artefacts cannot be controlled; instead museums need to embrace ambiguity and find ways to engage with the various forms of experience their collections can elicit in viewers. The review indicates, that artist-led intervention projects can provide opportunities to reassess museum practices (see Sections 2.5. Artist engagement) and to enable audiences to partake in museum interventions (see Section 2.5.1.8. Going digital). Digital technologies can open the wealth of artistic and cultural artefacts found in museum collections to widened active participation.

Digital content has the potential to be shared widely online and can encourage imitation, creativity and exchange. Online repositories of digital 3D forms have given rise to a growing community of digital 3D enthusiasts, made up of both professional and hobbyist users (see Section 2.3.3. Digital repositories of museum artefacts online). Increasingly, museums are opening up to collaborative projects with technologists and new media artists through hackathon events. These hackathons are undertaken to develop new tools and applications (see Section 2.3.4 Museum hackathons), but they also hold potential as a new form of museum intervention, which can uncover new readings of museum artefacts.

The museum dream space (see Section 2.4.5. Digital media and the museum dream space) is an important field of museum experience. It has been known since Annis introduced the concept in his essay *The museum as a staging ground for symbolic action* (1986) and was developed further by Gaynor Kavanagh in her book *Dream Spaces: Memory and the Museum* (2000). Nonetheless, the museum dream space has so far received little attention in connection with digital museum strategies. Although creative digital museum practices are beginning to emerge (see Section 2.3.4. Museum hackathons, and Section 2.5.1.8. Going digital), there are few examples of academic research in this field. Some scholars have begun to investigate creative digital strategies and their impact, but few have investigated the links between digital creativity and museum dream space experience. One notable example is the doctoral research of Katarzyna Warpas. In her doctoral thesis *Designing for Dream Spaces* (2014), Warpas points out that digital multimedia installations can be used to foster affective dream space experiences in museum galleries. However, Warpas focuses on closed multimedia experiences, which are installed in the museum and are not open to 'hacking' (see Glossary) and change. She recognises the affective potential of digital technologies, but does not engage with their potential for collaboration and open cultural exchange. This area of museum experience now merits further academic research. In particular, the potential of digital technologies to engage with the museum dream space demands a thorough investigation. More research is necessary to explore the creative use of digital heritage materials, their potential use in accessing the museum dream space and their wider cultural implications.

The liminal qualities of digital 3D reproductions make them suited to the exploration of liminal realms and experiences in the museum context, such as the dream space. For this research, digital 3D models of museum artefacts were shared with artists in order to observe interactions and outcomes, to identify similarities with previous forms of artistic museum interventions, and to discover unprecedented forms of museum engagement. The following chapter discusses the choice of research methodologies used to collect data during this research.

3.Research methodology

3.1. Introduction

Creative strategies of digital engagement have potential to engage with the ‘personal and subjective ways in which visitors make meaning (such as through life experiences, opinions, imaginations, memories and fantasies)’, these are frequently ‘ignored and more often invalidated in museums, where they tend to be regarded as naïve and inappropriate’ (Kavanagh, 2000:161). To date, museum strategies and academic research in the field of digital heritage has focused disproportionally on the institutional and knowledge-based framing of digital 3D models. The creative use of digital 3D technologies in museums merits further investigation, as it has the potential to unlock areas of subjective museum experience (in particular the realm of museum dream space experiences) and to engage museum audiences in new ways. This chapter presents the methodology chosen to investigate this field of study.

For this research a creative and participatory approach was devised, which combines elements of museum intervention and hackathon projects with a practice-led research. Museum interventions can transform museums into experimental playing fields, or ‘living labs’ (see Björgvinsson *et al.*, 2010). Artists can create individual interventions, but they also have the opportunity to engage audiences in the active transformation of museums. For example, during Urs Fischer’s intervention project at the Geffen Contemporary Museum of Contemporary Art in Los Angeles in 2013, the artist filled the museum’s principal gallery with slabs of clay. Fischer invited the general public to come to the museum and to use as much clay as they liked to create anything they wanted (Fig.8). This resulted in a ‘data-dump that was polished, practiced, wild, and crude’ (Kilston, 2013), which revealed the diverse range of interests, skills and ideas that visitors brought to the museum.

Fig.8 *YES*, Urs Fischer and various artists, Unfired clay sculptures modelled on-site by multiple authors, intervention project undertaken at the Geffen Contemporary MOCA, Los Angeles; 2013. Dimensions variable. Photographed by Stefan Altenburger © Urs Fischer

Like Fischer's slabs of clay, digital 3D models are pliable and can be used as malleable raw material from which new forms and artefacts are created (see Section 2.4.3. Digital copies), given the necessary access to data, software and the necessary editing skills. The creation of new works from digital 3D models of heritage artefacts can reveal how individuals interpret heritage artefacts, it can provide an insight into the associative thoughts and memories triggered in the museum dream space and open up new forms of museum engagement.

Museum hackathons provide a way to experiment with digital applications in museums, to allow new content to emerge and to draw on the expertise of external parties. For example, during the Metropolitan Museum's first 3D hackathon in 2012, digital artists and programmers created new work from 3D models of museum artefacts (see Section 2.3.4. Museum hackathons).

For this research the model of co-creation and engagement applied in collaborative museum interventions and hackathons was developed into a creative, participatory and practice-led research methodology. A case study project was undertaken in collaboration with the National Museum Cardiff to foster artist engagement with digitally rendered museum artefacts. The case study was designed as practice-led research and the creative practice of artists was fundamental in the research.

This chapter (Chapter 3 Research Methodology) explains the rationale for the choice of appropriate methodologies and research techniques and identifies case studies, questionnaires, interviews, and comparative analysis as valid methods for collecting research. Section 3.2. details the choice of research methods and the validity and effectiveness of the chosen research methodology. Section 3.3. presents the theoretical framework of the research methodology. Section 3.4. lays out how data was collected during the research. Section 3.5. explains how data analysis was undertaken. Section 3.6. discusses the validity and potential of the research methodology.

3.2. Methodological approach

There have been on-going academic debates on the appropriateness of different methods in social research (Olsen, 2011). The central focus of these disputes is the dichotomous way in which qualitative and quantitative research methods are frequently presented. Qualitative research methods can be criticised for their focus on interpretation rather than quantification, as well as for a perceived lack of objectivity. Qualitative research is sometimes deemed unscientific, subjective and full of bias (Denzin and Lincoln, 1998:7). Quantitative research, on the other hand, has come under criticism for its lack of consideration of cultural circumstances and for the assumption that social research could be free of subjective viewpoints. Qualitative forms of enquiry have the advantage of being suited to the exploration of how experience is created and given meaning. They can take into account the multiple paradigms that shape the field of study, whereas quantitative research relies on inferential materials and is less likely to capture cultural impact. Researchers increasingly employ both qualitative and quantitative methods in order to exploit the advantages of both approaches; qualitative and quantitative methods can now be viewed as complementary.

Natural sciences can be studied directly. The humanities and social sciences, on the other hand, 'deal with the reality as we perceive it (…) The external observer discovers a subjective meaning attributed by the actor only indirectly, by studying traces that his or her actions leave on material objects, visual images, texts, pieces of art and so forth.' (Oleinik, 2011:859-60). Readings of museum artefacts can be highly personal (see Section 2.4. The museum object) and a focus on objective facts would risk ignoring the wealth of subjective experience which museums offer. Therefore, qualitative methods were chosen in this research, in order to gain insight into the cultural implications of the creative digital engagement with museum artefacts. However, some data was quantified during the analysis stage to uncover statistical correlations and overarching themes, such as the relative frequency of particular themes in artworks or of editing processes, which might otherwise have been missed by the researcher.

Qualitative methods used in this research include surveys and interviews as well as the creation and analysis of artefacts and artworks. Data was collected in the course of a case study designed to foster artist engagement with 3D models of ceramic museum artefacts from the National Museum Cardiff and through a comparative case study of a digital art project undertaken by the artist Oliver Laric in collaboration with the Usher Gallery and The Collection in Lincoln (see Section 4.3. Comparative case study: the Lincoln 3D Scans project). These studies were undertaken to draw on the tacit knowledge of artists, who are audiences as well as potential contributors to museum collections.

Alongside the investigation and participant-led creation of artefacts, the exhibition of artefacts was also used as a research tool. An exhibition at the National Museum Cardiff, the (Im)material Artefacts display, was set up to create a setting within which the remixed artefacts ad the originals entered into a visible contextual relationship with each other, so that their impact on audiences and the institiution could be assessed (see Chapter 4.2.5. Public exhibition).

Triangulation was used in order to increase the validity of research findings. In social science research, 'triangulation refers to using more than one particular approach when doing research in order to get richer, fuller data and/or to help confirm the results of the research' (Wilson, 2014:74). Four types of triangulation can be identified; data triangulation, investigator triangulation, theory triangulation and methodological triangulation (Wilson, 2014). During this research, data triangulation (using different sources of data) and methodological triangulation (using different methods of data collection) were used to increase the validity, scope and depth of the research.

3.3. Theoretical framework

Principles of practice-led research were applied in the design of the *(Im)material Artefacts* case study. The design framework of the *(Im)material Artefacts* case study was also influenced by the model of museum hackathons (see Section 2.3.4. Hackathons) and artist interventions (see Section 2.5. Artist engagement). Practice-led research and museum hackathons can create experimental spaces within which new forms of digital engagement with museum collections can be trialled (see Section 2.5.4. Hackathons) and artist interventions can approach museum collections and digital engagement from creative and unexpected angles. Together, these approaches can open museums up to creative experimentation, 'explore possible futures' (Irani, 2015) and experiment with the application of digital technologies. They can reveal new meanings and experiences, as well as new approaches to questions and problems faced by museums.

During this study, situations were created where museum artefacts, their digital 3D reproductions and remixed artworks became the focus of participants' thoughts and feelings and thus took on the role of 'intentional objects' (Husserl, 1859-1983:58, see Glossary). Data was collected on participants' consciousness experiences, such as perception, memory, fantasy, associative thought and emotions, which resulted from their participation in the study. By focusing on 'the things themselves' and studying connected acts of consciousness and this study followed a phenomenological framework (Küng, 1973).

3.3.1. Case study

Case study research 'is particular, descriptive, inductive and ultimately heuristic' (Somekh and Lewin, 2005:33). It draws many of its methods, such as observation and interviews, from ethnographic research. Case studies are a form of ethnography; their wider aim is to study cultural knowledge and customs. As a sub-set of ethnographical research, the case study aims to understand the nature of phenomena through the detailed investigation of cases and contexts. In real-world scenarios where 'events are not amenable to control by the investigator and when the questions posed are open-ended and multi-factored' (Candy and Edmonds, 2002:43) case studies are ideally suited to the exploration of phenomena within their context. Kohlbacher reports that:

> *'Case studies seem to be the preferred strategy when "how or "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context.'* (Kohlbacher, 2006:8).

Case studies can give detailed insight into 'a bounded microcosm of society' (Spencer, 2010:50), such as the 'microcosm' of a museum. One problem of this narrow focus of case studies is, that 'it is not possible to generalize statistically from one or a small number of cases to the population as a whole' (Somekh, 2005:33). It is hard to draw conclusions beyond the scope of the case study. However, readers are able to draw naturalistic generalisations from case study research by applying ideas from the case study to personal contexts (Zucker, 2009). Furthermore, case study research findings can be tested for wider relevance through comparative case studies and through reference to relevant literature and research (Simons, 2009).

Two general approaches to case study research can be broadly outlined:

> *'Some, deriving from social sciences, stressing social interaction and the social construction of meaning in situ; others, deriving from medical or even criminological models, giving far more emphasis to the 'objective' observer.'* (Somekh, 2005:33)

This research takes an ethnographic approach to case study research. The focus of this research lies on the cultural use and interpretations of museum artefacts and digital 3D models and investigates experiences and artefacts arising from the creative engagement with 3D models of artefacts.

3.3.2. Practice-led research

Practice research is a form of academic research that incorporates an element of practice in its methodology or research output. Two dominant approaches can be identified in research with a central practice element; practise-based and practice-led research. Although these two terms are 'increasingly interchangeable' (Gardiner and Gere, 2010:29) some distinctions can be made. In practice-based research new knowledge is gained by means of practice and the outcomes of that practice. In arts and humanities research, these may include artefacts such as artworks, music, digital media or performances and exhibitions. Whilst these outcomes are frequently contextualised through writing, the claim to originality and contribution to knowledge of practice-led research can only be obtained with direct reference to those outcomes.

The main focus of practice-led research, on the other hand, is to advance knowledge about or within practice. The results of practice-led research 'may be fully described in text' (Gardiner and Gere, 2010:29), sometimes even without

the inclusion of a creative outcome. Nonetheless, practice-led research includes practice as an integral part of its method and often falls within the general area of action research. During this study, the researcher did not produce creative work herself, artworks were created by participants in the course of a case study, and presented to an audience during an exhibition, which the researcher organised and oversaw. The outcomes of this study were then summarised and presented through a written thesis. Although this research contains a strong practice element, it is research-led, rather than research-based.
No single definition of practice-led research in the arts and humanities exists. However, practice-led research is widely understood to be personally situated, diverse and emergent.

> *'Artistic (practice-led) research does not really involve theory building or knowledge production in the usual sense of those terms (...) It creates room for that which is unexpected - the idea that all things could be different. (...) Art invites us and allows us to linger at the frontier of what there is, and it gives us an outlook on what might be.'* (Borgdorff in Biggs and Karlsson, 2010:61)

While these qualities can be seen as strengths of the practice-led approach, they are also frequently criticised for their subjectivity and a perceived lack of academic rigour (Barret and Bolt, 2010). Nonetheless, proponents of practice-led research argue, that the subjective nature of this method enables researchers to investigate areas of research that more objective methods are unable to explore, such as 'sensory and emotional perception' (Klein, 2010:6).

Within the context of practice-led research in the arts, the digital realm presents a new arena, that 'follows the café and studio and can advance our understanding of who we are, what we know and do' (Gardiner and Gere, 2010:31). Digital practice-led research is well suited to the exploration of this new and 'crucial part of cultural heritage' (Gardiner and Gere, 2010:31). Practice-led research in the form of digital art museum intervention can explore the new possibilities arising from the increased availability of digital 3D models of museum artefacts. Rather than follow the museum's traditional focus on knowledge-based mediation and research it fosters open inovation and creates a situation in which new uses of digital heritage and new understandings thereof can emerge (Eid and Younan, 2016).

In practice-led research, new knowledge is understood to emerge 'around the artist, artwork, viewer and context where each has a role in co-constructing meaning' (Sullivan, 2001:9). Art and artefacts can serve as inputs into knowledge production and outputs for knowledge communication during practice-led research (Nimkulrat, 2013). During during different stages of this study, artistic practice provided a source of data for analysis from which new knowledge was constructed. The multiple factors of the presentation, institutional context and audience perception of these artefacts were also taken into account. The creation of artworks from digital heritage by participants, the exploration of the original and metamorphosed works, their curation and the investigation of their cultural reception all formed part of the research process.

3.3.3. Comparative case study

Single case studies are inherently limited to data on a unique case. Therefore, it is not possible to tell from a single case whether the studied event represents a regularly occurring phenomena or an exception to the norm. The value of case study research can be increased when cases are studied comparatively (Zartman, 2005). 'Comparative case study exhibits the advantages of in-depth analysis of reality while overcoming the weaknesses of focusing on one case alone' (Zartman, 2005:7). The number of comparative cases depends on the intent of the researcher; the comparison of multiple cases can provide more data, but loses the detail and insight of smaller scale comparative studies. The comparison of a large number of cases through quantitative methods can give statistical overview of a field of study, but risks losing the cultural insight and detailed knowledge of the qualitative case study. Qualitative comparison of a small number of cases, on the other hand, conserves the advantages of the qualitative case study while at the same time testing concepts and theories for external validity against other cases.

During this study, data from the case study undertaken in collaboration with the National Museum Cardiff was collated with data from an external case through a comparative case study. In order to conserve the depth and detail of the qualitative case study it was decided to limit the number of comparative cases to a single case. In order to choose the most salient and homologous case, a number of digital artist interventions and collaborations with museums were reviewed. Today, many museums, artists and hobbyists are creatively experimenting with 3D models of museum artefacts. A trend of creating and sharing digital 3D models outside the control of museums through the use of photogrammetry technologies has emerged online (see Section 2.4.3. Digital 3D repositories of museum artefacts online). Artist projects make creative use of digital 3D technologies in the context of museums (See Section 2.5.2.7. Going digital). Museums are also increasingly experimenting with creative digital strategies such as museum hackathons (see Section 2.4.4. Hackathons) and are exploring ways to make 3D models of their collections available online (see Section 2.4.3. Digital 3D repositories of museum artefacts online).

From this developing field of creative digital museum engagement, Oliver Laric's award-winning[94] *Lincoln 3D Scans* project was selected as the most suited case for juxtaposition with the *(Im)material Artefacts* project. The two independently conceived projects share a great similarity in their conceptual design; both provide access to digital 3D models of museum artefacts for creative use and both collect and showcase the outcome of this creative use (this will be discussed in more detail in Chapter 4. Case Studies). While the *(Im)material Artefacts* case study was designed as a research case study, the *Lincoln 3D Scans* project was undertaken as an art project. The *Lincoln 3D Scans* project thus provided a real-world scenario of creative engagement against which findings from the *(Im)material Artefacts* research project could be tested for validity.

[94] *Lincoln 3D Scans* won the Contemporary Art Society's Annual Award for museums. See http://www.contemporaryartsociety.org/initiatives/annual-award/, accessed 05.02.2015.

3.4. Data collection

In this research, participant experiences, museum artefacts, digital 3D models and new artworks created from digital 3D models were treated as sources of data. Different methods were applied to collect this data during the study. Data was collected from questionnaires and interviews with artists, hobbyists, museum professionals and museum visitors. Visual data, in the form of museum artefacts, was selected from the National Museum Cardiff and new visual materials were created from the selected museum artefacts through 3D scanning. Further visual data in the form of new artworks was contributed by artists during the *(Im)material Artefacts* case study, and was retrieved from the *Lincoln 3D Scans* online gallery.

The following section presents in detail how data was collected from the *(Im)material Artefacts* study and the *Lincoln 3D Scans* project.

3.4.1. Surveys

Data on participating artists' experiences was collected through surveys and interviews. To obtain data on the creative phase of the (*Im)material Artefacts* project (see Section 4.2.4. Creation of artworks) participating artists were asked to fill out an online survey on SurveyMonkey[95] directly after the completion and submission of their artworks. This survey included closed questions, such as tick boxes and scales to rank, and open-ended questions, which allowed more detailed responses. The survey was arranged in three sections; section 1 contained questions on the artists' work and the technologies they employ in their practice. Section 2 contained questions on the artists' experiences with the *(Im)material Artefacts* project. Section 3 contained more general questions on the artists' thoughts on museums and digitisation (see Appendix A.4. Surveys). The survey took an estimated ten minutes to complete. Ten of the eleven artists

[95] See http://surveymonkey.com/ accessed 03.03.2014. For full questionnaire see Appendix A.4. Surveys.

who had contributed artworks towards the *(Im)material Artefacts* project completed the survey. The questionnaire spanned a wide range of topics, which did not all prove to be directly relevant to the research. In addition artists sometimes skipped questions or ticked multiple boxes. Nonetheless the wide scope of the topics addressed in the questionnaire enabled the researcher to gain an initial understanding of participants' engagement with digital data, technologies and the museum context. The questionnaire functioned as a pilot study, which produced initial insights that were then used to inform the development of interview questions for the interview schedule (see Appendix A.5. Interview protocols).

To gather data from the *Lincoln 3D Scans* project, contact requests were sent to users who had provided links to their personal websites on the *Lincoln 3D Scans* online gallery. Four users responded to the researcher's emails and filled out a questionnaire concerning their experience with the *Lincoln 3D Scans* project (see Appendix A.4. Surveys). The questionnaire sent to users of the *Lincoln 3D Scans* project was modelled on the questionnaire filled out by artists participating in *(Im)material Artefacts*; it included tick boxes and open-ended questions, which allowed more detailed responses. The questionnaire was arranged in three sections; section 1 contained questions on the artists' background and the technologies they used in their work. Section 2 contained questions on the artists' experiences with the *Lincoln 3D Scan* project. Section 3 contained more general questions on the artists' thoughts on museums and digitisation.

3.4.2. Interviews

Artists participating in the *(Im)material Artefacts* case study, as well as users of the *Lincoln 3D Scans*, museum professionals and members of the audience were asked to share their experiences during interviews. Qualitative interviewing builds on existing conversational skills, but differs from ordinary conversations (DiCicco-Bloom and Crabtree, 2006). Unlike everyday conversations qualitative interviews are guided towards topics previously laid out in interview schedules by a researcher. Furthermore, qualitative interviews take place between strangers and provide data, which is later subjected to analysis. Unstructured and semi-structured interviews are common types of interviews used in qualitative research. During unstructured interviews 'the researcher suggests the subject for discussion but has few specific questions in mind' (Rubin and Rubin, 2005:5). This type of interview can prove helpful, when the researcher wants to broadly explore a field of study, gain insight into the interviewee's personal interests, or when he or she is not yet certain of the specific direction of the research. When the interviewer has more specific questions in mind, a semi-structured interview approach is frequently used. Semi-structured interviews contain both structured parts, during which the interviewer asks specific questions and unstructured parts, during which the interviewee is free to contribute his or her own points of view and to discuss topics beyond the themes addressed by the researcher. Topics that the researcher wishes to address during semi-structured interviews can be laid out in advance in the form of interview schedules. Semi-structured interviews enable the researcher to collect, compare and contrast specific information, while at the same time keeping the interview flexible so that additional information can arise.

Interview schedules were written for interviews with artists participating in *(Im)material Artefacts*, for audience members and museum staff. Interview schedules were also used to interview users of the *Lincoln 3D Scans* and museum staff involved in the execution of the project (see Appendix A.5. Interview protocols). As the majority of interviewees did not feel comfortable with visual and audio recording, interviews were recorded through shorthand note taking and notes were used to write longer reports as soon as possible after the interviews. Notes were cleaned up, repetitions edited out and overlaps and colloquialisms edited into coherent sentences. In order to capture the participants' different points of view as closely as possible the interviews were summarised using original tone and language of the participants and included direct quotes (see Appendix A.8. Interview summaries). The interview transcripts were then emailed to the participants and they were given the opportunity to review the material.

During interviews with artists participating in *(Im)material Artefacts* artists discussed their thoughts on museums and digital media, spoke about their artworks and shared the experiences they had had during their creative engagement with digital 3D models of museum artefacts. Interviews were conducted on Skype[96] using a webcam in order to establish rapport. These interviews took 30 minutes to an hour and were the first instance of verbal communication with the artists.

In order to gain an insight into the audience response to and perception of the *(Im)material Artefacts* display data was collected from interviews with visitors to the museum who had viewed the *(Im)material Artefacts* display. Museum visitors were enlisted for interviews through social media. Online blogs and social media were used to promote the *(Im)material Artefacts* exhibition through photographs, posts and updates. A recruitment call-out was also posted through these channels of communication. Six volunteers responded to this call out, and meetings were arranged at the National Museum Cardiff on an individual basis through email communication. Interviews with members of the audience took place in the galleries and the cafeteria of the National Museum Cardiff; the interviews took an about thirty minutes, including viewing of the display.

Interviews were also undertaken with individuals working at the National Museum Cardiff, in order to understand the museum-internal impact of *(Im)material Artefacts* and to take into account the informed points of view that museum staff could offer on this project. Andrew Renton, Keeper of Art at the National Museum Cardiff, was asked for help in identifying and approaching museum staff interested in sharing their views on the *(Im)material Artefacts* project. The Senior Curator of Applied Art and the Exhibitions and Programs Coordinator at the National Museum of Wales took part in interviews. These museum professionals shared their informed points of view and weighed up their experiences with the *(Im)material Artefacts* project against experiences with other displays and artist projects they had witnessed in the past. Interviews

[96] Skype is a communication software that allows users to make video chat and voice calls from computers, tablets, and mobile devices via the Internet. See http://www.skype.com/en/, accessed 24.04.2015.

were undertaken in their offices and lasted about thirty minutes.

One user of *Lincoln 3D Scans*, Will Kendrick, was interviewed in person in his studio in Bristol. Brit Bunkley, a visual artist living in New Zealand was interviewed via Skype. Both interviews lasted approximately 30 minutes and were recorded in the same manner as interviews with artists participating in *(Im)material* Artefacts. Other users responded to questions via email. Furthermore, online statements and comments on their work were collected from the users' blogs and websites. The Collections Access Officer at the Usher Gallery and The Collection in Lincoln, was also interviewed via Skype.

Approval for carrying out interviews was sought from the Cardiff Metropolitan University Ethics Committee. All participants were provided a participant information sheet prior to the interviews and were asked to sign a participant consent form (see Appendix A.7. Forms).

3.4.3. Visual data, creative practice and production

The methodology used in this research involves the creation of digital 3D models of museum artefacts and the study of new artworks derived from these digital 3D models. In the course of the research participants received digital 3D models and sent back edited 3D models and other digital material, such as animated videos or videogames. Audiences encountered the museum artefacts and artworks in museum glass cases. Therefore, the pactical functions and physical experiences, which these objects could potentially provide fell outside the focus of this study. Instead, the artefacts and artworks used and produced during the research were studied as visual materials and as 'intentional objects' (see Glossary).

The study of visual material can give insight into culture and human creativity. Artefacts and artworks can 'provide information which can be epistemologically valuable for cognitive agents such as we are' (Vidmar, 2010:333). They can inform our understanding of the world and contribute new knowledge by raising awareness and shaping and expressing memories, concepts and identities. The study of artworks and artefacts can provide 'insight into the social functions of the cultural product itself (…), but also gain access to broader and more profound aspects of society' (Margolis, 2011:197).

A number of research methods for study of visual material exist in museology, ethnography and the arts. Among them, semiology has been used as an effective approach towards institutional museum critique; 'semiotics of signification have received much attention from people studying, writing and working within museum studies' (Kavanagh, 1991:5). However, while 'the cultural analysis and de-construction of the museum serves well the intellect', it 'does not necessarily offer useful means of developing more effective, relevant provision' (Kavanagh, 1991:5). Semiotic theory assumes that 'individual subjects (individuals) do not construct their own messages, but are themselves constructed by the messages implicit in the experience of the museum' and that 'visitors are assumed to be passive and uncritical, incapable of making their own meanings' (Kavanagh, 1991:52). During this study, artists and museum visitors were actively involved in the creation of meaning, therefore semiotic analysis is ill suited for this research.

Malcolm Collier, (in Van Leeuwen, 2001), argues that visual materials are both creations and reflections of human experience. He asserts that the content of visual images 'is rarely shaped only by the constructive influences of recorders and subjects' and proposes a basic model for direct visual analysis that seeks information on the subject, production and function of visual material, rather than on the 'constructed character of images' (Van Leeuwen, 2001:39). Collier's direct method of visual analysis alternates between intuitive interpretation and structured analysis. He argues that in the initial stage of analysis of visual data 'feelings and impressions' can provide direction for further analysis (Van Leeuwen, 2001:39). This initial intuitive step involves repeated open viewing of the visual materials. This is followed by the creation of an inventory of visual data, a structured analysis and a return to the 'complete visual record', bearing in mind the context arising from the structured analysis (Van Leeuwen, 2001:39).

This model of analysis was employed in this study, as it allowed the researcher to analyse visual material in detail while at the same time keeping sight of their larger, overall context.

3.5. Undertaking data analysis

The aim of data analysis is to identify patterns in data, which enable the researcher to move towards a more general interpretation of the meaning of an event, object or setting. In this research, visual materials were subjected to a visual analysis and content analysis was used to evaluate surveys and interview transcripts. No exclusive definition of content analysis exists (Patton and Appelbaum, 2003:67); content analysis describes all procedures, which seek to analyse data by creating content categories. Content analysis has been criticised for falling short of dealing with 'cultural significance' (Kohlbacher, 2006). The existence of both qualitative and quantitative approaches towards content analysis further complicates matters;

> '*Qualitative content analysis is criticized for its highly subjective character and difficulties with controlling the impact of the coder's personality. Criticisms of quantitative content analysis, on the other hand, suggest that the exclusive reliance on frequencies makes the humanities and social sciences a province of the natural sciences.'* (Oleinik, 2011:860)

As the use of digital technologies in the arena of the museum has both technological and cultural significance, an approach to content analysis was used in this research, which involves qualitative-interpretative steps of analysis.

The success of content analysis depends greatly on the coding process. There exist both deductive and inductive procedures of category development. Deductive categories are formulated using themes theoretical derived from the analysis of texts (Rose, 2006). Inductive coding categories, on the other hand, are formulated as near as possible to the research material. In this research, both deductive coding categories, derived from the visual and content analysis, and inductive coding categories, emergent from the visual data and semi-structured interviews, were used during content analysis.

3.5.1. Analysis of interview and survey data

The surveys used in this research contained both closed and open-ended questions. Participant responses were collated with transcripts from interviews and analysed through content analysis.

Both inductive and deductive coding categories were developed to capture the complexity of the field of study. Deductive coding categories were developed from the literature and contextual review and in light of the research question. Inductive categories emerged from a process of repeated reading of case study material in the form of questionnaire responses and interview summaries, in order to achieve immersion and obtain a sense of overarching themes (see Section 5.3. Analysis of data from questionnaires and interviews).

The coding categories were formulated into an initial coding scheme, which was worked through and revised. Overlapping coding categories, which were so similar as to be indistinct from each other, were subsumed, before being formulated into the final coding scheme (see Appendix A.10.1. Coding categories). The final coding scheme was used to work through the interview summaries again. Words and phrases in the interview summaries, which capture key themes were highlighted and used as examples in the coding scheme (see Appendix A.10.1. Coding categories).

Data from the interviews and surveys of the *(Im)material Artefacts* case study and *Lincoln 3D Scans* were coded and analysed separately. In the comparative study of these projects the emerging themes were then correlated and investigated for overarching subjects.

3.5.2. Analysis of artefacts and artworks

For this study, Collier's model of visual analysis (see Section 3.4.3. Visual data) was used to analyse artefacts and artworks. As a first step, two inventories of visual materials were created, one for the *(Im)material Artefacts* and one for the comparative case, *Lincoln 3D Scans* project. These inventories brought together the digital 3D models and the new artworks developed from digital 3D reproductions.

These two sets of visual data were then investigated separately through a process of structured visual analysis. This was done through the creation of visual layouts, which presented the new artworks together with the original museum artefacts from which they derive (Fig.9a and Appendix A.10.2. Visual inventories). Analysis was then undertaken by comparing the original artefacts and the new works, and noting the similarities and differences created by the editorial choices of the artists. The artefacts and artworks were then regrouped into a second set of layouts. This time, the original artefacts were arranged together with all artworks wholly or partially derived from them (Fig.9b and Appendix A.10.2. Visual inventories). This second step of visual analysis examined the artworks through the lens of the original artefacts and the information associated with them. Although both processes of visual analysis are relatively similar the reversal of predominance resulted in a shift in perspective. The artwork-museum artefact pairings could be seen as remixes and originals in one instance, and as new originals and source material in the other.

A set of categories was developed from this visual analysis; terms, such as 'distortion' and 'duplication' were selected to describe the visible differences between the originals and the remixed artworks. These categories were designed to be exhaustive (every discernible difference between the 3D models and the new digitally remixed artworks had to fall into a category), exclusive (categories should not overlap) and enlightening (the categories should produce a relevant and coherent breakdown of the visual material). The resulting categories provided a context within which the visual data was again viewed as a whole.

Fig.9a *Monkey Heaven*, Katie Parker and Guy Davis (Future Retrieval), 3D render of the digital sculpture, with original museum artefacts used in the piece; 2014 © Sarah Younan

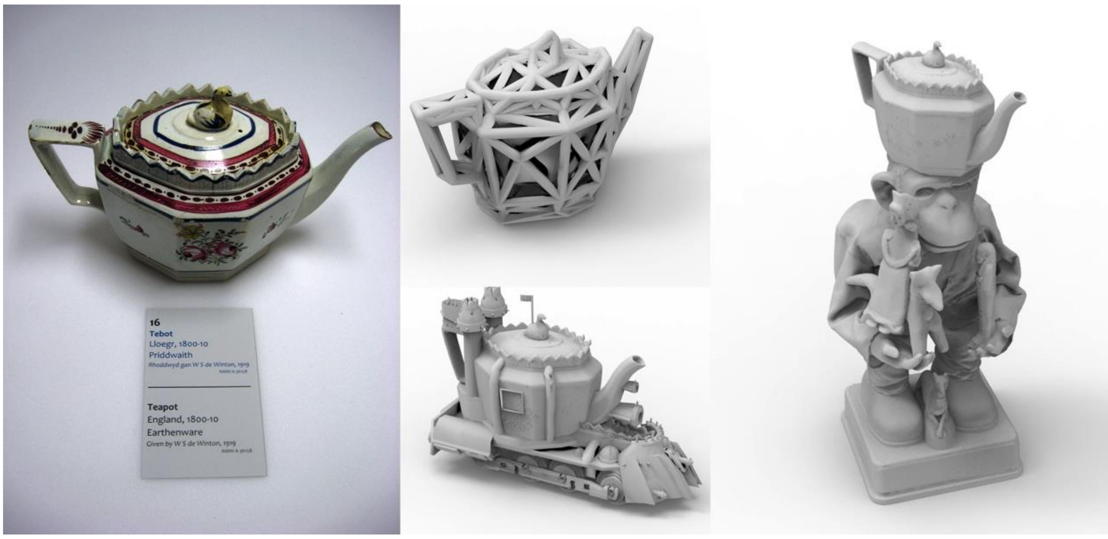

Fig.9b Teapot from the National Museum Cardiff (14.1cm x 22.8cm x 10.8cm), together with 3D renders of digital artworks derived or partially derived from it; 2014 © Sarah Younan

3.6. Discussion of research methodology

The focus of this research is on the cultural implications of creative engagement with digital 3D models of museum artefacts for audiences, artists, users and the museum institution itself. Quantitative methods cannot easily capture cultural circumstances and personal experiences, therefore qualitative research was undertaken during this study (see Section 3.2. Methodological approach).

Case study research was identified as a suitable research method (see Section 3.3. Theoretical framework) to allow an in-depth and detailed examination of the creative engagement with museum artefacts through the use of digital 3D technologies, as well as its related contextual conditions. The methods of triangulation and comparative case study were used to validate findings.

Research data was collected through questionnaires, interviews and from participant-produced visual material (see Section 3.4. Collection of data). These three sources provided a diverse range of textual, verbal as well as visual data. In order to gain an in-depth understanding and to help confirm the results of the research through a process of data triangulation, data analysis was undertaken using content analysis and structured visual analysis (see Section 3.5. Undertaking data analysis).

Data from the *(Im)material Artefacts* case study, which was a researcher-led project, was collated with data collected from an independent artist project outside the control of the researcher, the *Lincoln 3D Scans* project. The cases are described in detail in the following chapter (Chapter 4. Case studies).

4. Case Studies

4.1. Introduction

This chapter presents the *(Im)material Artefacts* case project and the *Lincoln 3D Scans* project, which were investigated as comparative case studies during this doctoral research. The projects share a similar conceptual design, even though they were conceived independently from one another. This chapter describes the projects, their similarities and dissimilarities and elaborates how they are suited for a comparative study.

This chapter is divided into two main sections, which present the *(Im)material Artefacts* case study and the *Lincoln 3D Scans* comparative case study. Section 4.2. gives a detailed description of *(Im)material Artefacts* case study. Section 4.3. presents a detailed account of the comparative case, the *Lincoln 3D Scans* project. Section 4.4. discusses the projects' suitability for a comparative study.

4.2. (Im)material Artefacts case study

In 2014, the *(Im)material Artefacts* project was undertaken as a collaborative case study at the National Museum Cardiff. For this study, ceramic artefacts from the storage collections of The National Museum Cardiff were selected and 3D scanned by the researcher. The resulting digital 3D models were shared with a number of artists, who were invited to respond to the digital artefacts by creating new work from them. A design brief was shared with participating artists outlining the project. It laid out the following guidelines:

- Artists were invited to access the 3D models of museum artefacts from the ceramics collection at the National Museum Cardiff via a shared Dropbox[97] folder.

- They were asked to select one or several of the 3D models and to create new artworks based on the digital models.

- Any form of work created using the digital 3D models was welcome, including screen-based work and digital files for 3D printing. The size of the 3D models for printing was limited to 26x15x15cm to control the cost of the project.

- After the initial open call, artists were given a four-month window to create work.

- The deadline for the submission of artworks was Monday the 3rd of February 2014.

All work received by the deadline date was included in the *(Im)material Artefacts* exhibition at the National Museum Cardiff. 3D files were printed at the National Centre for Product Design and Research[98]. The 3D printed objects, as well as screen-based works, were exhibited with the original ceramic museum artefacts from the 29th of April until the 29th of June 2014 in the ceramics galleries of the National Museum Cardiff. A symposium on artist engagement with museum collections, co-organised with Axisweb[99], took place in connection with the exhibition on the 14th of May 2014[100].

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[97] Dropbox is a file hosting service that offers cloud storage and file synchronization. Dropbox allows users to create and share folders on their computers. Files placed in this folder also are accessible through a website and mobile phone applications. See https://www.dropbox.com accessed 03.03.2014.
[98] This was funded via an Arts Council of Wales grant, a grant from the Welsh Institute of Research in Art and Design, and the researcher's private funds.
[99] Axisweb is an online platform for the contemporary arts in the UK. See http://www.axisweb.org/ accessed 29.04.2014.
[100] See http://www.axisweb.org/features/news-and-views/our-news-and-stories/behind-the-scenes-of-the-museum-artists-in-collections/, accessed 08.05.2015.

Fig.10a Ceramic artefacts from the storage collections of the National Museum Cardiff that were used in this research, dimensions variable, see Appendix A.3. Information on museum artefacts for more information; 2014 © Sarah Younan

Fig.10b 3D models of ceramic artefacts from the National Museum Cardiff , digitally rendered image; 2014 © Sarah Younan

4.2.1. Exploration and selection of museum artefacts

In the initial stage of the *(Im)material Artefacts* project, thirteen ceramic artefacts from the storage collections of the National Museum Cardiff (Fig.10a) were selected and digitised (Fig.10b). The objects were selected in collaboration with Andrew Renton, Keeper of Art at the National Museum Cardiff. Previous research in collaboration with the National Museum Cardiff (see Appendix B Background) had provided some insights into the ceramics collections in storage at the museum. For this reason, the focus on ceramic artefacts was taken forward in this study, in order to build on earlier insights. All artefacts used in the *(Im)material Artefacts* case study belong to the category of ceramic museum objects (for a detailed discussion of the individual pieces see Appendix A.3. Information on museum artefacts) and were selected from the museum's storage collections. This provided an opportunity to show artefacts that would not otherwise be put on display in the galleries and made handling and digitisation possible without interfering with the museum displays. The selected artefacts had to be suitable for 3D scanning, as complicated forms with undercuts could not be digitized with the tools and experience available. The selected ceramic artefacts stem from different cultures and periods in history and include both functional and figurative pieces, thus providing a diverse sample of ceramic objects held in store by the National Museum Cardiff. The ceramic artefacts were digitised using a NextEngine laser scanner (see Section 2.2.1. 3D scanning). Digital 3D models of the chosen objects were then shared with British and international artists.

4.2.2. Participating artists

While museums are bound to the representation of historically accurate information, artists are free to stroll into the realm of imagination and phantasy. Museums use digital 3D technologies within the delineated context of their key duties: preservation, display and research. In addition many museum curators lack knowledge on digital culture and technologies, which can hamper their understanding of the uses of digital 3D models. Artists pose different questions than heritage institutions; they are more likely to creatively engage with 3D models and to explore them in an experimental and open-ended manner. Furthermore, artists working in digital media are already familiar with digital culture and are practised users of digital editing tools. In qualitative research, case study participants are selected to be 'representative of the same experience or knowledge; they are not selected because of their demographic reflection of the general population' (Denzin and Lincoln, 1998:74). This was the case for artists participating in *(Im)material Artefacts*; the choice of this group was motivated by the need to find participants with the ability to work creatively with digital 3D models, and the artistic insight and confidence to discuss their experiences and thoughts.

Artists with experience in using digital technologies were recruited as participants in the *(Im)material Artefacts* case study through open calls posted on the Axisweb website[101], on the Design Wales blog[102] and the Bloc arts website[103]. To ensure the project would also receive submissions from further afield, a small number of international artists were contacted via email and personally invited to participate. Artists came from a variety of creative backgrounds, including ceramics, video game design, industrial design, film and graphic design. The open call provided an introduction to the project, informing artists about the outline of the project and their participation in this research (see Appendix A.2. Open call). Forty artists responded to the email invitations and the open call and were given access to the shared Dropbox folder with the digital museum models. The Dropbox folder contained 3D models of the digitized museum artefacts, as well as colour photographs of the scanned artefacts and background information from the museum archives (see Appendix A.3.1. Archival information).

Artists participating in the *(Im)material Artefacts* project were asked to submit

[101] See http://www.axisweb.org/ , the open call has since been taken down. Accessed 03.03.2014. For the open call document see Appendix A.2. Open call.
[102] See http://www.designwalesforum.org/blog/item/id/im-material-artefacts , accessed 03.03.2014.
[103] See http://bloc.org.uk/whats-exciting/immaterial-artefact/, accessed 03.03.2014.

finished work by Monday the 3rd of February 2014, just over a month prior to the proposed opening date for the *(Im)material Artefacts* showcase at the National Museum Cardiff. Out of the forty artists who had access to the shared Dropbox folder, eleven submitted finished artworks. These eleven artists included ten male and one female artist. The group included three artists from the UK, three artists from the United States, and one artist each from Denmark, Kenya, Egypt, Mexico and Panama (see Appendix A.6. Participant profiles for details on the participants).

4.2.3. Creation of artworks and data collection

Artists were given a four-month window to experiment and create new artwork with the 3D models of artefacts from the National Museum Cardiff. In order to avoid influencing their creative process, the researcher did not contact artists during the creative phase in which they selected, edited and re-imagined the 3D scans. During this creative stage, the participating artists employed various technological tools and processes to transform the 3D models of museum artefacts. Participating artists used over thirty different software programmes for animation, 3D and 2D editing. These included a range of commercially available 3D modelling and computer aided design (CAD) software such as Adobe editing programmes and Rhinoceros 3D[104], as well as free software such as the Autodesk suite[105] and open-source[106] software like Meshlab[107] and Blender[108].

[104] Rhinoceros 3D is a commercial 3D computer graphics application software. See https://www.rhino3d.com, accessed 05.02.2015.
[105] Autodesk 123D is a suite of free hobbyist CAD and 3D modelling tools. See http://www.123dapp.com, accessed 05.02.2015.
[106] Open-source describes software the source code of which is made available to the public. It is legal to study, change and distribute the software to anyone and for any purpose. Open-source software is very often developed in a public, collaborative manner.
[107] MeshLab is a free and open-source software 3D editing software programme. See http://meshlab.sourceforge.net, accessed 05.02.2015.
[108] Blender is a free and open-source 3D editing software programme. See http://www.blender.org, accessed 05.02.2015.

4.2.4. Artworks

The following artworks were produced for *(Im)material Artefacts*: by participating artists:

Fig.11a *Screwed Up*, Flemming Tvede Hansen, 3D render of digital sculptures; 2014 © Sarah Younan

Fig.11b *Screwed Up*, Flemming Tvede Hansen, 3D printed models (14cm x 10.2cm x 10.8cm) and original bonbonnière (8cm x 5.8cm x 5.8cm); 2014 © Sarah Younan

- The Danish artist Flemming Tvede Hansen[109] chose the 3D model of an 18th century Staffordshire bonbonnière (see Appendix A.3. Information on museum artefacts) to create work for *(Im)material Artefacts*. From the museum archives Hansen learnt that this object had a screw-on lid. This information had been lost in the scanning process, as the original artefact was scanned with the lid screwed on. Hansen produced a series of three bonbonnières, with twisted necks and screwed up faces (Fig.11a, 11b).

- The artist duo Katie Parker and Guy Davis (working together as 'Future Retrieval')[110] 3D scanned an antique monkey automaton and combined it with the digital 3D models of a teapot, a greyhound figurine, an archaic rider figure and an ushabti figure from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts) to create *Monkey Heaven* (Fig.12a, 12b).

Fig.12a *Monkey Heaven*, Katie Parker and Guy Davis (Future Retrieval), 3D render of digital sculpture; 2014 © Sarah Younan

[109] The artist's website: http://flemmingtvede.dk/index.html, accessed 12.10.2015.
[110] The artists' blog: http://futureretrieval.blogspot.co.uk/, accessed 12.10.2015.

Fig.12b *Monkey Heaven*, Future Retrieval, 3D printed model (17.6cm x 9.7cm x 10.8cm) and original artefacts from the National Museum Cardiff; 2014 © Sarah Younan

Fig.13a *Teapot Trainfortress*, Ian Cooke Tapia, 3D render of digital sculpture; 2014 © Sarah Younan

Fig.13b *Teapot Trainfortress*, Ian Cooke Tapia, 3D printed model (, 14.7cm x 23cm x 10.8cm) and original teapot from the National Museum Cardiff; 2014 © Sarah Younan

- Panama-born artist Ian Cooke Tapia[111] chose to work with the 3D model of a teapot from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts), which he turned into a steam-engine toy train (Fig.13a, 13b). The architectural ridge around the top of the teapot reminded Tapia of the architecture or towers and castles. Cooke imagined little people living in and around this teapot fortress. By building structures around the teapot model, adding cannons, wheels, and towers Tapia turned the teapot into a fortified castle on wheels

- The artist and games designer Jason Rouse[112] created a first-person shooter video game from the 3D scan of a Mexican mask (see Appendix A.3. Information on museum artefacts). Rouse transformed the 3D model into a computer game island, which players can wander across using keyboard commands. He drew inspiration from a recent trip to Mexico.

[111] The artist's website: http://cookecanvas.com/, accessed 12.10.2015.
[112] The artist's website: http://www.jasonrouse.co.uk/, accessed 12.10.2015.

Rouse created the first-person shooter game *Postcards from Mexico* (Fig.14a, 14b) using the multi-platform113 game creation system Unity[114]. *Postcards from Mexico* includes additional 3D models downloaded from the Unity asset store[115].

Fig.14a *Postcards from Mexico*, Jason Rouse, screenshot from video game; 2014 © Jason Rouse

Fig.14b *Postcards from Mexico*, Jason Rouse, overview of game map; 2014 © Jason Rouse

[113] The term multi-platform describes computer software or computing methods and concepts that can operate on multiple computer platforms, such as Windows, Macintosh or Linux operating systems.

[114] Unity is a consumer-targeted computer game development environment, which consists of a set of specialized design tools engineered to allow users to create computer games with no or little coding required. See http://unity3d.com/unity , accessed 29.01.2015.

[115] For example, a water tower used in the video game *Postcards from Mexico* can be downloaded here: https://www.assetstore.unity3d.com/en/#!/content/77, accessed 29.01.2015.

Fig.15a *Cupid Goat*, John Rainey, 3D render of digital sculptures; 2014 © Sarah Younan

Fig.15b *Cupid Goat II*, John Rainey, 3D printed model (20.3cm x 13.9cm x 9.4cm) and original figurine from the National Museum Cardiff; 2014 © Sarah Younan

- John Rainey[116], an artist from North Ireland, chose to work with the 3D model of a late 18th century Derby Porcelain figure of a cupid riding a goat (see Appendix A.3. Information on museum artefacts). The original

[116] The artist's website: http://www.johnrainey.co.uk/, accessed 09.12.2014.

Derby figurine was produced using industrial slip casting techniques; it is one example of many, rather than a unique sculpture. Rainey used digital manipulation to render the sculpture into a series of four individually distorted pieces (Fig.15a, 15b). Rainey also submitted a digital animation film, which shows the 3D model twist and distort into new shapes (Fig.16).

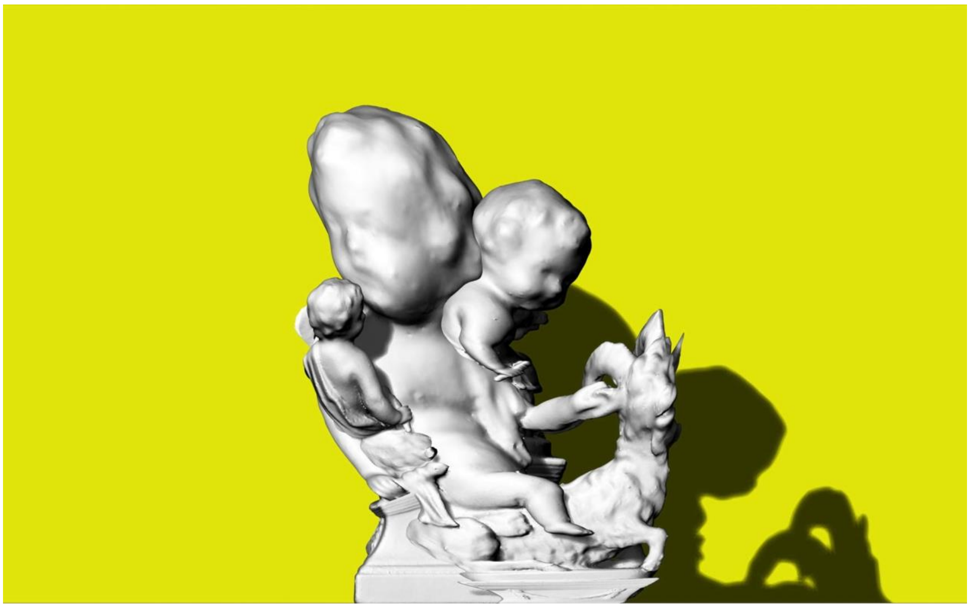

Fig.16 *Cupid Goat Interlude*, John Rainey, screen shot from animated film; 2014 © Sarah Younan

Fig.17 *Alien Fanfare*, Jonathan Monaghan, screen shot from animated film; 2014 © Sarah Younan

- For the *(Im)material Artefacts* project American artist Jonathan Monaghan[117] modelled a cup from the 3D scans of a bonbonnière, a 18th century stirrup cup and a cream jug (see Appendix A.3. Information on museum artefacts). Monaghan submitted this cup as a digital file for 3D printing, and also incorporated it in an animation film, which he also submitted for *(Im)material Artefacts* (Fig.17).

- Mexican designer Mario Padilla[118] chose to work with the 3D model of a Mexican mask (see Appendix A.3. Information on museum artefacts) from the collections at the National Museum Cardiff. Padilla added a fragile, lattice-structure body to the shape of the original mask (Fig.18a, 18b).

Fig.18a *Cantli*, Mario Padilla, 3D render of digital sculpture; 2014 © Sarah Younan

[117] The artist's website: http://jonmonaghan.com/, accessed 12.10.2015.
[118] The artist's website: https://www.behance.net/mariopadilla, accessed 12.10.2015.

Fig.18b *Cantli***,** Mario Padilla, 3D printed model and original artefact from the National Museum Cardiff; 2014 © Sarah Younan

Fig.19 *WsB-Transforma*, Mohamed Hossam, 3D render of digital sculpture; 2014 © Sarah Younan

- The Egyptian artist Mohamed Hossam selected the 3D model of an ancient Egyptian 'ushabti' figure (see Appendix A.3. Information on museum artefacts). Hossam's *WSB Transforma* (Fig.19) was regrettably not suitable for 3D printing and his artwork was not shown as part of the *(Im)material Artefacts* display at the National Museum Cardiff. A digitally rendered image of the 3D model was, however, displayed on the blog that accompanied the exhibition[119].

Fig.20 *Growing*, Zachary Eastwood-Bloom, 3D printed nylon and borax crystals, 14.9cm x 10cm x 10cm and 8cm x 5.8cm x 5.8cm; 2014 © Sarah Younan

- London-based artist Zachary Eastwood-Bloom[120] chose to work with the 3D model of a bonbonnière and the 3D model of a vase (see Appendix A.3. Information on museum artefacts) from the National Museum Cardiff. Eastwood-Bloom decreased the polygon mesh face count[121] of the 3D

[119] See http://immaterialartefacts.blogspot.co.uk/2014/04/wsb-transforma-mohamed-hossam.html, accessed 29.01.2015.
[120] The artist's website: http://www.zacharyeastwood-bloom.com/. Accessed 12.10.2015.
[121] A polygon mesh is a collection of vertices, edges and faces that defines the shape of a digital 3D object. If the number of faces is decreased, the shape of the 3D objects is simplified, similar to when the resolution of a digital image is decreased.

models, and printed them in nylon material. He then soaked the nylon lattice structures in a borax solution in order to allow crystals to grow on them. The crystals add complexity to the bare lattice structures (Fig.20).

Fig.21a *Teapot*, Zack Dougherty, 3D render of digital model; 2014 © Sarah Younan

Fig.21b *Teapot*, Zack Dougherty, 3D printed model and original artefact from the National Museum Cardiff, 14.1cm x 22.8cm x 10.8cm; 2014 © Sarah Younan

- For *(Im)material Artefacts* the American media artist Zack Dougherty[122] chose to work with the 3D scan of a teapot from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts). Dougherty, who usually produces work in GIF (see Glossary) format, took the opportunity to create a digital sculpture for 3D printing. Dougherty transformed the form into a lattice and placed a cup inside this structure (Fig.21a, 21b).

- The Kenyan artist and filmmaker Jeff Waweru[123] submitted a documentary style film and a wooden sculpture. The wooden sculpture *Curio Dog* (Fig.22a) is a hand made replica of a 17th century greyhound ornament from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts). Waweru commissioned it from local craftsmen who produce and sell work in little curio shops in Waweru's hometown Nanyuki. The carvers modelled the replica after a photograph of the original artefact, and a screenshot of its 3D model. Waweru produced a short documentary-style film of its creation (Fig.22b). The wooden replica and film submitted by Waweru were created without the use of digital 3D editing technologies.

Fig.22a *Curio Dog*, Jeff Waweru, wooden sculpture, 17.4cm x 23cm x 10.8cm; 2014 © Sarah Younan

[122] The artist's website: http://hateplow.tumblr.com/, accessed 12.10.2015.
[123] The artist's flickr account: https://www.flickr.com/photos/jeffwaweru/, accessed 12.10.2015.

Fig.22b *Curio Dog*, Jeff Waweru, screenshot from documentary film; 2014 © Jeff Waweru

Fig.23 *(Im)material Artefacts* display in the applied arts galleries of the National Museum Cardiff; 2014 © Dave Daggers

4.2.5. Public exhibition

The *(Im)material Artefacts* case study culminated in a public exhibition at the National Museum Cardiff[124] from the 29th of April until the 29th of June 2014. This exhibition allowed the researcher to collect audience feedback. The exhibition was also a motivational factor for participating artists as it gave them an opportunity to show their work in a national museum and thus provided them with stimulus to participate in the project.

Together with Andrew Renton, Keeper of Art at the National Museum Cardiff, a showcase of the artists' submissions and the original museum artefacts was installed in the applied arts galleries of the National Museum Cardiff (Fig.23). Initially, 3D printing demonstrations were planned as part of this display. Arrangements had been made with the 3D printer company Ultimaker[125] and three tabletop printers were scheduled to be set up and running during the exhibition. However concerns by the health and safety department prevented this. 3D printing displays would have drawn further interest from audiences and added a further dimension to this research. Instead, the digital artworks were 3D printed off-site at the National Centre for Product Design and Research[126] using stereolithography printing (see section 1.1.3. 3D Print) and the *(Im)material Artefacts* display was designed to be as unobtrusive as possible in order to create an environment that would allow visitors to see the display without additional distractions. The display was set up in standard museum display cases, which were emptied of their previous content and filled with the original artefacts and the artworks created by participating artists. A widescreen display was also set up to showcase screen-based artworks. A wall panel provided background information to the display (see Appendix A.9. *(Im)material Artefacts* exhibition), and a QR code (see Glossary) link to the *(Im)material Artefacts* blog page[127] provided further information on the project. The exhibition opened to the public on the 29th of April 2014.

[124] See http://www.museumwales.ac.uk/whatson/?id=7428, accessed 04.05.2015.
[125] See https://ultimaker.com/en, accessed 14.10.2015.
[126] See http://pdronline.info/ , accessed 28.03.2014.
[127] See http://immaterialartefacts.blogspot.co.uk, accessed 09.04.2015.

4.3. Comparative case study: the *Lincoln 3D Scans* project

The *Lincoln 3D Scans* project started in 2012, when the artist Oliver Laric was invited by the Usher Gallery and The Collection in Lincoln to propose an idea for the Contemporary Art Society's Annual Award for museums[128]. Laric proposed to 3D scan and subsequently publish all data for free, his proposal was chosen as the winning project.

This proposal led to the creation of the *Lincoln 3D Scans* website[129], where 3D models can be downloaded as STL files in order to be used without copyright restrictions. The *Lincoln 3D Scans* website includes a 'gallery', where the public can share images of the artworks they have created from the 3D scans[130]. Users of the website are invited to treat the digital 3D models as starting points for new works and have the possibility of sharing their creative responses to the 3D models via an online gallery[131].

Lincoln 3D Scans is an on-going project; users are able to access the 3D scans and submit their creative responses to the *Lincoln 3D Scans* online gallery, remixed artworks continue to be added to the website. For this research, scans and artworks were sampled from the *Lincoln 3D Scans* online gallery on the 9th March 2015, and the website was saved for further study and reference as a PDF file.

Lincoln 3D Scans and *(Im)material Artefacts* share a number of similarities, which make the projects well suited for a comparative case study:

- Both projects take 3D scans of museum artefacts as the starting point for the creation of new work

- During both projects the 3D scans were shared digitally via the Internet

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[128] Every year, the Contemporary Art Society Annual Award supports a UK museum to work with an artist of their choice to commission a new work that, once completed, will remain within the museum's permanent collection. See http://www.contemporaryartsociety.org/initiatives/annual-award/, accessed 05.02.2015.

[129] See http://lincoln3dscans.co.uk, accessed 05.02.2015.
[130] see http://lincoln3dscans.co.uk/gallery/, accessed 23.01.2015.
[131] See http://lincoln3dscans.co.uk/gallery/, accessed 21.01.2015.

- The projects are both collaborative

- Both projects were wide in scope and included contributions from all over the world

However, there are also a number of differences between *Lincoln 3D Scans and (Im)material Artefacts*:

- *Lincoln 3D Scans* was conceived as a conceptual artwork, of which Oliver Laric is the principal author. *(Im)material Artefacts*, on the other hand, was designed as a case study and the researcher played the role of facilitator and organizer, rather than author.

- *Lincoln 3D Scans* is an open-ended, ongoing project; 3D Scans remain available online and new work continues to be added to the online gallery. In contrast, *(Im)material Artefacts* had a fixed schedule and culminated with an exhibition at the National Museum Cardiff.

- The *Lincoln 3D Scans* artworks are displayed via and online gallery, *(Im)material Artefacts* was exhibited as a glass case display in the applied arts galleries of the National Museum Cardiff.

- For *(Im)material Artefacts* 3D scans were made from ceramic artefacts held in storage at the National Museum Cardiff; the 3D scans made for *Lincoln 3D Scans*, on the other hand, include artefacts made from different materials and encompasses artworks as well as applied arts objects.

4.3.2 3D scans of artefacts from Lincoln

Like the *(Im)material Artefacts* project, *Lincoln 3D Scans* makes digital 3D models of museum artefacts available for creative use. The sculptures and artefacts that were digitised for *Lincoln 3D Scans* (Fig. 24) stem from different cultures and periods in history and include both functional and figurative pieces, as well as 3D models of objects that are found in the museum for practical purposes (such as, for example, a chair).

The City and County Museum in Lincoln (now known as The Collection) opened to the public in 1907. The early museum was focused on local connections and contained natural history specimens, archaeological and ethnographical artefacts and decorative art. By 1974 the primary focus of the City and County Museum had shifted to local archaeology. In 2005 the City and County Museum in Lincoln merged with the Usher Gallery and was renamed as The Collection: Art and Archaeology in Lincolnshire (The Collection in short).

Fig.24 Some of the 3D scans available for download on the *Lincoln 3D Scans* website

The Usher Gallery was originally built to house the private collection of watches, miniatures, porcelain and silver of the jeweller and businessman James Ward Usher. Usher bequeathed his collection and money to build a gallery to the City of Lincoln following in 1921. Today, the joint collections of the Usher Gallery and The Collection encompass local and foreign archaeology, geology, natural history, arms and armour, ethnographical artefacts and the applied and decorative arts. On the 9th March 2015 seventy-four digital 3D models of artefacts from the Usher Gallery and The Collection in Lincoln were available on the *Lincoln 3D Scans* website[132]. Digital 3D models available on the website included scans of busts, sculptures, architectural features, and functional artefacts, in wood, plaster, stone and other materials, a museum model of Homo Heidelbergensis, a fragment of an Anglo Saxon pelvis bone and a 21st century office chair. The 3D models of museum artefacts are presented with little background information on the *Lincoln 3D Scans* website; under an image of the artefacts their name, maker, period, material, and sometimes inscriptions found on the objects are presented[133]. When users click on an object, they are taken to a link where they can download an STL file of their chosen 3D model[134]. On this web page users also have the possibility of following a link to an archive page[135] on the original object. The online archive of the Usher Gallery and The Collection gives background information, such as physical dimensions, material, period and maker for the original museum artefacts digitized for the project. For a number of digital models, such as the 3D model of an office chair[136], no archival information is available.

4.3.2. Users

The *Lincoln 3D Scans* project enables open use of 3D models of museum artefacts available online. Users can share their work on the *Lincoln 3D Scans* online gallery[137], but are under no obligation to do so. On the 9th of March 2015 thirty-eight users had uploaded forty-nine images and GIFs (Graphics Interchange Format, see Glossary) to the *Lincoln 3D Scans* online gallery. Their engagement with the digital 3D models of museum artefacts follows a similar pattern as the engagement of *(Im)material Artefacts* participants: downloading of digital 3D files, creative use, display of the resulting works.

[132] See http://lincoln3dscans.co.uk, accessed 29.01.2015.
[133] See http://lincoln3dscans.co.uk, accessed 29.01.2015.
[134] See for example http://lincoln3dscans.co.uk/the-prodigal-son/, accessed 29.01.2015.
[135] See for example http://www.lincstothepast.com/THE-PRODIGAL-SON/463738.record?pt=S, accessed 29.01.2015.
[136] See http://lincoln3dscans.co.uk/in-progress-chair/, accessed 29.01.2015.
[137] See http://lincoln3dscans.co.uk/gallery/, accessed 04.05.2015.

It was possible to retrieve background information on some users of the *Lincoln 3D Scans* website via links to their personal websites[138]. Like the *(Im)material Artefacts* participants, *Lincoln 3D Scans* users come from a variety of cultural backgrounds. Contributions to the *Lincoln 3D Scans* gallery were made by users from Brazil, France, New Zealand, Norway, the UK, Poland, Spain, the Netherlands, and the United States. However, it was not possible to confirm the nationality or identity of most users, as many shared work on the *Lincoln 3D Scans* gallery under alias names and did not provide links. The alias names of twenty-five users whose work was examined for this study appear to be male names and seven alias names appear to be female, the remaining aliases (such as *4vector* or *Madeinneverland*) do not signal the likely gender of the users[139].

Unlike participants of the *(Im)material Artefacts* project, these users do not necessarily have a creative background or possess skills in the use of digital 3D editing technologies. Although some *Lincoln 3D Scans* users are artists, such as Jonathan Monaghan, who also made work for *Lincoln 3D Scans*, most users are creative hobbyists.

4.3.3. *Lincoln 3D Scans* artworks

This section presents an overview of the artworks sampled from the *Lincoln 3D Scans* online gallery on the 9th March 2015. The comparison of these works with the artworks submitted for *(Im)material Artefacts* revealed similar traits and motifs as well as differing content. Artworks uploaded to the *Lincoln 3D Scans* gallery include animated GIFs (See Glossary), digitally rendered images and virtual environments, photographs of 3D prints, and multimedia installations. Some artworks are ambitious in their presentation and level of detail, while other works are examples of experimentation and play. In this section, exemplary artworks are presented in clusters, grouped according to their format

[138] On the *Lincoln 3D Scan* online gallery to which volunteers can submit work, with the possibility of providing links to their personal blogs or websites, the researcher was able to find the contact details of ten *Lincoln 3D Scans* users in this way.

[139] User names and aliases only point towards the possible gender of the users, this cannot be taken as evidence of their real-life gender identity.

and style.

Animated GIFs:

- *Prehistoric Poltergeist (Product Cycle) (ii)* shows a 3D model of a Homo Heidelbergensis effigy rotating in front of the snowstorm of a static television display[140], surrounded by flying smartphones (Fig.25).

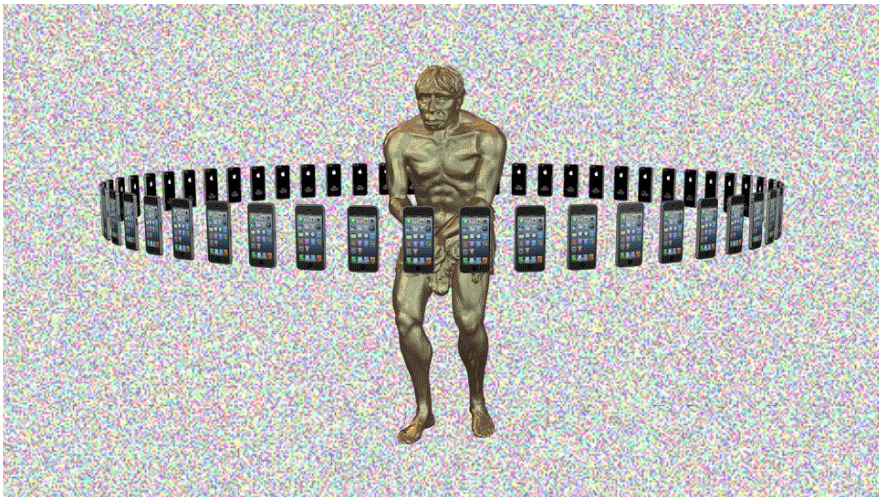

Fig.25 *Prehistoric Poltergeist (Product Cycle) (ii)*, Tom Pounder, still image from animated GIF

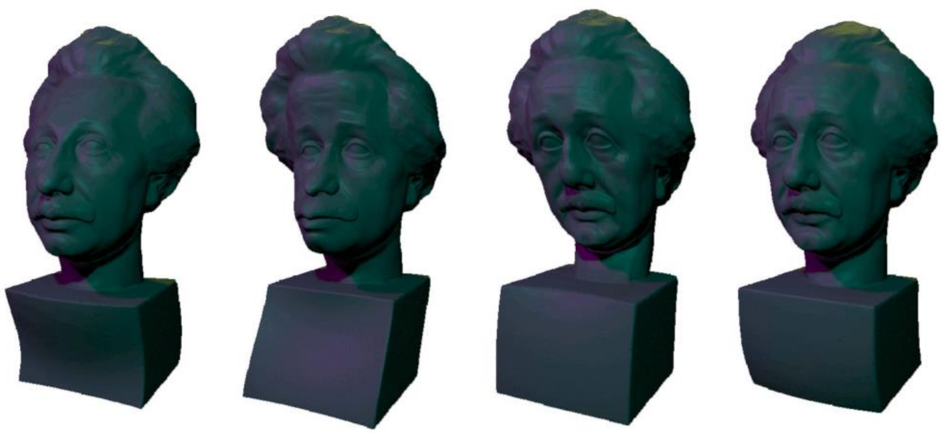

Fig.26 *EINSTEIN*, Mathew Williamson, still image from animated GIF

[140] The random flicker of dots of static television displays appears when no transmission signal is received by television sets. This 'snowstorm' is the result of electronic and magnetic 'noise' accidentally picked up by the television sets.

- *EINSTEIN* (Fig.26) by Mathew Williamson is an animated GIF of the 3D model of a bust of Einstein created by Arthur Lowenthal in 1930. Waves appear to run through the bust.

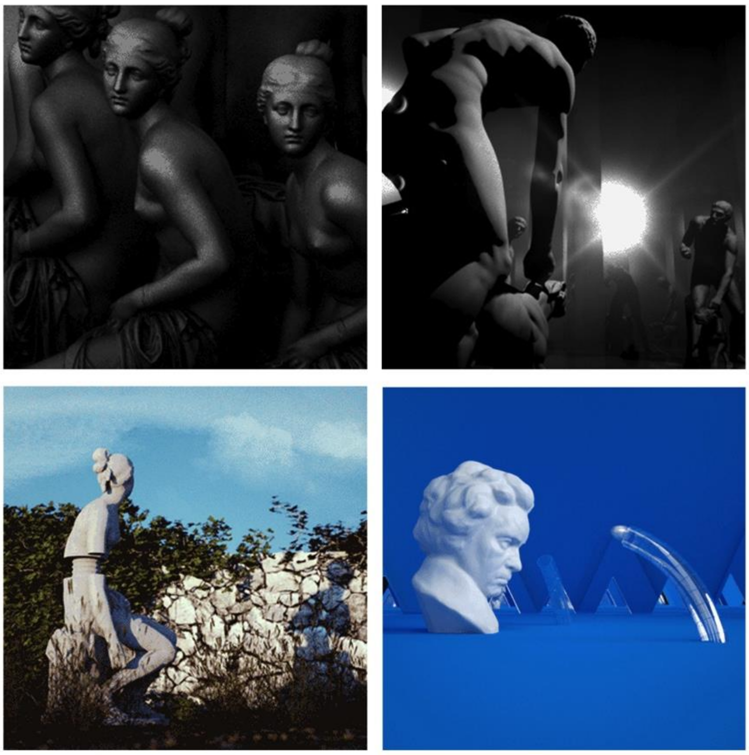

Fig.27a-d *Untitled 1-4*, Spyro, still images from animated GIFs

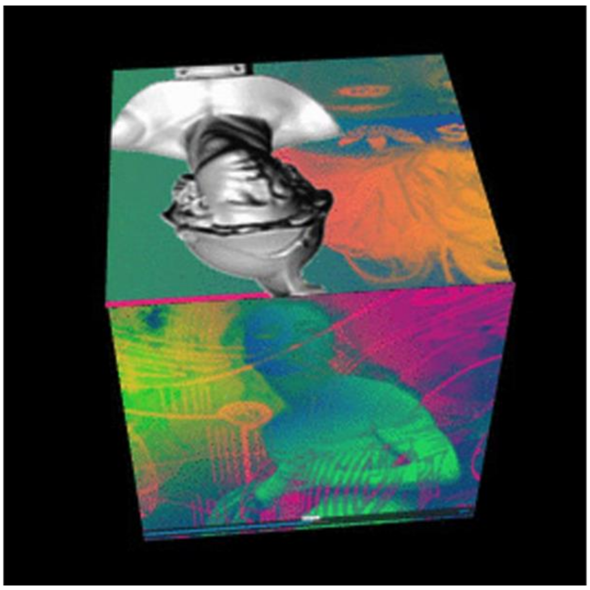

Fig.28 *Untitled*, Will Kendrick, still image from animated GIF

- Four surrealistic GIFs of classical statues by the user Spyro - an endless parade of bathing nymphs, a hunter and his dog with rotating lights and light sources and mirrors, a nymph in a garden that twists round and upwards, revealing a screw in the centre of the figure and a bust of Beethoven facing a clear tube that shoots white balls against its forehead (Fig.27a-d).

- *Untitled* by the user Will Kendrick shows a colourful rotating cube, with 2D images of the *Lincoln 3D Scans* on its surface (Fig.28).

Rendered images:

- Several works shared by users on the *Lincoln 3D Scans* online gallery were created through the application of texture maps. Texture mapping describes the wrapping of a 2D graphics surface, called a texture map, around a 3D model[141]. In this way the surface of the 3D model takes on the appearance of a solid, textured object. Many of the artworks in the *Lincoln 3D Scans* online gallery have textures that resemble stone, marble and metals (Fig.29); other works sport colourful and lustrous surface textures (Fig.30).

[141] This can be explained, in simplified terms, as equivalent to applying wallpaper to a wall surface.

Fig.29 *Untitled*, b2przemo, digitally rendered image of digital 3D model with marble texture

Fig.30 *Untitled*, Leah Ferrini, digitally rendered image of digital 3D model with metallic, lustrous texture

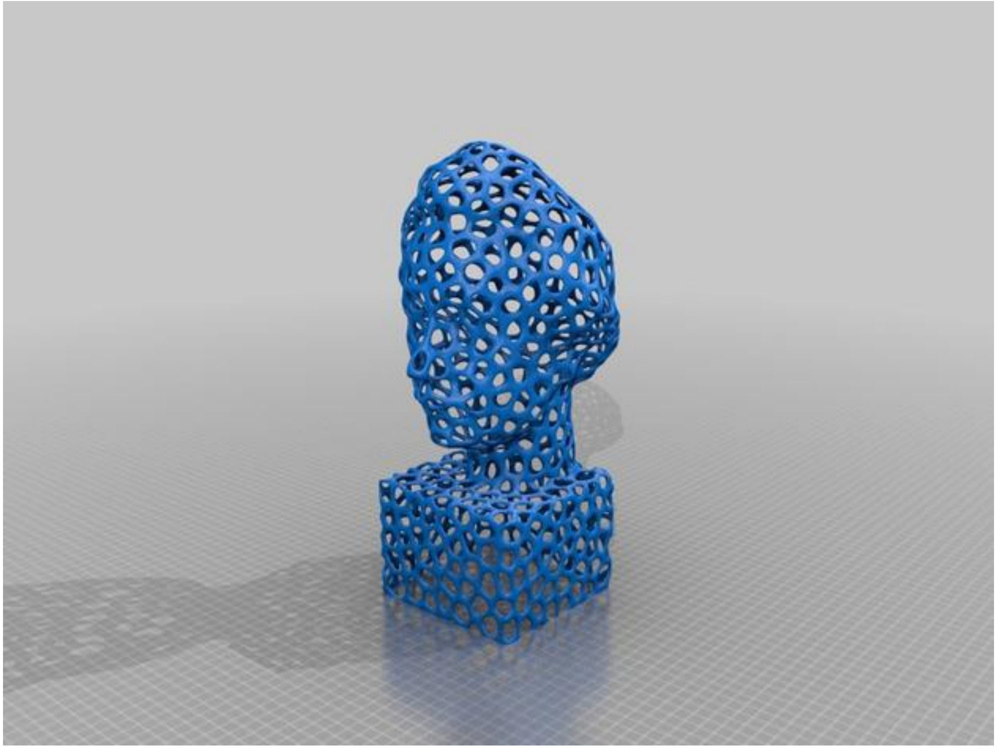

Fig.31 *Einstein Bust (Voronoi Style)*, 3DWP, digitally rendered image of digital 3D model

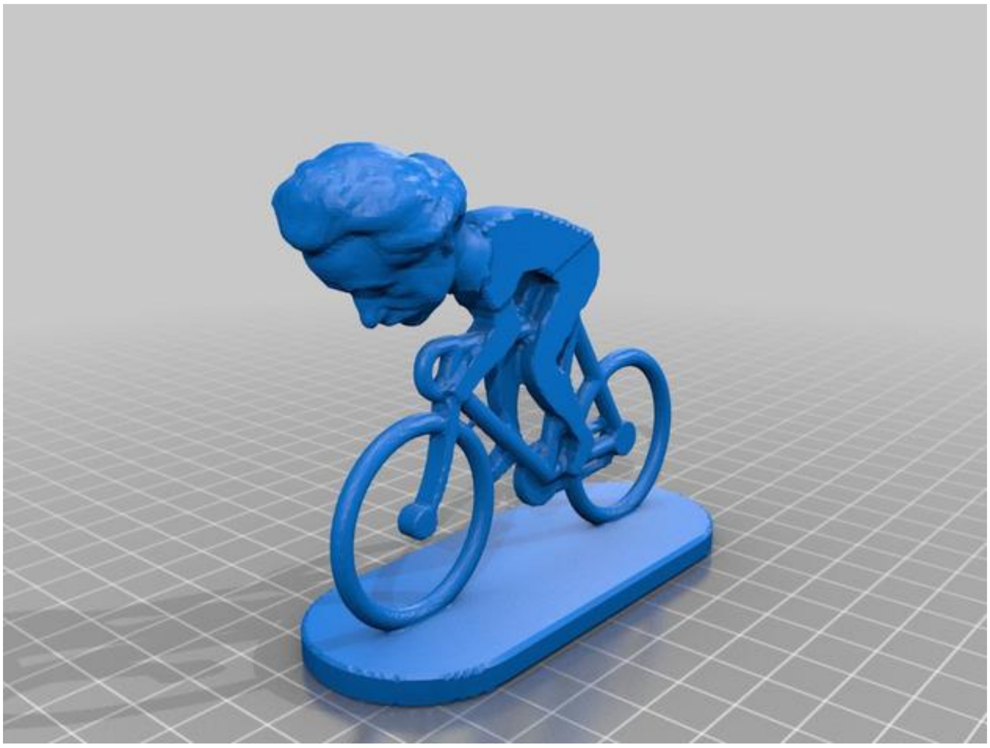

Fig.32 *Einstein Wins Tour De France*, DanBot, digitally rendered image of digital 3D model

Fig.33 *Untitled*, Andreas Martini, digitally rendered image of 3D model in digital environment

- The form of the 3D models is transformed in a number of works. *Einstein Bust (Voronoi Style)* reinvents the Einstein bust as a lattice structure with Voronoi patterns[142] (Fig.31). *Einstein Wins Tour De France* shows Einstein riding a bicycle (Fig.32). Andreas Martini's *Untitled* (Fig.33) presents the 3D model of a 2nd century bust of Aphrodite with tentacle shapes sprouting from her face. *Draped Beethoven* shows the digital 3D model of a 20th century bronze bust of the composer hidden under the folds of a digital 'fabric' (Fig.34). *Untitled* by the user Rune J. W. shows the 3D model of a medieval helmet blossom into a flower (Fig.35).

[142] In mathematics, a Voronoi diagram is a partitioning of a plane into regions based on distance to specified points (called seeds, sites, or generators). The corresponding region of each seed consists of all points closer to that seed than to any other. The resulting patterns are called Voronoi patterns. They can be generated using algorithms, as was probably the case for *Einstein Bust (Voronoi Style)*.

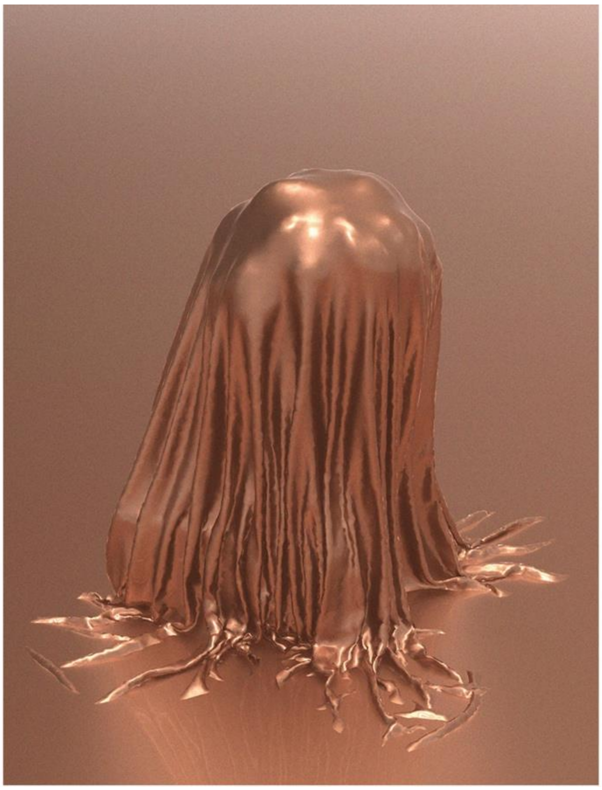

Fig.34 *Draped Beethoven*, Hugo Scibetta, digitally rendered image of 3D model

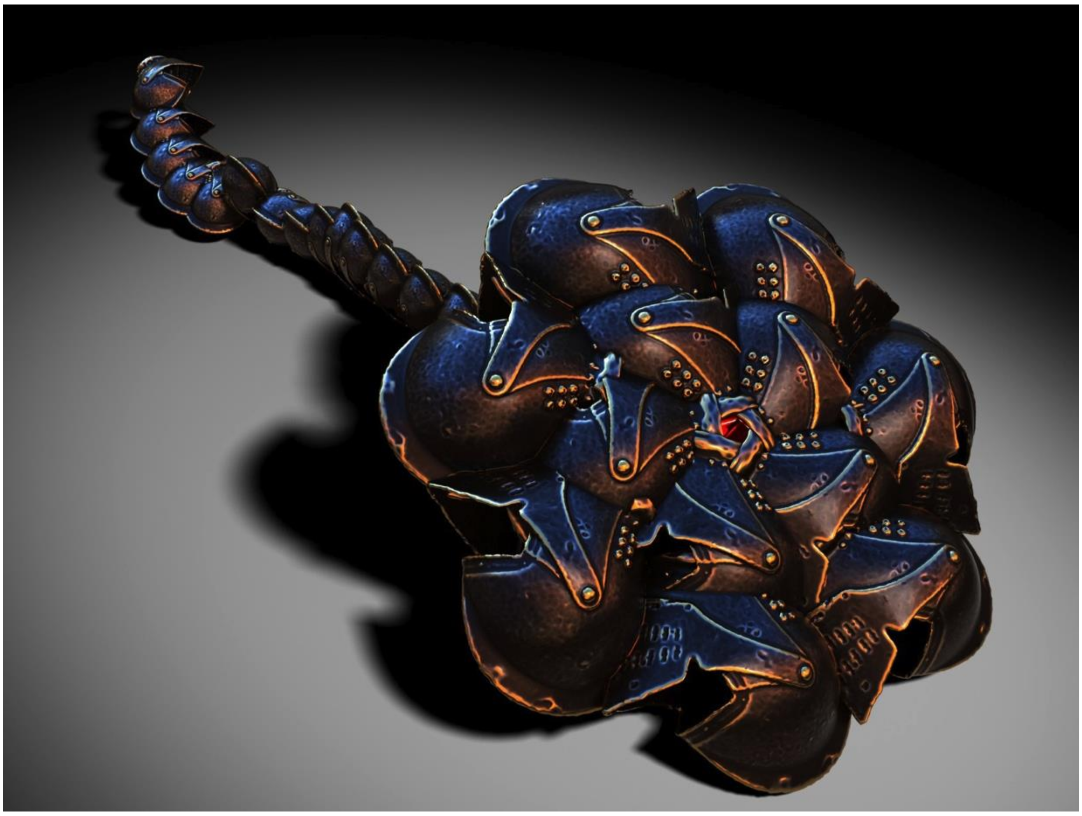

Fig.35 *Untitled*, Rune J. W. digitally rendered image of 3D model

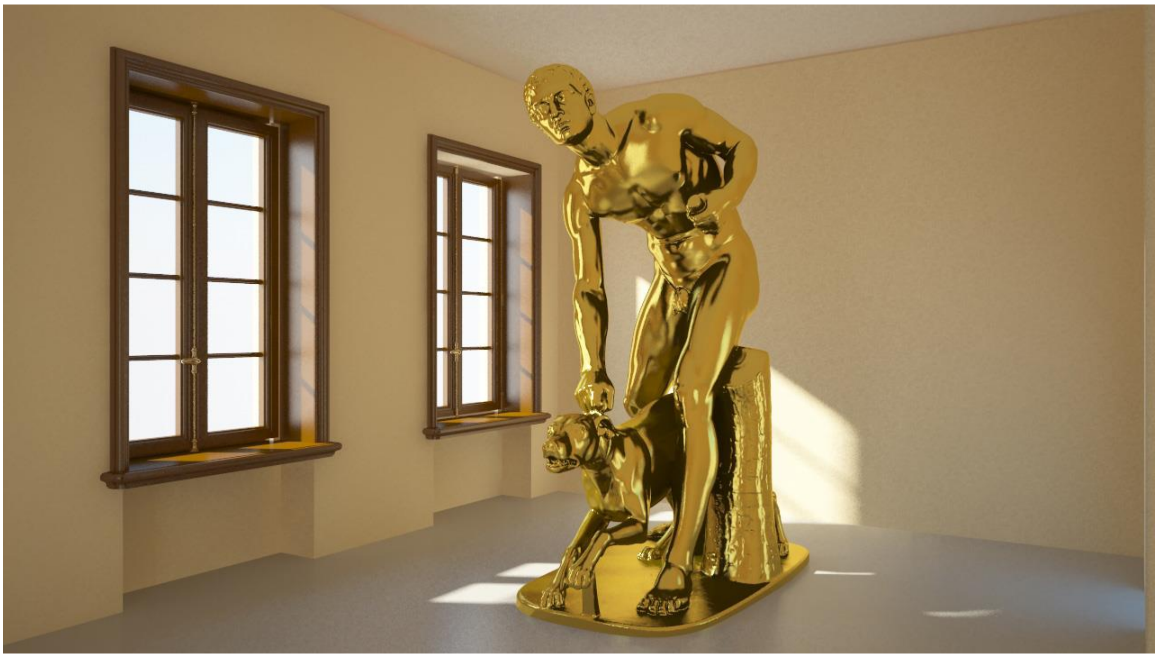

Fig.36 *Untitled*, Suresh N Yadav, digitally rendered image of 3D model in digital environment

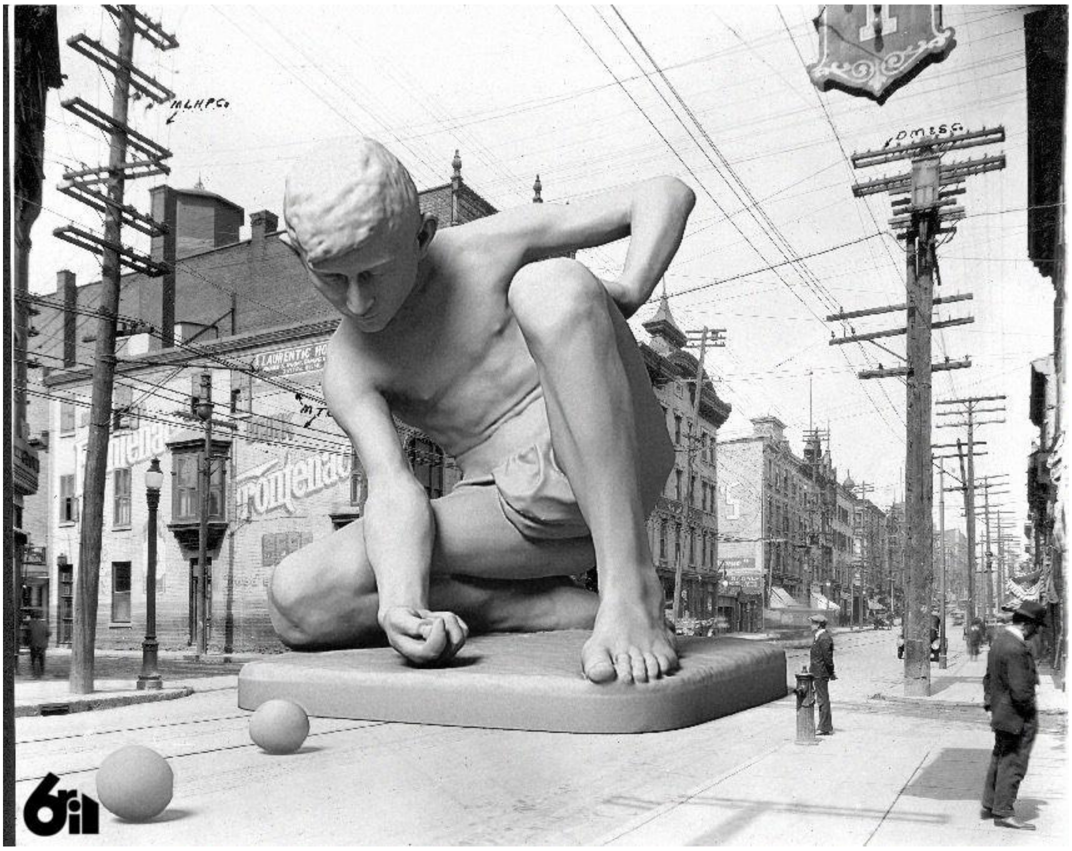

Fig.37 *Marble Boy*, Cyril, monochrome digitally rendered image of 3D model in digital environment

Fig.38 *Virtual Museum Project*, Joe Rigby, scene from virtual museum environment

- Several of the *Lincoln 3D Scans* remixes are set in digital environments; we find the 3D models in digital interiors (Fig.36), in the street (Fig.37), and in simulated museum settings (Fig.38).

3D prints:

- Scan the World[143] uploaded fifty-one photographs of 3D printed models, some of the images show the support structure of the prints (Fig.39a) and emphasise the stepped surface characteristic of 3D Prints (Fig.39b).

- *3D prints in collection* (Fig.40) showcases an arrangement of found objects with two bright pink 3D prints of an untitled sculpture from the *Lincoln 3D Scans* collection.

- Brit Bunkley uploaded images of distorted 3D prints (Fig.41a) and a 3D print with inset text (Fig.41b).

[143] Scan the World is a non-profit initiative, focused on the creation of an open-source, user-generated digital archive of fully 3D printable sculptures, artworks and landmarks from across the globe. See Section 2.3.3. Digital 3D repositories of museum artefacts online, see also https://www.myminifactory.com/users/Scan%20The%20World, accessed 05.05.2015.

Fig.39a *Untitled*, Scan the World, 3D print with support structures, dimensions not known

Fig.39b *Untitled*, Scan the World, detail of 3D print, dimensions not known

Fig.40 *3D prints in collection*, Hannah Conroy, 3D prints and found objects, dimensions not known

Fig.41a *Venus and Cupid*, Brit Bunkley, 3D print, dimensions not known

Fig.41b *Untitled*, Brit Bunkley, 3D print, dimensions not known

Multimedia installations:

- Katie Green organized a dance workshop using the 3D model of a nymph from the *Lincoln 3D Scans* project. Three photographs titled *Dance Workshop With Nymph Model* show students experimenting with a projection of the model of the nymph using shadow, form and body movements (Fig.42).

- Will Kendrick posted a photographs that show the *Lincoln 3D Scans* models used in projections (Fig.43a) and as holograms (Fig.43b).

Fig.42 *Dance Workshop*, Katie Greene, photographs from dance workshop with projections of 3D scans

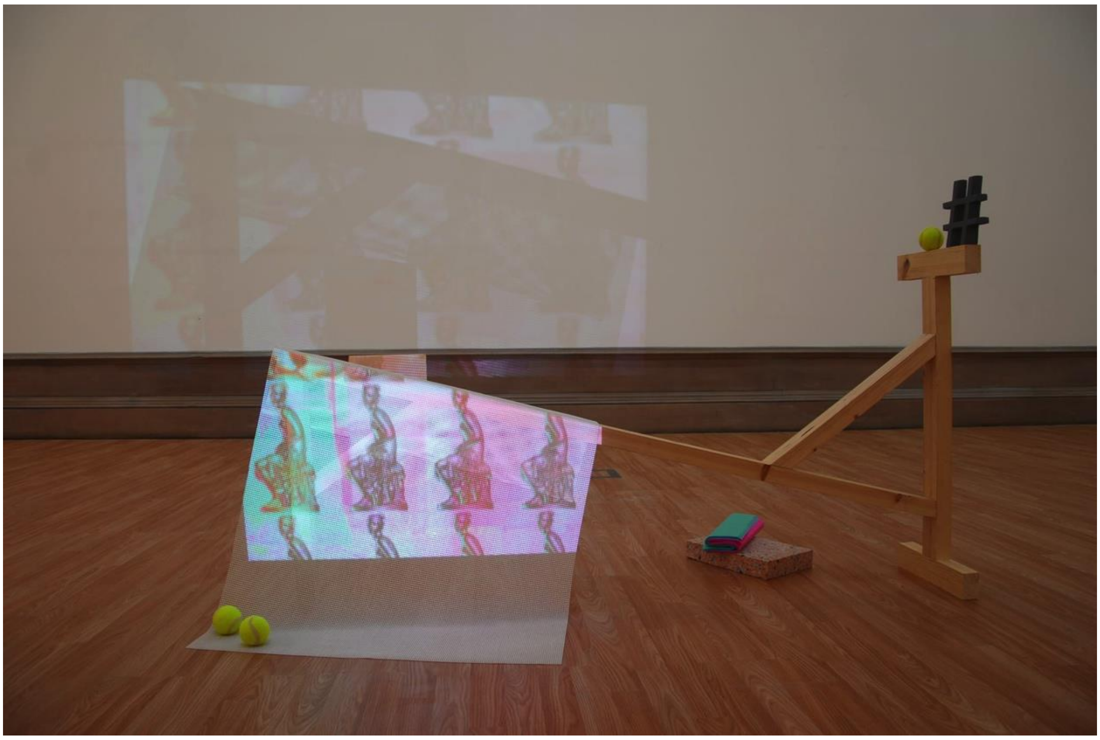

Fig.43a *Untitled*, Will Kendrick, installation with projection of 3D scans

Fig.43b *Untitled*, hologram of 3D model in glass case, *Illuminate* show at the Roman Baths, Bath; 2015

4.4. Discussion

The two projects investigated through a comparative case study for this thesis share similarities in their conceptual design; both made 3D models of museum objects available for creative use, and encouraged the production of remixes and new artworks. However, the projects differ in their execution; while *(Im)material Artefacts* culminated in a physical exhibition in the applied arts galleries of the National Museum Cardiff, *Lincoln 3D Scans* is exhibited online through a website[144]. *(Im)material Artefacts* was undertaken as a one-off project with a fixed end date, whereas *Lincoln 3D Scans* remains accessible online, and users continue to access 3D models, and to create digital remixes which are continually added to the website. The conceptual design of *Lincoln 3D Scans* is more open than that of *(Im)material Artefacts*; it is open to the public and there are no

[144] See http://lincoln3dscans.co.uk/, accessed 20.04.2015.

restrictions on the size, format or content of the digital remixes. *(Im)material Artefacts*, on the other hand, made 3D models available to a select number of artists and some restrictions were given for the scale and format of new artworks. *(Im)aterial Artefacts* also culminated in an exhibition at the National Museum Cardiff, which allowed audiences to see 3D printed and digital work installed in the museum galleries, rather than on their computer. Furthermore, *(Im)material Artefacts* was designed as a research project, whereas *Lincoln 3D Scans* was conceived and executed as an artist museum intervention.

Nonetheless, the projects share the overarching idea to create digital repositories of 3D forms from museum collections, and to use them in an experimental and creative manner. Consequently, the artworks produced in the course of projects share conceptual and aesthetic similarities. The *Lincoln 3D Scans* project provided a comparative case, which was analysed side by side with the *(Im)material Artefacts* case study.

5. Analysis

5.1. Introduction

This chapter reflects upon and discusses data from the case study investigations. The following sections present key observations from the investigated cases regarding the creative use of 3D models, the emerging possibilities of creative engagement with museums through digital technologies, and the impact of these projects in the museum setting. Creative engagement with museum artefacts through the use of 3D technologies was found to have an impact on multiple levels; their effect on the museum and the original artefacts; their role as a trigger of creativity and learning; their relationship to art history and previous forms of museum intervention and their connection to the museum dream space.

In this chapter, the above themes are discussed in four sections. Section 5.2. discusses the new artworks in relationship to the original artefacts and artworks. Section 5.3. investigates them in the context of art history and museum intervention. Section 5.4. explores how the projects engaged with the museum dream space. Section 5.5. looks into the possibilities of transformation through digital editing. Section 5.6. investigates the impact of the projects in the institutional setting of the museum.

5.2. Artefacts and artworks

This section interrogates data on how artists and users navigated the context of the original artefacts while working with digital 3D models of museum artefacts.

Digital 3D models do not share the material or functional qualities of the original artefacts and are removed from their culture of origin and historical trajectories. However, they continue to share a meaningful relationship to the physical originals. Participants in the *(Im)material Artefacts* project and users of the *Lincoln 3D Scans* website did not see the original museum artefacts, which were scanned for the projects. Nonetheless, the digital models provided artists with an understanding of the form of the original artefacts, and of their scale. Furthermore, the artists participating in the *(Im)material Artefacts* case study and users of the *Lincoln 3D Scans* website had access to the archival information kept by the museums. In addition, participants in the *(Im)material Artefacts* project were able to view digital colour photographs of the original artefacts. This section illuminates how the qualities of the original artefacts and their transformation through 3D digitisation influenced artists.

The following sections present artworks that engage with the context of the original artefacts. Section 5.2.1. discusses new artworks that respond to the practical or ritual function and formal characteristics of the original items. Section 5.2.2. discusses how new artworks engage with the history of production and materiality of the originals. Section 5.2.3. collates findings from this section.

5.2.1. Function and form

Museum artefacts are removed from everyday use and put on display. However, they retain their potential use as functional artefacts[145]. 3D scans, on the other hand, do not replicate the functional potential of original artefacts. The following artworks were inspired by the context of functionality of the original artefacts and its loss through digitisation.

[145] This is however not a given; there are instances where the use of objects falls into obscurity or is misidentified. It is usually possible to tell if an artefact had a practical function, but it is not always easy to identify this function.

Fig.44 3D scanning at the storage facilities of the National Museum Cardiff in Nantgarw, the bonbonnière was scanned with her lid screwed shut; 2014 © Dave Daggers

Fig.45 *Screwed Up*, Flemming Tvede Hansen, digitally rendered image of the 3D models submitted by the artist; 2014 © Sarah Younan

For *(Im)material Artefacts* a bonbonnière from the National Museum Cardiff was scanned with its lid screwed fast (Fig.44). Consequently, the digital 3D model appeared to represent a closed form. Hansen's work *Screwed Up* (Fig.45) responds to this loss of function and information between the original and the digital model. *Screwed Up* consists of a series of three 3D-printed bonbonniéres that have been digitally twisted and transformed. The pieces reference the physical action of unscrewing the lid of the ceramic box. They function like an animation, conveying a sense of movement and transformation. Hansen's' *Screwed Up* references physical actions through a digital transformation of shape and alludes to the loss of function through 3D scanning.

Dougherty became interested in the function of a teapot; he transformed the 3D model of a teapot from the National Museum Cardiff into a lattice structure and placed a cup inside it (Fig.46). The piece was 3D printed for exhibition. The 3D printed new teapot could potentially function as a container, but it would have to be dipped into liquid to be filled, and the lattice would make the act of pouring difficult, if not impossible. Dougherty's artwork transforms the practical teapot into an impractical cup. 'It is a glorified teacup,' Dougherty explained; 'I really wanted it to be useable, but irony is often my go-to approach'.

The former use of historical artefacts can include ritual as well as practical functions. Hossam's submission for *(Im)material Artefacts* was inspired by the ritual function of an Egyptian ushabti figure from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts). Ushabti figures served as grave goods in Ancient Egypt. They were placed in tombs and were intended to carry out manual labour for the deceased in the afterlife. Hossam's *WSB Transforma* (Fig.47) was inspired by the voyage of the ushabti into the afterlife; 'I wanted to incorporate the idea of movement, continuation and transformation, the piece also represents a balance between life and the afterlife'. The title of Hossam's work, *WSB-Transforma,* is derived from the ancient Egyptian word *wSb* ('answer'). Called 'answerers', ushabti figures carry inscriptions asserting their readiness to answer the summons to work.

Fig.46 *Teapot*, Zack Dougherty, 3D printed digital model, 14.1cm x 22.8cm x 10.8cm; 2014 © Sarah Younan

Fig.47 *WsB-Transforma*, Mohamed Hossam, digitally rendered image of 3D model; 2014 © Sarah Younan

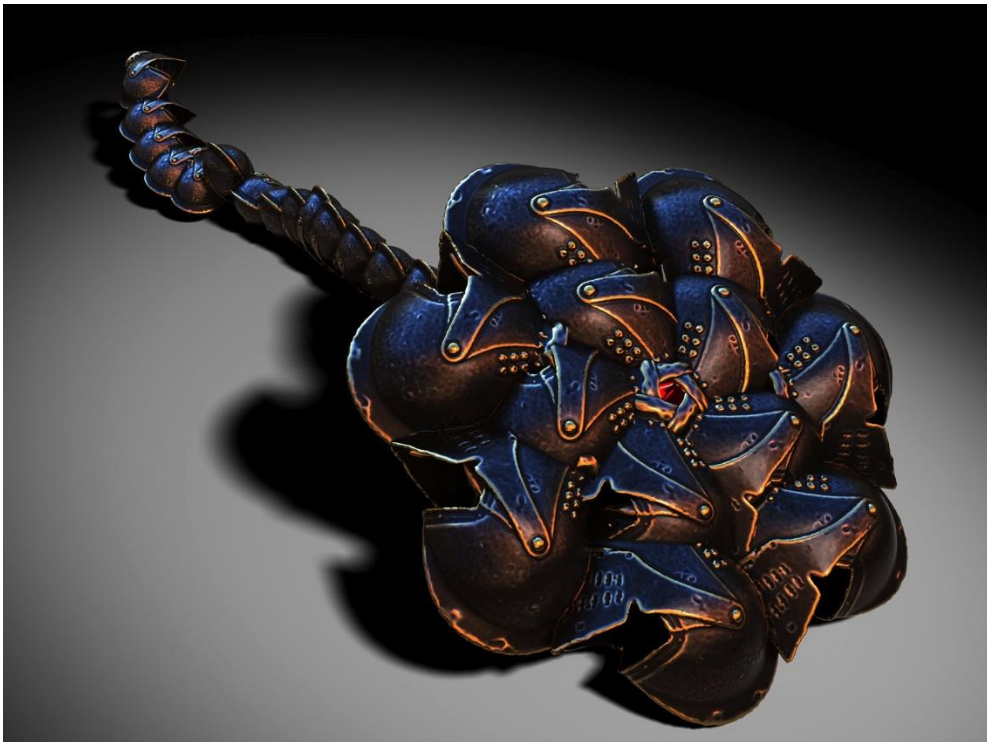

Fig.48 *Untitled*, Rune, digitally rendered image

Rune's *Untitled* (Fig. 48), created for the *Lincoln 3D Scans*, also takes inspiration from the practical use of the original artefacts. The piece consists of multiple digital models of a medieval iron helmet that Rune joined together and arranged into the shape of a flower. The helmet's association to warfare inspired him to create a symbol of peace from the helmet's digital model; 'the use of a medieval helmet, replicated and textured to form a sort of iron rose says, "make peace not war" '.

Both projects, *(Im)material Artefacts* and *Lincoln 3D Scans*, employed STL files to share 3D models. STL files describe only the geometry of a 3D object without any representation of colour or texture. However, they accurately represented the form of the original artefacts. The aesthetic qualities of artefacts can be faithfully reproduced through 3D digitisation, unlike their functional qualities.

Ian Cooke Tapia took inspiration from the architectural qualities, the parapet-like rim and angular shape, of a teapot from the National Museum Cardiff (Fig.49). They reminded him of the architecture of towers and castles.

Fig.49 Teapot from the National Museum Cardiff with architectural ridge, 14.1cm x 22.8cm x 10.8cm; 2014 © Sarah Younan

Fig.50 *Teapot Trainfortress*, Ian Cooke Tapia, 3D printed model, 14.7cm x 23cm x 10.8cm; 2014 © Sarah Younan

This association led to a concept for his artwork; Cooke imagined the teapot as an architectural/mechanical fortress with 'little people' living in it. He built structures around the teapot model, adding cannons, wheels and towers and turning the teapot into a fortified castle on wheels (Fig.50).

5.2.2. Materiality and production

Like the functional nature of artefacts, their materiality is not replicated in the digitisation of objects. However, artists and users were able to learn about the material qualities and history of production of the artefacts scanned for (*Im)material Artefacts* and *Lincoln 3D Scans* from archival data, which they were able to access online. The digital 3D models do not share the materiality or history of production of their original counterparts. Nonetheless artists' knowledge of these original qualities informed how they engaged with the 3D models. The following artworks engage with the materiality of the original artefacts and its loss through digitisation.

For *(Im)material Artefacts* Eastwood-Bloom transformed the 3D model of a bonbonniére and the 3D model of a vase from the National Museum Cardiff into fragile lattice structures (Fig. 51a). He then 3D printed the lattice structures and grew borax crystals on them. Through stripping the forms back to their 'minimal bones'[146] and allowing physical processes to change their appearance Eastwood-Bloom translated the museum objects into new forms. Nonetheless, he chose to create a material link between his new works and the original ceramic museum artefacts; 'Borax is used in many ceramic glazes'. The use of borax in his work *Growing* (Fig. 51b) references the original materials used in the production of the original ceramic objects.

[146] Eastwood-Bloom used this term to referr to the digital wireframe model, not the bones of the porcelain work.

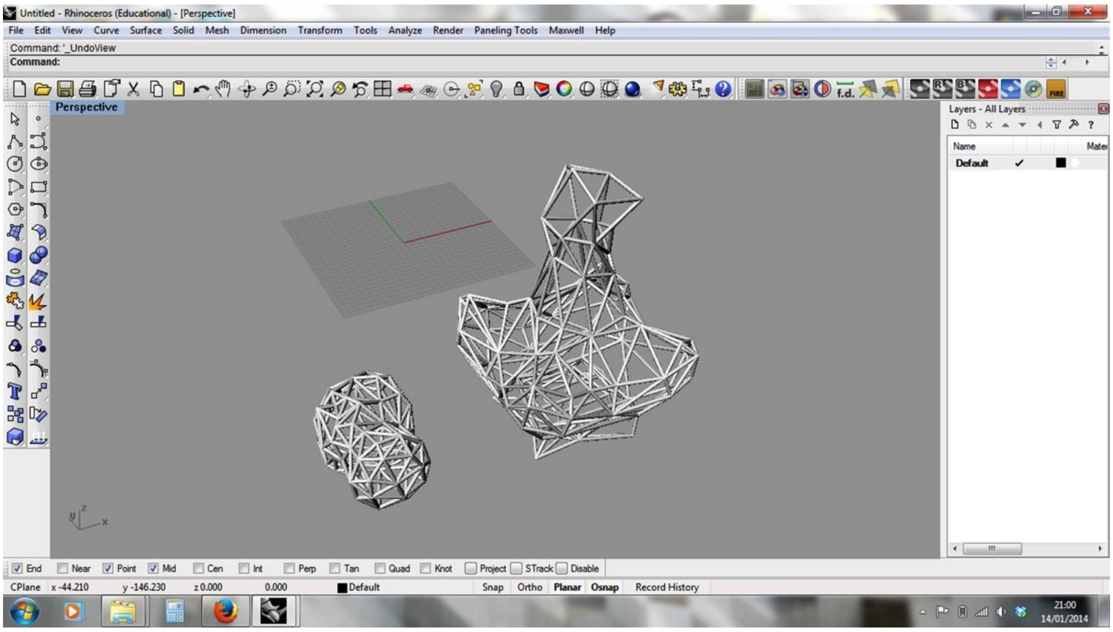

Fig.51a *Growing*, Zachary Eastwood-Bloom, screenshot of work in progress, 2014 © Z. Eastwood-Bloom

Fig.51b *Growing*, Zachary Eastwood-Bloom, 3D printed nylon and borax crystals, 14.9cm x 10cm x 10cm and 8cm x 5.8cm x 5.8cm; 2014 © Sarah Younan

Fig.52 *Untitled*, Ismael Mensa, digitally rendered image with 'marble' texture

A number of works from the *Lincoln 3D Scans* online gallery show attempts to emulate the material qualities of the original museum artefacts. Many of the artworks in the *Lincoln 3D Scans* online gallery were texture mapped (see Glossary) to resemble materials that were used in the production of the original museum pieces, such as marble, wood and metals (Fig.52). By rendering their 3D models with 'historical' surface textures, such as marble and stone, users emulated the look of historical sculptures. Users who 3D printed physical replicas of the digital 3D models they had downloaded from the *Lincoln 3D Scans* website also devised ways of using gilder's paste, paint, wax and metal powders to give their 3D prints the appearance of historical sculptures (Fig. 53).

Fig.53 *Napoleon Bust*, 3DWP, 3D printed model, treated with black paint and gilders' paste, dimensions not known

Several users of *Lincoln 3D Scans* opted to use paint, varnishes, gilders paste and spray paint to alter the surface of their 3D prints;

> *'I dry brushed with silver Gilder's Paste to highlight the folds of the cloth and other details';*

> *'After priming and painting it black I used a wax to make it look like antique gold.'*

Fig.54 *Cupid Goat I-IV*, John Rainey, digitally rendered image of 3D models; 2014 © Sarah Younan

Digital editing makes it easy to tweak the shape of digital models and 3D printing supports mass customisation[147]. Artists Hossam, Rainey and Padilla engaged with the theme of production through their artworks. For his piece *wSb-Transforma* (Fig.47, p. 131) Hossam worked with the 3D model of an ushabti from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts). Ushabtis are the most numerous of ancient Egyptian antiquities to survive, as they were originally produced in huge numbers. Hossam used multiplication to reflect the large numbers of ushabti figures produced in ancient Egypt; 'there are so many of these ushabtis, large numbers, not just one, so I wanted to work with multiples'.

Hansen and Rainey also worked with multiplies: Hansen produced a series of distinctive forms from the 3D model of a slip-cast bonbonnière using digital 3D editing (Fig.54, p.138). Rainey transformed the 3D model of a ceramic figurine of cupid riding a goat into a series of four new sculptures. The resulting four *Cupid Goats* subvert the idea of mass production; the original form is transformed into a series of individual pieces.

[147] As 3D prints do not rely on moulds or tooling, it makes no difference if one object is printed a hundred times, or if a hundred slightly different models are manufactured.

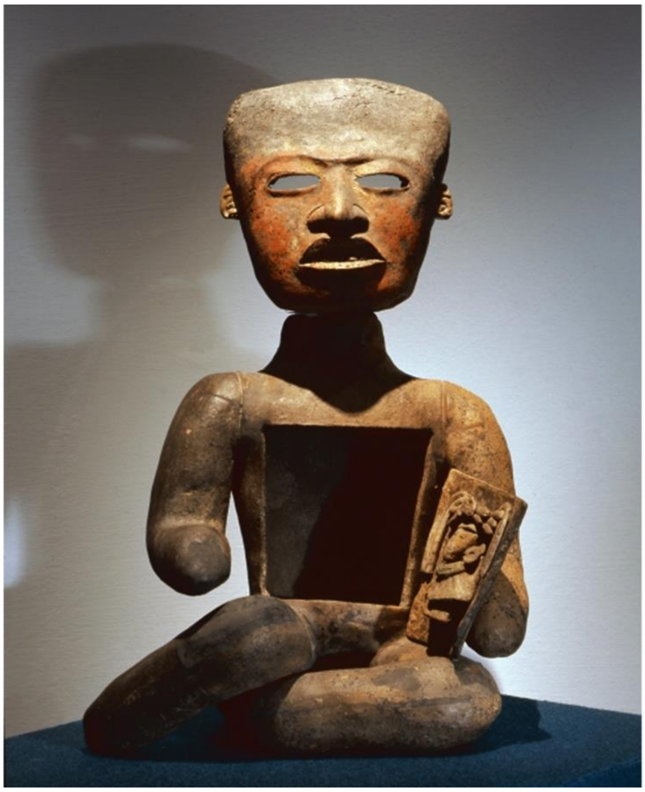

Fig.55 Seated Teotihuacan figure with open stomach to receive offerings, from the Museo Arqueologico de Teotihuacan, Mexico, dimensions not known; ca.300

Padilla chose to work with the digital 3D model of a Mexican mask (see Appendix A.3. Information on museum artefacts). Since the National Museum Cardiff provided scarce archival information on the piece Padilla undertook his own background research. He approached experts from the National Museum in Mexico[148], and discovered that the mask is likely to have been the head of a Teotihuacan figurine, rather than a mask. Such ceramic figurines were mass-produced from moulds for ceremonial use by pre-Hispanic Teotihuacan craftsmen (Fig.55). Teotihuacan figurines were fashioned as prototypes to produce moulds, from which basic forms were then press-moulded. These were then given more detail and decorated individually to create a more unique appearance.

[148] Padilla's research led to a clearer understanding of the original artefact and his findings were recorded in the archives at the National Museum Cardiff.

Fig.56 *Cantli*, Mario Padilla, 3D printed model, 26.7cm x 20.3cm x 9.8cm; 2014 © Sarah Younan

Padilla took inspiration from this making process; he physically modelled a clay body in a similar sitting position to figurines found in Teotihuacan (see Cowgill, 2008, Scott, 2001). Padilla digitized the clay figure with a homemade scanner and then merged it with the 3D scan of a Mexican mask from the National Museum Cardiff. Padilla then digitally altered the surface geometry of his figure, to 'embellish' it. His working methods consciously echo the succession from modelled prototype, to reproduction and surface decoration, which the original artefact underwent. Padilla's work *Cantli* (Fig.56) is directly inspired by the historical background and history of production of the original artefact.

5.2.3. Discussion

This research suggests that artists and users may navigate the meaning and qualities of the original artefacts through creative engagement with digital 3D models. They may reflect on the loss of information occurs during digitisation, for instance through references to the original functional nature of the artefacts. Artistic responses to the form and aesthetic appearance of artefacts may emphasise and focus attention on the qualities of form, for example by emphasising the architectural qualities of a teapot.

The material qualities of an artefact partially influence its value and meaning; a porcelain vase is likely to be more expensive than a similar vase made from stoneware clay; a rubber ball can be treated as a toy, whereas a glass bauble is more likely to be used as a decoration. Digital 3D models possess no inherent materiality; they are stored in bits, as ones and zeros. Bits lack intrinsic meaning until they are read and performed as a visual image or a 3D print (see Section 2.4.2. Digital copies). Nonetheless, some artists and users displayed an interest in the materiality of the original artefacts during this study. Some users processed their 3D printed artworks post-3D printing to make them resemble the materiality of the original artefacts in an attempt to heighten their resemblance to the originals and to reinforce the connection between the originals and their reproductions.

The method of production of a physical artefact plays an important role in how the object is valued and perceived. For example, a wheel-thrown ceramic pot carries different cultural meanings to a mass-produced vase. Some of the participating artists took the history of production of the original artefacts into account in the production of new work from the 3D models during this study. They integrated original materials and steps of production and responded to mass-produced items by reinventing them as individually customised works.

The engagement with the functions, materiality and histories of production of the original artefacts may be seen as a nostalgic form of engagement with the digital 3D models; it references a remote past and is inspired by qualities that have been lost by the passage of time, through the object's inclusion in the museum and through 3D digitisation. Nostalgia is often a response to continually changing material and symbolic environments. It is 'a way of trying to understand change, to reconcile it with the remembered past and relate it to particular strands of continuity in the present' (Keightley and Pickering, 2012:115). Artists focused on the qualities of the original artefacts to emphasize the links between the historical artefacts and their digital 'offspring'.

5.3. Digital possibilities

Digital technologies can be used to simulate all kinds of classical mechanical machines and media, such as sculpting tools, a typewriter, or a paintbrush. At the same time they open up new possibilities of manipulation, such as mirroring and the merging of form, which would not be achievable through manual manipulation. Digital 3D models can be manipulated without physical limitations, such as material stresses and gravity. Nonetheless, the pre-set editing options of software programs can limit the editing choices available to their users. Digital editing tools have specific characteristics; they enable users to do new things at the same time as they prevent them from doing other things[149] (Jones, 2012:3).

This section investigates how artists participating in the *(Im)material Artefacts* project and users of the *Lincoln 3D Scans* website responded to the affordances and constraints of digital 3D technologies and how these technologies informed their creative engagement with the 3D scanned museum artefacts. Section 5.5.1. explores how the affordances and constraints of digitisation and 3D editing were explored by participating artists. Section 5.5.2. looks into the ways participants used 3D printing. Section 5.5.3. investigates how some participants combined digital and non-digital methods in their work. Section 5.5.4. discusses findings from this chapter.

[149] One limitation is the loss of information that occurs during 3D scanning. As discussed previously, digital 3D digitisation does not fully replicate all qualities of the original artefacts. The discrepancies between the original artefacts and the digital 3D models can create tension, which artists explore in their work. For a discussion of how this loss of information influenced the creative choices of participants see Section 5.2. Artefacts and artworks.

5.3.1. 3D digitisation and editing

Digitisation can free data from its source; through 3D digitisation the form of an object is displaced from its origin and can be accessed in different locations around the world, at the same time. During *(Im)material Artefacts* artists from the UK, Mexico, the United States, Kenya, Denmark, and Egypt accessed 3D models from the National Museum Cardiff. Users from Brazil, France, Norway, the UK, Poland, Catalonia, the Netherlands, the United States and New Zealand shared their work on the *Lincoln 3D Scans* gallery. The wide scope of the projects was made possible by the use of digital technologies and the easy international exchange of information possible on the Internet. One participant remarked, that 'digital technology enables you to make something happen across the ocean'.

Some participants employed 3D scanning technologies to combine digital 3D models of objects from the National Museum Cardiff with 3D scans of other artefacts. For instance, Parker and Davis created a 3D scan of a monkey automaton and combined it with several 3D scans from the National Museum Cardiff. Parker and Davis found the monkey automaton in an upstate New York antique mall and digitised it using photogrammetry software. The digital assemblage *Monkey Heaven* combines objects from distant locations into a new artwork (Fig.57). Padilla also used 3D digitisation to combine the 3D model of a Mexican mask from the National Museum Cardiff with a body he physically modelled in clay and 3D scanned using a home-made 3D scanner[150] to create his digital sculpture *Cantli* (Fig.56, p.140).

[150] Padillo used an open-source Arduino microcontroller to build his 3D scanner. A number of online tutorials and youtube videos with instructions on building diy 3D scanners can be found online, see for example https://www.youtube.com/watch?v=n9UiJGrGvfY, accessed 14.10.2015.

Fig.57 *Monkey Heaven*, Katie Parker and Guy Davis (Future Retrieval), screenshot of work in progress, 2014 © Future Retrieval

Fig.58 *Postcards from Mexico*, Jason Rouse, game map. Work in progress; 2014 © Jason Rouse

Some artists and users of the museum 3D models faced challenges due to the high resolution of the models. Rouse, Hossam, Waweru and Tapia had technical problems with the large size of the 3D models, and adjusted their work processes accordingly. Rouse had initially wanted to turn the 3D model of a Mexican mask (see Appendix A.3. Information on museum artefacts) into a collectible game item, however the 3D model caused the crash of the first game engine he tried to feed it into. The high polygon count[151] of the 3D scan moved him to 'think big' and turn the mask itself into a digital landscape (Fig.58). Hossam also struggled with the file size of the 3D models; 'I tried out different libraries, but the file was too large, finally I edited the piece in CINEMA 4D[152]'. Tapia's computer crashed repeatedly due to the large file size, he found a solution by modelling around the 3D object; 'I found that as long as I didn't work on the model directly, it was ok'. Waweru, whose computer was not powerful enough to handle the large file size of the 3D models, resorted to digital video and craft processes as an alternative to digital 3D editing (see Section 5.5.3. 5.3.3. Hybrid practices). The 3D models used in the *Lincoln 3D Scans* project were also of a large file size, one user reported;

> *'…often one is interested in reducing complexity while retaining most details, to make the memory usage/file size more manageable (…) combining low poly meshes with high resolution displacement maps could offer a more efficient way of sharing even more detailed models without going into very huge (high poly) file sizes.'*

Artists and users who experienced technical difficulties frequently looked for solutions online; 'I searched a lot of resources online, I even wrote to other artists asking for advice'. A number of them learned all their 3D editing skills through UG content, such as online tutorials and discussion boards from affinity

[151] Unlike the high-resolution 3D scans created for this research, 3D models used for video games usually have a low polygon count. Polygons are two-dimensional shapes with multiple sides connected at vertices to enclose the shape. In 3D animation, these polygons are connected along their sides and vertex points to build 3D models. More polygons in a model can mean more detail and smoother renders, but it can also mean longer render times and more problems caused by overlapping lines and vertices.

[152] CINEMA 4D is a 3D modeling, animation and rendering application developed by MAXON Computer GmbH, see http://www.maxon.net/en/products.html accessed 27.02.2014.

groups, which form around open-source software like Blender[153] (see also Section 5.6.3. Learning experiences).

Digital editing tools are challenging to novice users, however, to the experienced user 3D editing tools open up a wealth of possibilities. The artist John Rainey identified a different set of operations unique to digital editing, which he termed 'essentially anti-material'; scaling, duplication and distortion. For *(Im)material Artefacts* he chose to work within the limits of these three forms of digital manipulation, to produce *Cupid Goat I-IV* (Fig.54, p.139). Even with Rainey's self-imposed editing restrictions, *Cupid Goat* illustrates how digital 3D models can be transformed into an array of new and distinct forms using software commands.

The animated GIF of a bust of Einstein from the *Lincoln 3D Scans* gallery also illustrates how digital 3D models can move beyond the physical restraints of material sculptures; the GIF shows the Einstein bust wobble and transform as though waves were moving through the model (Fig.59).

While most analogue creative processes have physical limitations[154], digital editing is potentially open-ended; the 3D models used in *(Im)material Artefacts* and *Lincoln 3D Scans* could be endlessly transformed; actions can be undone and different versions of an object can be saved. The finished forms presented to the public were chosen by participating artists from an infinite number of possibilities. As one museum visitor remarked; 'it is interesting to see at what point the artist stops. You get an insight into the artist's mind and the process'.

Some artists transferred part of their editing process on autonomous systems. An autonomous system is a process, physical, mathematical or otherwise, which determines features of an artwork, such as procedural generator programmes. Procedural generators transform digital objects by calculating a new texture or geometry according to pre-set guidelines, outside the direct control of the artist.

[153] Blender is a free and open source 3D editing programme, see http://www.blender.org, accessed 24.04.2015.
[154] Water- and oil colours, for instance, dry once they are painted on to a canvas; clay can no longer be manipulated after it has been fired; a piece of wood that has been sanded off can not be completely reattached again.

Fig.59 *EINSTEIN*, Matthew Williamson, series of still images from animated GIF

Fig.60 *WsB*-Transforma, Mohamed Hossam, digitally rendered image of 3D model; 2014 © Sarah Younan

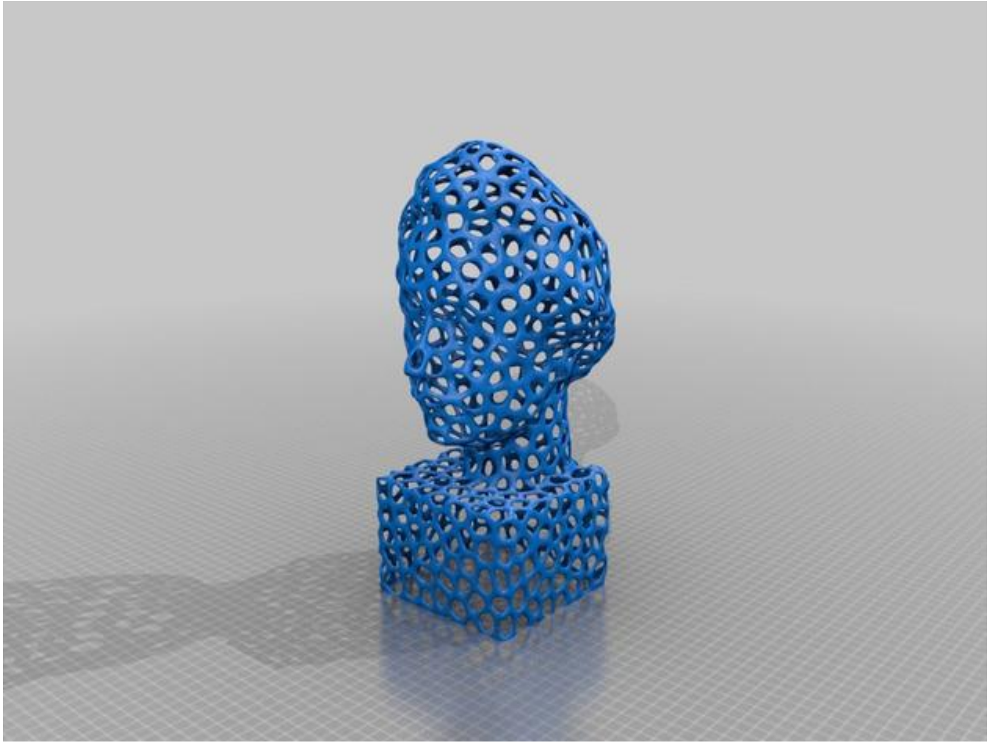

Fig.61 (*Einstein Bust (Voronoi Style)*, 3DWP, digitally rendered image of 3D model

Artworks, which are produced wholly or in part using autonomous systems are known as generative art[155] (see Glossary). Hossam and Padilla both used procedural generators to create the geometrical spiral of *WsB Transforma* (Fig. 23) and the lattice structure of *Cantli* (Fig.56, p.140). (*Einstein Bust (Voronoi Style)* from the *Lincoln 3D Scans* website (Fig.61) also appears to have been created using a procedural generator to transform the 3D form into a lattice structure of Voronoi patterns[156].

[155] Zachary Eastwood-Blooms *Growing I* and *II* can also be understood as generative artwork. Eastwood-Bloom used physical processes, rather than algorithmic software, to transform the surface of his artworks. The borax crystals, which Eastwood-Bloom grew on his objects, add complexity to the bare lattice structures. Crystals are formed from a regular repeated pattern of connected atoms or molecules, the physical process of growing crystals transforms the surface of the object beyond the immediate control of the artist.

[156] In mathematics, a Voronoi diagram is a partitioning of a plane into regions based on distance to specified points (called seeds, sites, or generators). The corresponding region of each seed consists of all points closer to that seed than to any other. The resulting patterns are called

The use of procedural generators shifts some editorial control from the artist to the generator he is using and raises questions of authorship. To some degree, the distribution of editorial control always depends partially on the software used for 3D editing; all editing software comes with pre-set functions and limitations. Unless they write their own software programmes, artists and users continuously follow predetermined automated processes during digital editing (see also Section 2.2.2. 3D editing).

Digital 3D models of museum artefacts exist outside the constraints of the real world. Through 3D printing they can enter physical reality, but they can also remain in the digital realm, where virtual worlds can be created around them using digital editing tools.

It is possible to create spaces, which can be interactively explored by users, such as Jason Rouse's *Postcards from Mexico* (Fig.62), or Joe Rigby's *Virtual Museum* Project (Fig.63). Alternatively, these virtual 'worlds' can also be presented as films or through still images. Jonathan Monaghan's *Alien Fanfare* (Fig.64) is an example of a virtual environment presented through an animated film. Editors can control various settings of animation films, including light sources, camera angles and backgrounds. Furthermore, animated films can show transformations of the 3D models over time.

John Rainey's animation *Cupid Goat – Interlude*, for example, is set in a yellow room or box. Lit by a single of-screen light source, the solitary 3D model twists, multiplies and transforms (Fig.65). This animation is an interpretation of the digital editing process. The jerking, twisting images with their disturbing soundtrack of cracking bones and tearing fabric[157] give a taste of the fantastical transformations the digital model undergoes under Rainey's control. Like his series of 3D-printed *Cupid Goats*, Rainey's film shows the endless possibilities digital editing brings to the form-finding process.

Voronoi patterns. They can be generated using algorithms, as was probably the case for *Einstein Bust (Voronoi Style)*.

[157] Rainey downloaded sounds for his animation from the website www.soundsnap.com , accessed 10.11.2014.

Fig.62 *Postcards from Mexico*, Jason Rouse, scene from first-person video game; 2014 © Jason Rouse

Fig.63 *Virtual Museum Project*, Joe Rigby, still image from virtual online museum environment with 3D model and 'visitor'

Fig.64 *Alien Fanfare*, Jonathan Monaghan, still image from animated film; 2014 © Jonathan Monaghan

Fig.65 *Interlude*, John Rainey, still image from animated film; 2014 © John Rainey

Fig.66 Clockwise from top left: *Untitled*, Eva Papamargariti; *Mars Pavillion*, Mikel007; *Virtual Museum*, Emanuele Ricciardi; *The Checkpoint* (detail), Jonathan Monaghan

A number of works from the *Lincoln 3D Scans* gallery also appear set within digital environments (Fig.66). Digital environments have now become so convincing, that it is sometimes difficult to discern if an image is a photograph of a physical 3D print in a real environment, or a digitally rendered virtual scene. The *Marble Player* (Fig.67) for example, might have been 3D-printed and photographed in a domestic setting, or the 3D model could have been used to produce a digitally rendered image. It is not possible to tell if the scene is a digital simulation, a photograph or the digitally mapped interior of a real room.

Fig.67 *Marble Player*, Boris Quezada, 3D printed model in domestic environment or digitally rendered scene?

5.3.2. 3D print

Through 3D printing, digital 3D models can be manufactured as physical artefacts. Nine artists submitted STL files (see Glossary) for *(Im)material Artefacts*, their digital models were manufactured using stereolithography 3D printing technologies at the National Centre for Product Design and Development Research, Cardiff (see Section 2.2.3. 3D print). 3D printing offers a computerised method of production, which provided artists with the opportunity to get their designs, as one participant described it, 'out of the computer'.

Most 3D-printed artefacts exhibited in *(Im)material Artefacts* were 3D-printed in Cardiff; artists participating in *(Im)material Artefacts* sent digital 3D files to the researcher and 3D printing was undertaken in their absence. Only Zachary Eastwood-Bloom's *Growing I and II* were 3D-printed in London, as the artist needed to undertake further physical alterations to the 3D-printed forms. It is not unheard of for artists to delegate the realization of their artwork to the institution acquiring the work. This is not without risk for the artists; in 3D printing a number of technical faults and human errors can occur. 3D printing involves manual finishing processes, such as polishing, dusting and varnishing. Nonetheless artists participating in *(Im)material* Artefacts had no reservations about delegating the final step of physically manufacturing their artwork.

Size restrictions for artists' 3D models were specified in the project brief for *(Im)material Artefacts*, however not all artists took note of these guidelines. *Monkey Heaven* by the artist duo Davis and Parker had to be rescaled to a third of its original size prior to 3D printing in order to save costs. Davis and Parker were not concerned by this transformation of their digital 3D model; 'I didn't even discuss the size with you at all, I always assumed that it would be smaller'. Most artists participating in *(Im)material Artefacts* shared this nonchalant stance towards the details of 3D printing and left decisions concerning the scale, materiality and resolution of the 3D print open. Hansen had thought about the material his pieces would be executed in, but did not demand a definite solution; 'I imagine them 3d-printed in plastic, but they could be interesting in porcelain as well if possible'. Artist's responses from the questionnaire further indicate an 'anything goes' stance towards 3D printing. This indicates that they perhaps see the edited files as the new artworks, of which 3D prints are not the only possible manifestation[158]. In the questionnaire artists were asked to imagine a scenario in which a 3D artwork needed to be reprinted; 'If the original software, technology or material were not available anymore, would a reprint still be an acceptable replacement?' (see Appendix A.4. Surveys). Only one artist indicated he would have objections to a reprint of his work, all other participants felt a reprint would be an acceptable replacement.

3D prints displayed on the *Lincoln 3D Scans* gallery were in all likelihood 3D printed by users themselves using tabletop 3D printers. These home-size printers produce less detailed 3D prints than commercial 3D printers. Most table top 3D printers print with plastic spool.

[158] This is by no means generally true for all artists working with digital editing and 3D print; a number of artists working in these media understand 3D prints as the final artworks.

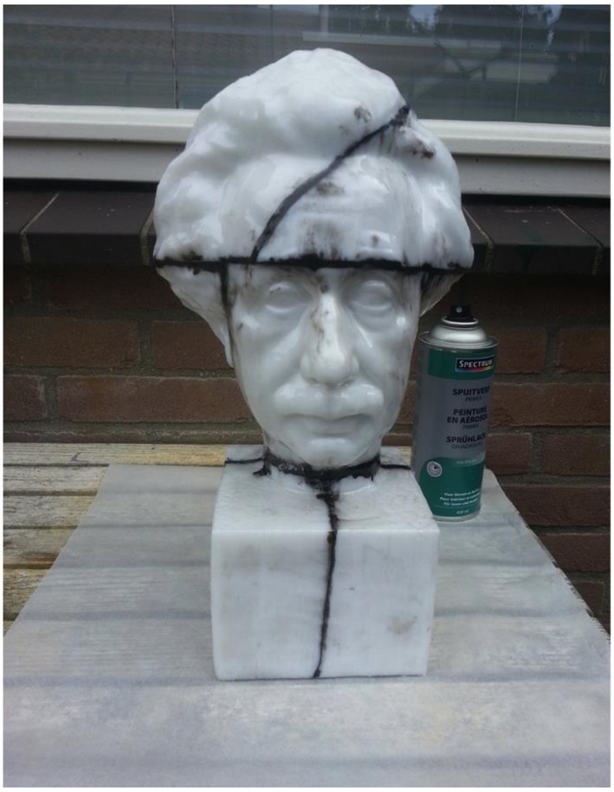

Fig.68 *Albert Einstein Bust*, 3DWP, model assembled from 3D printed parts, dimensions not known

The size of 3D prints that can be produced on a table top 3D printer is generally restricted to a print volume of about 20x20x20 cm, however these technologies continue to evolve rapidly. 3D printing on home 3D printers does not always run smoothly, frequently users have to deal with technological glitches and physical malfunctions[159]. However, 'the constraints of tools can drive creativity and innovation' (Jones, 2012:10) and some users manipulated their 3D prints post manufacturing to give them the surface finish they desired (see Fig.53, p.138) or to assemble larger forms from separate 3D prints (Fig.68).

[159] The 'art of 3D print failure' is celebrated on a flicker account run by 3D printing enthusiast Richard Horne; see https://www.flickr.com/groups/3d-print-failures/pool/, accessed 23.03.2015.

5.3.3. Hybrid practices

Digital technologies are opening up new possibilities for creative practice and craft in both physical and virtual realms. Digital models of museum artefacts can inspire creativity beyond the digital realm. During this research, a small number of artists and users did not work exclusively with digital 3D technologies to produce new artworks for *(Im)material Artefacts* and *Lincoln 3D Scans*, and some did not use digital 3D technologies at all.

Zachary Eastwood-Bloom grew borax crystals on his 3D printed forms; his creative approach combined digital and physical processes. The borax crystals give complexity to the bare lattice structures. Crystals are formed from a regular repeated pattern of connected molecules. Like the digital artworks, which were made using procedural generators (see Section 5.5.1. 3D digitisation and editing), Eastwood-Blooms *Growing I* and *II* (Fig.51, p.135) is a generative artwork; instead of algorithmic software Eastwood-Bloom used the physical process of growing crystals to transform the surface of the object beyond his immediate control. Other artists and users also combined digital and physical processes; Padilla modelled physical form in clay and digitised it using a homemade scanner. A number of *Lincoln 3D Scans* users used physical processes (such as painting) to alter the appearance of their 3D printed models (see Section 5.2.2. Materiality and production).

Some artworks were produced by artists entirely without the use of digital 3D technologies, for example *Curio Dog* by Jeff Waweru. *Curio Dog*, a wooden replica of a 17th century greyhound ornament, was carved by craftsmen, who produce and sell work in little curio shops in Waweru's hometown Nanyuki (Fig.69). No form of digital 3D editing was used in its creation and Waweru did not work directly with the digital 3D model. Instead, Waweru showed the woodcarvers images of the original artefacts and 3D models and commissioned them to create a replica; 'I took printed images along to these guys, a colour photo of the original artefacts, and screen prints of the 3D models'. Waweru produced a short documentary style film of its creation.

Fig.69 *Curio Dog*, Jeff Waweru, work in progress; 2014 © Jeff Waweru

The film shows the woodcarvers at work, carving the dog out of a block of wood, sanding its surface and polishing the piece. Waweru was driven to find alternatives to 3D editing, because the processor and memory of his computer was not powerful enough to edit the large 3D files and he had no way of accessing the tools he would have needed to work with the 3D files. Instead, he relied on manual craftsmanship. Waweru's documentation of the creation process emphasises these qualities; while Rainey's *Interlude* (Fig.65, p.151) shows the transformation of a 3D model into *Cupid Goat* without any visible contact, Waweru's documentary shows transformation through manual labour, often focusing on the calloused hands of the woodcarvers.

From the *Lincoln 3D Scans* project, *Mars on Mars (*Fig.70) and Umland and Kyprianou's *Untitled* (Fig.71) both relied on 2D rather than 3D editing tools to create digital collages, in which images of the digital 3D models[160] are inserted into pictures. The author of *Mars on Mars*, cited a lack of 3D editing skills as the reason for his use of 2D editing tools.

[160] These 2D images of the 3D models are reproductions in a double sense; they are 2D replications of 3D replications of original artefacts.

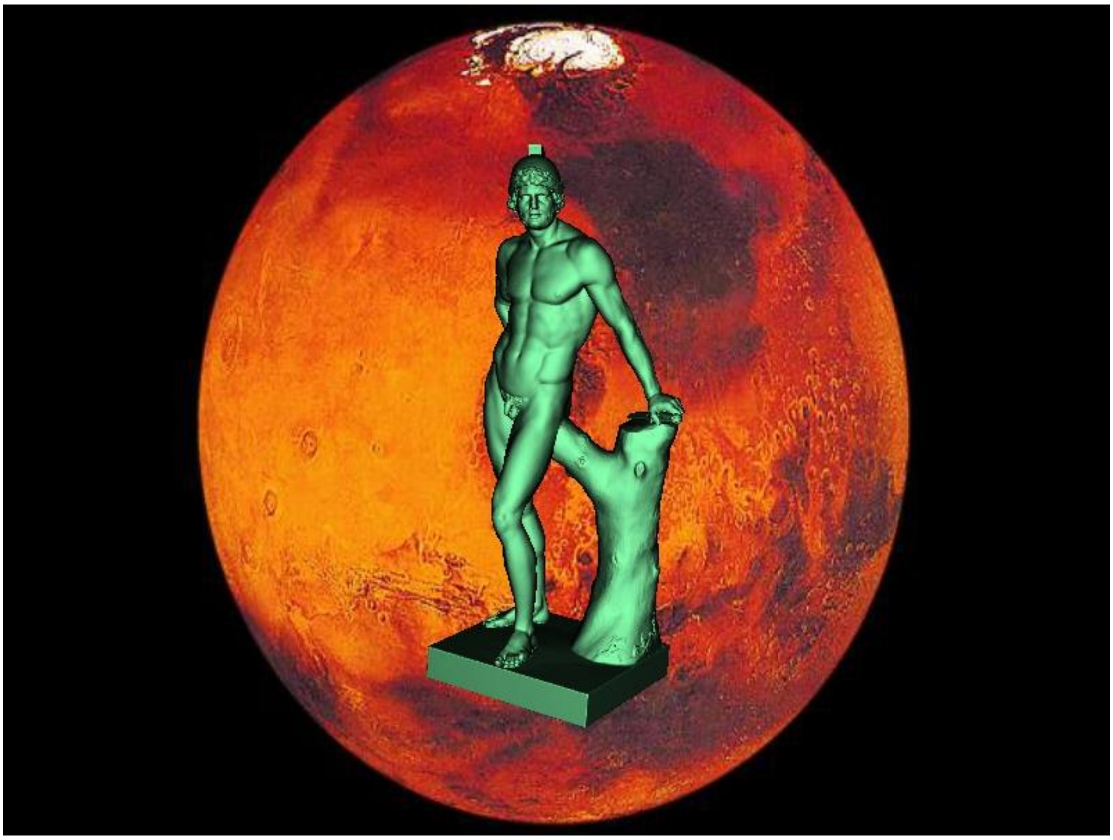

Fig.70 *Mars on Mars*, Ashley Gallant, digital 2D collage

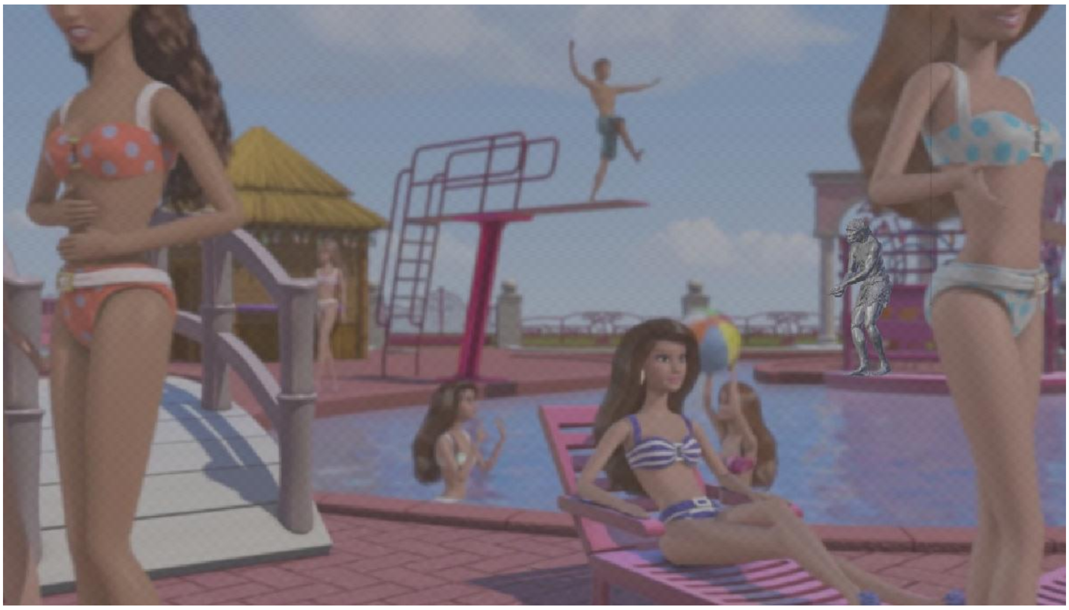

Fig.71 *Untitled*, Malynda Umland and Sophia Kyprianou, digital 2D collage

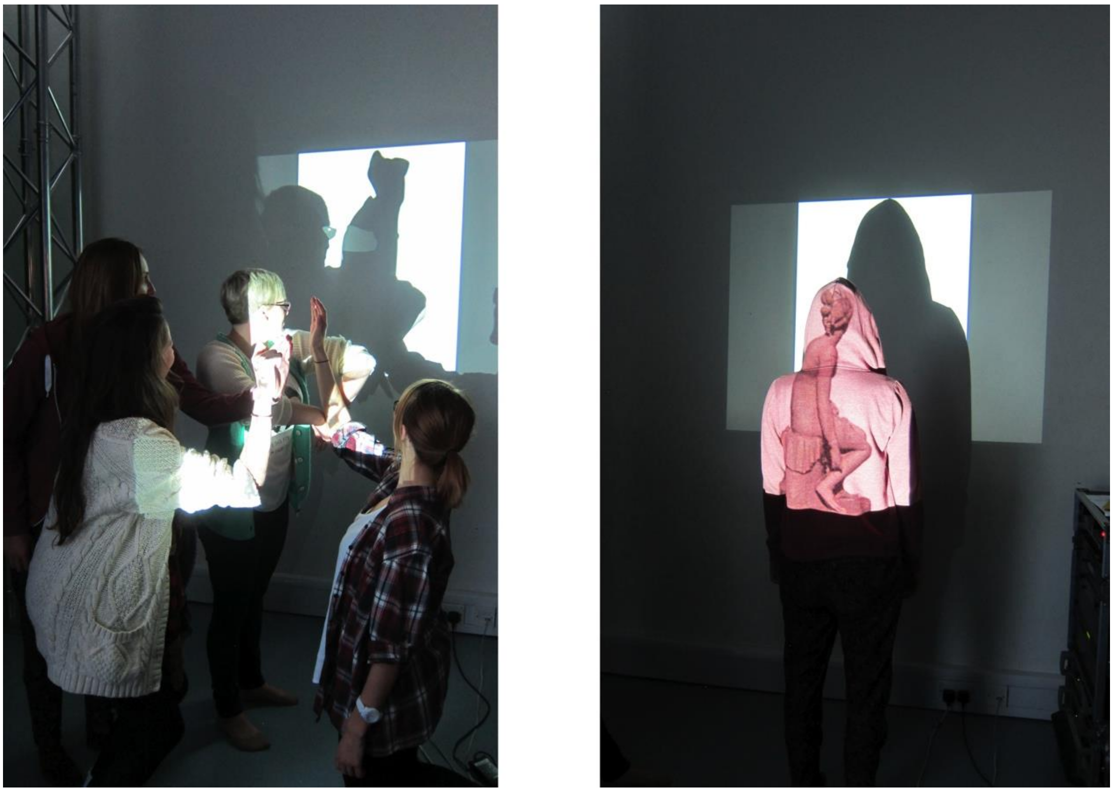

Fig.72 *Dance Workshop with Nymph Model*, Katie Green, photographs from workshop

Dance Workshop with Nymph Model was also undertaken without the use of digital 3D editing tools. In the images, dance students use their bodies and drapes to create shadows and to interact with a projection of one of the *Lincoln 3D Scans* models (Fig.72). This project emphasises the human body and physical actions and uses the 3D model as a resource to explore movement and shape, without the use of digital 3D editing technologies.

Even though the artworks discussed in this section were created without the use of digital 3D editing tools they nonetheless rely on digital technologies to some degree. All artists and users accessed 3D models via the Internet. They used computers, video and 2D editing software, and digital tools such as a projector and digital cameras.

5.3.4. Discussion

Digital 3D editing tools come with their own sets of affordances and constraints; they offer new possibilities of engagement and, at the same time, limit the ways in which users can interact with the digital 3D models. They afford new possibilities of manipulation beyond what would be possible through the physical manipulation of artefacts. In the context of the museum, they make available the form of artefacts that are otherwise out of reach, making it possible to access, distribute and alter them. Through digital 3D scanning, the form of artefacts can be disconnected from its origin and accessed from different locations around the world, at the same time, via the Internet. This enables an international exchange of information and allows artists to combine materials sourced from different locations. Unlike ceramic artefacts, which possess a definite form once they have been fired, digital artefacts can be endlessly altered. Digital editing is a potentially open-ended process. There is no set point at which a digital form can be seen as finished; only the artist's editorial choice determines when an object is finished.

At the same time as it opens up new possibilities, the use of digital editing software shifts full editorial control away from the artist and raises questions of authorship. All editing software comes with pre-set functions, which define the ways in which a digital 3D model can be manipulated. The editor chooses from these functions in order to interact with the digital 3D model. Unless he is able to write new software programmes the editor is continuously forced to follow predetermined, automated processes; creative choices take place within this demarcated arena. During this study, some artists chose to let go of editorial decisions even further by using automated digital processes, such as procedural generators. However, all creative processes and tools, including non-digital tools, possess defined limits; at times it is these limitations that move artists to push the boundaries of the possible. Constraints can drive creativity and innovation and push users to come up with new and creative solutions. Rouse, for example, repurposed video game software and used it in ways for which it was not originally intended to create his artwork.

Realistic environments can be created using digital 3D editing software. The realistic appearance of digitally rendered images and scenes can confuse the distinctions between physical and digital objects. 3D printing further blurs the boundaries between digital file and physical artefact; through 3D printing digital 3D models can be manufactured as physical objects. 'The use of fabrication opens up an important temporal gap between plan and realization' (Buskirk, 2003:6) and raises questions of authorship. *(Im)material Artefacts* artists submitted digital 3D files for manufacture. They complied with curatorial choices concerning materiality and scale of the 3D prints. This suggests, that they saw the digital files as the new 'originals', and 3D printing as one 'entry point'; a possibility of rendering them into recognizable representations. This appears to confirm Nelson Goodman's theory that any performance of a piece of art, which corresponds suitably to its notation, can be counted as authentic (Goodman, 1969). However, not all artists and users appear to share this mind set, as many processed the 3D prints further after manufacture, in order to create finished artworks. In these cases, manual manipulating of the 3D prints conributed to the final form of the pieces and was an essential part of the making process.

Some artists and users combined digital and physical processes and some created new work without the use of digital 3D editing tools. These projects raise questions concerning access to digital technologies, and skill in the use of digital tools. Lack of access and knowledge can inhibit the creative engagement with digital 3D models of museum artefacts. At the same time, these examples show that digital 3D models of museum artefacts can inspire actions and experiences, even when users are not able to interact directly with the 3D files. Digital 3D models of museum artefacts may be appropriated and used even without digital 3D editing tools.

5.4. Art context

(Im)material Artefacts and *Lincoln 3D Scans* employ strategies of reproduction and remixing of earlier forms. Both projects are inherently historical, as they

reference earlier works and clearly signal this fact. Artworks that consciously and openly reproduce previous work, whole or in parts, enter into a dialogue with art history. Furthermore, 'appropriation can function as a means of reworking art history itself' (Sturken, 2009:61).

This section investigates *(Im)material Artefacts* and *Lincoln 3D Scans* within an art historical context. Section 5.4.1. explores artworks within the context of artistic museum interventions. Section 5.4.2. investigates strategies of reproductin and remixing in art. Section 5.4.3. discusses the projects in the context of surrealism, play and liminality. Section 5.4.4. discusses findings.

5.4.1. Museum intervention

(Im)material Artefacts and *Lincoln 3D Scans* both follow in the history of artist interventions in museums. *(Im)material Artefacts* and *Lincoln 3D Scans* employ several of the strategies of museum intervention discussed in Section 2.6.2.. These include digital reproduction, distribution and transformation (see Section 2.6.2.7.); 'mining' the museum (see Section 2.6.2.1.); engagement with the museum display (see Section 2.6.2.4.); online display as a type of 'mock museum' (see Section 2.6.2.2.).

'Powerful new technologies are magical because they function as magic, opening up novel and protean spaces of possibility within social reality' (Davis, 2004:216). Digital technologies can bring magic[161], fantasy and personal interpretations into the museum and metamorphose the past; '(…we) no longer rely on representation as veridical witness; invention and fantasy are livelier substitutes' (Hein, 2000:86). Artists and visitors to the (*Im)material Artefacts* display sensed the 'magical' possibilities afforded through digital 3D technologies;

[161] Here magic is used in the sense of the illusionary, conjuring tricks and make-believe, not in the occult sense of supernatural forces.

'They are a bit like a hallucination';

'You can take a journey with the piece and enter into the imagination';

'Digital technologies can be approached very seriously but when I first began to work with these technologies I left a model to be printed overnight. I felt like the shoemaker whose work is being executed by elves while he sleeps';

'I imagine that software gives me the possibility to create almost everything, from entire worlds (like the Pandora planet from Avatar[162]) to unseen microscopic worlds of cells';

'There is something quite fantastical about these technologies.'

Through the digital transformation of museum objects, alternative realities and ways of understanding museum collections are revealed. The museum becomes engaged in 'a vital relationship with transmuted reality' (Beumer and Wolfson, 2008:96), which stands in contrast with the traditional focus on factual information grounded in authentic material objects. In 'the physically and intellectually controlled environment of the museum – where fixity has always been prized' (Parry, 2007:14), the fluid qualities of digital media enable creative and potentially disruptive actions.

While the original museum artefacts possess a definite and 'finished' form digital 3D models can play a transitory role; they can be distributed, edited and transformed. During museum intervention, digital 3D models are employed as palimpsests; the 3D forms are scraped clean of previous context and take on new forms and meanings. The forms come to 'mean and mean again' (Hebdige, 1988) as they are 'poached' (see Certeau and Rendall, 2002) and repurposed. This form of museum intervention is potentially open to anyone. With a number of digital

[162] Here, the interviewee is referring to James Cameron's film *Avatar*, produce by Twentieth Century Fox. See http://www.avatarmovie.com/index.html, accessed 22.04.2015.

models of museum artefacts available online and access to software tools that enable users to create and edit their own 3D models (see Section 2.3.3. Digital 3D repositories of museum artefacts online) the creative reuse of digital models of museum artefacts is not restricted to artists invited by the museum. Anyone can now potentially undertake digital forms of museum intervention and display them online. Museum interventions that take place outside the scope of the institution can be seen as invasive, or might even be regarded as a form of vandalism (see Section 2.5.1.7.). However, digital museum intervention poses no risk to original museum artefacts, since it is possible to create digital copies without risk of damage and to copy and distribute them without devaluing the original artefact (see Section 2.4.3. Digital copies). Nonetheless, 'potential loss of editorial control (…) and the increased mutability of content' are 'at odds with the clarity and authority of the curator's prized authorship' (Parry, 2007:109).

User-generated 3D models, digitisation and editing tools, digital access to 3D models and the possibility to self-publish (for example on an online blog) have enabled non-artists to undertake forms of 'museum invention' that are independent of museum institutions. However, in order to access 3D models of artefacts that are presented in galleries in a way, which makes photogrammetry difficult (for example in reflective glass cases), or to access 3D models of objects that are held in storage, the collaboration with museums is still essential. During collaborations with museums, such as *(Im)material Artefacts* and *Lincoln 3D Scans*, museum curators and artists face the choice of which objects to digitise. This selection process is not unlike the curatorial choice of objects for display in museum galleries. Conceptual design, subjective taste and artistic vision play a role in this selection process. *(Im)material* Artefacts was defined through a number of curatorial decisions: to only digitize ceramic artefacts; to use objects from different eras and locations; to select functional as well as decorative items. Furthermore, *(Im)material Artefacts* was displayed in the ceramics galleries of the National Museum Cardiff, rather than, for example, in the fine art galleries. During the selection of artefacts for *Lincoln 3D Scans* different curatorial decisions were made. The 3D models produced for this project include examples of classical sculpture, as well as some ethnographical artefacts.

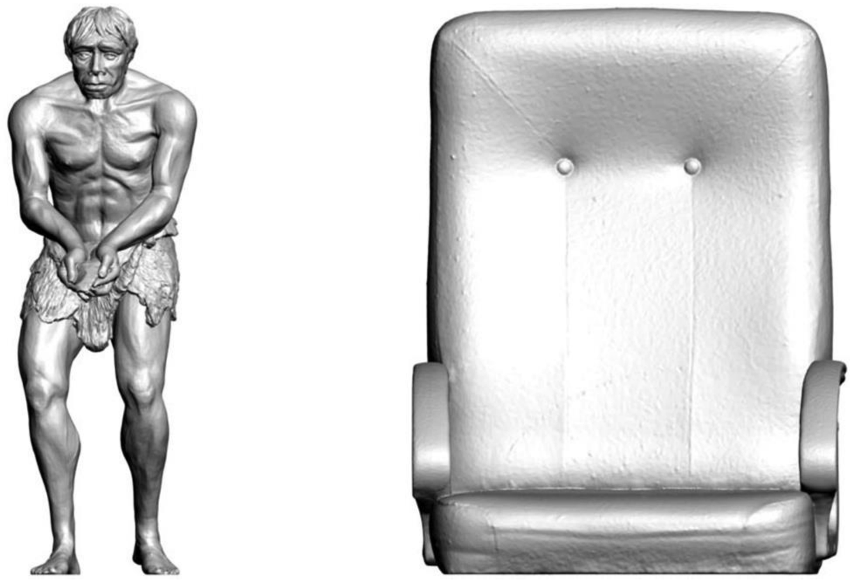

Fig.73 3D scans from *Lincoln 3D Scans*, digitally rendered images of 3D models

The selection also includes ‘inauthentic’ museum items, such as a caveman diorama figure and a functional chair (Fig.73). This selection by the curators *of Lincoln 3D Scans* prompts reflection on the difference between everyday objects and museum artefacts.

5.4.2. Remix art

Digital 3D technologies are conducive to the development of art that is remixes digital 3D models of museum artefacts. 3D imaging technologies have increased access to previously unavailable material. Today, the ‘practice of borrowing and building on existing work has become very common in digital media (…) mashups and remixes build on the work of others’ (Jones and Hafner, 2012:45). Appropriative art and forms of artistic copying and remixing, including assemblage, collage, incorporation, montage, parody, pastiche, quotation and reproduction have become ubiquitous in today’s culture (Hoesterey, 2001). Dyer (2007) suggests that, in certain historical periods, ‘in which new media suddenly make available a huge range of hitherto unaccessible works’ (Dyer, 2007:131), forms of artistic remix and apropriation can become more frequent and characteristic. The increased access to artefacts and artworks, brought about by new technologies can give rise to an increased 'sense of the variability of ways of doing things' (Dyer, 2007:131).

Practices of digital remixing have predecessors in art history. In the mid to late 19th century art schools encouraged students to study and draw from the best examples of classical and Renaissance art (see Section 2.4.2. Originals and copies). The resulting works were not generally considered as art, however postmodern thought has led to a revaluation of reproductive and remixed art. Famous works, such as Duchamp's *ready-mades* and Warhol's *Brillo Boxes* paved the way for remixed and appropriative art. Artists today freely employ strategies of adaption, appropriation, assembly, collage, distortion, sampling, refiguration, and so forth in their work (Hoesterey, 2001).

All artworks produced for *(Im)material Artefacts* and *Lincoln 3D Scans* are in some form based on digital 3D models of museum artefacts. However, we can identify different strategies of derivation in the artist's approaches. Several artworks incorporate elements, which were not made by the artists and users themselves. In this respect they follow in traditions of appropriation and the readymade aesthetic object. The readymade is:

> *'A work of art which becomes a work of art by the fact that (…) the artist declares it a work of art, without there being any participation from the hand of the artist in question to make it so. In other words, it's an object already made, that one finds'* (Kilborne, 1960)

When creating a readymade it is the designation by the artist, which gives the everyday 'found object' an entirely new meaning. Sometimes a readymade artwork, such as Duchamp's bicycle wheel, will also include minor modifications by the artist. In 1915 the readymade presented a challenging approach to the art world and the concept greatly influenced a number of art movements, such as Dada, Surrealism, Pop art, and others. Today, the readymade 'as we understand it in modern art is the utilization of unaltered objects' (Hsu and Lai, 2012:80). However the term readymade can also describe the artistic juxtaposition of two or more found objects together and can be used to describe altered found objects. As part of a readymade artwork the found object 'functions as the primary content of an artwork but is not made by the artist, and its prior functions are redefined by their reallocation to the artistic context' (Hsu and Lai, 2012:80).

Collage and assemblage are concepts closely associated with the readymade (Hsu and Lai, 2012), as they also utilize found materials. Collage describes the assembly of 2D and sometimes 3D found materials, such as newspaper clippings, junk and photographs, into a composite painting or relief. The term 'assemblage' is sometimes used to describe 3D 'collages' made through the combination of found objects. Both collage and assemblage can also include elements created by the artist.

Parker and Davis assembled digital reproductions of several physical artefacts in their work. The pair submitted a digital sculpture for *(Im)material Artefacts*, which combines the 3D scan of a monkey automaton with 3D scans of a teapot, a greyhound ornament, an Egyptian shabti and an archaic rider figure from the National Museum Cardiff (see Appendix A.3. Information on museum artefacts). The artists bought the original monkey automaton from an antique store and reproduced and digitised its form through 3D scanning. They then assembled the 3D scan of the automaton with the 3D scans of the museum objects from the National Museum Cardiff.

Some of the artworks created for *(Im)material Artefacts* and *Lincoln 3D Scans* include 'found' born-digital 3D models and other 'found' digital content, frequently sourced online. The water tower, plants and boulders in Rouse's video game *Postcards from Mexico,* for example, are born-digital 3D models, which were downloaded from the Unity asset store[163] (Fig.74). The 3D models available on video game development platforms such as Unity fulfil various aesthetic and functional purposes, such as providing shelter in a video game. Rouse transformed these video game models into ready-mades by using them in his artwork, thus recontextualizing them without changing their appearance.

[163] Unity is a cross-platform game engine, which allows users to develop video games for web plugins, desktop platforms, consoles and mobile devices. Through the Unity Asset Store users purchase and exchange 3D models. The water tower used by Jason Rouse for example is available for free at the Unity Asset Store. See https://www.assetstore.unity3d.com/en/#!/content/77, accessed 11.10.2014.

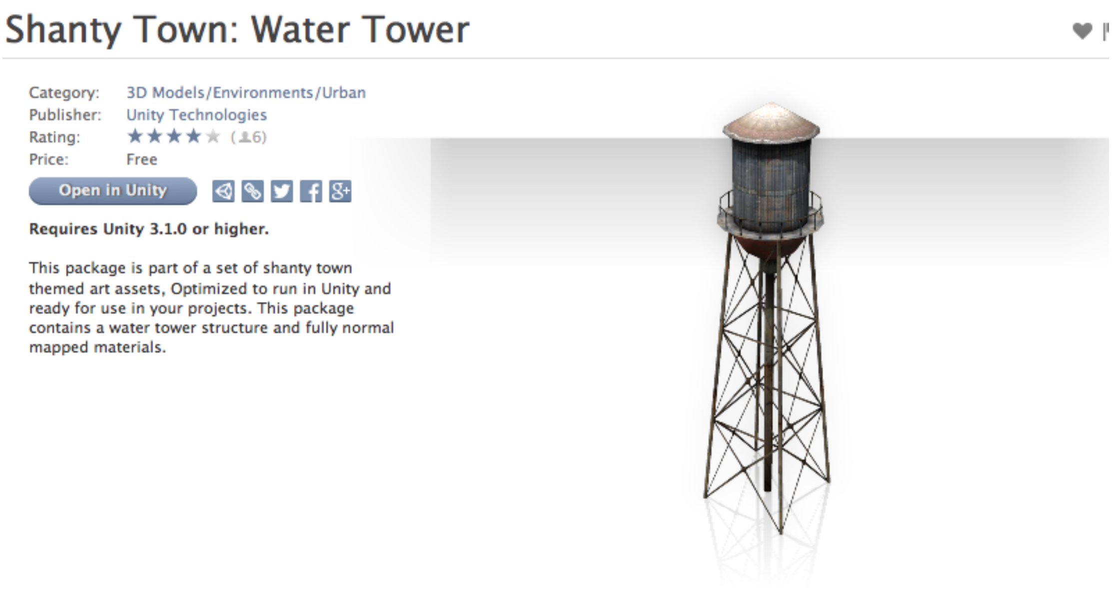

Fig.74 The 3D model of a water tower used in John Rainey's *Postcards from Mexico* is available on the Unity asset store

Rainey also used material he found online to create his animation *Interlude*. The artist used sound files, which he downloaded from Soundsnap[164], an online repository of digital sound and music files, much like the 3D repositories discussed previously in this thesis (see Section 2.3.3. Digital 3D repositories of museum artefacts online). The sound effects available on Soundsnap can be used in videogames, films, as system alerts, or as samples in digital music. Rainey downloaded sound effects with titles such as *Balloon Inflating, Flesh peeling and skull opening slowly, Plastic moving, Shuffling Gravel* and *Household Thud* and remixed and layered these sounds. He described his animation as a 'definite hybrid of digital content'.

Sometimes the content of artworks can be aproprioted in contextual and abstract ways, for example when an artwork references the themes and concepts of another work. Monaghan's digitally rendered image *The Checkpoint (after Dürer)* (Fig.75), for example, is a tribute to Albrecht Dürer's monumental 16th century woodcut the *Triumphal Arch* (Fig.76).

[164] See www.soundsnap.com, accessed 03.02.2015.

Fig.75 *The Checkpoint (after Dürer)*, Jonathan Monaghan, digitally rendered image © Jonathan Monaghan

Fig.76 *The Triumphal Arch of Emperor Maximilian I of Germany (1459-1519)*, Albrecht Dürer, woodcut; 1515

The rendered image references the aesthetics, theme and form of the woodcut. Furthermore, Dürer's *Triumphal Arch* is of a remarkable size; in a similar vein, Monaghan's digitally rendered image of *The Checkpoint* is presented online as a large, high-resolution image[165]. Viewers are able to zoom in on the picture in order to discover every detail. The theme of *The Checkpoint* also quotes from Dürer;

> *'It is kind of a modern triumphal arch, and tongue-in-cheek celebration of condos and boutique hotels, material decadence. It also becomes like a fortress. So the same way Dürer created the print to deify Maximilian, I am deifying our material desires.'*

Monaghan used digital 3D models from the *Lincoln 3D Scans* website to decorate the façade of *The Checkpoint* (Fig.77); the digital 3D models are included to support the historical 'look' of the work; the use of the *Lincoln 3D Scans* is motivated by their close resemblance of the original classical statues, and their contextual connection to heritage and culture.

Derivative art moves away from its original sources, until the boundaries between reproductions and new original art becomes blurred. Even when originals are faithfully reproduced 'the very act of selection deforms the original' (Dyer, 2007:57). As a form of cultural poaching (see Certeau and Rendall, 2002), apropriative and remixed art builds upon and recontextualises previously existing material. As a group, such artworks help viewers to realise that 'given ways of saying or making or performing things are not simply the inevitable human way those things are said, done and performed' (Dyer, 2007:131).

The multiplicity of forms and interpretations possible through digital museum interventions can nurture critical thought, question the authorative position of museums and allow fact and fiction to come together in a creative symbiosis.

[165] See http://jonmonaghan.com/work/the-checkpoint/, accessed 02.02.2015.

Fig.77 *The Checkpoint* (detail), Jonathan Monaghan, digitally rendered image © Jonathan Monaghan

5.4.3. A third space

Many of the artworks created for *(Im)material Artefacts* and *Lincoln 3D Scans* engage with and emphasise the liminal qualities of the digital 3D models. They make visible the endless possibilities of 3D editing and engage the original artefacts with fantastical and transmuted realities. *Draped Beethoven* (Fig.78), for instance, presents the 3D scanned form shrouded under a virtual cloth; the original form is potentially there, under the drape, but transformed, obscured, almost completely hidden from view. Patricia Ferguson's *Inner world Grantham Tomb 1 and 2* (Fig.79b) dissolves the 3D forms into incorporeal wireframes and presents them from unusual angles. The viewpoint of her digitally rendered images is located inside the 3D models; viewers of her work look out from the 'tomb' through layers of polygon mesh, the originally solid form becomes abstracted, delicate and ethereal.

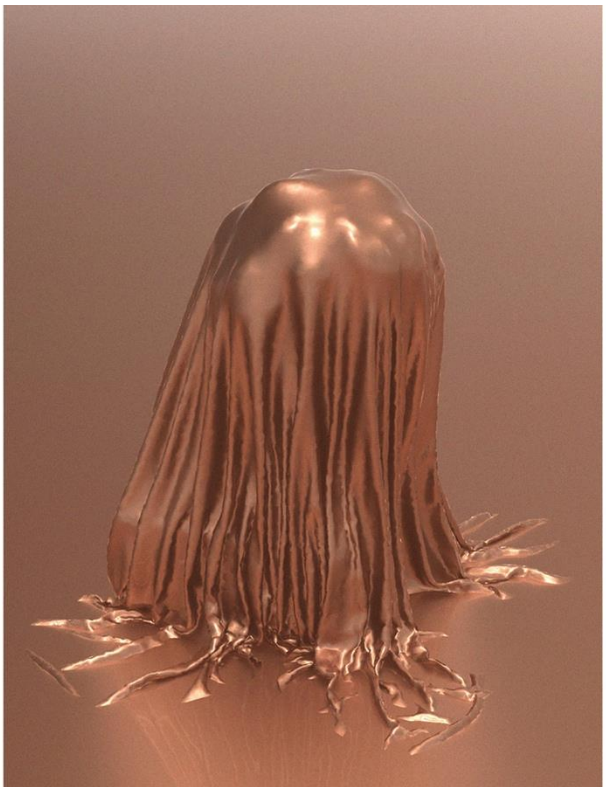

Fig.78 *Draped Beethoven*, Hugo Scibetta, digitally rendered image

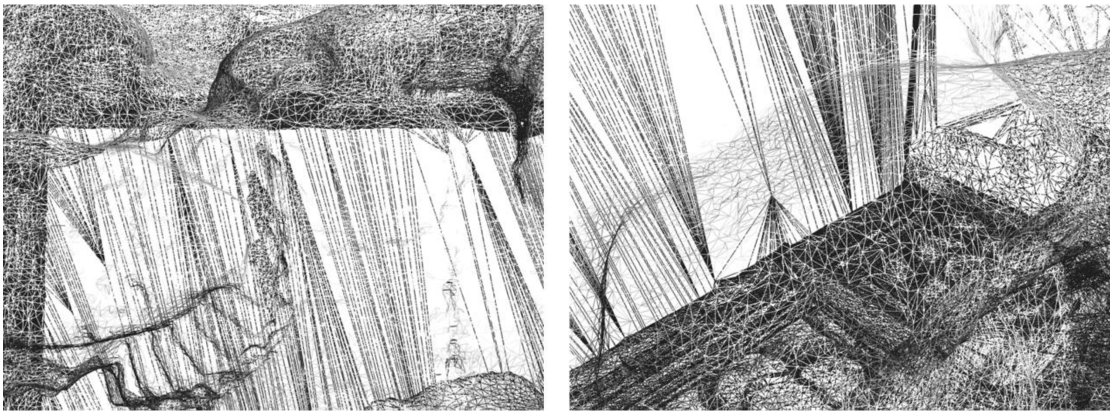

Fig.79 *Grantham Tomb 1 and 2*, Patricia Ferguson, digital images

Other artists transformed the form of the 3D models; Brit Bunkley's distorted 3D prints (Fig.80), Matthew Williamsons' *EINSTEIN* (Fig.81), and Rainey's *Interlude* (Fig.82) distort and twist the form of real objects into warped shapes.

Fig.80 *Wood Nymph*, Brit Bunkley, 3D printed model, dimensions not known

Fig.81 *EINSTEIN*, Matthew Williamson, still image from animated GIF

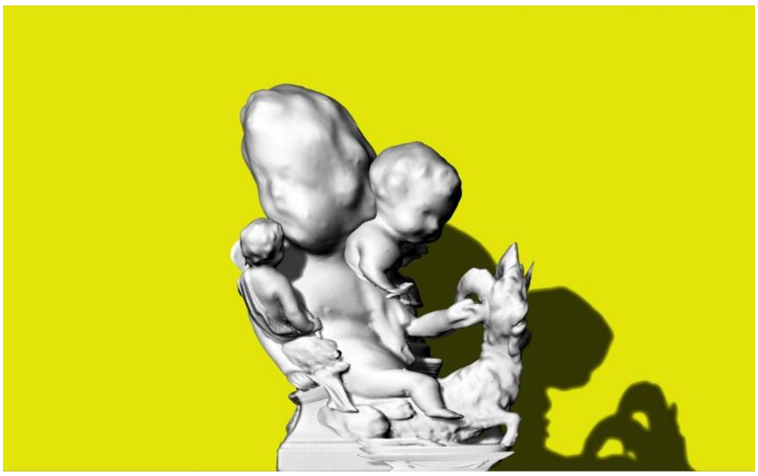

Fig.82 *Interlude*, John Rainey, still image from animated film; 2014 © John Rainey

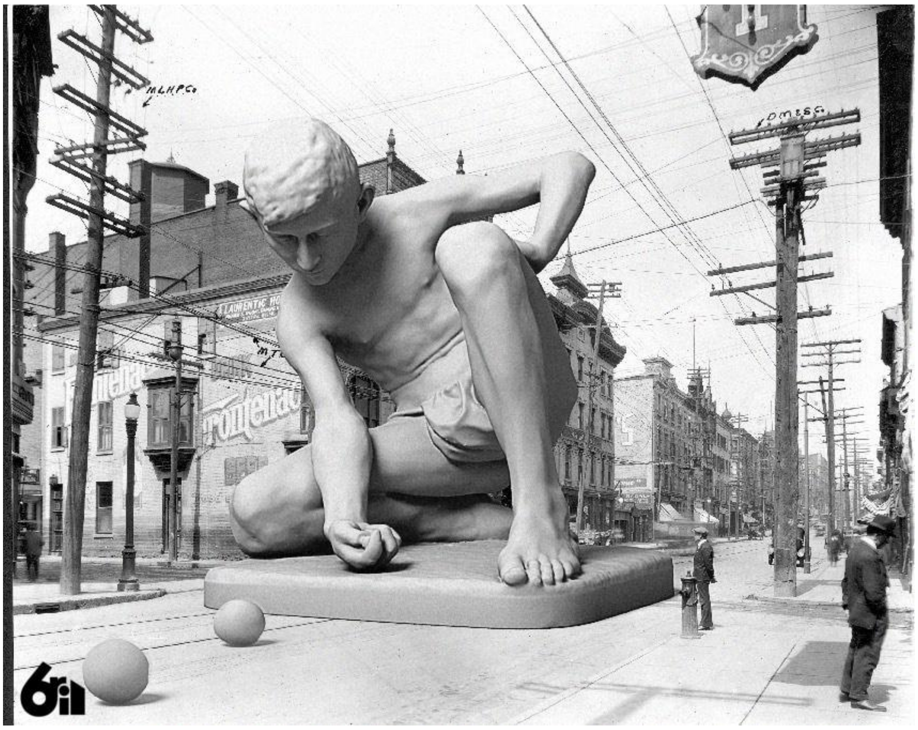

Fig.83 *Marble Boy*, Cyril, monochrome digitally rendered image

Fig.84 *Alien Fanfare*, Jonathan Monaghan, still image from animated film; 2014
© Jonathan Monaghan

Other artworks, like *Marble Boy* (Fig.83) and *Alien Fanfare* (Fig.84) position 3D models within unreal dreamscapes. A precedent for these unreal and dreamlike scenes and objects can be found in surrealist art. In his first *Manifesto of Surrealism* (1924) André Breton called on artists, to: 'resolve the previously contradictory conditions of dream and reality into an absolute reality, a super-reality' (Breton, 1924). Surrealists frequently employed methods of reproduction and sampling (Schjeldahl, 2013). 3D surrealist works were 'often made out of objets trouvés' (found objects); they 'melded contradictions to create something new, triggering surprising associations in the minds of viewers' (Pfeiffer, 2011:9). Inspired by Sigmund Freud's theories, surrealists were interested in exploring dreams and the working of the unconscious human mind through their irrational images.

The digitisation of museum artefacts creates liminal objects, which are open to digital manipulation and play. In *Art as Play?: The Digital and the Surreal* (2009), Ellen Handler Spitz writes that to create art as the surrealists did, 'that is, by elaborating objects along lines other than those for which they were originally intended', is to:

> *'Approximate the activity of, say, the exploratory three-year-old who takes an egg slicer out of the kitchen drawer and, by twanging its wires, transforms it into a musical instrument'.* (Spitz, 2009:114)

Tapia's *Teapot Trainfortress* (Fig.85) is an example of digital play; the artist drew direct connections between playing with his mother's kitchen utensils and his creation of new work from the digital 3D model of a museum artefact. Davis and Parker also approach their creative practice in a playful manner. During their interview, the artist duo described how they 'collage', 'goof' and 'juggle' with real and digital artefacts. These artists embrace play as an intuitive and subconscious creative strategy and do not consciously ascribe meanings to their actions and work; 'we do ask ourselves what does it mean? What does a monkey mean? What does the teapot on its head mean?'

Fig.85 *Teapot Trainfortress*, Ian Cooke Tapia, 3D printed model, 14.7cm x 23cm x 10.8cm; 2014 © Sarah Younan

Surrealist artists tried to 'invoke through their work a mental state known to psychoanalysis as the realm of transitional phenomena or potential' (Spitz, 2009:114). Winnicott describes this realm as a 'third area', which is situated 'neither inside the individual nor outside in the world of shared reality' (Winnicott, 2001:110), it is the liminal realm of play and the imagination, and of museum dream space experience (see Section 2.4.1. The museum object).

5.4.4. Discussion

Both *(Im)material Artefacts* and *Lincoln 3D Scans* make use of earlier works through reproduction and remixing. By using digital 3D models of heritage artefacts in creative ways artists and users created digital 'assemblages that hold various temporal references, tapping from previously stored and inscribed cultural resources' (Boomen *et al.*, 2009:12).

As a form of museum intervention, the creative engagement with digital 3D models of museum artefacts presents a challenge to established institutional practices. Instead of using digital 3D models to support museum's core duties of collection, preservation and display, *(Im)material Artefacts* and *Lincoln 3D Scans* employ digital 3D models to metamorphose and play with the past. This goes against the traditional focus of museums on factual information and authentic objects. It opens up new possibilities of reading and interpreting museum artefacts. Through digital 3D editing the reproductions of museum objects can take on new meanings. This process is now potentially open to anyone. The 'potential loss of editorial control' brought about by digital museum interventions is 'at odds with the clarity and authority of the curator's prized authorship' (Parry, 2007:109) and challenges established ways of reading and engaging with museum artefacts. At the same time, the possibility of creative engagement and access and the cumulative force of the originals and the remixes generates value (Kosnik, 2012). Furthermore, collaborative digital museum interventions open up new areas where curatorial choices are relevant, such as the selection of objects for digitisation.

Artistic apropriation and remixing are not new or uniquely digital phenomena; they have 'been used and talked about for at least the last few centuries' (Rose, 1991:35). Digital remixing follows in the footsteps of older traditions of appropriation, such as collage, assemblage and the readymade aesthetic object. Nonetheless, digital 3D imaging technologies have increased access to previously unavailable forms and are paving the way for new forms of museum interventions.

The remixed artworks created for *(Im)material Artefacts* and *Lincoln 3D Scans* incorporate elements not made by the artists and users themselves. These include the 3D scans, which were used in the projects; some artists also used 'found' born-digital materials. The content recycled from previous artworks does not always need to be in the form of reproductions of an existing object, whole or in parts – it can also be contextual and abstract. Derivative works gradually move away from the original pieces and become new originals.

Many of the artworks submitted for *(Im)material Artefacts* resemble surrealist art. Like surrealist artworks, they draw on the subconscious and employ strategies of play. Surrealists looked towards transitional phenomena and liminal realms to inspire their art making. They hoped to access a liminal realm of transitional phenomena through their work. This 'third area' (Winnicott, 1971) of creativity and subrational thought is conceptually related to the museum dream space. The surreal qualities of the remixed museum artworks can thus be understood in connection with dream space experience.

5.5. Dream space

This section explores how the dream space was experienced by artists, users, museum staff and audiences in the course of this study. Participants engaged with dream space experiences during the making of digital artworks and in the course of their exhibition. These experiences were captured through surveys and interviews, as well as through the creation of new artworks by artists.

Museum visitors frequently read museum objects in personal and subjective ways, informed by life experiences, opinions, and memories (see Section 2.4. The museum object). This intimate process of museum meaning making takes place in a sub-rational field termed the museum 'dream space' (Annis, 1986, Kavanagh, 2000, see also Section 2.4.5. Dream space). Digital 3D models of museum artefacts are inherently suited to engage with dream space experience (see Section 2.4.6. Digital media and the museum dream space).

The following sections give artists', users' and viewers' accounts of memory recollections and dream space experiences in response to digital 3D models of museum artefacts and artworks created from them. While artists participanting in *(Im)material Artefacts* had direct access to digital 3D reproductions of museums artefacts, creating new artworks from them, viewers encountered the outcomes of these creative processes in a gallery environment. Users of *Lincoln 3D Scans* also had direct access to digital 3D models of museum artefacts, which they were able to download and alter. Section 5.5.1. illuminates how participants' memories of events in the past were triggered during this project. Section 5.5.2. explores how digital artefacts can act as memory portents. Section 5.5.3. discusses examples of present-day and popular culture associations triggered by the digital 3D models. Section 5.5.4. reveals how artists' personal and national identities were expressed in their work. Section 5.5.5. discusses findings.

5.5.1. Memories

Digital 3D models of museum artefacts can function as memory carriers, they are liminal objects, through which memories and thoughts can be recalled, engaged with and transformed. Interviewees sensed this liminality;

> *'Something happened between the objects and the video, it unsettled me slightly, but in a good way';*
>
> *'They are a bit like a hallucination';*
>
> *'The old ones are solid and the new ones are fluid.'*

Unlike their physical counterparts, digital models of museum artefacts are malleable and can enter into the private realm of their users (see Section 2.4.3. Digital copies). The *(Im)material Artefacts* project was felt to validate personal responses to museum objects and to stimulate 'approachable' content, which could appeal to audiences in a personal manner;

> *'It allows personal interpretations';*
>
> *'It invites people from any background';*
>
> *'This show engages audiences on a personal level';*

> *'All people are slightly self-obsessed, and at the same time desperate to communicate, to share feelings and thoughts, projects like this can succeed in bringing the individual in and establishing a personal connection.'*

Participants reported instances of memory recollection. Rouse, who designed the video game *Postcards from Mexico* based on the 3D model of a Mexican mask, reported a long-standing fascination with Mexico; 'the first shooter game I designed as a kid was set in an Aztec temple'. Rouse still holds a fascination for what he describes as the 'bloody rituals' of pre-Hispanic Mexico. He alludes to the brutality of Aztec sacrifices by referencing the style of violent first-person shooter games in his work.

Fig.86 Holiday photograph from Oaxaca, Mexico, Jason Rouse; 2013 © Jason Rouse

Rouse drew on memories of a visit to Mexico and used photographs taken during trips to the Oaxaca hills as references for his work (Fig.86). The landscape of Oaxaca, which Rouse described as being 'worthy of conservation as a historical landmark' inspired the appearance of his video game landscape.

Ceramic artefacts can play an intimate role in our private lives; they are often tied into family histories (see Section 2.2. The museum object). Furthermore, since the 18th century drinking tea has become associated with British culture (Standage, 2007) and the 'cuppa' remains a strong feature of everyday life in the UK. Today, most tea is conveniently brewed in mugs from teabags and the teapot is no longer a fixture in the everyday British tea 'ceremony'. Teapots have now become a nostalgic artefact of the recent past. The domestic nature of the teapot, as well as it's connection to recent British history help to understand some of the reactions that the teapot used in *(Im)material Artefacts* as well as the new artworks created from it triggered in artists and viewers.

One visitor to the National Museum Cardiff was reminded of his grandmother; 'my gran used to collect teapots. She had all kinds of different teapots (…) she would have loved this showcase'. The artist Ian Cooke Tapia stated that he was 'immediately drawn' to the teapot when looking at the 3D models from the National Museum Cardiff; 'It called to me'. Tapia added cannons, wheels and towers to the 3D model of the teapot, turning it into a fortified castle on wheels, reminiscent of the toys he would construct as a boy; 'It was almost like a flashback; as a kid I would always take old items or kitchen utensils, and make them into toys'. His work *Teapot Trainfortress* (Fig.85, p.176) is such a repurposed object, created in the same playful manner as Cooke's homemade toys. As well as paying reverence to childhood memories, Tapia's piece also draws from his lived everyday experience; he drew a connection between his teapot train and the fact that he lived 'next to train tracks' at the time of its creation.

5.5.2. Memory tokens

Objects can mediate human relationships and become linked to personal and social identities (Morgan and Pritchard, 2005), they provide opportunities for self-expression and personal engagement. At the same time, memories of personal or cultural stories that are linked to prior knowledge or experiences can be stimulated by the physical characteristics of objects.

A number of interviewees described digital 3D models as memory tokens: artefacts capable of triggering memory recollection and assisting in processes of reminiscence. They described the 3D files as 'relics', 'tourist objects' and 'icons';

> *'I am clinging to the past in a very progressive way, pushing it forward, rather than dragging it behind. The 3D models are like tourist objects';*
>
> *'I print the Einstein model a lot for people as a gift';*
>
> *'In Italy I saw bust of Dante Alighieri, and when I recognize it at the 3D Lincoln website I instantly downloaded a digital version of it';*

Fig.87 *Curio Dog*, Jeff Waweru, wooden sculpture, 17.4cm x 23cm x 10.8cm; 2014 © Sarah Younan

> *'Where an object has been lost or broken perhaps the 3D model can be kept like the photograph of a loved one. It could help to continue the process of remembering';*

> *'This 3D model is somewhat of an icon, I found I wanted to do something to it.'*

Waweru's *Curio Dog* (Fig.87) draws a direct connection between museum objects, digital 3D models and 'curios', or souvenirs. Like souvenirs, digital 3D models are portable reproductions, often of a different scale and quality, and certainly much younger, than the historical originals which they represent. While most souvenirs are bought during a tourist visit, digital 3D models of heritage artefacts can increasingly be downloaded from the Internet. They are accessible anywhere at anytime and are no longer necessarily connected to the experience of visiting a place or seeing an original object. They substitute visits and real-world experiences through surrogate engagement. In one sense they are 'over-elaborated, redundancy writ large' (Mack, 2003:133), virtual and superficial;

> *'Yet, in another sense, this is experience expanded through artificially widening the memory of it. This is not absurd behaviour. After all, what is the visit to a museum exhibition but a surrogate for visiting and experiencing material in the context from which it ultimately derived?'* (Mack, 2003:133)

Souvenirs enter into the private realm of the home and become transformed into personal effects, which form part of highly context-rich and personal narratives (Morgan and Pritchard, 2005). 3D models of museum artefacts alike can support processes of remembering and reminiscence. When a souvenir enters into the private sphere its original, public and shared meaning is overlaid by the personal meaning it acquires (Morgan, 2005:34). Similar processes can occur when digital 3D models of museum artefacts are appropriated; the public meanings of the original museum artefacts can become overwritten by personal associations. In this way, the digital artefacts are transformed into personal effects, inscribed with memories and personal meanings. Unlike souvenirs, digital 3D models of heritage artefacts can be edited and personalised. With the necessary editing skill users are able to leave a personal mark on digital 3D models of heritage artefacts and forge personal connections. ‘We alter the past to become part of it as well as to make it our own’ (Lowenthal, 1985:331). The act of leaving personal traces on historical objects and sites (by example, by carving ones name into a monument, or removing bits of material) can be seen as an illegitimate form of creating memory tokens and taking souvenirs. Through digital 3D technologies, this is now possible without transgressing legal boundaries or endangering historical artefacts and sites.

Souvenirs help to connect people to certain personal or cultural events; ‘what matters is that we capture some souvenir of the event, something to prove that “I was there”’ (Campanelli, 2010:169). Stewart (1993) argues that the souvenir is connected to the identity of its owner.

Fig.88 *Laric Nymph Toilet*, Pedro Perex, digitally rendered image

'Because of its connections to biography and its place in constituting the notion of the individual life, the memento becomes emblematic of the worth of that life and of the self 's capacity to generate worthiness' (Stewart, 1993:139). In a similar vein, museum artefacts and their digital reproductions are connected to the cultural sphere of the museum and its 'cachet' of authenticity, history and high culture. Consequently, digital 3D models of museum artefacts can be used to confer prestige, or, contrarily, to question notions of prestige associated with museums. *Laric Nymph Toilet*, for example, debases the 3D model of a nymph, by placing it on a toilet (Fig.88).

Liminal objects provide a 'basis of symbolism and creativity'; people frequently use liminal objects to weave 'a continuing narrative of caring and relationships as well as self-identity' (Fitzpatrick, 2012:89). New artworks created from digital models of heritage objects can function as synthetic memory objects; instead of simply reminding us of a place or time, as the traditional souvenir and other memory objects do, our memories can be integrated in the digital artefacts themselves. This opens up the possibility of sharing personal interpretations.

> *'Souvenirs should be seen as objects of transition, of in between-ness, which mediate the past and the present and the domestic and public (…) they are simultaneously emblematic of both the self and the other and retain the power to temporarily detach an individual from the present through memory and metaphor. Souvenirs therefore emerge as objects of thresholds, set apart from the everyday through the meanings attributed to them by their owners as prisms of remembrance.'* (Morgan and Pritchard, 2005:46).

Souvenirs are often connected to the concept of travelling. Similarly, the new artworks created during this research enabled viewers to take a journey into the dream space of the participating artists. Rouse's *Postcards from Mexico* in particular allows viewers to become 'tourists' and to explore. One viewer described her experience as 'taking a journey with the object'. The videogame blends the artist's personal responses with the digital 3D model that triggered them. Rouse referred to his holiday photographs when he designed the video game landscape of his 'imaginary Mexico'; anyone can now visit his memories of Mexico through the digital artefact.

Digital 3D models of museum artefacts can be transformed into souvenirs of the dream space, that make users personal interpretations of museum artefacts viewable. Souvenirs can help to conserve 'memories neither fully formed nor yet definitely forgotten (…) memories in limbo: memory as a lingering sore, stranded between routine recollection and total forgetfulness' (Mack, 2003:117). As souvenirs of the dream space, digital 3D models of museum artefacts play a role in documenting and sharing dream space experience beyond an individual level. As dream space souvenirs, the artworks created from digital 3D models of museum artefacts preserve individual dream space experiences. The museum dream space and experiences associated with it are not usually the object of documentation and preservation. Digital 3D models can bring a new dynamic to the museum dream space, as souvenirs they stand in direct contrast to forgetting.

Memory is not 'a static, nostalgic condition, but an active and on going dynamic' (Mack, 2003:9). Keightley and Pickering (2012) argue, that it is necessary to recognise that remembering and the visualisation of the past involve creative and imaginative processes, what they term the 'mnemonic imagination':

> *'We can posit the mnemonic imagination as generating the action which allows continuity with the past to be achieved while also allowing for the accumulation of new experience, and the sense that it will contribute to a story that is still unfolding. It makes possible the grasping together of the past, present and future in ways that create new meaning.'* (Keightley and Pickering, 2012:63)

Digital 3D models can play a part in helping museums and other cultural institutions to accommodate and respond to memory and dream space experiences.

5.5.3. Present-day associations and popular culture

Popular culture and media have become a source of information that affects how we imagine the past and how we interpret historical cultural artefacts. During the *(Im)material Artefacts* project, everyday experiences, associative thought and popular media had an impact on the new work artists created from 3D models of museum artefacts. The influence of popular culture and media is also visible in artworks shared on the *Lincoln 3D Scans* gallery. Video game references appear in the work of Rouse and Monaghan.

Fig.89 *Alien Fanfare*, Jonathan Monaghan, still image from animated film; 2014 © Jonathan Monaghan

Monaghan used video game visuals to construct eerie, futuristic scenes; his animation *Alien Fanfare* contains references to gaming culture[166]. Everyday objects such as satellite dishes, a giant observation camera and a Mercedes star reference contemporary anxieties concerning consumerism and mass surveillance (Fig.89). Monaghan's animation also blurs conceptual divisions between the organic and the inorganic. The spacecraft has biological features,

[166] Such as the Mega Man figurehead attached to the golden cup in Monaghan's animation. Mega Man is a popular video game character.

such as a large gaping mouth and whip-like tail. Today, science and technology are moving towards bionic states. Researchers are developing manufactured body parts, computer chip implants, genetically engineered organs, and digital technologies, which link human brains with computers (Soper, 2003:99). By including cyborg creatures and digital surveillance technologies in his animation Monaghan taps into contemporary anxieties about where developments in digital technologies might lead. His animation uses digital 3D models of museum artefacts to create a surreal vision of the future; ‘I am thinking about how technology is changing us, as a society, but also as a species’.

Rouse’s video game *Postcards from Mexico* not only takes inspiration from popular media, it transforms the 3D model of a Mexican mask into a video game environment, which can be navigated using keyboard commands. The first-person perspective of Rouse’s game *Postcards from Mexico* is typical of shooter games. Cliché first-person shooter game props, such as ammunition crates, barbed wire and watchtowers are scattered throughout the digital landscape of *Postcards from Mexico*. However, Rouse’s video game offers no shoot-offs with enemies; the exploration of the topography of the island is the sole action available in the game.

Fig.90 *Monkey Heaven*, Katie Parker and Guy Davis (Future Retrieval), 3D printed model, 17.6cm x 9.7cm x 10.8cm; 2014 © Sarah Younan

Everyday experiences and contemporary culture influenced the creation of the piece *Monkey Heaven* (Fig.90). Davis and Parker described their creative process as a process of goofing around, juggling and riffing[167] of real and digital artefacts. The title *Monkey Heaven* was inspired by a pop song by the Pixies. By infusing artefacts with contemporary meaning Davis and Parker aim to make old objects relevant by tying them into present-day culture; 'we are searching to reanimate old tattered things, to make them precious'. This playful approach led to unanticipated results; the monkey with his loot seems to reference King Kong movies, or is the primate with his cultural artefacts a comment on evolution and culture? While Davis and Parker allowed pop culture to influence their work, they did so in a sub-conscious, rather than a thought-out manner; 'we do ask ourselves what does it mean? What does a monkey mean? What does the teapot on its head mean'.

Tapia described his sculpture *Teapot Trainfortress* (Fig.91) as 'something from a dystopian future, where people live in outlandish mobile houses'. The 'dystopian future', which Tapia referred to, is a popular subject of action movies and video games. Popular films such as *Mad Max Fury Road* (2015), *Children of Men* (2006), *The Road* (2009) or *The Book of Eli* (2010) are set in dystopian futures, where people struggle to survive in ruined environments and broken societies. In these films, people are exposed to remnants of material culture from a time prior to the catastrophe, which ended civilization (i.e. our present culture). But, like Tapia's teapot, these surviving artefacts are decontextualized and often repurposed towards new uses. *Prehistoric Poltergeist* (Fig. 92) deals with similar themes; the GIF shows a 3D model of a Homo Heidelbergensis effigy rotating in front of the snowstorm of a static television display[168], surrounded by flying smartphones.

[167] In this context the term riff describes inspiration and improvisation expanding on something recognizable.

[168] The random flicker of dots of static television displays appears when no transmission signal is received by television sets. This 'snowstorm' is the result of electronic and magnetic 'noise' accidentally picked up by the television sets.

Fig.91 *Teapot Trainfortress*, Ian Cooke Tapia, 3D printed model, 14.7cm x 23cm x 10.8cm; 2014 © Sarah Younan

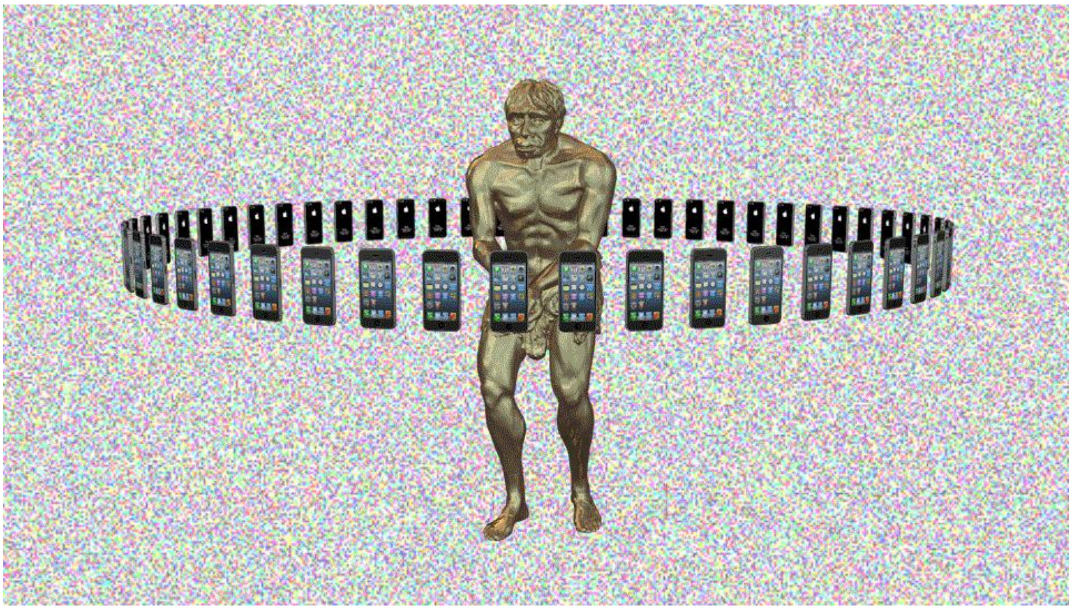

Fig.92 *Prehistoric Poltergeist*, still image from animated GIF

Prehistoric Poltergeist brings together the 3D model of a museum artefact with tokens of consumer culture, to question present-day culture, and where it might take us:

> *'The GIF asks: in our bloated middle age, will we laugh like old software billionaires at our impoverished early experiments in simulation? Will we find ourselves counter cultural aristocrats in a continual virtual 60s, an immersive orgy of pleasure and ecstasy? Or will we spot our smartphones and peripherals in the survivor's hand cart, covered in grime, in the darkness, relics from a distant era, repurposed as bat, blunt instrument, spade?'*

The blending of past and future, utopic and dystopic visions, and the acts of looking back and projecting forward inspired these artworks. They give examples of how mass media, in this case popular film, has become a context, within which objects from the past are understood within the context of the present and future. Keightley and Pickering argue, that the past is necessary in imagining the future; 'the past is continually being revised in order to accommodate an open and continually unfolding future.' (Keightley, 2012:7). Furthermore, they contend that 'mnemonic imagination', or an imaginative understanding of the past, provides a way to achieve continuity with the past, to accumulate new experiences and to contribute to a story that is still unfolding. 'It makes possible the grasping together of the past, present and future in ways that create new meaning' (Keightley, 2012:63).

5.5.4. Identity

This section looks at how individual threads of identity were expressed in the *(Im)material Artefacts* project. National identity played a role in the creation of new artworks for *(Im)material* Artefacts. The Egyptian artist Hossam chose to work with the 3D model of an artefact that shares his cultural background; 'I am proud of my country's heritage and culture'. His close contact with Egyptian antiquities and his insight into ancient Egyptian culture inspired Hossam's creative approach to working with the digital model; ‘I am an artist and educator and have worked as a guide and educator at the Egyptian Museum Cairo’.

For Padilla, who is Mexican, the *(Im)material Artefacts* project also provided an opportunity to work with historical artefacts from his home country. Padilla chose to work with the 3D model of a pre-Hispanic Mexican mask (see Appendix A.3. Information on museum artefacts). Padilla undertook research to retrace the mask’s history. He reported feeling closer to pre-Hispanic Mexican culture through his involvement in the *(Im)material Artefacts* project; ‘I feel like I am keeping something going’.

A number of participants engaged with ethical questions concerning the use and interpretation of museum objects from other cultural backgrounds (see also 2.4. The museum object and its reproductions). One interviewee suggested, that 3D imaging technologies could contribute towards restoring cultural artefacts to their original context, or to repatriate the original items to their original culture; ‘you could let go of the originals but still pass on all the information’. He also argued that it was important for museums to safeguard artefacts which might not be suitable for digital creative engagement; ‘if there was a piece with a difficult cultural background it would not be alright to just have a play with it’.

Brit Bunkley, a New Zealand based artist, used digital 3D models from the *Lincoln 3D Scans* project to create 3D printed work. Bunkley’s 3D printed pieces include a bust of Napoleon, with the historical quote ‘la révolution est terminé, je suis la revolution’ (‘the revolution is over, I am the revolution’) etched into its cheeks (Fig.93). Bunkley chose this quote to make a statement on the leader as a historical figure; ‘this quote shows how far he betrayed the revolution’. Bunkley was also inspired by Māori cultural traditions; he embedded the quote on both cheeks of the Napoleon bust, ‘like a Māori moko tattoo’.

Fig.93 *Untitled*, Brit Bunkley, 3D printed model, dimensions not known

Bunkley demonstrated an awareness of the problems surrounding cultural appropriations. He argued that digital reproductions of heritage artefacts need to be used in a culturally informed way; 'I ask myself – am I going to offend anyone,' he explained; 'I was scanning Māori sculptures recently, but a Māori lady I spoke with explained that I should not use the 3D scans of these warrior monuments. I am very aware of how sensitive it could be.' In Māori belief and in other cultural belief systems the affective properties possessed by real artefacts are sometimes seen to 'inhere in their digital surrogates' (Salmond, 2012:217). On a personal level, many people believe that digital reproductions can share the ontological qualities of original artefacts, and digital technology can be connected to the metaphysical[169] (Davis, 2004); 'the pagan and the paranormal have colonized the twilight zones of pop media' (Davis, 2004:4). One artist expressed the sentiment,

[169] In South Africa, for example, traditional healers offer their services online, read http://afkinsider.com/50917/traditional-medicine-booming-healers-embrace-technology/. In Europe and America, tales of communication with the dead through software applications are quite common; see for example http://www.reddit.com/r/nosleep/comments/29kd1x/my_dead_girlfriend_keeps_messaging_me_on_facebook. Both accessed 26.03.2015.

that 'taking pictures or 3D scans, it can be like capturing a soul.' This view was echoed by viewers of the *(Im)material Artefacts* museum display. One museum visitor argued that the creative engagement with digital 3D models of museum artefacts 'should capture the soul of the piece, they should not be a shape exercise.'

Several artists and museum visitors saw creative engagement with digital 3D models of museum artefacts as a way of continuing the trajectories of the objects. Many artists felt that they were following in the footsteps of the original makers of the museum artefacts. As one participant explained; 'I take pleasure in the idea that these objects were made by hand a long time ago, now I continue them on another path'. Artists described the 3D models as emotionally entities:

> *'more than mere props and shapes';*
>
> *'we have respect for the material and subject matter we work with';*
>
> *'we do not want to destroy or humiliate (…) we are respectful towards the objects we work with, towards their histories'.*

Davis, who created *Monkey Heaven* (Fig.90, p.188), reported a degree of identification; 'maybe I'm the monkey, and I'm in heaven, juggling with these objects, celebrating these things from the past'.

5.5.5. Discussion

Liminal 3D models of heritage artefacts can enable engagement with heritage artefacts on the level of the museum dream space, where 'our inner experiences find a mesh with the outer experiences which museums provide' (Kavanagh, 2000:175). In order to understand the museum dream space, Annis invites us to 'consider, for a moment, museum objects detached from their labels and the order that museum design has given them', in such a state, he argues, museum content is transformed into 'patterns, shapes, colours' (Annis, 1986:169). 3D digitisation effectively transforms museum objects into digital 'patterns and shapes' and removes them from the contextualising museum environment. This type of de-contextualised content can 'jolt memory' (Annis, 1986:169) and trigger dream space experiences. During the study, participants experienced memory recollections triggered by their engagement with digital 3D reproductions of museum artefacts.

Digital heritage can be compared to souvenirs; both are portable reproductions of particular cultural, natural or historical objects or places and are seen as inauthentic. While most souvenirs are bought during a tourist visit digital reproductions are no longer necessarily connected to the experience of visiting a place or seeing an original object. This substitution of virtual for real experience can be seen as superficial, but in another sense 3D models artificially widen users experience of and engagement with original artefacts. A number of artists incorporated themes of memory and associations in their work, their pieces can be understood as tokens, or souvenirs, of the dream space.

Today, popular culture and digital media powerfully influence how people engage with the past. Furthermore, the past is an essential ingredient in order to imagine possible futures. A number of artworks from *(Im)material Artefacts* and *Lincoln 3D Scans* employed the 3D models of historical museum artefacts to reflect on the future. Their visions of the future were also strongly influenced by video games and post-apocalyptic visions gained from popular culture and film. The pervasiveness of digital technologies can inspire enthusiasm as well as fear. Artists created dystopic visions of the future that reflect on the relationship between human culture and technologies, on materialism and consumption. These works reflect contemporary anxieties and imagine the future by referencing the past.

Human identity is influenced and shaped through interaction with artefacts. Artefacts can be tied into cultural and personal identities. Two artists, who shared the same cultural background as digitised artefacts from the National Museum Cardiff, were strongly influenced by this connection. Both related to the artefacts through their cultural backgrounds and sought to impart their knowledge on the historical context of the artefacts in their work. If digital artefacts are seen to share the cultural connections and ontological qualities of their original counterparts new practices of repatriation and cultural restoration become possible. At the same time, the appropriation of objects invested with personal and cultural identities can create conflicts, for example, when the culture of origin forbids the reproduction or re-contextualisation of a particular artefact.

Engagement with digital 3D reproductions of original museum objects can foster feelings of closeness to the original objects. Artists and users felt they had forged new relationships with the original artefacts, having 'seen every corner' of their digital 3D copies. They saw their engagement with the digital 3D models as a continuation of the creative work begun by the artists and craftsmen who produced the original pieces. Furthermore, they described their creative use of the 3D models as a continuation and extension of the trajectories of the original artefacts. Some participants described the 3D models themselves as entities with personalities and histories.

5.6. Institutional setting

This section investigates *(Im)material Artefacts* and *Lincoln 3D Scans* within the context of the museum setting. The majority of findings in this section stem from interviews conducted during the *(Im)material Artefacts* exhibition at the National Museum Cardiff. During this exhibition, the remixed artworks entered into the context of the museum, and it was possible to assess their impact, and the impact of the project, during in-situ interviews with visitors and museum professionals. The *Lincoln 3D Scans* project was not shown as a physical exhibition, but through an online 'gallery'[170]. Nonetheless, *Lincoln 3D Scans* had an impact on its host institution, as was revealed during an interview with the collections access manager at The Collection in Lincoln.

This section examines the impact of the case studies in their institutional setting. Section 5.6.1. discusses critical responses by museums visitors and staff to the *(Im)material Artefacts* display. Section 5.6.2. investigates how visitor expectations of museums are changing through the influence of digital media. Section 5.6.3. explores the effects remixed artworks have on the original museum artefacts. Section 5.6.4. discusses how learning experiences were triggered by the projects. Section 5.6.5. names possible obstacles to the access and use of 3D models of museum artefacts. Section 5.6.6. looks into copyright and legislative challenges to the open use of 3D models. Section 5.6.7. weighs up institutional control against creative freedom. Section 5.6.8. discusses findings.

5.6.1. Critical voices

This section focuses on problems encountered in relation to the display of the *(Im)material Artefacts* artworks at the National Museum Cardiff. Members of staff from the National Museum Cardiff criticised the set up of the display; the Exhibitions and Programs Coordinator at the National Museum of Wales felt that the showcases, which were used for the exhibition, were not an ideal solution; 'you can't fit oranges into square boxes'. MacAvoy put these 'display problems' down to a lack of time and resources. The Senior Curator of Applied Art at the National Museum Cardiff, identified the absence of live 3D printing demonstrations during the show as a missed opportunity; 'people are often very interested in process'.

Members of the audience also criticised aspects of the museum display (Fig.94). For the *(Im)material Artefacts* exhibition screen-based artworks were displayed on a flat screen, installed between the two museum glass cases, which held the

[170] See http://lincoln3dscans.co.uk/gallery/, accessed 05.04.2015.

original artefacts and the 3D-printed artworks. The videos played in a repeating loop, which repeated after nineteen minutes. Interviewees reported feeling uncomfortable standing in front of the screen for that amount of time; ‘I was looking for a seat’; ‘I would not stay to watch the whole video’. Information on the videos was provided in the form of QR codes, which linked to the *(Im)material Artefacts* blog. By scanning the QR code with a smart phone or mobile device viewers could access this additional information. Interviewees criticised the lack of alternative ways of accessing this background information. They felt that the QR codes excluded a part of the public not up to date on digital technologies and all those who do not own a smartphone. A number of interviewed museum visitors would have liked to see clearer wall signage.

Fig.94 *(Im)material Artefacts* display in the applied arts galleries of the National Museum Cardiff; 2014 © Dave Daggers

Interviewees appreciated the concept behind *(Im)material Artefacts*, the ‘mix of old and new and the re-imagination of things’ appealed to most. However interviewees also remarked, that they were ‘not so sure about the pieces themselves’. The new artworks appeared to ‘depend on the original artefacts for value’ and visitors felt, that the remixed 3D models might lack context without the original artefacts; 'without the originals, the new artworks would be just another thing on a shelf.'

The new *(Im)material Artefacts* artworks were criticised for several reasons, including a lack of depth and new content, and the perceived over-reliance on the novelty value of the digital technologies used in the project;

> *'I am not a Luddite, and some of these objects are actually quite pretty. But nothing there really grabbed me';*
>
> *'This is nothing new, Malevich was already doing the same thing with his Supremacist Teapot in 1923';*
>
> *'This doesn't go beyond the level of experimentation. I guess you have to start somewhere. But it takes time to assimilate and digest the possibilities of new technologies.'*

Some interviewees were reserved concerning digital and 3D-printed art;

> *'Digital technologies have enabled a lot of mediocrity, a certain feel for art can lack with computers, it sometimes lacks vision and life';*
>
> *'It is interesting because it is new right now';*
>
> *'The plastic of 3D prints can be unappealing.'*

Some interviewees stated a preference for hand-made objects, which 'carry more emotional and sensual value';

> *'They can bring a feeling of closeness between the viewer and the artists who originally touched and moulded the artefacts by hand';*
>
> *'There's something I like about the gesture of the hand, the contact an object has had with people during its making.'*

These feelings of unfamiliarity and ambiguity towards the digital and 3D-printed artworks were summed up by on interviewee; 'I don't know whether they are art, but they might be'.

5.6.2. Moving with the times

Museums can be seen as stuffy and inflexible. Members of the audience, who were interviewed at the National Museum Cardiff for this research, expressed some levels of frustration with the display and the museum itself. Especially younger interviewees refused to see the museum in a reverential manner. They criticised the slow pace of change in museums and expressed the wish to be able to engage with museum collections in their own way;

> *'Museums have to keep moving with the times,* (points to a large painting, installed behind the museum café counter) *how long do you think this has hung there? Probably at least since the sixties';*
>
> *'The generation of people that saw museums in that light is dying off, our generation has a short attention span';*
>
> *'My attention span isn't amazing, unless my attention is grabbed I won't go to read the background information';*
>
> *'I've just taken photos and can have them on my computer, when I get back home, maybe that's when I'll look at them again and take more time';*
>
> *'People want to curate their own experiences more, they are not looking for linear experiences.'*

Museum staff from the National Museum Cardiff saw creative digital museum projects like *(Im)material Artefacts* as a way to enable museums to keep up with the changes brought about by digital media.

> *'I like crowd sourced and open source collaborations. People are cherry-picking from different places and creating fusions. Museums should be a vital component in sustaining and improving this process. They can work as a repository (…) looking after the past, in the present, for the future';*
>
> *'Ceramic art often gets overlooked, 3D art projects can make artefacts more appealing in line with our digital society'.*

Interviewed audience members agreed, that projects like *(Im)material Artefacts* and *Lincoln 3D Scans* have the potential to open museums up to new audiences and new possibilities of engagement;

> *'This show is suggestive to the public. You can have your own interpretations';*

> *'this show invites people from any background';*

> *'I think there is a political level to this project. Museums traditionally conserve objects and keep them precious, the distribution and experimentation with 3D models goes against this.'*

Interviewees pointed towards digital 3D technologies as a way of creating and experimenting with historical forms;

> *'Perhaps these technologies will make it easier for some to create work';*

> *'It is not too time consuming and you can see variations of a form, this makes it easier to explore possibilities and find new designs';*

> *'I feel like I can hold them* (the museum objects) *and play with them, and that's never happened before, they have always been behind glass.'*

A number of interviewees expressed the opinion, that projects like *(Im)material Artefacts* project and *Lincoln 3D Scans* could foster creative thought, 'inspire new thoughts and feelings'; and have an impact on 'the way people think ';

> *'(museums) are trying to unlock creativity in people who aren't necessarily used to thinking in a creative way, not just artistic creativity, but also ways of independent thinking. Museums (…) can tell people something about who they are and where they come from';*

> *'In museums, there is a danger of being spoon-fed information. Instead, this project encourages intrigue';*

> *'They prompt the imagination';*

> *'I am excited about looking at museums in new ways';*
>
> *'You can take a journey with the piece and enter into the imagination, it allows viewers to have an experience.'*

Museums are now beginning to act as repositories of both digital and physical artefacts. Digital technologies are gaining increasing importance in people's everyday lives and can influence their conceptualisation of the past. Museums face the challenge of adapting to the rapid cultural and social changes brought about by digital technologies. Nonetheless, they continue to remain relevant as social spaces, which preserve and display physical collections;

> *'Museums should still preserve that physical element';*
>
> *'I recently read an article about how digital technologies are leading us into a "Abramovic situation", were art is supposed to exist without any objects. But with scanning and 3D print the focus is on objects again. People will always be into objects, perhaps scanning and 3D print are a way to bridge the digital gap';*
>
> *'In the end no-one wants to stare at a screen all day, museums are social physical spaces and we will always need such spaces'.*

5.6.3. Feedback loops

Reproduction has long been understood to have effects on the authenticity and aura of the original artefacts (see Section 2.4.2. Originals and copies). In the context of the museum, the digitisation and creative re-use of artefacts raises questions concerning the effect of the new artworks on the original artefacts, and vice-versa.

> *'Because of the way that mashups and remixes build on the work of others, they pose some interesting questions, of both philosophical and practical nature. They challenge us to rethink beliefs about originality,*

intellectual property and ethics.' (Jones, 2012:45)

The long-held fear remains, that copies might weaken the authentic and auratic qualities of the original (see Section 2.4.2. Originals and copies). However, participants in the *(Im)material Artefacts* and the *Lincoln 3D Scans* projects did not see the production and sharing of digital 3D replications as a threat to physical museum collections of original artefacts. On the contrary, interviewees felt that digital 3D imaging and 3D printing contributed towards the appreciation of the original artefacts, their qualities and age;

'Those remixes make the original pieces stronger. They bring out their age';

'The museum pieces remain attractive, because they remain out of reach';

'I liked the fact they were real objects, some very old, and I could see them on my computer';

'Because of the remixes I spent more time looking at the originals, I was even looking for a seat';

'The new work made me re-evaluate the old objects';

'The contrast between the original pieces and the contemporary items and technologies give a strong impression of the time which has passed between then and now';

'The museum pieces are the core, they seem to be saying look at me, I'm living and beautiful';

'They are the source and provide a key to understanding the new work'.

One interviewee described the interplay between the originals and their remixed digital reproductions as a 'feedback loop'. In *The migration of the aura* (2010) Latour and Lowe argue that such a direct correlation exists between the auratic power of the original and the number of its copies;

'*The intensity of the search for the original depends on the amount of passion and the number of interests triggered by its copies. No copies, no*

> *original. In order to stamp a piece with the mark of originality, you need to apply to its surface the huge pressure that only a great number of reproductions can provide.'* (Latour and Lowe, 2010:4)

Users, artists, viewers and museum professionals shared the view that digital 3D reproduction and remixing could infuse the original artefacts with more power, tying them into a contemporary context. Several interviewees saw this as a process of reviving muted museum artefacts;

> *'Before they entered the museum these artefacts were used, cherished and looked after, in museum storage their energy might have slowed down, through luck they were now chosen for this project';*

> *'This is the thing I love about art, you can revive the dead branches, reconnect the forgotten to something new.'*

In his seminal work *The Work of Art in the Age of Mechanical Production*, Walter Benjamin argued that technological methods of reproduction jeopardise the authority and authentic core of an object, and thus its aura (Benjamin, 2008, see also Section 2.4.2. Originals and copies). However, readily accessible and inauthentic digital reproductions seemed to heighten viewer experiences of the aura of original artefacts. The contrast between the malleable reproductions and the stable originals fed into this process. One museum visitor observed; 'the originals just exist, they are the origin, the new ones can be changed.' Furthermore, unlike the accessible digital 3D models the original objects remain out of reach. A visitor argued, that 3D models make the original even more 'beguiling and attractive', because 'the originals still remain out of reach'.

Some interviewees held a critical stance towards the concept of authenticity; 'authenticity is a construct, it is projected on to the object and has a lot to do with monetary value'. Reproduction, sharing and remixing, on the other hand, were seen as a positive form of progression;

> *'A lot of my work is about copying and reproduction, in art education there is often a push for originality, but copying has always been a way of learning, and most art is derived from copies';*
>
> *'I have no problem with someone taking my work and making new stuff from it, I see it as a progression';*
>
> *'We are building on what is already there, and creating work on which the next generation will build. Art is an evolutionary progress, rather than a sequence of divine inspired moments.'*

5.6.4. Learning experiences

Projects like *(Im)material Artefacts* and *Lincoln 3D Scans* can offer new perspectives on museum artefacts, and enable an exchange of information. Interviewees identified the projects as sources of informal and experiential learning;

> *'People don't like to be told what to think, but if you can make them laugh they are more open to suggestions (…) humour is a way to introduce truth without putting people on the back foot';*
>
> *'Often very target-based teaching methods can leave children with learning difficulties behind (…) this could give kids who can not easily approach textual information more confidence.'*

Some artists and users were stimulated to undertake further research on the artefacts they were accessing as 3D scans. Padilla, for example, undertook a private background research on the Mexican mask from the National Museum Cardiff with the help of specialist staff from the National Museum of Anthropology, Mexico. The information he discovered helped the National Museum Cardiff to correct errors in their archival information on the original artefact.

Users who uploaded *Lincoln 3D Scans* models to other 3D file repositories frequently re-shared the 3D models with additional background information. The user 3DWP, for example, shared the 3D model of an Einstein bust on Thingiverse together with photographs and information about the original bronze bust, which he had researched himself[171]. Frequently, users undertook forms of research on the original artefacts while engaging with the 3D models:

> *'The textured version of the Einstein bust was mainly an experiment in texturing and lighting to make the features of the face as visible as possible. Interesting to see the details of such a historic person.'*

> *'I find it interesting to experiment/doodle with various techniques to see if this can give additional insight or new impressions'*

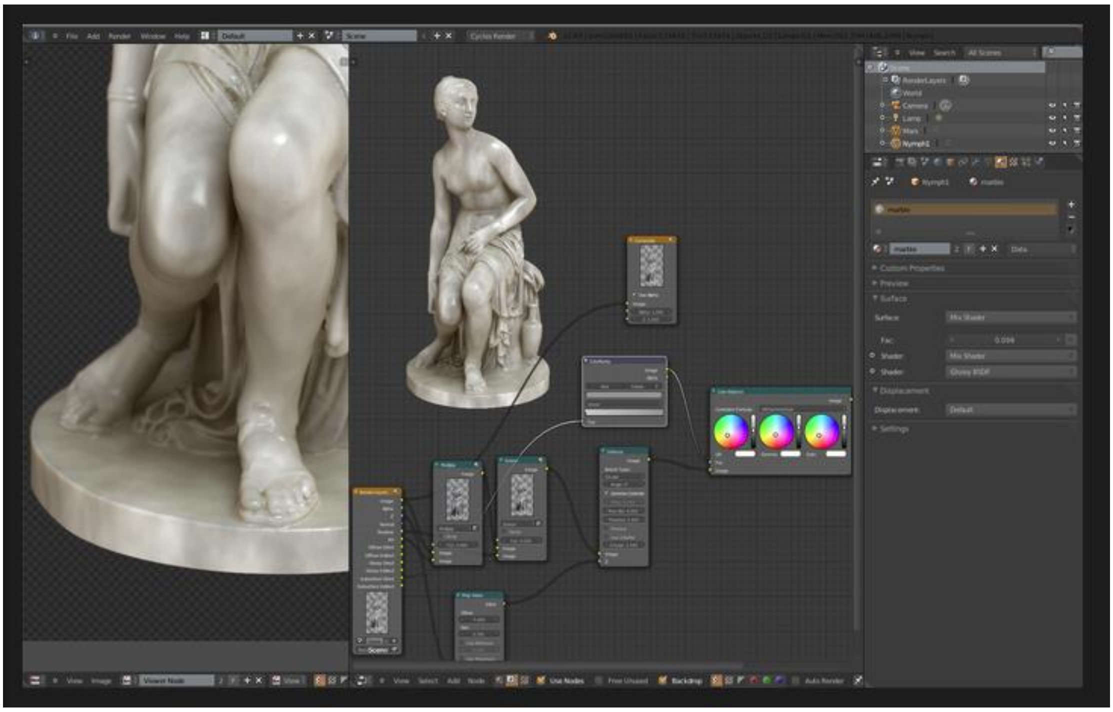

Fig.95 Illustration from user-generated tutorial , b2przemo

[171] See http://www.thingiverse.com/thing:317004, accessed 13.10.2015.

> *'I wonder if a particular way of texturing and/or lighting can shed more light on the history of the object? How did this look in its prime? Can I make it look better?'*

> *'Working with a 3D model can make details apparent, that would otherwise go unnoticed.'*

For some users of the *Lincoln 3D Scans* models, the museum models offered highly detailed and realistic 3D forms, which they used to create tutorials for UG online learning resources (Fig.95), to experiment with editing software and for test rendering;

> *'I tried to master materials in Blender and I wanted to find some natural form like historical sculptures with correct dimensions. I found what I needed at Lincoln 3D Scans (…) great models with correct dimensions (…) all 3D scan data from 3D Lincoln Scans are very useful for architectural interiors rendering.'*

Projects like *(Im)material Artefacts* and *Lincoln 3D Scans* allow for experiential learning and self-motivated research. They can also expose museums to new ways of thinking about their collections and can lead to learning experiences for museums. For the Senior Curator of Applied Art at the National Museum Cardiff, the project raised a number of questions:

> *'It brings new processes, new objects and new expressions of materiality to the museum. We will also face new challenges in the conservation of such objects. (…) Should museums buy the 3D files with the objects? How do they relate? Are they like a preparatory sketch to a painting or like a design drawing, or is the data the artefact? And how could it be displayed?'*

The Usher Gallery and The Collection in Lincoln faced similar questions through their collaboration with Oliver Laric. New museum practices and new knowledge emerged from this project, the collections access manager at The Collection in Lincoln explained:

> *'We 3D printed some of the files and send them out to schools now. Our archaeologist is using 3D scanning to research the marks on some of our sculptures; they can be seen a lot better on the 3D scans. We are also looking into digital restoration and want to make GIFs of the 3D models part of our archive web page. We have also removed all restrictions on photography in our galleries.'*

The *Lincoln 3D Scans* project also influenced the accession policies of the Usher Gallery and The Collection in Lincoln. Digital works, which are created using new or emerging software applications, are vulnerable to software obsolescence. Innovation in digital media advances at a rapid pace. Software programmes, file formats and processes, are continuously replaced with new products and formats, in order to preserve the accessibility of digital files, museums therefore have to be able to update file formats and the software on which they are viewed. The *Lincoln 3D Scans* project highlighted this need to museum staff at the Usher Gallery and The Collection in Lincoln:

> *'We have changed our accession policies in order to be able to collect digital pieces. It was important to include the right to format-shift in our contracts with artists, to ensure we will be able to ensure digital work remains viewable.'*

Other institutions were also able to acquire knowledge from the *Lincoln 3D Scans* project:

> *'A lot of museums now phone us for example to ask for advice in buying 3D scanners. We have received a lot of feedback from users and tech industries. One organisation used the scans to beta-test their projects. The forensic department even got in touch because they were interested in 3D scanning.'*

Collaboration with artists can foster innovation in museums and promote new, digital forms of engagement with museum collections. Museum professionals from the National Museum Cardiff and The Collection and Usher Gallery in Lincoln agreed, that digital art projects presented a way for museums to experiment with the boundaries of established practice, to be more innovative and to engage and experiment with digital media:

> *'It has given us the impetus to broaden our horizons, it has introduced new technologies and new ways of thinking about the collections and what impact they can have.'*

5.6.5. Digital divides, digital literacies

Historically, whenever technologies evolve rapidly, access to and literacy in the new technologies become important aspects of social inclusion (Thompson, 2008). People who do not have access to the necessary digital tools or who do not know how to use them are excluded from processes that exploit these technologies. They are hampered in their ability to participate. Mathew Mitchell argues that this 'may be a threat to social and economic justice' (Mitchell, 2002:1).

Access to digital technologies and knowledge of how to conceptualise and use them, is increasing around the world, with Asia and the West in the lead but with strong progress in Africa (Parker, 2007). However, ubiquity of access and use cannot be assumed. Various factors, including socioeconomic status, education level, geography, age, disability, language, and literacy, can leave people without access to technology (Jaeger *et al.*, 2012). Another dividing force is the rapid development of digital technologies; the high turnover rate of digital technologies creates gaps between individuals 'who have the time, energy, motivation, and resources to keep pace and those who do not' (Mitchell, 2002:13). Furthermore, new access issues grow and persist as new digital materials (such as 3D models of heritage collections) are created and stored electronically. In principle the Internet is improving an open and international exchange of data and ideas. However, critics argue, that the expanding use of the

Internet and digital media is ‘not flowing evenly and smoothly (…) within countries or across the world.’ (Hassan, 2004:156). 3D models online are mostly accessible for an affluent minority with high speed Internet and computers. The disparities in the ownership and access to these media can potentially create or reinforce socio-economic inequalities based on the digital marginalization of the poorer classes and of regions with limited access to digital technologies and the Internet (Martin and Creeber, 2008:123).

In this research, the Kenyan artist Jeff Waweru did not have access to the necessary tools to undertake 3D editing of the museum scans (see Section 4.2.4. Artworks). However, he was able to creatively overcome this by employing craftsmen instead of using digital tools. Nonetheless, this complicated his participation in the *(Im)material Artefacts* exhibition; while other artists were able to send in digital files on the day of the deadline, Waweru had to plan ahead to ship his work from Kenya[172].

The disproportionate distribution of access to the Internet and to digital technologies is widely referred to as the ‘digital divide’ (see Glossary). In the mid 1990s, during a time of transition when the Internet went from a novelty to a necessity, ‘digital divide’ emerged as a term to talk about the inequalities between those who did or did not have access to the Internet. Today, the term has no clear-cut definition; it can be used to describe and discuss varying levels of access and skill in the use of digital technologies.

> *‘15 years ago when we used the term digital divide, we were talking largely about the question or the concern around access to technology (…) now when we talk about it, I think it’s less about access to technology and more about participation.’* (Watkins, 2011:1-2)

In order to participate in the use of digital technologies, individuals need to possess certain skills. Today, in numerous social and cultural practices ‘one's ability to participate is predicated on one's ability to become digital’ (Mitchell,

[172] This caused further expenses, which were however covered by the exhibition budget.

2002:2). Digital data is in a constant state of motion. Information may migrate through different states and media and change in the process;

> *'All media can now slide from one to the other. A book can stimulate public discussion in a thousand places at once. An e-mail conversation can be published by its participants. An essay intended for public consumption can anchor a private argument, parts of which later become public. We move from public to private and back again in ways that weren't possible…'* (Shirky, 2010:56)

Familiarity with digital media and tools is therefore important in personal as well as public matters. It is imperative that audiences and users are able to navigate the digital information they receive. As new social practices are emerging online, digital literacy has also become an important social skill, which enables people to 'engage in particular social practices, to assume appropriate social identities, and to form various social relationships' (Jones, 2012:12).

From this perspective, access to and command of digital tools can be understood as a matter of (digital) literacy; not knowing how to access and use technologies is becoming equivalent to not knowing how to read and write. The concept of digital literacy 'builds on the concept of the digital divide to indicate the ability not just to access digital infrastructure but also to utilize it' (Jaeger *et al.*, 2012:5). Digital literacy 'is critical, because it increases the size of the community that can make use of any given bit of knowledge' (Shirky, 2010:140). The term 'literacy' describes the ability to read and write; 'digital literacy' therefore describes how people make use of digital tools (how they 'write' with them) as well as how they conceptualise digital materials (how they 'read them').

Projects that enable individuals to creatively engage with digital 3D models of museum artefacts can promote digital literacy. Whenever they faced challenges, artists and users practiced and improved their digital editing skills, making use of or contributing to UG learning resources;

> *'I searched a lot of resources online, I even wrote to other artists asking for advice.'*

> *'The community helps to make it happen. I am not a 3D artist, I just followed the evolution of Blender since 2007.'*

At the same time, viewers of the *(Im)material Artefacts* display, who were interviewed for this research, displayed an intuitive grasp of the possibilities and issues raised by the creative use of digital 3D files in the museum context;

> *'It takes time to assimilate and digest the possibilities of new technologies. Digital technologies caused a huge leap in photography, it has become a lot easier to take images and to change them (…) perhaps these technologies will make it easier for some to create work.'*

> *'Museums traditionally conserve objects and keep them precious, the distribution and experimentation with 3D models goes against this, it also raises copyright questions.'*

Furthermore, *(Im)material Artefacts* and *Lincoln 3D Scans* had a positive effect on the digital literacy of museum staff. Artists and users downloaded, edited and 3D printed digital 3D models of museum artefacts. Museum staff and viewers viewed and interpreted the work produced by artists and users in the museum gallery and online. Both forms of engagement contribute towards digital literacy; while the manipulation of digital heritage can help to increase digital editing skills (the 'writing' aspect of digital literacy), the viewing and interpretation of digitally altered reproductions of museum artefacts can increase individuals' conceptual grasp of digital tools and products (the 'reading' aspect of digital literacy).

5.6.6. Museum policies

To date, the creation of digital 3D models from museum collections lies in a legislative grey zone. In museum galleries, where photography is allowed, the creation of photogrammetric 3D models is also possible. UG digital 3D content from museums is predominantly created using photogrammetry software, which generates 3D models from digital photographs. It would be hard to police restrictions on the creation of 3D reproductions, while at the same time allowing photographs to be taken in museum galleries. While laser 3D scanning uses different methods than photogrammetry and can result in higher quality 3D models, the resulting models are nonetheless similar, and are usually saved under the same file formats (STL, OBJ and other formats); it therefore makes little sense to develop different policies towards these methods of 3D digitisation.

The digital 3D reproduction of works in museum collections and the further use of these reproductions pose legal and ethical questions. One of the main legislative questions faced in this context is the question of ownership and copyright. ‘Fuzzy copyright and ownership concerns’ frequently hold museums and individuals back, and can negatively impact on ‘how people engage with works of art that are free for all to reimagine’ (Bogle, 2015). Generally, copyright protection ceases after certain period of about fifty or seventy years after the author’s death. After this time, works are in the public domain and are free to use. This includes the right to make copies (including digital 3D reproductions) and to sell these reproductions (Petri, 2014). Reproductions are not generally covered by copyright protection, unless they are sufficiently original to qualify as new works. This raises more difficult questions as to what constitutes originality. Although the creation of digital 3D scans involves subjective decisions and processes, 3D reproductions are not generally conceptualised as new artworks, and therefore do not automatically fall under copyright protection. In theory, digital 3D reproductions of museum artefacts are in the public domain and should be freely available for further use. Nonetheless, museums often follow restrictive policies concerning the creation and distribution of reproductions from their collections. Museums frequently limit the creation and distribution of digital 3D models, due to fears of misuse and copyright theft; 'data theft is a worry (…) replica sellers could pillage museum collections with computer-vision software' (Callaway, 2014). Digital 3D models pose a potential threat to sources of museum revenue, such as their gift shops, as it is possible to print a 3D reproduction, instead of purchasing memorabilia and gifts in the museum gift shop. Museum professionals are ' worried about protecting "their" objects once online, about copyright and reproduction rights and about the potential for widespread forgery' (Robson *et al.*, 2012:98-9).

The creation of high quality 3D models can be costly. It is therefore understandable that some museums aim to possess exclusive rights of digital reproductions to raise income. However, digitisation does not need to be expensive; initiatives like *Scan the World*[173] offer open-source and free-for-all alternatives to the 3D digitisation packages offered by commercial service providers. Digital 3D models created for academic research in the Arts and Humanities must adhere to agreed standards in order to be reliable, transparent and susceptible to comparison and peer review (Bentkowska-Kafel and Denard, 2012). When exploring free and open-source alternatives, museums have no guarantee that the resulting digital 3D models adhere to the high standards of quality and fidelity necessary to undertake academic research. Even so, when 3D digitisation is undertaken with the aim of enabling open and creative engagement, lower resolution 3D models can be acceptable[174]. In general, however, artists and users preferred high-resolution models; they identified the high detail of the *(Im)material Artefacts* and the *Lincoln 3D Scans* models as a sign of quality, as larger files carry more information and appear more realistic when rendered on a computer. Petri argues, that 'when museums provide the public with high-quality reproductions, they can expect to be paid for their services' (Petri, 2014:10). He contends, however, that commercial and non-commercial users should be charged different rates.

[173] See https://www.myminifactory.com/users/Scan%20The%20World, accessed 08.06.2015.
[174] At times, they might be easier for hobbyists to work with, as they are less likely to crash programmes and cause problems through their large file size.

3D digitisation can also raise cultural and ethical challenges. Frequently, artefacts in museum collections come from different cultural contexts; many were taken under circumstances, which would no longer be considered ethical today[175]. This means that different cultural and political groups might have vested interests in museum collections. While 3D digitisation can enable these groups to have greater access to cultural objects, it also opens them up to appropriation by third parties. Some cultural groups consider digital representations to be able to share the affective authenticity and ontological qualities of original artefacts (see Section 2.4.3. Digital copies). When digital 3D models are deemed to have affective authenticity, new and meaningful possibilities for the repatriation[176] and reinstatement of objects towards their historical or cultic use become possible. At the same time, some uses of such 3D models could offend groups who feel emotionally and culturally connected to these artefacts. As guardians for cultural artefacts, museums are conscious of their moral and ethical obligations. The openness of digital media can make it difficult to oversee and regulate the trajectory of digital reproductions; derogatory treatment, misinformation and the misuse of content are almost inevitable.

While it raises questions and challenges, open access to digital heritage artefacts can also be profitable for museums. The appropriation of museum objects and the creative acts of individuals and groups confer new value and appeal on museum collections and can function as a form of advertising and promotion (Kosnik, 2012, Scholz, 2012). Furthermore, museums maintain their collections and develop strategies 'for the purposes of education, study and enjoyment' (Museum Definition by the International Council of Museums, ICOM, 2007). By providing access to digital reproductions of artefacts from their collections and allowing their creative use museums can support these strategic aims.

[175] For example, objects which were taken as the spoils of war or during times of colonial occupation.

[176] See for example the initiative to digitally repatriate collections of Chinese artefacts in European museums: http://www.digitalmeetsculture.net/article/chinese-cultural-artifacts-that-are-in-europe-go-back-digitally-to-china/, accessed 06.06.2015.

5.6.7. Control or chaos?

During the *(Im)material Artefacts* and *Lincoln 3D Scans* projects, different steps were taken to enable creative engagement with digital 3D models of objects from the museums' collections. While artists were recruited through an open call for the *(Im)material Artefacts* project and 3D models were shared on an individual basis, *Lincoln 3D Scans* allowed full and unrestricted access to 3D models (see Chapter 4. Case studies). The collections access manager at The Collection in Lincoln, who led the *Lincoln 3D Scans* project in collaboration with Laric, recounted; 'we did not have the skills to do much with the 3D files, we decided to give away the files for other people to use'. The Usher Gallery and The Collection in Lincoln faced the challenge of weighing up the risks and benefits of providing open access to 3D models of objects from their collections online. 'It's a whole minefield this area,' the collections access manager at The Collection in Lincoln related, 'our lawyers told us that copyright law is lagging behind; there are no precedents for digital 3D reproductions'. In order to mitigate risks the museum 'prepared cease and desist orders and apologies in case anything went wrong'.

The trajectory of the *(Im)material Artefacts* and *Lincoln 3D Scans* 3D models has extended beyond the scope of the project. Some of the *(Im)material Artefacts* models were re-shared via MyMiniFactory.com after the completion of the project[177]. Furthermore, the researcher created a lesson plan for the Ultimaker CREATE educational online resource[178]. The *Lincoln 3D Scans* 3D models also continue to be circulated via other online repositories[179]. One user who re-shared content from *Lincoln 3D Scans* explained that he hoped to enable other people to use the scans as a resource; 'it was merely a way to show people (on Thingiverse) that there were some great models online and I chose a few to edit for them to download and print'. On 3D editing theme boards and 3D file sharing

[177] See https://www.myminifactory.com/category/national-museum-of-cardiff, accessed 15.10.2015.
[178] See http://www.createeducation.co.uk/lessons/, accessed 18.10.2015.
[179] See for example http://www.thingiverse.com/thing:412723, http://www.blendswap.com/blends/view/71428 and https://www.myminifactory.com/object/napoleon-at-the-usher-gallery-lincoln-uk-2958, accessed 22.04.2015.

websites users are able to share resources, tips and to communicate[180]. When users begin to interact with each other 'communities of practice' can form; these can be viewed as social learning systems (Wenger, 2000). They provide a 'shared repertoire of communal resources – language routines, sensibilities, artefacts, tools, stories, styles, etc.' (Reeve *et al.*, 2002:164). The activities of communities of practice can produce 'user-generated content emerging out of the free time and wilful contributions of millions of people' (Fish and Srinivasan, 2012:138).

Through their re-contextualisation and re-distribution by users, 3D models of museum artefacts can enter into new contexts of use and exchange. This might not always be contexts that museums condone; 'given the chance, people will often do something other than what is expected of them out of sheer defiance' (Shirky, 2010:95). Furthermore, misinformation can be distributed with the digital 3D models when they are re-shared outside the scope of museums[181]. This introduces new social dilemmas for the museum institutions in charge of safeguarding the original artefacts. Should they be equally responsible for preventing culturally insensitive, historically misleading or distasteful uses of digital content sourced from their collections?

In his book *Cognitive Surplus: Creativity and Generosity in a Connected Age* (2010), Clay Shirky explores this dilemma and describes three possible scenarios. In the first, open use of new technologies is condoned 'without regard for existing cultural or social norms or potential damage to current social institutions', the second scenario sees 'the fate of new technology (…) in the hands of the people responsible for the current way of doing things' and a third scenario 'assumes a balanced conversation between radicals and traditionalists' (Shirky, 2010:209). While this last scenario might at first appear to be the most beneficial, Shirky argues, that 'the right answer is actually the first one, "As Much

[180] See for example http://www.blendswap.com/blends/view/71428, accessed 13.10.2015.
[181] This happened when *(Im)material Artefacts* 3D models were re-shared via MyMiniFactory.com; the models were initially described as photogrammetric models, even though they are lazer scans. This error has since been rectified. See https://www.myminifactory.com/category/national-museum-of-cardiff, accessed 18.10.2015.

Chaos as We Can Stand"' (Shirky, 2010:209). When it comes to the application of new technologies, Shirky argues that;

> *'The actual negotiated transition can happen only by letting the radicals try everything, because given their inability to predict what will happen, and given the natural braking functions of social diffusion, most of it will fail. The negotiation that matters isn't between radicals and traditionalists; instead it has to be with the citizens of a larger society, the only group who can legitimately decide how they want to live, given the new range of possibilities.'* (Shirky, 2010:211)

The project design of *(Im)material Artefacts* project initially took a cautious approach towards the distribution of digital 3D models; the digital 3D models used in the project were distributed to a select group of artists. This allowed the researcher to control the scope of the project and to keep a clear oversight of participants and their actions. The 3D models were made available online without copyright restrictions following the completion of the project[182]. Lincoln 3D Scans, on the other hand, follows a more open - 'As Much Chaos as We Can Stand' - approach; 3D files were made publicly available without guidelines or copyright restrictions. While both projects followed a similar conceptual design (see Chapter 4 Case Studies) and both spawned new artworks of comparable aesthetic qualities and with similar thematic content, *Lincoln 3D* Scans had an arguably greater public impact than *(Im)material Artefacts*; it reached a wider audience and effected practical changes in the Usher Gallery and The Collection in Lincoln. Most importantly, the digital 3D models produced for *Lincoln 3D Scans* continue to be downloaded, remixed, printed and shared, and thus continually engage users with digital heritage.

The investment of artists' and users' time, energy and focus generates new work and experiences and thus gives value to digital museum interventions such as *Lincoln 3D Scans* and *(Im)material Artefacts*. It can also generate renewed

[182] The 3D models are available via MyMiniFactory, see https://www.myminifactory.com/category/national-museum-of-cardiff, accessed 21.10.2015.

interest in museum collections, attract new audiences and confer 'on objects new value and appeal, and so is effectively a type of advertising' (Kosnik, 2012:101). Since the creative efforts of artists and users generate value, they are a form of digital labour. In the introduction to his edited book *Digital labour: the Internet as playground and factory* (2012), Trebor Scholz argues that digital labour can be seen as a form of exploitation, as people invest energy and time into a kind of productivity that will benefit another party, without receiving compensation in the form of wages or social benefits, such as healthcare, for their time and effort.

Artists and users who created artworks for *(Im)material Artefacts* and *Lincoln 3D Scans* did not receive monetary rewards for their actions. However, they benefitted in other ways; during the *(Im)material Artefacts* project participating artists were at least partially motivated by the invitation to show their work in a national museum. Furthermore, 3D printing of their work was covered by the project budget and after the completion of the project the 3D printed forms were sent to them free of charge. *Lincoln 3D Scans*, on the other hand, did not offer any incentives to its users other than the free use of 3D models and the possibility of uploading and showing work on the *Lincoln 3D Scans* website. Users were also able to show their work and share content through other websites, such as *Blenderswap* or *Thingiverse*[183]. These websites provide a forum for affinity groups, where members can appraise each other's work, give input, share and learn. Social exchange plays a significant role in motivating users to spend time and energy on creative digital projects, 'the sharing, in fact, is what makes the making fun' (Shirky, 2010:19);

> *'Personal value is the kind of value we receive from being active instead of passive, creative instead of consumptive. (…) This energy drives the world's hobbyists (…) there's great value in seeing that we are not alone.'*
> (Shirky, 2010:172)

[183] See http://www.blendswap.com/blends/view/71428 and http://www.thingiverse.com/thing:387976, accessed 29.04.2015.

5.6.8. Discussion

Digital 3D technologies have begun to have a considerable impact on museums. However, the field is still in its early stages and is liable to change. Experimentation with the application of new concepts in the context of museum institutions can be fraught with difficulties. Conventional methods of museum display are not always suited to the display of new, digital artefacts. Today, audiences demanded more engaging forms of display and improved access to content and contextual background information. Viewers of the *(Im)material Artefacts* display showed great interest in the conceptual design of the project. Many identified the concept as more important than the individual new artworks. This also applies to the *Lincoln 3D Scans* project, where the concept *is* the artwork. As singular pieces, the new digitally remixed artworks were sometimes seen to lack depth and originality and to overly rely on the novelty value of digital 3D technologies. Interviewees shared the opinion that museums continue to be important as physical and social spaces, and that digital technologies and digital copies might augment, rather than replace, their physical characteristics.

In an exhibition setting, where original artefacts and their remixes are shown together, feedback loops can develop between the originals and the digitally remixed artworks. Fears that reproductions and remixes might weaken the auratic qualities of the original pieces were not confirmed by audience experiences. Instead, the contrasting qualities of the new artworks and the original pieces were seen to amplify the age, authenticity and primacy of the museum originals.

Digital intervention was seen by interviewees as a way to increase the pace of change in museums and to help heritage institutions to keep up with digital developments. *(Im)material Artefacts* and *Lincoln 3D Scans* employed digital 3D technologies with the aim to allow individual, personal and subjective interpretations of museum artefacts. This approach was seen by interviewees as a way to stimulate creative thought and critical reflection. Interviewees described the projects as humorous and anti-authoritative, as engaging and approachable. Creative digital experimentation can help museums to engage with digital media and popular culture, thus stimulating new interest and attracting new audiences.

3D models have potential as a learning resource[184]. Participants in *(Im)material Artefacts* and *Lincoln 3D Scans* engaged in self-directed learning and exchanged knowledge online. This included both technical expertise and historical understandings. Digital 3D scans are suitable for the practice of digital skills. Creative engagement with digital 3D models can present a new form of research and discovery and support experiential self-directed learning for users. The digital literacy of viewers was also engaged, as they understood the new artworks in a digital context and thus made use of their abilities to contextualise and 'read' digital technologies. Some participants faced challenges in the use of digital tools, which they overcame through trial and error, self-directed learning and knowledge exchange with learning communities.

Online communities frequently create rich resources for self-directed learning. These learning resources are, however, only open to people with access to the Internet and to the necessary technological tools. People who lack these resources remain excluded from such learning experiences and cultural exchanges. However, the example of Jeff Waweru's *Curio Dog* showed that it is possible to creatively overcome, or bypass, digital deficits and obstacles.

Museums stand to learn from open, creative and collaborative digital projects. By fostering creative experimentation with digital 3D models from their collections, museums can experiment with the boundaries of established practices. In order to embrace innovation museums must expose themselves to risk. 'Lots of small, inexpensive failures, and the cultivation of more of a culture of experimentation and continuous improvement' enables museums to experiment with new

[184] Ultimaker, manufacturers of 3D printers, for example offer a small range of open teaching resources. I was invited to contribute a lesson plan and used the 3D model of an ushabti from the National Museum Cardiff, to put together a short lesson plan, which educators can download and develop further. See http://www.createeducation.co.uk/lessons/, accessed 19.04.2015.

practices and concepts (Chan, 2014). Not all products of this form of engagement are meaningful of valuable. While they can initially 'bring about a rapid fall in average quality', Shirky argues that 'over time, experimentation pays off, diversity expands the range of the possible, and the best work becomes better than what went before' (Shirky, 2010:51).

For the Usher Gallery and The Collection in Lincoln the open approach of *Lincoln 3D Scans* pioneered a new approach to the use of 3D technologies and fostered learning experiences for users as well as for museum staff. In response to the project, museum internal policies were amended to become more suited to the collection and curation of digital artefacts. By cultivating 'a culture of experimentation and continuous improvement' museums can take steps to develop new strategies and policies, in tune with digital developments and contemporary culture (Chan, 2014).

Museums rely on users to 'activate' their digital resources; this can raise questions of copyright, ownership and investment. Affinity groups create value through their creative engagement with digital projects like *Lincoln 3D Scans* and *(Im)material Artefacts*. This begs the question, whether artists and users should be compensated for their time and energy. However, it appears that users' motivations are strong enough that they gravitate towards practices, which they experience as rewarding. Digital creative engagement with museum collections can fulfil basic and universal psychological human needs for competence, autonomy, and relatedness; users of digital heritage can be seen as intrinsically motivated to undertake creative projects (see Deci, 1972).

6. Interpretation of Findings

6.1. Introduction

Findings from the research indicate that digital 3D technologies can support creative and open forms of museum intervention, which foster learning and dream space experiences, and engage museums with metamorphosed objects and imagined realities. By focusing on creative uses of digital 3D models in the museum environment this research has contributed a new perspective to the discussion of digital heritage, which frequently revolves around knowledge-based strategies. This chapter reviews the implications of findings arising from this study and discusses potential areas of future research.

In the following sections the findings are developed and discussed in relation to three main areas of interest. These include institutional museum practices and the artistic impact of creative uses of digital 3D technologies in a museum context. The implications of such practices for the exploration of the museum dream space, both from the perspective of creative makers and viewers, are also discussed. Section 6.2. describes the institutional impact of digital 3D technologies and their potential to alter curatorial praxis. Section 6.3. illuminates the impact of digital heritage models on creative and artistic practices. Section 6.4. reveals their significance in relation to the museum dream space. Section 6.5. draws themes together and discusses the implications of this study for possible future areas of research and praxis.

6.2. Institutional considerations

Findings from this research indicate areas of museum practice, where the creative use of digital 3D technologies can present museum curators with new challenges, but also with new opportunities. These include the legislation of digital 3D reproductions, the curation and display of digital 3D content in museums, potential uses and markets for digital 3D models and their potential as an educational and artistic resource.

Digital 3D models become meaningful to individuals when they are used and invested with time and energy (see Section 5.6.7. Control or chaos?). The success of creative digital projects depends on user interaction and public interest. It is therefore commendable that museums aim towards a wide distribution of digital 3D models from their collections and allow as much 'chaos' as possible (see Shirky, 2010) to experiment with the use of new technologies. Factors like funding, museum policies, and of course the personal stance of museum professionals influence the amount of chaos that can be tolerated. This varies from institution to institution. There is no one solution to fit all. Museums must find approaches to the creation, distribution, access to and use of digital 3D models, which suit their institutional policies and aims.

Museums can produce and publish 3D models on their own, in collaboration with academic institutions[185], with individual artists[186], as part of a museum hackathon[187], or in collaboration with companies[188] and interest groups[189]. 3D models can be made accessible for free[190] or as commodities[191]. Collaborations

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[185] See for example this article on the Digital Soane Competition, a collaboration between the Royal Collage of Art and Sir John Soane's Museum: http://www.artec3d.com/news/The+Digital+Soane%3A+How+Artec+3D+scanners+bring+together+new+technologies+and+contemporary+art_29966, accessed 15.06.2015.

[186] Cosmo Wenman for example has been campaigning for open access and creating 3D models of museum artefacts for years. See https://cosmowenman.wordpress.com, accessed 21.06.2015.

[187] See for example the Metropolitan Museum of New York's 3D hackathon: http://www.metmuseum.org/about-the-museum/now-at-the-met/features/2012/high-tech-met/3-d-hackathon, accessed 21.06.2015.

[188] The British Museum for example has collaborated with leading 3D specialists Sketchfab, to offer a service that allows people to download and print 3D models of museum artefacts. See https://sketchfab.com/britishmuseum, accessed 21.06.2015.

[189] Interest groups and initiatives, such as Scan the World undertake free 3D scanning in museums, see https://www.myminifactory.com/users/Scan%20The%20World, accessed 21.06.2015.

[190] The Asian Art Museum, for example, is one of a number of American museums who have begun to share digital 3D models via the 3D repository *Thingiverse*. See https://www.thingiverse.com/AsianArtMuseum/about, accessed 12.06.2015.

[191] The Bulgaria-based company Threeding, for example, signed cooperation agreements with the Regional Historical Museum of the Black Sea city Varna and the Regional Historical Museum of Pernik. Under the agreement, Threeding can 3D scan part of the museum exhibits and sell the digital models on its website. See https://www.threeding.com/products.php?user_id=149, and https://www.threeding.com/products.php?user_id=84, accessed 12.06.2015.

also provide a way for museums to create and distribute teaching resources[192]. Digitisation can also take place outside the scope of museum initiatives; a growing number of museum visitors are independently experimenting with the creation of UG 3D models from museum collections (see Section 2.3.3. Digital 3D repositories of museum artefacts online).

Curators can enable or curb the creation of UG 3D models in their galleries through curatorial strategies. To create a complete photogrammetric model of an object photographs of the item have to be taken from all angles (see Fig.95). If a museum artefact is positioned close to a wall, or inside a reflective glass case, it becomes near impossible to create accurate photogrammetric models from it (Younan and Gill, 2013). In this manner, it is possible for museums to selectively regulate the creation of 3D models in their galleries, without the need to restrict photography. Curators can also decide to encourage photogrammetry activities by presenting objects in ways that allow them to be viewed and photographed from a 360-degree angle and by sharing practical knowledge and instructions with their visitors[193].

Digital 3D models can be used to experiment with new methods of curation. For example, they offer fresh scope for commissioned art projects. Museums can share digital 3D models with selected artists, nationally and internationally, at a relatively low cost and effort. This approach is suited to the creation of digital artworks, but can also be effective in support of art projects that combine manual skills and digital practice (see Section 5.3.3. Hybrid practices). Alongside their digital uses, 3D models can inspire non-digital creativity, without the need for high-speed computers and specialist software skills.

[192] For example *CREATE*, an initiative by 3D printer producers Ultimaker, offers lesson plans that use digital 3D models to convey educational content. A 3D model from the National Museum Cardiff was used to create a lesson plan for this resource. See http://www.createeducation.co.uk/lessons/, accessed 12.06.2015.

[193] See for example this blog entry by Don Undeen, Digital Media specialist at the Metropolitan Museum of Art in New York; http://www.metmuseum.org/about-the-museum/museum-departments/office-of-the-director/digital-media-department/digital-underground/posts/2013/3d-printing, accessed 19.06.2015.

Fig.97 Photogrammetric model created using 123D Catch software. Model taken in the National Museum Cardiff during a preparatory study (see Appendix B.2. Photogrammetry case study), the small cameras indicate at which points photographs were taken to create the model; 2013 © Sarah Younan

Findings from this research indicate, that audiences value access to digital content and information, but also wish for museums to retain their traditional focus on material objects and physical displays. Nonetheless, it can be beneficial for museums to examine digital content created from their collections and to harvest UG content online for further research or to display in their galleries and online. Digital technologies allow artefacts and ideas to move in and out of museums, without disrupting traditional museum spaces. For example, museums can choose to augment artefacts in their galleries through the use of digital 3D technologies and marker-based 'tagging' (Yu and Hunter, 2010, see also Glossary). Marker-based tags can link objects in the real world to digital content, such as web pages and other multimedia. Already, a number of museums are employing tagging to augment objects in their galleries with additional information, for example during folksonomy projects (Trant, 2009). To enable access to UG digital 3D content in museums, tagging could be used to augment museum artefacts with 3D models and remixes. Marker-based tagging can be undertaken at a minimal cost and does not intrude much on traditional museum displays. It allows digital content to enter into the museum galleries without altering the overall aesthetic of the gallery displays. Tagging could also be used to augment environments outside the museums. Digital 3D models can be 'installed' in public spaces using marker-based tagging, and viewed using smart phones and other mobile devices. Hackers, researchers and heritage institutions are already experimenting with the augmentation of heritage sites and other spaces with digital content; digital 3D models of museum artefacts have potential to enrich this field of museum practise.

The 3D digitisation of artefacts could open up new sources of revenue for museums. Digital 3D models can be used in the creative industries, and have great potential in relation to developing virtual reality (VR) and augmented reality (AR) technologies. In digitally rendered scenes, high-quality 3D scans of real artefacts appear more realistic to the human eye than born-digital 3D models. Born-digital forms are created out of mathematical coordinates and often have fewer vertice points than 3D scans. The kind of perfect straight edges created in 3D modelling are rarely found in real life. Real life artefacts contain more 'faults' than born-digital 3D models; they are rarely perfectly clean or symmetrical. As a result, digital 3D scans and photogrammetric models of real artefacts appear realistic due to their asymmetric, 'grungy' geography and surface data (Slick, 2015). 3D scanning creates copies of objects and locations and can reduce the time and cost of 3D modelling and visualisation. Already, video game producers[194], filmmakers[195] and other creatives are exploring the use of digital 3D scans as a replacement for born-digital 3D models. A demand for realistic 3D models exists in the creative industries, for example in the video game and visual effects industry[196]. This demand is likely to increase with the proliferation of VR and AR technologies. 3D models from museum collections could potentially be used in the creation of videogames, films and VR and AR environments.

[194] For example, the video game *Get Even* will be one of the first videogames to almost exclusively use 3D scans of real-world objects and places in its game world. See http://venturebeat.com/2014/11/20/get-even/, accessed 12.06.2015.
[195] In the creation of the film *Worldwar Z*, for example, 3D scanning was used to digitize weapons and other props, as well as actors and their elaborate costumes, see http://www.artec3d.com/case_studies/Artec+scanners+were+engaged+in+the+making+of+"World+War+Z"_24439, accessed 12.06.2015.
[196] Companies like Infinite Realities cater to the demand for high-quality 3D scanning and post-processing. See http://ir-ltd.net/, accessed 26.02.2015.

Through contextualising information and presentation, digital 3D models can continue to share some of the ontological qualities of the originals and remain connected to the museum and its context of authenticity and authority. The creative industries could draw on museum collections to find digital 3D models that convey a ‘sense of pastness which is used as an attractive gloss’ (Keightley and Pickering, 2012:141); strategies like this are frequently used in marketing (Keightley and Pickering, 2012) and could also be effective in video games, films, and other media. Digital technologies permit content from museums to permeate popular media. As discussed previously in this thesis (see Section 2.4.5. Digital media and the museum dream space) mass media and popular culture feeds into the way people imagine the past. If museum artefacts and their reproductions receive more circulation through mass media and popular culture the accuracy of historical representations could be increased. In turn, a more historically informed and faithful representation of the past in popular culture and mass media could inform the public’s historical imagination and have an impact on how people visualise the past.

Museums play a role in the production and shaping of knowledge (Hooper-Greenhill, 1992). They are potent environments for experimental and self-directed learning;

> *‘The best learning experiences come when people are actively engaged in designing things, creating things, and inventing things - expressing themselves. It’s not just a matter of giving people opportunities to interact with technologies or using technologies, but if we want people to really be fluent with new technologies and learn through their activities, it requires people to get involved as makers - to create things.’* (Rheingold, 2011)

Findings from this research suggest, that creative engagement with digital 3D reproductions of museum artefacts can stimulate self-directed learning and lead to an increase in digital literacy. During this study evidence was collected of self-directed learning in artists and users and of the online sharing of knowledge and skills, both technical and historical (see Section 5.6.4. Learning experiences).

Digital museum interventions were also found to foster insights and learning experiences for museum staff. The curation, collection and storage of digital artefacts raise a number of questions for museums. It has become relatively common for museums to acquire born-digital and 3D-printed works[197]. Frequently, museums acquire these artefacts in the form of 3D prints. However, the acquisition of digital files and licences to print might be a viable alternative, especially since the materials used in 3D printing are frequently in peril of rapid deterioration[198]. Artists participating in *(Im)material Artefacts* held the view that reprints offered a valid way of displaying digital 3D files (see Section 5.3.2. 3D print). This suggests, that digital files and licences to reprint need to be explored as a viable alternative to the collection of physical, 3D printed pieces. When collecting digital files museums must bear in mind the challenges of rapid change in digital media and implement policies to make sure files remain readable.

6.2.1. Discussion

Museums are under pressure to adapt to the rapid technological, cultural and social changes brought about by the fast developments of digital 3D technologies. Frequently, these new tools and processes are implemented in museums to support the traditional activities, which they have been pursuing for centuries (see Section 2.3. Digital Museum Strategies), these maintain expert curatorial control over collections and interpretation. This research contributes a new perspective on the debates concerning digital heritage, by focusing on the creative, rather than knowledge-based uses of digital 3D models. Findings from this research suggest that museums should consider creative uses of 3D technologies in their institutional strategies to allow new cultural and artistic processes of heritage engagement to emerge. Through the curation of gallery

[197] For example, The V&A acquired two prototype 'Liberator' 3D printed guns in 2013. See http://www.dezeen.com/2013/09/15/va-museum-acquires-first-3d-printed-gun/, accessed 15.06.2015.

[198] The researcher was part of a research collaboration with the V&A, which looked into this specific problem, see http://www.designwithheritage.org/material-migrations/, accessed 15.06.2015.

displays and the selection of artefacts for digitisation curators can play an important role in regulating or enabling digital access to museum collections. To formulate effective strategies, museum curators and other staff must gain digital literacy; this can be achieved through collaboration and engagement with artists and users. Digital objects need to be curated, thus museum curators are under pressure to learn new skills and to adapt established curatorial procedures. Collaborations with artists provide a good learning experience and enable museum professionals to experiment with the boundaries of their established practices.

Digital 3D models can be disseminated internationally, and have potential as commodities in the creative industries. Not only does this open up potential sources of revenue for museums; greater diffusion of digital heritage in popular media could also contribute to people's historical imagination and inform how the past is portrayed in popular culture. Participants in this research supported an open-use approach and argued that 3D models of museum artefacts should be in the public realm. However, digital 3D models of museum artefacts that are open for creative uses are also be open to vandalism. During this research artists and users engaged with digital 3D models of museum artefacts in a 'respectful'[199] manner. Nonetheless, 3D material from museums could be used in ways that might offend cultural and interest groups. Historically and culturally sensitive museum artefacts, such as the clothing of holocaust victims, might not be suitable for creative digital re-use.

Digital 3D scanning and printing technologies are currently receiving widespread attention in the media. However, the fascination of the new is likely to wear itself out. Furthermore, 3D technologies are rapidly evolving, with formats and technologies developing at a rapid pace. Digital museum interventions provide an alternative to heavy investment in long-term solutions. Unlike museum hackathons, these interventions are more open and less focussed on solution finding. They engage with memory processes, creativity and play and

[199] Katie Parker: 'We do not want to destroy or humiliate'. See interview transcripts in Appendix A.8. Interview summaries.

bring forth new understandings in an experimental and explorative manner. These projects allow museums to harness the creativity of artists and the fluidity of digital media and to experiment with 3D technologies. In preparation of longer-term strategies, digital artist interventions allow museums to experiment and to embrace risk, 'a prerequisite to allow significant innovation to take hold' (Stein, 2015).

6.3. Artistic impact

One of the services of museums has long been to provide artists with rich material to inspire their art making (see Section 2.4. The museum object and its reproductions). Digital 3D technologies have potential to support this function of museums. Through the creation and release of digital 3D models from their collections, museums can continue their role as sources of artistic inspiration in a digital arena. Furthermore, artist-led intervention projects can provide opportunities to reassess museum practices (see Sections 2.5. Artist engagement). As a form of artistic intervention, the creative engagement with digital 3D models questions some of the core values of museum institutions and challenges the institutional mediation of objects. In this thesis, examples of museum interventions using digital 3D technologies were discussed and two cases were studied in detail. This research has revealed the potentially ground breaking impact of digital heritage as a creative resource.

This section summarises the reverberations of artistic and creative uses of digital 3D technologies in the context of the museum. Section 6.3.1. discusses digital 3D reproduction and remixing as an art form. Section 6.3.2. presents the use of digital 3D technologies as a new strategy of museum intervention. Section 6.3.3. discusses the overall artistic impact of the creative use of digital heritage models.

6.3.1. Digital remixes

During this research artists explored the aesthetic and formal qualities of digital reproductions of museum artefacts, their relationship to past, present and future and the relationships between technology and culture (see Section 5.4. Art context). They also explored personal memories, narratives and associations in their work (see Section 5.5. Dream space).

3D models can be used as 'found objects' from which artists create new remixed artworks, such as digital assemblages and remixes (see Section 5.4.2. Remix art). Without the contextualising influence of the museum, digital heritage artefacts can be re-appreciated as things that belong to the individual, rather than as things that must be narrated through the museum institution. Digital 3D reproduction enables artists to 'poach' (see Section 2.4.4. Digital poaching) historical forms and to bring together materials sourced from different contexts, different spatial and temporal locations and by different authors.

Remixes and reproductive artworks are always the work of multiple authors, as the creators of such works build on the ideas and artworks of previous makers. Remixed digital artworks can question the romantic notion of the singularly inspired artist. Instead, anyone with the necessary hardware and software tools and digital skills can now graze their way through the pastures of digital media, appropriating and transforming cultural content and artefacts. Participants in this research embraced the ideals of digital maker culture and open culture movements (see Section 2.3.4. Museum hackathons and Section 2.4.4. Digital poaching) and pursued collaborative approaches in the creation of artworks.

The impact of digital remixes can extend to the original artefacts. This blending of virtuality and authentic objects does not pose a threat to the auratic experience of original museum artefacts. On the contrary; original objects can become charged with new energy when they enter into a context with digital reproductions and remixes. 'Manipulation value' can be seen as a new kind of auratic value, which 'depends on the extent of (…) openness for manipulation'

(Boomen *et al.*, 2009:102). Digital heritage artefacts can gain value through their reproducibility, potential distribution, and role in the mass media. This research evidences the position that digital access to museum collections increases the auratic impact and status of the original. Research data further suggests that the creative use of digital reproductions 'recharges' the originals and the juxtaposition of fixed and unchanging originals with fluid and transformed remixes can emphasise the age, precedence and authenticity of the original artefacts (see Section 5.6.2. Feedback loops).

Digital 3D models are not bound by physical space or temporal distance, when heritage artefacts are digitised 'the past is sucked into the orbit of the present, ready to be called up on screen' (Huyssen, 1994:253). During this study, artists and users described their artworks as a way of continuing the legacy of the historical makers and of extending the trajectories of the original artefacts. By building on the work of historical makers they created connections with a larger historical context, placing themselves on a continuum with artists and craftsmen of the past. The past can provide nostalgic and reassuring comforts to those grappling with a rapidly changing present and an unknown future, at the same time, it is a rich source of information that people use to think about the future. Museums excel as instruments for the contemplation of human time, as they offer visitors the opportunity to create temporal narratives (Bedford, 2012). During this research, artists and users created work that contemplates the past, present and the future, weaving patterns of continuity and discontinuity within these temporal fields.

Artists and users also employed digital 3D models to express their sense of national identity and cultural heritage. Through digital editing they left their personal mark on digital heritage artefacts and presented their ideas and interpretations through the digital heritage objects. The liminality of the digital 3D models enabled artists and users to weave continuing narratives of creativity and as self-identity'. Their artworks function as synthetic memory objects; they were invested with personal meaning and some became intimately meaningful to their makers. The personalisation of digital historical objects enabled participants to alter the past, to become part of it and to make it their own. Findings from this study suggest that users and artists employed digital 3D models to weave continuous narratives of human creativity and identity in which they have a place and a relationship to artists and artisans of the past.

6.3.2. Digital museum intervention

In this thesis, different strategies of artist museum interventions are discussed. They include: engagement with stored museum collections; artist-made mock museums; engagement with museum archives; intervention at the level of the museum display; artists acting as guides to museum collections; site-specific interventions; un-authorised museum interventions; emerging examples of digital museum interventions (see Section 2.5.1. Forms of artistic museum engagement). The case studies investigated during this research were found to employ several of these strategies, including engagement with stored collections through digital reproduction, distribution and transformation, engagement with the museum display and online display as a form of 'mock museum'. This section discusses how digital technologies bring new possibilities to these precedent forms of museum intervention.

The increased diffusion of content possible through digital 3D technologies serves to democratise museum intervention. Museum audiences are increasingly discovering freely available photogrammetry software, in combination with digital 3D editing and 3D print, as tools suited to the reproduction and exploration of museum objects (see Section 2.3.3. Digital 3D repositories of museum artefacts online). Freely available 3D resources and the possibility to self-publish have enabled forms of 'museum invention' independent of museum institutions. Although users do not always conceptualise their work in these terms, the UG content created, shared and manipulated by a growing number of digital makers outside the scope of museum institutions can be understood as an unauthorised form of museum intervention. This form of unauthorised

intervention does not necessarily enter into the physical space of the museum, although there are possibilities for the 'digital invasion' of museums[200].
The creative use of digital heritage engages with a number of recent cultural developments and shifts in group structures and collective agency, including 'social' and DIY and maker movements on the Internet, online sharing platforms and repositories, online communities and open culture principles (see Section 2.3.4. Museum hackathons). 3D digital reproductions can be used by individuals to assert claims on the historical and cultural objects that museums hold for the public. In this sense, UG digital heritage models and the artworks created from them posses emancipatory potential.

Creative projects such as *(Im)material Artefacts*, *Lincoln 3D Scans* and the various private endeavours of individual artists and hobbyists present a form of disruption within the museum context. The museum is traditionally considered as a place of permanence and preservation. Through 3D digitisation museum artefacts can be reproduced as fluid and malleable digital forms. The symbolic destabilisation of museum artefacts subverts the sense of permanence of museums. Digitally transformed museum artefacts combine historical fact with virtual fantasy, convey alternative and fictional narratives and disrupt the ordered discourse of the museum.

The historian David Lowenthal argues that any type of 'interaction with a heritage continually alters its nature and context, whether by choice or by chance' (Lowenthal, 1985:263). Furthermore, fantasy and the imagination play an important role in recalling the past (Keightley and Pickering, 2012). The creative transformation of digital heritage communicates this ever-changing nature of heritage interpretation. It reveals the importance of fantasy and the imagination and encourages a questioning stance towards circulated images and narratives. Furthermore, the creative engagement with digital heritage fosters important digital literacy skills and critical thought.

[200] *The Reaccession of Ted Shawn*, for example, uses mobile app to trigger location-specific augmented realities throughout the Museum of Modern Art in New York. This app was not commissioned or approved by the Museum of Modern Art. See http://www.thereaccessionoftedshawn.com, accessed 09.06.2015.

6.3.3. Discussion

Participants in this research created new artworks from digital heritage artefacts, which follow in artistic traditions of derivation and appropriation. Artists and users edited digital 3D Models to reflect their personal interpretations and associations, thus offering alternatives to the institutional and historical interpretation of artefacts and formulating connections between themselves, historical objects and their makers.

The increased diffusion of content possible through the use of digital 3D models serves to democratise museum intervention. They challenge the authenticity of objects (while at the same time, paradoxically, augmenting it) and defy institutional historical narratives. The creative use of digital 3D reproductions of museum artefacts creates a sense of continuity with the past, while also enabling new experiences to emerge. Participants in this research felt they were contributing to a story that is still unfolding, by bringing together and reflecting on the past, present and future in ways that create new meaning. This juxtaposition of real and virtual narratives, objects and experiences serves as a reminder that ‘it is imagination which allows the past to persist actively in the present’ (Keightley and Pickering, 2012:65).

As a form of museum intervention the digital appropriation and transformation of virtual heritage can be understood as cultural poaching, or creative consumption; it engages with museums and the objects and knowledge they hold, but rejects institutional narratives and permanence in favour of personal interpretations and fluidity of meaning. While the resulting artworks are not always of great aesthetic value, or in the best taste, they nonetheless engage with deeply challenging frameworks and concepts. Taste is an important means ‘by which social distinctions are maintained and class identities are forged’ (Jenkins, 2013:16):

> *‘Taste distinctions determine not only desirable and undesirable forms of culture but also desirable and undesirable ways of relating to cultural*

objects, desirable and undesirable strategies of interpretation and styles of consumption.' (Jenkins, 2013:16)

Rather than dismiss digital and 3D printed remixes and reproductive artworks as unoriginal, garish, over-hyped and superficial, their creation should be seen as an emancipatory, productive and critical way of engaging with heritage and a promising new method of artistic museum intervention.

6.4. Extending dream space

Museums can be spaces of intrigue, daydreams and fantasy; in the museum dream space, personal memories and associations feed into the interpretation of museum artefacts and individual experience blends with shared reality. The museum dream space can be experienced without the need to physically access artefacts. Although touch can stimulate memory and reminiscence (Kavanagh, 2000) it is possible to have experiences associated with the dream space (such as association and memory recollection) without the need for physical access. During this research, digital 3D reproductions of heritage artefacts were found to be capable of jolting 'memory or recognition' and of provoking 'internal associations or fantasy, desire and anxiety' typical of the museum dream space (Annis, 1986:169). These findings suggests, that digital heritage artefacts can provide a way to engage with and express dream space experiences. The potential of digital technologies to trigger dream space experiences has previously been investigated in the doctoral research of Katarzyna Warpas (2013). However, the research presented in this thesis contributes new knowledge by introducing a participatory element to this field of study. Furthermore, findings from this study indicate, that the creative use of digital heritage not only triggers dream space experience, but can also be used as a valid tool for the study of this realm of museum experience.

The dream space is a 'third area' (see Winnicott, 1971); a liminal realm of play and the imagination. 3D digital reproductions of museum artefacts also possess liminal qualities (see Section 2.4.3. Digital copies, and section 2.4.5. Digital media and the museum dream space). They can be associated with the public sphere of the museum, while at the same time moving beyond its scope and becoming connected to the private and intimate sphere of individuals. Poised on the threshold between reality and the imagination, they can be used to create any kind of digital imagery, artefacts or 'reality' (VR). Liminal artefacts are conducive to creativity and play; given the necessary digital editing skills, digital 3D models of museum artefacts can be transformed to depict the ideas and memories encountered in the museum dream space. These memories and associations can be drawn from the past as well as from everyday experiences, thoughts and popular culture (see Section 5.5.3. Present-day associations and popular culture). Through creative digital acts, associative thought, personal memories, popular culture, everyday occurrences and personal identities can enrich museum artefacts.

During this research, participants attached memories, associations and personal narratives to digital 3D models of museum artefacts, thus transforming them into tokens or souvenirs[201] of the dream space (see Section 5.5.2. Memory tokens). At first glance, this might appear like a replacement of real with virtual experience. However, these digital objects can also be understood to artificially widen experiences of heritage and to enrich memories of real events through associative processes[202]. Furthermore, virtual and constructed experiences are part and parcel of museums. After all, museums are artificial places, in which objects are de- and recontextualised in order to orchestrate experiences (Mack, 2003). Museums are already engaged in a vital relationship with transmuted reality. The museum dream space is an essential, albeit not often recognised, area of experience in museums, which can be extended and explored through the creative use of 3D technologies.

[201] Ian Cooke Tapia's *Teapot Trainfortress* and Jason Rouse's *Postcards from Mexico* are examples of this.
[202] For instance, Mario Padilla formed a link between his piece *Teapot Trainfortress* and early childhood memories.

6.4.1. Discussion

Projects like *(Im)material Artefacts* and *Lincoln 3D Scans*, as well as the creative actions of hobbyists and online communities, provide an opportunity to ask 'what if?'; to engage with alternative, virtual and impossible realities; to reinvent and fertilise the past. Museums are tasked with conserving the past. However, they must also keep it alive and relevant in the present. Digital 3D objects can have viable lives within new cultural and artistic practices. The case studies investigated in this research have shown that digital 3D models of museum artefacts can be used to undertake forms of cultural poaching, which weave meaningful connections between present-day experiences and the past.

Memories, associations and emotions are the threads that connect museum artefacts with personal meanings. Experiences like these were reported by artists as well as by museum visitors during this study. However, the artists, who digitally manipulated 3D models of museum artefacts, reported dream space experiences more frequently and vividly than the viewers of their metamorphosed artworks. The use of digital 3D technologies as tools for the creative exploration of museum artefacts can extend the impact of the museum dream space by liberating individual and collective memories. Digital 3D technologies can be used to expand the museum dream space from a private field of experience into an accessible realm of share experience. Through digital reproduction, transformation and digital display as well as 3D printing, dream space content can manifest in the real world, become visible and materialised.

6.5. Summary and Implications for the future

There is vast potential for museum artefacts to be accessed and repurposed by new audiences: used in computer games; movies; and a variety of other creative projects. Furthermore, this body of research reveals that uses of 3D models that do focus on their creative, playful and liminal qualities can have beneficial repercussions for museums and their audiences. They generate increased

interest in museum collections, they re-charge objects in collections and extend their trajectories, they foster self-directed research and learning experiences and they provide a way for museums to experiment with lateral solution finding and to test out novel and experimental approaches.
Digital 3D reproductions increase the possibilities of accessing museum artefacts; they democratize museum interventions and enable users to engage in processes of remix, customisation and manufacture. When they are accessed, used and invested with personal narratives, digital heritage artefacts can become intimately meaningful. 3D digitisation can 'activate' objects, which lie dormant in museum storages. This provides a new opportunity for museums to use objects kept in storage and gives users and audiences an opportunity to discover heritage objects that are not displayed in museum galleries, to become active as creators and to be inspired by museum collections in new ways. When individuals take on the role of the artist, they are able to engage with museum collections in new and meaningful ways. Artist interventions can encourage a questioning stance towards museums and their mediation of institutional knowledge, it can uncover new layers of meaning in museum collections and foster a creative dialogue with the collected and archived past (see Section 2.5. Artist engagement). Findings from this research suggest, that the open and creative use of 3D technologies in museums can generate on-going narratives that weave together the past and present, thus contributing to the continued relevance and intrigue of the past within the present.

Digitisation can be expensive for museums and it is unrealistic to propose that museums digitise and share online the entirety of their collections. Instead, this thesis proposes that museums undertaking 3D digitisation of parts of their collections opt to share their digital 3D models using creative commons licensing whenever possible. Furthermore, it is recommended that they enable and support the creation of 3D UG content in their galleries and that they collaborate with artists[203], with open culture and digitisation initiatives[204] and with online

[203] Jonathan Monaghan, who participated in *(Im)material Artefacts* and also created work for *Lincoln 3D Scans*, for example, is an artist who has begun to specialise on the creative exploration of museum collections using digital 3D technologies. He has collaborated with a number of

3D platforms[205] to create 3D models. Once museum objects have been digitised, their digital 3D reproductions can be infinitely reproduced and shared without further cost. Digital 3D models only become exclusive if museums are resistant to their open and creative use; when they are withheld or when access to them is restricted. It is not enough to create digital heritage content, museums also need to be prepared to consider the use of these digital materials in new ways. In order to use these technologies to their fullest potential more research is necessary to develop museum policies that enable audiences to digitally 'poach' museum artefacts. As the examples given in this research show, a number of museums are already engaging with these possibilities. However, few museums are undertaking efforts to follow the trajectories of these models, or to enrich their collections and archives with remixes and digital reproductions in order to enable feedback processes between the old and the new, despite the potentially beneficial impact this could have. More research, digital interventions and workshops with museum staff and audiences are necessary to enable museums and their audiences to use these technologies to their fullest potential.

Digital 3D models bear closer resemblance to original artefacts than other means of digital reproduction, such as photography. This research indicates that they possess evocative qualities and share in the ontological content of the originals. Like their original counterparts they have been found to foster creative and sub-rational responses and to trigger experiences connected to the museum dream space. Furthermore, digital 3D models are liminal artefacts; they can be transformed in ways that give shape to these dream space experiences. The resulting forms can be visualised as digital artworks, or manufactured physically using 3D printing. A diverse and international public can potentially engage with these processes, as digital 3D copies can be shared across geographic and temporal zones. Through this digital extension of the dream space experiences

institutions and is building up an impressive portfolio of digital and 3D printed artworks, see http://jonmonaghan.com, accessed 25.06.2015.

[204] Such as *Scan the World*, who are engaged in digitising museum collections in 3D and sharing models online for free, see https://www.myminifactory.com/users/Scan%20The%20World, accessed 15.06.2015.

[205] Such as Sketchfab, who are presently collaborating with the British Museum, see https://sketchfab.com/britishmuseum, accessed 15.06.2015.

and associations can become public and accessible, which previously existed only in the mind of individual viewers. Consequently, digital 3D technologies hold considerable scope for the exploration of dream space experiences. They can play an important role in the exploration of the liminal processes through which people invest artefacts with memories and personal meanings.

Research undertaken by Katarzyna Warpas (2014 and 2013) indicates, that digital technologies can leverage the evocative aspects of physical artefacts and promote museum experiences that are personal and engage with the museum dream space (Warpas, 2014). She argues that artefacts can be enhanced in museum galleries by subtle and non-obtrusive digital means. However, her research proposes the delivery of pre-fabricated digital content and does not investigate how these technologies can be used to enable productive audience engagement. This research has shown, that 3D digital technologies can also help museums to make their collections more accessible, engaging and inspiring. The museum dream space is a personal space, which digital technologies can potentially render public and visible. Therefore, projects that engage with dream space experience should not be presented through closed displays, but should offer the potential for engagement and contribution. The management and delivery of digital dream space projects requires further exploration through case studies and collaborations with museums and museum audiences.

6.5.1. Future plans

Museums provide an ideal environment for the exploration of artefacts and the institutional, cultural and individual ways in which they become invested with meaning. Digital technologies, including 3D scanning, editing and printing technologies, are gaining increasing importance as a means of engaging with museum artefacts. This thesis proposes that artist interventions in museums provide a way to explore connections between artefacts and memory processes. More research in museums, using a similar theoretical and practical framework, is needed to substantiate this claim and to explore these on-going cultural developments.

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Glossary and Acronyms

2D – Two-dimensional (flat)

3D - Three-dimensional

3D model – In this thesis, the term '3D model' is used to describe digital 3D scan reproductions of museum artefacts. The term is used interchangeably with the terms 'digital model'; 'digital 3D model'; 'digital reproduction'; 'digital 3D reproduction'; 'digital copy'; 'digital 3D copy'; 'digital heritage model'; 'digital heritage artefact'; digital heritage'; 'digital 3D model of museum artefact/object'.

3D Scanner - 3D scanners come in many forms. They can capture the shape and sometimes the surface appearance of physical objects or environments. 3D scans are typically stored as X Y Z coordinates in a point cloud file.

Accuracy - The accuracy is the closeness of a models' measurements to the original measurements.

Adaption – Making a tool fit the goal of the user, rather than following its originally intended use. Often referring to new ways of tool use that were not intended by the designer of those tools.

Affective authenticity – The perceived or experienced subjective, emotional, non-cognitive presence of a thing.

Algorithm – A step-by-step process, mathematical formula or set of operations to be followed to solve a problem or perform a particular task.

Anastylosis - An archaeological term describing a reconstruction technique whereby a monument or artefact is restored using the original elements to the greatest degree possible.

Appropriation – the act of introducing a particular tool or artefact into a new social context, or of taking it out of a previous context, in order to designate ownership.

Artefact/Artwork - In this thesis the digital and physical artefacts created by artists participating in *(Im)material Artefacts* and by users of *Lincoln 3D* Scans, are referred to as 'artworks' or 'works'. The original museum items are called 'artefacts' in the thesis. These terms have been adopted to create clarity in the writing. They are not meant to distinguish between the artistic values of the two groups of objects. The museum objects are termed artefacts, as they are held in the applied arts section of the museum and were used for practical tasks prior to their inclusion in the museum collections. The works created by artists and users are termed 'artworks' or 'works' as they were created for the sole purpose of creative engagement and display and hold no practical function.

Augmented reality (AR) – Describes the real-time use of information in the form of text, graphics, audio and other virtual enhancements integrated with real-world objects. It is this real world element that differentiates AR from virtual reality.

Artist intervention - The term art intervention applies to art designed specifically to interact with an existing structure or situation, be it another artwork, the audience, an institution or in the public domain. In this thesis, the term is used to describe artist projects that take place in or engage with the realm of the museum.

Aura – A quality integral to an artwork that cannot be communicated through mechanical reproduction techniques. The term was used by Walter Benjamin in his influential 1936 essay *The Work of Art in the Age of Mechanical Reproduction*.

Authentic/ authenticity – The quality of something being what it appears to be. Used by Walter Benjamin to describe the qualities of an original work of art as opposed to a reproduction.

Blog – an easy-to-use website that displays content or posts similar to a journal or diary.

Born-digital – Term used to describe things that were first conceived using digital tools, as opposed to being created by hand or being copies of non-digital artefacts or events.

CAD - Computer Aided Design. CAD is an umbrella term for software that aides in design; both 3D and 2D editing.

Cognitive - relating to, being, or involving conscious intellectual activity (as thinking, reasoning, or recalling something)

Coordinates – Numbers that denote a location.

Crowdsourcing – the processes of finding solutions to a task or challenge from a broad, distributed set of contributors using the Internet and social collaboration techniques. Crowdsourcing applications typically include mechanisms to attract participants, stimulate relevant contributions and select winning ideas or solutions.

Cultures of use – the conventions, norms and values that emerge around tools in particular groups of users.

Data – 'Facts' in their 'raw' form, includes words, texts, numbers, symbols, artefacts and perceptions.

Digital archiving - Storing data digitally. Museum objects are increasingly scanned and processed for digital archiving purposes. Digital archiving is also necessary to increase the searchability of digital resources on computers and online.

Digital divide – Socioeconomic and other disparities which separate those people who have opportunities and skills enabling them to benefit from digital resources, especially the Internet, and those who do not have these opportunities or skills.

Digital heritage – In this thesis, the term 'digital heritage' is used to describe heritage materials that have been digitised and are stored as digital reproductions. The term can also indicate digital materials, which are deemed worthy of preservation for future generations.

Digital labour – Online activity, such as the creation of content and the use of blogs, social networking sites, wikis, micro blogs and content sharing sites, which is done for fun, without payment and creates value.

DVL – Digital visual literacy is the ability to create and understand visual information created or presented digitally and to critically evaluate digital visual materials (2D and 3D).

Edge - A line representing the boundary of adjacent vertices in digital 3D editing programmes. See Vertex.

Fab lab - A collaborative space for 3D printing and other forms of digital manufacture.

Face - A connection of edges on a plane representing a boundary, field, or solid surface in 3D editing.

FDM – Fusion Deposition Modelling; a 3D printing process that constructs objects by means of a temperature-controlled head that extrudes thermoplastic material layer by layer.

Folksonomy – User-generated metadata collections, also known as social tagging

Generative art - Generative art is art made using a predetermined system that often includes an element of chance, is usually applied to computer based art

GIF – Graphics Interchange Format, a bitmap image format in widespread use on the Internet due to its wide support and portability. The format supports animations

Hackathon - An event, typically lasting several days, where media developers, experts and others come together to create digital prototypes that aim to address problems in a particular domain, usually making heavy use of data. Hackathons are also referred to as hack days, hackfests or codefests

Hacking - Appropriating, adapting, modifying and remixing digital media to make it better fit ones purpose, for enjoyment or in response to the demands of a particular situation.

Ideology – a system of ideas, practices and social relationships that govern what is considered right or wrong within a particular social group.

Intentional object – An objects that is the focus of thoughts and feelings. Intentional objects can coincide with real objects (such as an car or photograph), or they can be imagined (such as vampires, or events in the future).

Maker space – See Fab lab

Marker-based tags – Visual cues (markers) than can be read by a wireless mobile device to access information, content or Internet addresses, see Tags.

Mashup – a combination of two or more cultural artefacts, often through digital editing.

Media – A material or abstract artefact used for communicational purposes.

Meme - An activity, concept, catchphrase or piece of media that spreads, often as mimicry, from person to person via the Internet.

Mesh - A collection of faces, edges, and vertices that makes up the geometry of a digital 3D model (appears as a lattice structure).

Metadata – Data, which describes a piece of data by linking it to a concept or pinpointing to another piece of data.

Metamorphosed objects – In this thesis, the term metamorphosed objects is used to describe digital artworks that are based on 3D scan models, but have been transformed into new works using forms of digital editing.

Online affinity space – a virtual place where people interact around the central focus of a shared interest or goal and form a online community.

Ontology - In computer science and information science, an ontology is a formal naming and definition of the types, properties, and interrelationships of the entities that exist for a particular domain of discourse.

Open source – Referring to software systems for which code is publicly available and can be accessed and reprogrammed by users.

Pervasive game – A pervasive game is one where the game play experience is extended into the real world.

Photogrammetry - The practice of determining the geometric properties of objects from photographic images. Due to increasingly user-friendly, freely available photogrammetric software physical access and technological insight are no longer required to create digital three-dimensional copies from photographs. Photogrammetry is used in surveying and mapping and to obtain reliable information about the measurements of physical objects.

Point Cloud - A point cloud is the computer visualization of the XYZ coordinates that describe a physical object or environment. Each point represents a point on the surface of the object or in the environment.

Rendering - To generate a 2D view from a digital 3D model of a scene, using a computer.

Resolution - The spacing of points in a grid. The higher the resolution, the more detail is captured digitally.

Remix – Content that is created by editing and modifying prior content generated by others.

SLA – Stereolithography, a method of 3D printing that produces objects by curing a photoreactive resin layer by layer, also known as optical fabrication, photo-solidification, solid free-form fabrication, solid imaging and resin printing

Rendering - 3D Rendering is the process of producing an image based on three-dimensional data stored within a computer

STL - Standard Tessellation Language. STL is a internationally recognized file format that stores XYZ coordinate measurements and their normals. STL is the standard file format for 3D printing.

Tag – Metadata attached by users to online content. See metadata.

Texture map – Settings that determine the appearance of the surface of a digital 3D model.

Triangulation - Using trigonometric functions to calculate measurements, used in photogrammetry. See Photogrammetry.

UCG (User Generated Content) - term used to describe any form of content such as video, blogs, discussion form posts, digital images, audio files, and other forms of media that was created by consumers or end-users of a system or service and is publically available to others.

Vertices - The 3-dimensional coordinates of a digital 3D model

Virtual archaeology – The use of 3D computer models of ancient artefacts and archaeological sites as surrogate or virtual replicas of the original in archaeological research. This term was introduced by Paul Reilly in 1990.

Virtual reality (VR) - a computer-generated 3D environment that surrounds a user and responds to that individual's actions

Appendix A Case Studies

A.1. Introduction

Appendix A contains materials relating to the case studies undertaken during this research, including case study protocols, questionnaires, information on museum artefacts, background information on the participants in the research and interview summaries. This section also presents material related to the *(Im)material Artefacts* exhibition, such as the signage displayed during the show.

A.2. Open call

A digital leaflet was circulated via social media and art blogs to recruit participants for the *(Im)material Artefacts* project (Fig.97).

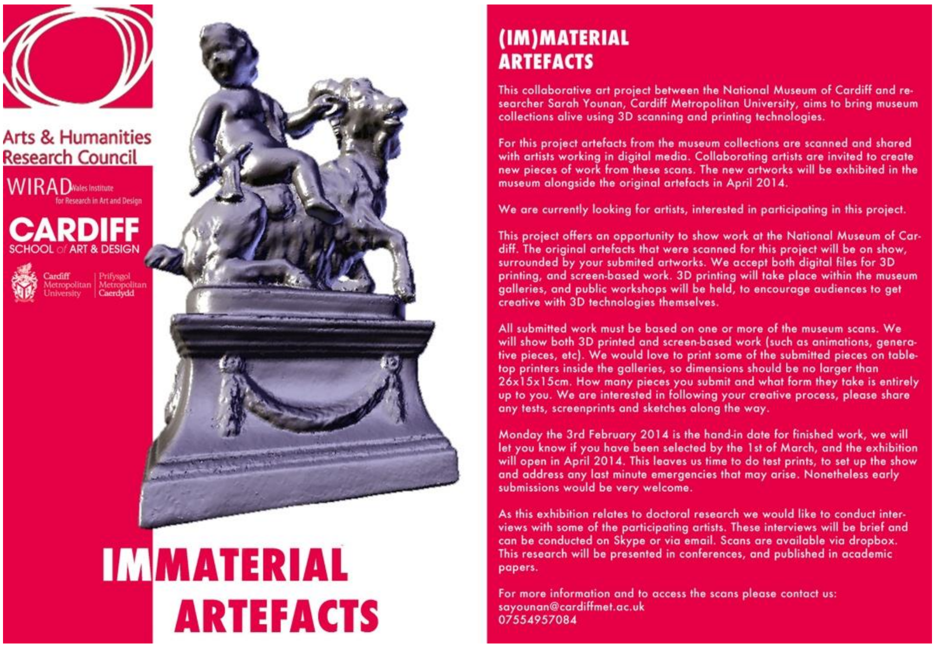

Fig.97 Open call for the *(Im)material Artefacts* project; 2013 © Sarah Younan

The text on the flier read:

'This collaborative art project between the National Museum Cardiff and researcher Sarah Younan, Cardiff Metropolitan University, aims to bring museum collections alive using 3D scanning and printing technologies. For this project artefacts from the museum collections are scanned and shared with artists working in digital media. Collaborating artists are invited to create new pieces of work from these scans. The new artworks will be exhibited in the museum alongside the original artefacts in April 2014. We are currently looking for artists interested in participating in this project. This project offers an opportunity to show work at the National Museum Cardiff. The original artefacts that were scanned for this project will be on show, surrounded by your submitted artworks. We accept both digital files for 3D printing and screen-based work. 3D printing will take place within the museum galleries and public workshops will be held, to encourage audiences to get creative with 3D technologies themselves. All submitted work must be based on one or more of the museum scans. We will show both 3D printed and screen-based work (such as animations, generative pieces, etc.). We would love to print some of the submitted pieces inside the galleries, so dimensions should be no larger than 26x15x15cm. How many pieces you submit and what form they take is entirely up to you. We are interested in following your creative process, please share any tests, screen prints and sketches along the way. Monday the 3rd February 2014 is the hand-in date for finished work, we will let you know if you have been selected by the 1st of March and the exhibition will open in April 2014. This leaves us time to do test prints, to set up the show and address any last minute emergencies that may arise. Nonetheless, early submissions would be very welcome. As this exhibition relates to doctoral research we would like to conduct interviews with some of the participating artists. These interviews will be brief and can be conducted on Skype or via email. Scans are available via dropbox. This research will be presented in conferences and published in academic papers.'

A.3. Information on museum artefacts from the National Museum Cardiff

This section establishes the histories and context of the original ceramic artefacts from the National Museum Cardiff that were digitised for the *(Im)material Artefacts* case study. The archival information on these artefacts was shared with artists participating in the case study. This archival data gives information on the material of the artefacts, the time and place of their production and also provides a short description of the pieces. The archival records were incomplete for some of the artefacts; further research into the museum archives and records of accessions and communications, as well as a study of literature on similar artefacts, revealed more about the history of the selected ceramic pieces.

The museum in Cardiff began collecting ceramics in 1882, with a focus on the collection of Welsh pottery and porcelain. At the time the museum was known as the *Cardiff Municipal Museum*. By 1902 the museum had begun a campaign to become recognized as a national museum[206] and Robert Drane, an honorary curator at the museum since 1896, was charged with the development of the museum's ceramics collections. Drane expanded the ceramics collections through the acquisition of English and Continental pieces. The ceramics collections also grew through donations, including substantial collections assembled by private collectors, as well as smaller donations of family heirlooms and other individual pieces.

Fig.98 *Devil and pope cup (stirrup cup)* from the National Museum Cardiff, slip-cast pearlware with glaze and under-glaze decoration, h15.8cm x diam8cm, Staffordshire; ca.1780-1790 © Dave Daggers

[206] The museum was successful in its campaign and in 1905 a government committee selected Cardiff as the location for a new national museum.

A 18th-century pearlware Staffordshire stirrup cup, which presents the face of the pope with a papal crown, and the face of the devil when it is reversed (Fig.98) was bought by the museum from Mr Winstone, an art and antiques dealer, alongside twenty nine other artefacts in 1902. The Winstones seem to have been a family of antique dealers, as ‘Winstone’, ‘H Winstone’, ‘M Winstone’, ‘W Winstone’ and ‘Harry Winstone jnr’ appear in records of acquisitions by the museum from the late 19th into the early 20th century. Stirrup cups were used to drink wine, port or sherry. Stirrup cups were often used to pronounce toasts during a horseback hunt (hence the name stirrup cup). They have no base and cannot be put down by the drinker. Two mirror-image faces are relief-moulded on either side of the stirrup cup from the National Museum Cardiff. When the cup is inverted the upper face is presented, representing the Pope with the papal crown above forming the top of the cup. When the cup is reversed for drinking, the lower face representing a devil with horns and a leering expression is presented. The cup was probably made during ‘the time of the Gordon Riots when anti-popish feelings were running high’ (Lewis and Lewis, 1984:222).

In 1904 records show that an 18th-century patch box in the shape of a female head (Fig.99a and b) was acquired from Mr Richards, an antiques dealer from Nottingham, together with 12 other artefacts. The patch box was digitized for the *(Im)material Artefacts* project. In this thesis it is consistently described as a ‘bonbonnière’, in line with new museum interpretation of the artefact[207]. A bonbonnière is a small ornamental box or lidded jar for confectionery. The bonbonnière from the National Museum Cardiff has the form of the head of a female figure wearing a ribboned bonnet[208] over her hair. A round domed screw-on lid fits onto the bottom of the neck; the underside of the lid is chipped and cracked. The bonbonnière was probably produced in Leeds, where similar slip-cast bonbonnières in the form of heads were produced in the 18th century (Towner, 1978).

[207] Andrew Renton, Keeper of Art at the National Museum Cardiff, suggests that the box might have been used to keep snuff or sweets. In this thesis it is assumed that the box was used to store sweets, it is thus described as a ‘bonbonnière’.
[208] The museum archives record that the female head wears a headdress of around 1750.

Fig. 99a

Fig. 99b

Fig.99a and b patch box or snuff box and lid *(bonbonnière)* from the National Museum Cardiff, slip-cast and press-moulded creamware, glazed and enamelled, 8cm x 5.8cm x 5.8cm, probably produced at Leeds; late 18th century © Dave Daggers

Fig.100 Vase with cover from the National Museum Cardiff, moulded porcelain, glazed, enamelled and gilded, 14.9cm x 10cm x 10cm, Coalport; ca. 1825-1845 © Dave Daggers

A number of objects that were used in the *(Im)material Artefacts* project come from the donations of private collectors. Wilfred de Winton, who supported the national museum campaign, was a banker and private collector of 18th- and 19th-century English and Continental porcelain. Between 1917 and his death in 1929 de Winton donated over three thousand ceramic artefacts to the museum. De

Winton had an interest in factory marks and patterns, his activities as a collector were motivated by a drive to assemble representative specimens, which he classified and categorised. Three artefacts digitised for the *(Im)material Artefacts* project stem from the large collection of porcelain donated to the museum by de Winton; a vase with cover (Fig.100), a cream jug (Fig.101) and a teapot with cover (Fig.102). All three were gifted to the museum in 1918, together with two thousand and seventy nine other ceramic pieces from de Winton's private collection.

Fig.101 cream jug from the National Museum Cardiff, moulded soft-paste porcelain, glazed with transfer prints, 5.5.cm x 11.2cm x 8cm, Bristol/Worcester; ca. 1750-1752 © Dave Daggers

Fig.102 teapot from the National Museum Cardiff, slip-cast and press-moulded pearlware, glazed with underglaze, 14.1cm x 22.8cm x 10.8cm, England; early 19th century © Dave Daggers

Another private collector who donated her collections to the museum in Cardiff was Miss Elizabeth Humphreys-Owen. Humphreys-Owen collected figurative 18th-century English porcelain. She donated ceramic artefacts from her collections, as well as family heirlooms, such as pieces of silverware and watercolour paintings to the museum in 1966, 1976 and 1993. An 18th-century porcelain figure of Cupid riding a goat (Fig.103), donated to the museum by Humphreys-Owen together with fifty six other artefacts in 1966, was digitised for the *(Im)material Artefacts* project. The National Museum Cardiff kept a record of Humphreys-Owen's written communications. Her many long letters to the museum provide an insight into what motivated her to donate her collections to the museum. Humphreys-Owen was meticulous in her book keeping; she shared an extensive list of her donated pieces with the museum, including notes that traced the succession of previous owners within her own family, a family tree and descriptions of family crests. Professor Susan Pearce writes that to a collector 'essentially a collection is what he believes it is' (Pearce, 1994:158); from her extensive communications with the museum in Cardiff it appears that to Humphreys-Owen her collection was a way of continuing her family legacy. Humphreys-Owen never married and had no children of her own; her donations were perhaps partially motivated by the wish to enshrine and preserve her family legacy through the national museum.

Fig.103 figurine *(cupid riding a goat)* from the National Museum Cardiff, slip-cast and press-moulded soft-paste porcelain, glazed and enamelled, 18.2cm x 9.9cm x 7cm, Derby; ca. 1775-1785 © Dave Daggers

A less substantial donation to the museum by Mrs Blight in 1947 included two glass rolling pins and a pair of 19th-century Staffordshire earthenware greyhound ornaments. Possibly these objects were family heirlooms, which Blight did not want to keep, but could not bring herself to throw away either. One of the pair of greyhounds was digitised for the *(Im)material Artefacts* project (Fig.104). The earthenware greyhound rests on an oval hollow base with a hole leading into it at one side; it might have been used as a penholder.

Fig.104 greyhound ornament (possibly pen holder) from the National Museum Cardiff, slip-cast earthenware, glazed, enamelled and gilded, 8.9cm x 12cm x 4.8cm, Staffordshire; ca. 1850-1875 © Dave Daggers

Fig.105 ushabti (Egyptian burial figure) from the National Museum Cardiff, press-moulded faience, 12.7cm x 3.4cm x 1.6cm, Egypt; ca. 600 BC © Dave Daggers

There is no trace of the arrival of the three oldest artefacts digitized for the *(Im)material Artefacts* project. The trajectory of an Egyptian ushabti figure (Fig.105), a Cypro-Archaic rider figure (Fig.106) and a Mexican mask (Fig.107a) was not recorded in the archives of the National Museum Cardiff.

The ushabti from the National Museum Cardiff (Fig.105) was made around 600BC. It is made from faience, a self-glazing ceramic paste discovered in ancient Egypt and commonly used to produce ornaments, vessels, figurines and jewellery. The ushabti is roughly moulded, of a blue-green colour and with incised hieroglyphics round the waist and down the front. Ushabtis (also known as Shabti or Shawabti figures) are ancient Egyptian funerary figurines. Their role was to serve the deceased in the afterlife; hieroglyphic inscriptions on these figures assert their readiness to answer summons to work. Like most ushabtis the ushabti from the National Museum Cardiff is of small size, and was mass-produced through press moulding.

The riding figure from the National Museum Cardiff (Fig.106) was probably hand-modelled in the Eastern Mediterranean cultural sphere during the Cypro-Archaic II period (600-480 BC). Similar artefacts from the Cypro-Archaic II period were found at the archaeological site of Athienou-Malloura[209]; they were used as votive offerings and as grave goods (Averett, 2011:139-140).

Fig.106 Cypro-Archaic rider figure from the National Museum Cardiff, modelled terracotta, 17.3cm x 16.7cm x 7.8cm, Cyprus; ca. 600 BC © Dave Daggers

Fig.107a Mexican mask from the National Museum Cardiff, slip-cast earthenware, glazed, enamelled and gilded, 8.9cm x 12cm x 4.8cm, Mexico; ca. 400 BC © Dave Daggers

Fig.107b Seated Teaotihuacan figure with open stomach to receive offerings, from the Museo Arqueologico de Teotihuacan, Mexico, dimensions not known; ca.300 BC

[209] See http://sites.davidson.edu/aap/, accessed 10.02.2015.

The Mexican mask from the National Museum Cardiff (Fig.107a) is likely the fragmented head of a Teotihuacan figurine (see for example Fig.107b). Teotihuacan was an ancient city in central Mexico, which flourished in pre-Aztec Mexico, between around 100 BC and around 500 AD. Teotihuacan terracotta figurines were found in the thousands and are likely to have played a part in household rituals (Cowgill, 2008).

A.3.1. Archival information

The following descriptions of the artefacts used in the *(Im)material Artefacts* study come from the archives of the National Museum Cardiff. They were available online to participants during the study.

Object number : NMW A 36152
Identification : cup
Notes : Pope and Devil cup (stirrup cup)
Factory Unknown : 1780-1790 ca. : Staffordshire
Material : pearlware, glaze
Technique : slip-cast, under-glaze colours, glazed
Inscription type : Label, handwritten
Measurements : h(cm) 15.8, diam(cm) 8
Description :
Cup, pearlware with a blue tinge to the glaze, conical form, relief-moulded with to either side of the cup two mirror-image faces, when the cup is inverted the upper face is presented, representing the Pope with the papal crown above forming the top of the cup, when the cup is reversed the lower face representing a devil with horns and a leering expression is presented, the faces and papal crown picked out in orange, blue and black, the sides of the faces moulded with acanthus leaves painted green.
Category : Earthenware

Object number : NMW A 37476
Identification : figure (cupid riding goat)
Factory Derby, England : 1775-1785 ca : England
Material : soft-paste porcelain
Technique : slip-cast, moulded, enamelled, glazed
Inscription type : incised mark
Measurements : h(cm) 18.2, l(cm) 9.9, w(cm) 7
Description :
Figure of Cupid riding a goat, soft-paste porcelain, pedestal base; a red cloak is draped over Cupid, the goat is black and white and the sides of the base are decorated with wreaths and swags, glazed.
Category : English porcelain

Object number : NMW A 38273
Identification : vase, with cover
Factory Coalport : 1825-1845 ca. : England
Material : hard-paste porcelain
Technique : moulded, painted, gilded, glazed
Inscription type : painted inscription
Measurements : h(cm) 14.9, l(cm) 10, w(cm) 10
Description :
Vase and cover, hard-paste porcelain, square rococo base, square body with protruding rounded corners narrowing into a column-shaped bottle neck, square-shaped stopper; the square body and stopper are in the shape of modelled acanthus petals and leaves in majenta and green with gilt flourishes.
Category : English porcelain

Object number : NMW A 32971
Identification : ornament
Notes : greyhound
Factory Unknown : 1850-1875 ca : Staffordshire
Material : earthenware, enamel, gilding, glaze
Technique : slip-cast, enamelled, gilded, glazed

Measurements : h(cm) 8.9, l(cm) 12, w(cm) 4.8

Description :

Ornament in the form of a greyhound, earthenware, on an oval hollow base with a hole leading into it at one side, the greyhound reclining and arranged with the head to the left, with forelegs crossed, tail curling around it to one side, and head raised with a collar around the neck; painted in shades of pinky-orange with the nose and eyes picked out in black, and a yellow-brown collar, the base covered with a dark blue ground with a gilt line around the front.

Category : Earthenware

Object number : NMW A 37643

Identification : jug, cream

Factory Worcester : 1750-1752 ca : England

Notes : Bristol/Worcester. Dr Wall period

Material : soft-paste porcelain

Technique : turned, moulded, painted, transfer-printed, glazed

Inscription type : no marks

Measurements : h(cm) 5.5, l(cm) 11.2, w(cm) 8

Description :

Cream Jug, soft-paste porcelain, scalloped rim, flat pad base, projecting lip, square handle with thumb rest; a shell is modelled under the lip and the body is moulded with flowers and flourishes forming two cartouches containing painted flowers and a painted crane.

Category : English porcelain

Object number : NMW A 36158

Identification : teapot and cover

Factory Unknown : 19th century (early) : England

Material : pearlware, glaze

Technique : slip-cast, press-moulded, assembled, under-glaze colours, glazed

Inscription type : Label, handwritten

Measurements : h(cm) 14.1, l(cm) 22.8, w(cm) 10.8

Description :

Teapot, pearlware with a blue tinge to the glaze, diamond form with waisted foot, straight sides and sharp shoulder, a pointed gallery moulded with short leaves, curving spout, square-shouldered angular handle, diamond-shaped domed cover with to the top a finial modelled in the form of a swan, a pierced steam hole to one side; decorated with to either side of the body conventional floral sprigs and sprays in pink, yellow and green, around the shoulder and rim of the cover borders of red and blue bands and red dots, further blue bands around the lower body and gallery.
Category : Earthenware

Object number : NMW A 35625
Identification : patch box and lid (bonobonniere)
Notes : or snuff box
Factory Unknown : 18th century (late) : England
Notes : Probably produced at Leeds
Material : creamware, enamel
Technique : slip-cast, press-moulded, assembled, enamelled, glazed
Measurements : h(cm) 8, l(cm) 5.8, w(in) 5.5
Description :
Patch box or snuff box, pale cream-coloured earthenware with a greeny-yellow tinge to the glaze, in the form of the head of a female figure wearing a ribboned bonnet over her hair, a round domed screw-on lid fits onto the bottom of the neck; painted in red and black enamels, the face picked out in red and black, the hair painted black, the bonnet picked out in black with a red ribbon around it, the lid painted with a spray of stylized red and black flowers. The underside of the lid chipped and cracked.
Category : Earthenware

Object number : NMW A 39453
Identification : ushabti figure
Maker Unknown : Egypt , 664-525 BC ca, late period
Material : powdered quartz composite

Description : Probably made from a composition of powdered quartz or sand mixed to a paste with a cement containing an alkaline agent, normally soda. This body is sometimes referred to as faience. The glaze is probably a powder form glaze painted on before firing of either lime and soda or potash and soda with copper providing the turquoise colouration.
Measurements : l(cm) 12.7
Description : Ushabti figure, faience
Category : Antiquities

Object number : NMW A 37367
Identification : figure (rider)
Category : Ceramics
Note: No full database record for this piece. Possibly from Greek / Eastern Mediterranean cultural sphere and the closest comparisons are from Cyprus, C6 BC (Cypro-Archaic II).
Category : Antiquities

Object number : NMW A 39266
Identification : mask
Material : earthenware
Description : Mask, earthenware.
Note: Appears to be Mexican, may be stone rather than earthenware (perhaps with some surface clay), could be Aztec.
Category : Antiquities

A.3.2. *Lincoln 3D Scans*

The *Lincoln 3D Scans* project aims at making 3D models of the museum collections available to an audience outside of its geographic proximity and to treat the objects as starting points for new works. All models can be viewed, downloaded and used without copyright restrictions from http://lincoln3dscans.co.uk . All 3D models on this website are scans of objects from the Usher Gallery and The Collection in Lincoln.

A.4. Surveys

During this study, surveys were sent to the participants of the *9Im)material Artefacts* and the *Lincoln 3D Scans* projects. The surveys were similar to each other and featured a number of yes/no questions, tick boxes and open questions. The surveys served to gain an initial understanding of how partcipants engaged with and thought about digital 3D models of museum artefacts. They informed the questions, which were later, posed to participants during interviews.

A.4.1. Survey *(Im)material Artefacts*

The following survey was sent to artists participating in the *(Im)material Artefacts* project:

Questionnaire (Im)material Artefacts

The (Im)material Artefacts project investigates the potential of digital three dimensional (3D) tools, specifically 3D scanning and 3D print technologies, to foster new forms of artist engagement with museum collections.
Thank you for agreeing to take time to fill in this questionnaire and helping us in our study. We would like to gain more insight into your creative process, your choice of technology, and your views on working with 3D scans of museum artefacts.

In Section 1 we are interested in finding out about you and the technologies you use in your work. In Section 2 we would like to find out more about your experiences with this project. In Section 3 we would like to know more about your thoughts on museums and digitization.

The questionnaire will take approx. 10 minutes to complete. The results of this questionnaire will be published in a PhD thesis and might be used to write academic papers. The data will be used for analysis in an anonymized form. If you consent to your name being associated with quotes, please indicate so at the end of the questionnaire.

All questions are purely optional.
Thank you for taking the time to fill out this questionnaire.

Name…………………………………………………………………………………………..

Contact details……………………………………………………………………………..

Section One; Technologies

1.What best describes you?
Sculptor
Crafts maker
Visual artist
Product designer
Graphic Designer
Other (please specify)

2. During concept development, are your initial ideas immediately expressed digitally or do you develop your concept first by means of traditional methods, such as sketching/modelling etc.? Please briefly describe your process

3. What would you consider to be the distinctive qualities of your work? Qualities may include, but are not limited to, software or material manipulation, experimentation with materials or technology used or a unique concept/design etc.

4.What is your artistic background? What media have you worked in and how did you come to work in digital media?

5. What file formats and editing tools do you most commonly use?

6. What software programs do you use?

7. How do you store finished digital work?

8. Do you still work with files created in the past 8-10 years?

9. In your work, do you

a. build your own digital 3D models?

b. use 3D scanning?

c. use photogrammetry?

10. If a museum acquired one of you physical pieces, would you be willing to include a copy of the digital file and specifications of the technology and materials used with the purchase?

Section Two; Digital 3D Models of Museum Artefacts

11. The *Lincoln 3D Scans* represent actual historical artefacts, was this relevant to your engagement with the 3D models you worked with? Please explain.

12. Which digital files did you choose to work with, and what motivated your choice?

13. What best describes your action towards of the digital files;

Digital Distortion

Recontextualisation

Animation

Personalising

Other (please explain)

14. A museum has acquired a rapid prototype (3D print) of a digitalborne artefact. The piece has started to discolour, what action should the museum take:

a. Nothing, it is part of the piece's history

b. Keep it on display but control light exposure and temperature.

c. Reprint using the same materials and technology.

15. If the original software, technology or material were not available anymore, would a reprint still be an acceptable replacement?

a. Yes, using the closest matching material/software/technology available

b. Yes, any print of the original file can be considered authentic

c. No

Section Three; You and the Model

16. Does the work you have made for the *Lincoln 3D Scans* project incorporate and element of narrative (i.e. does it, in any way or form tell a story or relate to any form of storytelling)? (Please explain)

17. After engaging with the 3D model of a museum artefact would you feel more inclined to visit the museum in order to see the original artefact?

18. Do you now feel you 'know more' about the original artefact, or in some other way have a different relationship with it? (Please explain)

19. Please use this space to add further comments on topics we might have missed

Thank you very much for your participations in this study.

A.4.2. Survey *Lincoln 3D Scans*

The following survey was sent to participants in the *Lincoln 3D Scans* project:

Questionnaire Lincoln 3D Scans

This questionnaire is structured in three sections. In section one we would like to find out more about the technologies you used to interact with the *Lincoln 3D Scans.* Section two contains questions on your theoretical understanding of and conceptual engagement with the 3D models of museum artefacts. In section three you will be asked questions about your personal interests and influences.

All questions are purely optional.
Thank you for taking the time to fill out this questionnaire.

Name……………………………………………………………………………………………..

Alias or artist name used on *Lincoln 3D* website……………………………………

Contact details……………………………………………………………………………..

<u>Section One; Technologies</u>

1.What best describes you?
Sculptor
Crafts maker
Visual artist
Product designer
Graphic Designer
Other (please specify)

2. During concept development, are your initial ideas immediately expressed digitally or do you develop your concept first by means of traditional methods, such as sketching/modelling etc.? Please briefly describe your process

3. What would you consider to be the distinctive qualities of your work? Qualities may include, but are not limited to, software or material manipulation, experimentation with materials or technology used or a unique concept/design etc.

4.What is your artistic background? What media have you worked in and how did you come to work in digital media?

5. What file formats and editing tools did you use to interact with the *Lincoln 3D Scans*?

6. Did you meet any technological challenges? If so, please describe any steps you have taken to work with/challenge or overcome the limitations of the technology.

Section Two; Digital 3D Models of Museum Artefacts

7. Is your contribution to the *Lincoln 3D Scans* gallery a;
Artwork
Doodle
Experiment
Other (please explain)

8. The *Lincoln 3D Scans* represent actual historical artefacts, was this relevant to your engagement with the 3D models you worked with? Please explain.

9. Which digital files did you choose to work with, and what motivated your choice?

10. What best describes your action towards of the digital files;
Digital Distortion
Recontextualisation
Animation
Personalising
Other (please explain)

11. Have you continued to use the *Lincoln 3D Scans* beyond the scope of the project itself? (Please explain)

Section Three; You and the Model

12. Does the work you have made for the *Lincoln 3D Scans* project incorporate and element of narrative (i.e. does it, in any way or form tell a story or relate to any form of storytelling)? (Please explain)

13. After engaging with the 3D model of a museum artefact would you feel more inclined to visit the museum in order to see the original artefact?

14. Do you now feel you 'know more' about the original artefact, or in some other way have a different relationship with it? (Please explain)

15. Please use this space to add further comments on topics we might have missed

Thank you very much for your participations in this study.

A.5. Interview protocols

The following interview protocols were written in preparation of interviews with participating artists, museum staff and members of the audience.

A.5.1. *(Im)material Artefacts*

Artists Which museum object(s) did you chose? Why? Please describe what you did with the 3D model(s). Can you describe your creative decisions and thought processes? Did you encounter any problems? Did the contextual information (museum archive data) influence you in any way? Did other background/contextual knowledge on the original artefacts influence you? How would you describe your artwork? How do you think about museums? What do you like/ dislike about them? How do you usually engage with museums? How long have you been using digital technologies? What do you like/ dislike about working digitally? While you were working with the digital model(s) did you find yourself thinking about anything in particular? If yes, did this influence your work? What did you gain from this project?

Museum staff Which challenges are faced by museums wishing to engage with digital technologies? What worked well? What didn't? Where could improvements be made?

How can projects like this engage museum audiences? Did you feel particularly intrigued by any individual piece? Which and why? What do you think audiences can take from this project? What impact has this project had for you? Did it have an impact on the museum? If so, how? What are your impressions of this project? Has this project raised any further questions for you?

Audience Do you come to museums often? What do you do in museums? Are you interested in digital 3D technologies/ 3D print? How do you feel about these technologies? Would you like to download digital models of museum artefacts? If yes, what would you like to use them for? Did you feel particularly intrigued by any individual piece? Which and why? What do you think audiences can take from this project? What 'worked' for you, what did not? How do you think projects like this can change people's relationship with museums?

A.5.2. *Lincoln 3D Scans*

Users Which 3D scan(s) did you chose? Why? Please describe what you did with the 3D model(s). Can you describe your creative decisions and thought processes? Did you encounter any problems? How would you describe your artwork? How do you think about museums? What do you like/ dislike about them?

How do you usually engage with museums?
How long have you been using digital technologies?
What do you like/ dislike about working digitally?
While you were working with the digital model(s) did you find yourself thinking about anything in particular? If yes, did this influence your work?
What did you gain from this project?

Museum Staff

Can you tell me more about the *Lincoln 3D Scans* project? What led to the collaboration with Oliver Laric? How was the project conceived and executed?
What were your aims?
What worked well? What didn't?
Where could improvements be made?
How can projects like this engage museum audiences?
What do you think audiences take from this project?
What impact has this project had for you? Did it have an impact on the museum? If so, how?
Has this project raised any further questions for you?

A.6. Participant profiles

The following artists participated in (Im)material Artefacts:

The Danish artist Flemming Tvede Hansen works as a scholar at the Danish Design School. His background is in ceramics and his work explores how he as a ceramist can use digital media and tools in his creative work with form .

American artists Katie Parker and Guy Michael Davis, work collaboratively as Future Retrieval. They create work using three-dimensional scanning and digital manufacturing. Parker and Davis frequently work with found objects and use ceramic mould making as well as digital technologies in their practice .

Ian Cooke Tapia, a young artist and illustrator from Panama, participated in the (Im)material Artefacts project during his MA studies in illustration at the Cardiff School of Art and Design while on a three-month exchange.

Jason Rouse is a Cardiff-based artist; in his work he employs digital editing technologies, video game technologies, as well as traditional painterly techniques to apply the aesthetics of landscape painting to digital landscapes .

The Irish artist John Rainey uses digital 3D editing technologies to explore forms through transformation . Rainey frequently uses 3D printing technologies, and occasionally employs traditional ceramic manufacturing techniques.

The American animation artist John Monaghan frequently uses digital 3D models of museum artefacts in his work. In 2012 he participated in the first Hackathon at the Metropolitan Museum of Art. He has since gone on to work with museums on a regular basis. Monaghan uses 3D scans, found and modelled 3D forms, to create surreal images and animated films that blend history with science fiction .

Mario Padilla is a young maker and industrial designer from Mexico, he has a strong interest in 3D printing and the Maker movement.

Mohamed Hossam is an Egyptian designer and digital artist, Hossam acted as the Google Student Ambassador in Egypt at the Helwan University and undertook internships at the Egyptian Museum in Cairo, during which he led art workshops.

The London-based artist Zachary Eastwood-Bloom has a background in ceramics. In the creation of his current work, Eastwood-Bloom is concerned with the relationships of history, craft and digital technologies .

The American Artist Zack Dougherty is best known for his animated GIFs, which are frequently shared online on art and visual culture blogs such as Colossal , Ignant and news aggregators like the Huffington Post . Dougherty uses 3D and

2D editing to create GIFs of everyday and historical objects, which he presents within new and surprising situations .

Jeff Waweru is a Kenyan photographer and filmmaker. He lives in Nanyuki, Kenya and works in documentary photography and film. Waweru created work for the (Im)material Artefacts project without using any form of digital 3D editing.

A.7. Forms

Participant information sheets and participant consent forms were sent to all participants in this study. The following forms were read and signed by all artists, users, museum staff and museum visitors who participated in this research.

A.7.1. *(Im)material Artefacts*

Artists

Participant Information Sheet

Title of Project: (Im)material Artefacts

Background

This collaborative art project between the National Museum Cardiff and PhD researcher Sarah Younan, Cardiff Metropolitan University, aims to bring museum collections alive using 3D scanning and printing technologies. For this project artefacts from the museum collections are scanned and the 3D models are shared with artists working in digital media. Artists who choose to collaborate in (Im)material Artefacts are invited to create new pieces of work from these scans. These new artworks will be exhibited in the museum alongside the original artefacts in April 2014.

This research project will explore how digital 3D scanning and printing technologies can foster new forms of artist engagement with museum collections.

We would like to invite you to contribute to this project by creating new artworks from 3D scans. As this project forms part of a PhD study, we would like to ask you to fill out a questionnaire about your experiences and we would appreciate your participation in interviews. Data gathered from this project will be used for research purposes and might also be published, but no material will be used without your prior consent.

Your participation in the research project

In brief, you have been invited to use digital 3D scans of artefacts chosen from the ceramics collections at the National Museum Cardiff and to create new works of art from them. Artworks created during this project will be entered into an exhibition at the National Museum Cardiff, to be displayed on screen or as 3D prints.

How will you participate in this project?

If you agree to participate in this project, there are three main things that will happen.

1. You will be given access to 3D scans of artefacts from the National Museum Cardiff via a shared Dropbox folder.
2. You will be invited to create new artworks based on these scans, either screen-based or for 3D print, and to submit them for exhibition at the National Museum Cardiff.
3. You will be asked to fill out a questionnaire concerning your experience with this project. You might also be asked to participate in audio-recorded interviews.

Are there any risks?

We do not think that there are any risks involved in this project. Data will be shared and collected via the Internet. We will keep your submitted artworks stored safely. Unless agreed otherwise, digital data will be deleted after the completion of this project.

What do we do with your data?

Your artworks will be exhibited in the National Museum Cardiff; they will be documented through screenshots and photography. After completion of the project the original files will be deleted. The researcher will only keep secondary images of your work.
Your submitted work will be fully attributed to you at all times. Images of your work will be used to illustrate publications and talks and may be displayed online.

You will be asked to fill out a questionnaire and you might be asked to participate in an interview. Interviews will be audio recorded. Unless agreed otherwise you will be quoted by your name/artist pseudonym. This data will feed into doctoral research and might also be used to write research papers for publication. You will be given opportunity to read and veto the use of your quotations in any publishable material.

Are there any benefits from taking part?

You are likely to benefit by association with this project. Your work will be exhibited during a group exhibition at the National Museum Cardiff and will be widely disseminated through presentations and publications. There will be no cost to you.

What happens next?

With this letter you will find a consent form to complete. This is for you to give permission for your work to be exhibited as part of the exhibition at the National Museum Cardiff and for your data to be used in this research. If you are willing to participate, this form should be completed and returned to the researcher.

How we protect your work:

All your data and submitted digital work will be stored securely. At the end of the exhibition at the National Museum Cardiff and after the evaluation study we will destroy the digital artworks from our computers. We will only keep secondary images (screenshots and photographs) of your work.

This project is voluntary and you are free to withdraw at any time, without giving any reason, in which case all your data and documentation of your work will be deleted from our computers.

Further information

If you have any questions about the research or how we intend to conduct the study, please contact us.

Sarah Younan, Research Associate
Cardiff School of Art and Design
Howard Gardens Campus
Cardiff, CF24 0SP
+44(0) 7554957084
sayounan@cardiffmet.ac.uk/ younansarah@yahoo.com

PARTICIPANT CONSENT FORM

Reference Number:

Participant name:

Title of Project (Im)material Artefacts

Name of Researcher: Sarah Younan, Cardiff Metropolitan University

---

Participant to complete this section: Please initial each statement

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have them answered satisfactorily.

2. I understand that my participation in this project is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree to take part in the above study.

4. I agree to interviews being audio recorded.

5. I agree to the use of quotes in publications, having previously viewed the transcript.

6. I agree to my artworks being exhibited in the course of a public exhibition at the National Museum of Cardiff, in April 2014.

7. I agree for images of my work to be used as illustrations in publications.

3. I agree to use the 3D files shared during this project for creative purposes only, and to credit the National Museum of Wales with intellectual property of the original scan files.

4. I agree for photographic images, other visual materials (screenshots) and quotes from interviews to be attributed to my name in publications.

______________________________ ______________

Signature of Participant Date

______________________________ ______________

Person taking consent Date

Further information

If you have any questions about the research or exhibition, please contact us.

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Museum Staff

Participant Information Sheet

Background

This doctoral research explores how digital 3D scanning and printing technologies can foster new forms of artistic and creative engagement with museum collections.

We are interested in the impact the (Im)material Artefacts showcase had at the National Museum Cardiff. In order to gather data you will be interviewed about your views and impressions of this showcase.

Data gathered from this questionnaire will be used for research purposes and will be included in a PhD thesis and academic papers.

What kind of questions will you be asked?

We would like to find out more about your thoughts on heritage artefacts and digital technologies. You will be asked about your views on the (Im)material Artefacts project and showcase. We would also like to find out more about your experiences with artist projects, interventions and audience engagement as a museum professional.

You will be quoted name. This data will feed into doctoral research and might also be used to write research papers for publication. You will be given opportunity to read and veto the use of your quotations in any publishable material.

Are there any risks?

We do not think that there are any risks involved in this project.

What happens next?

With this letter you will find a consent form to complete. This is for you to give permission for your data to be used in this research. If you are willing to participate, this form should be completed and returned to the researcher.

This project is voluntary and you are free to withdraw at any time, without giving any reason, in which case all your data

will be deleted from our computers.

Further information

If you have any questions about the research or how we intend to conduct the study, please contact us.

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sayounan@cardiffmet.ac.uk/ younansarah@yahoo.com

PARTICIPANT CONSENT FORM

Reference Number:

Participant name:

Title of Project (Im)material Artefacts

Name of Researcher: Sarah Younan, Cardiff Metropolitan University

---

Participant to complete this section: Please initial each statement

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have them answered satisfactorily.

2. I understand that my participation in this project is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree to take part in the above study.

4. I agree to interviews being recorded through note taking.

5. I agree to the use of quotes in publications, having previously viewed the transcript.

6. I agree for quotes from interviews to be attributed to my name in publications, after I have had the chance to review them.

_________________________________ _______________

Signature of Participant Date

_________________________________ _______________

Person taking consent Date

Further information

If you have any questions about the research or exhibition, please contact Sarah Younan, Research Associate, Cardiff School of Art and Design, Howard Gardens Campus, Cardiff, CF24 0SP

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Museum Visitors

Participant Information Sheet

Background

This doctoral research explores how digital 3D scanning and printing technologies can foster new forms of artistic and creative engagement with museum collections.

We are interested in how the (Im)material Artefacts showcase at the National Museum Cardiff is perceived by viewers. In order to gather data you will be interviewed about your experience of this showcase.

Data gathered from this questionnaire will be used for research purposes and will be included in a PhD thesis and academic papers.

What kind of questions will you be asked?

We would like to find out more about your thoughts on heritage artefacts and digital technologies. You will be asked about your views on the (Im)material Artefacts project and showcase.

You will be quoted name. This data will feed into doctoral research and might also be used to write research papers for publication.

You will be given opportunity to read and veto the use of your quotations in any publishable material.

Are there any risks?

We do not think that there are any risks involved in this project.

What happens next?

With this letter you will find a consent form to complete. This is for you to give permission for your data to be used in this research. If you are willing to participate, this form should be completed and returned to the researcher.

This project is voluntary and you are free to withdraw at any time, without giving any reason, in which case all your data will be deleted from our computers.

Further information

If you have any questions about the research or how we intend to conduct the study, please contact us.

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PARTICIPANT CONSENT FORM

Reference Number:

Participant name:

Title of Project (Im)material Artefacts

Name of Researcher: Sarah Younan, Cardiff Metropolitan University

---

Participant to complete this section: Please initial each statement

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have them answered satisfactorily.

2. I understand that my participation in this project is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree to take part in the above study.

4. I agree to the use of quotes in publications.

6. I agree for quotes to be attributed to my name in publications.

Signature of Participant Date

Person taking consent Date

Further information

If you have any questions about the research or exhibition, please contact Sarah Younan, Research Associate, Cardiff School of Art and Design, Howard Gardens Campus, Cardiff, CF24 0SP

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A.7.2. *Lincoln 3D Scans*

Users

Participant Information Sheet

Background

This doctoral research explores how digital 3D scanning and printing technologies can foster new forms of artistic and creative engagement with museum collections.

We are interested in how you participated in the *Lincoln 3D Scans* project. We would like to ask you more questions about the work you created from the *Lincoln 3D Scans*, about your practice and what motivated you to take part in the project. In order to gather data we would like to ask you to share your experiences with the *Lincoln 3D Scans* project in the course of an informal interview.

Data gathered from this research will be included in a PhD thesis and academic papers.

Your participation in the research project

You will be asked to participate in an interview. The interview will be recorded through notes. No audio or photographic records will be taken.

After the interview a write up of the interview will be sent to you for verification. You are free to amend this summary, to veto it whole or in parts and to withdraw your participation at any time.

What kind of questions will you be asked?

We would like to find out more about your experiences with the *Lincoln 3D Scans* project. You will also be asked about your general approach to museums and digital technologies.

Unless you raise concerns you will be quoted by the name. Quotes will be used for academic writing. It will be made clear in these texts, that you are speaking for yourself, and not on behalf of the Usher Gallery and The Collection in Lincoln.This data will feed into doctoral research and might also be used to write research papers for publication. You will be given opportunity to read and veto the use of your quotations in any publishable material.

Are there any risks?

We do not think that there are any risks involved in this project.

What happens next?

With this letter you will find a consent form to complete. This is for you to give permission for your data to be used in this research. If you are willing to participate, this form should be completed and returned to the researcher.

You will also be sent a questionnaire, please fill in and return this questionnaire to the researcher.

This project is voluntary and you are free to withdraw at any time, without giving any reason, in which case all your data will be deleted from our computers.

Further information

If you have any questions about the research or how we intend to conduct the study, please contact us.

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PARTICIPANT CONSENT FORM

Reference Number:

Participant name:

Title of Project Research Interviews

Name of Researcher: Sarah Younan, Cardiff Metropolitan University

---

Participant to complete this section: Please initial each statement

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have them answered satisfactorily.

2. I understand that my participation in this project is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree to take part in the above study.

4. I agree to the use of quotes in publications, having previously viewed the transcript.

4. I agree for quotes from interviews to be attributed to my name in publications.

________________________ ____________

Signature of Participant Date

________________________ ____________

Person taking consent Date

Further information

If you have any questions about the research, please contact us.

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Museum Staff

Participant Information Sheet

Background

This doctoral research explores how digital 3D scanning and printing technologies can foster new forms of artistic and creative engagement with museum collections.

We are interested in how the *Lincoln 3D Scans* projects was conceived and put into practice, and what motivated the project. In order to gather data we would like to ask you to share your experiences with the *Lincoln 3D Scans* project in the course of an informal interview.

Data gathered from this research will be included in a PhD thesis and academic papers.

Your participation in the research project

You will be asked to participate in an interview. The interview will be recorded through notes. No audio or photographic records will be taken.

After the interview a write up of the interview will be sent to you for verification. You are free to amend this summary, to veto it whole or in parts and to withdraw your participation at any time.

What kind of questions will you be asked?
We would like to find out more about your experiences with the *Lincoln 3D Scans* project. You will also be asked about your general approach to museums and digital technologies.

Unless you raise concerns you will be quoted by the name. Quotes will be used for academic writing. It will be made clear in these texts, that you are speaking for yourself, and not on behalf of the Usher Gallery and The Collection in Lincoln.This data will feed into doctoral research and might also be used to write research papers for publication. You will be given opportunity to read and veto the use of your quotations in any publishable material.

Are there any risks?
We do not think that there are any risks involved in this project.

What happens next?
With this letter you will find a consent form to complete. This is for you to give permission for your data to be used in this research. If you are willing to participate, this form should be completed and returned to the researcher.
You will also be sent a questionnaire, please fill in and return this questionnaire to the researcher.

This project is voluntary and you are free to withdraw at any time, without giving any reason, in which case all your data will be deleted from our computers.

Further information

If you have any questions about the research or how we intend to conduct the study, please contact us.

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PARTICIPANT CONSENT FORM

Reference Number:

Participant name:

Title of Project Research Interviews

Name of Researcher: Sarah Younan, Cardiff Metropolitan University

Participant to complete this section: Please initial each statement

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have them answered satisfactorily.

2. I understand that my participation in this project is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree to take part in the above study.

4. I agree to the use of quotes in publications, having previously viewed the transcript.

4. I agree for quotes from interviews to be attributed to my name in publications.

______________________________ ________________

Signature of Participant Date

______________________________ ________________

Person taking consent Date

Further information

If you have any questions about the research, please contact us.

Sarah Younan, Research Associate

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A.8. Interview summaries

A.8.1. (Im)material Artefacts

Artists

Flemming Tvede Hansen, 10.03.2014

Flemming Tvede Hansen's practise and research combine art, craftsmanship and digital editing and 3D printing technologies. In his practice Hansen combines digital processing with an intuitive grasp of form and materials. Hansen develops software and models his born-digital objects from scratch before 3D printing them.

His participation in the (Im)material Artefacts project presented Hansen with a different challenge. For this project ceramic artefacts from the collections at the National Museum Cardiff were selected for 3D scanning, and the resulting digital 3D models were made available to a number of artists. Participating artist were invited to create new artworks based on the digital 3D scans. Hansen chose the 3D model of an English 18th century patch box, or bonbonniere, to work with. He had previously experimented with 3D scanning himself, and found the 3D scan models reminded him of Duchamp's Readymades. Like Duchamp's Readymades, found objects, which Duchamp chose to declare as pieces of art, Hansen's Screwed Up was also reflects a sense of irony, humour and ambiguity. The title holds an ironic double meaning; the face of the patchbox lady has been 'screwed up' and twisted about, but digitization has also 'screwed' with the original qualities of the artefact. Hansen understands the scanning process as a transformative action, which translates the museum artefact into something new. "This 3D model is somewhat of an icon," he explains, "I found I wanted to do something to it". Hansen's artistic practise usually focuses on the aesthetic impact of the digital sculptures he creates, however this time he found himself working with narrative. From the museum archives Hansen learnt that this object had a screw-on lid. This information had been lost in the scanning process; as the original artefact was scanned with the lid screwed on. Hansen's work playfully references this loss of information and function between the original artefact and the 3D model. The original artefact would have been held and twisted to open it; Hansen's digital editing of the 3D scan mimics this physical action. He produced a series of 3 bonbonnieres, with twisted necks and screwed up faces. Digital scanning removes the intrinsic physical qualities of the original artefact, capturing only its surface information. As a result the digital model could be twisted and distorted "as though it was rubber". Hansen chose to produce a series of 3; the pieces function like an animation, conveying a sense of movement and transformation.

Katie Parker and Guy Davis *(Future Retrieval)*, 14.03.2014

Katie Parker and Guy Michael Davis work collaboratively as *Future Retrieval*, their large monkey sculpture looks like it has just raided an antique shop. The monkey is balancing a teapot on his head, a greyhound ornament rests gracefully between his legs, and he is clutching an Egyptian shabti and an archaic rider figure in his big hands. The monkey is a 3D scan of a battered automaton Parker and Davis found in an upstate New York antique mall, his loot is made up of 3D scans of ceramic artefacts from the National Museum Cardiff.
'We are often drawn to grotesque mannerist figures' Parker explains; 'the moving monkey automaton looked beat up, unfixable, pathetic, but saveable.' The pair decided to take the monkey automaton back to their studio, where they 'collage', 'goof' and 'juggle' with real and digital artefacts. Here, jokes, experiences and contemporary culture all come into play in the creation of new work. Real life interaction with the monkey automaton also influenced Parker and Davis' creative choices; 'I always put stuff in his hands' Parker explains.
The title Monkey Heaven was inspired by a pop song by the Pixies; by infusing artefacts with contemporary meaning Future Retrieval are making old objects

relevant and tying them into present-day culture. ‘We are searching to reanimate old tattered things, to make them precious,’ explains Davis. This playful approach can lead to unexpected results; the giant monkey with his loot seems to reference King Kong movies, or is the primate with his cultural artefacts a witty comment on evolution and culture? ‘We do ask ourselves what does it mean? What does a monkey mean? What does the teapot on its head mean?’ Although Davis and Parker engage with the historical and cultural meanings of the 3D scans they stop short of attaching prescribed meaning to their work. They often work with 3D scans of real life artefacts and have amassed a digital collection of curiosities, artefacts and taxidermy. Parker and Davis re-use, collage and rescale 3D models from this digital library. Things that were broken are fixed digitally, dead animals are re-animated; a love for cultural artefacts inspires their work. ‘Although our work can be quite funny we are respectful towards the objects we work with, towards their histories,’ Parker explains, ‘we do not want to destroy or humiliate.’ Davis agrees, that the objects they gather and work with are more than mere props and shapes; ‘we have respect for the material and subject matter we work with, we riff off the objects.’ The joy Future Retrieval have in their work shows in the finished pieces; ‘maybe I’m the monkey’ Davis muses; ‘and I’m in heaven, juggling with these objects, celebrating these things from the past.’

Ian Cooke Tapia, 04.03.2014

Ian Cooke Tapia was immediately drawn to the teapot when looking at the 3D museum models. ‘It called to me’, he says. The architectural ridge around the top of the teapot reminded him of the architecture or towers and castles. This quickly led to a concept for what he would make of the digital scan. Cooke imagined little people living in and around this teapot fortress.

However the large size of the 3D model limited his interaction with it. The complex mesh with its many polygons and large file size made 3D editing tricky. Cooke found a solution in modelling around the 3D object; ‘I found that as long as I didn’t work on the model directly, it was ok’. He began building structures around the teapot model, adding cannons, wheels, towers and turning the teapot into a fortified castle on wheels; 'like something from a dystopian future, where people live in outlandish mobile houses.' Instead of remodelling the scanned object Cooke found himself modelling around it, adding bits and pieces, this way of working reminded him of how he used to build his own toys as a kid; 'It was almost like a flashback; as a kid I would always take old items or kitchen utensils, and make them into toys.' The Teapot Trainfortress is such a repurposed toy, created in the same playful manner as Cooke's earliest playthings. The resulting structure is a mixture of teapot, fortress and steam engine train; 'maybe it's because I live next to traintracks now' Cooke explains. The Teapot Trainfortress will be printed in fire-engine red, a tribute to the Tonka trucks Cooke owned as a child.

The museum background of the teapot model was of no great importance to Cooke, his creative approach was influenced by the technical challenges he encountered, and by the architectural shape of the teapot; 'I read all the archive information, but then I forgot about it.'

Jason Rouse, 13.02.2014

Jason Rouse[210] created a video game for *9Im)material Artefacts*; the landscape the game is set on is a 3D model of a pre-Hispanic Mexican mask. Rouse chose the Mexican mask based on his childhood fascination with Mexican culture; 'the first shooter game I designed as a kid was set in an Aztec temple.'

Initially Rouse trialed turning the mask into a collectible game item, however the 3D model caused the crash of the first game engine he tried to feed it into. The high polygon count[211] of the 3D scan moved him to 'think big' and turn the mask

[210] Jason Rouse's website; http://www.jasonrouse.co.uk/ accessed 24.02.2014.
[211] 3D models used for video games usually have a low polygon count, much unlike the 3D scans created for this research. Polygons are two-dimensional shapes with multiple sides connected at vertices to enclose the shape. In 3D animation, these polygons are connected along their sides

itself into a digital landscape. Rouse reduced the number of polygons in the 3D model, thus reducing the file size. In designing the digital landscape for *Postcards from Mexico* Rouse drew inspiration from photographs taken during one of his trips to the Oaxaca hills in Mexico, a landscape which he describes as being worthy of conservation as a historical landmark. The back of the mask has a more jagged and craggy surface and looks 'more like Mexico'. However Rouse chose to work on the face of the artefact after positioning it in different angles, in order to show of the most easily recognizable features of the piece.

While navigating through the first-person shooter game *Postcards from Mexico* the Mexican mask remains hidden in plain sight, players can wander from the shack in its mouth to the water tower perched on its forehead, without realising the secret nature of the landscape they are exploring. Rouse has filled the digital landscape of his 'imaginary Mexico' with sand, gras, trees and the occasional wooden crate, shed, or watertower. These models are 'found objects'; they are born-digital[212] 3D files downloaded from the Unity asset store[213]. Unity is a cross-platform game engine, which allows users to develop video games for web plugins, desktop platforms, consoles and mobile devices. The Unity asset store[214] allows users to purchase and exchange 3D models, and to build them into their own computer games. The watertower used in *Postcards from Mexico* for example was downloaded for free[215]. The 3D models available on Unity and other comparable file-sharing websites can be regarded as new types of artefacts; they fulfill various aesthetic and functional purposes, such as providing shelter or presenting obstacles in a video-game, or fleshing out a digital landscape in order to make it appear more realistic.

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and vertex points to build 3D models. More polygons in a model can mean more detail and smoother renders, but it can also mean longer render times and more problems caused by overlapping lines and vertices.

[212] The term born-digital refers to materials that originate in a digital form.

[213] The watertower, for example, is available in for free on the Unity asset store site; https://www.assetstore.unity3d.com/#/content/77 accessed 20.02.2014.

[214] https://www.assetstore.unity3d.com/#/category/0 accessed 20.02.2014.

[215] This watertower was still available on the 20.02.2014, see https://www.assetstore.unity3d.com/#/content/77 accessed 20.02.2014.

Rouse creative practice merges his interest in video game design with an interest in traditional landscape painting, especially late eigteenth century an early nineteenth century romantic landscape painting. Rouse's paintings render fictional locations taken from computer games into 'real' landscapes. Rouse employs traditional painterly techniques, such as using blue hues to emphasize distance. He has also designed a number of game maps[216] for the browser-based first-person shooter game Half-Life. Rouse is interested in the eeriness and stillness of shooter-game environments that have been created for simulated violence. The first-person shooter game *Postcards from Mexico* connects the violence of video games to the ritual violence of ancient Aztec rituals, and to the drug-related violence Mexico faces as a modern state.

Jeff Waweru, 11.04.2014

For *(Im)material Artefacts* ceramic artefacts from the collections at the National Museum Cardiff were selected for 3D scanning, and the resulting digital 3D models were made available to a number of artists. Participating artist were invited to create new artworks based on the digital 3D scans. Jeff Waweru, a Kenyan photographer, designer and filmmaker contributed a film and a wooden sculpture for this project. The *Curio Dog*, a wooden replica of a 17th century greyhound ornament, was carved by local craftsmen, who produce and sell work in little curio shops in Waweru's hometown Nanyuki. Waweru produced a short documentar-style film of its creation. 'I took printed images along to these guys,' Waweru explains; 'a colour photo of the original artefacts, and screenprints of the 3D models.' Waweru told the carvers that he wanted them to make a piece for a 'university student in the UK who is organising an exhibition in a museum' and invited them to pick the object they wanted to re-interpret in their curio style.

The carvers chose to work with the object they understood the best; the greyhound ornament. 'They didn't really get some of the other stuff,' Waweru

[216] The simulated landscapes of video game levels are described as game maps.

relates 'like the boy on the goat, they where laughing about that, like is he sitting on a donkey?' The carvers went to work on location in their curio stalls, producing work in a production line; the tasks of carving, sanding and polishing the artefact are shared by the team. Much like the original ceramic museum objects the artefacts produced in the curio shops of Nanyuki are the work of skilled craftsmen, produced by a small team in a production line, and traded as decorative domestic items.

In the video Jeff Waweru shot of the artefact's production the carvers chew miraa[217], joke and trade single cigarettes as they work. 'There is a lot of microtrade going on,' explains Waweru 'it's pretty much like a little world'. The curio shops are scattered along a road next to army training grounds and British soldiers from the British Army Training Unit Kenya (BATUK) looking for suvenirs or gifts for their friends and family in the UK are their main customers[218]. When there are no British troups the carvers sell their work to tourists on the other side of Nanyuki town, next to a battered roadsing informing passers-by that they are crossing the Equator. The influence of the British soldiers is visible in some of the more outrageous objects the craftsmen produce; carved shields sporting the logos of British football clubs, and wooden minions from Disney's *Despicable Me*. 'These soldiers are probably not considered artsy-fartsy back home, they probably don't go to museums much' Waweru muses, 'but here they support the local art industry.'

John Rainey, 27.02.2014

[217] Miraa, also known as ghat in the UK, is a psychoactive shrub which is cultivated around the Mount Kenya area. The bitter bark of the miraa plant has a stimulating effect when chewed.
[218] For an example of just how important the soldiers are for the curio traders see http://news.sky.com/story/1047403/kenyan-traders-hit-by-uk-troop-restrictions accessed 12.03.2014.

John Rainey chose to work with the 3D model of a late 18th century Derby Porcelain figure of a cupid riding a goat.
Rainey chose the figurine based on his preference for figurative pieces, he also related to the playfull nature of the piece. 'Digital technologies can be approached very seriously' Rainey explains; 'but when I first began to work with these technologies I left a model to be printed overnight – I felt like the shoemaker whose work is being executed by elves while he sleeps. There is something quite phantastical about these technologies.'
Rainey is interested in the transformative possibilities of 3D editing. He identifies scaling, duplication and distortion as forms of digital manipulation, which are 'essentially anti-material'. For *(Im)material Artefacts* Rainey chose to work within the limits of these three strategies to produce a series of four *Cupid Goats*. All four *Cupid Goats* include elements of scaling, distortion and duplication. Rainey used multiplication to turn the goat and cupid into multiheaded Cerberus creatures for *Cupid Goat 1* and *2*. The emphasis of *Cupid Goat 3* and *4* lies on scaling and distortion, with the cupids head mushrooming into a giant balloon as the goat twists in strange angles.

For *(Im)material Artefacts* Rainey also produced an animation, which showcases the transformation of the 3D model. This film was produced through the stopmotion animation of a series of screenshots he took while editing *Cupid Goat.* The animation is not a documentation of the editing process, instead the animation gives a taste of the phantastical transformations the digital model undergoes under John Raineys control.

The original Derby figurine was produced using industrial slip casting techniques, it is one example of many, rather than a unique sculpture. In creating a series of dissimilar *Cupid Goats* Rainey subverts this idea of mass production, using digital manipulation to render each sculpture into an individual piece. Whereas the original ceramic sculpture is decorated with pink and blue glazes Rainey prefers a monochrome finish on his pieces. The results subvert the saccarine Derby figurine into a haunting series of sculptures.

Jonathan Monagahan, 03.03.2014

An empty sea beneath a dark sky; to the electric music of Evan Samek a spacecraft floats into view. It rotates slowly revealing ornamental golden decorations, a Mercedes star, a giant surveillance camera, a strangely organic mouth and tails. The craft reaches the shore and expels a winged golden cup. The cup is orbited by two satellites in the shape of a lady's head and contains a rainbow coloured orb. It flaps its wings as the spaceship floats away. Then the cup flies away out of the picture, leaving behind an empty dark sea and the splashing of the waves.

This animation by Jonathan Monaghan, it is accompanied by a 3D print of the flying cup. Monaghan modelled the cup from 3D scans of an 18th century stirrup cup, a bonbonniere (sweet box) and a cream jug.

This form of digital engagement is not new to Monaghan. He taught himself how to design game maps and to use digital 3D editing in high school and went on to study computer graphics and fine art. Monaghan often drew inspiration from museum collections. His visual style blends photo-realism and video games with historical shapes and forms, mixing past and contemporary culture. 'I would often take my sketchbook to the museum, now 3D scanning has made museum artefacts available in a much more literal sense.' Monaghan worked as a studio assistant to Barry X Ball[219]. He also undertook a residency at MakerBot Industries in 2011 and participated in the 2012 Hackathon at the Metropolitan Museum New York. Monaghan argues that digital engagement can change museum collections from passive hoards of artefacts into sources of interactive content. 'Projects like this take artefacts and make them creative content' Monaghan explains; 'people can engage creatively with museum artefacts, rather than consume them passively.'

In comparison to other museum hacks (Im)material Artefacts focuses less on 3D digital technologies, and more on the artistic content, giving participating artists

[219] See http://www.barryxball.com/, accessed 15.10.2015.

more time to create nuanced artwork. From the synthetic soundtrack of Alien Fanfare, to the Mega Man figurehead attached to the golden cup Monaghan's work contains many references to gaming culture. There is also a touch of consumerism and perhaps paranoia, as the spacecraft's giant observation camera rolls in its socket behind a golden Mercedes star like a roving eye. In the animation Alien Fanfare the cup Monaghan has created from museum scans comes complete with wings, satellite dishes, a multi-coloured orb and spacecraft stabilisers. Its 3D printed counterpart feels like an artefact from another world. Monaghan sees no great dichotomy between the material and the virtual, or between the real and the phantastical. There is an absurd, surreal, almost scary quality to his work. 'I am thinking about how technology is changing us, as a society, but also as a species' he explains. In Monaghan's phantastical futuristic creations technology and nature, history and phantasy, humour and fear mix, as the past and the future unfold together.

Mario Padilla, 24.03.2014

'I'm not a master craftsman' Mario Padilla claims, but when it comes to creating beautiful sculptural forms he does not let technical difficulties stand in his way. Padilla is a young maker and industrial designer from Mexico; he chose to work with the 3D model of a Mexican mask from the collections at the National Museum Cardiff. Padilla's working method does not distinguish between physical and digital tools, in order to give the mask a body Padilla sculpted a master model from clay, which he digitized using a 3D scanner he had put together from a kinect sensor[220] and a rig made of Lego. Padilla then combined the scan data of the Mexican mask with the clay body he had modelled for it, and applied

[220] Kinect is a line of motion sensing input devices by Microsoft for Xbox 360 and Xbox One video game consoles and Windows PCs. The device features an RGB camera and a depth sensor, which can provide 3D motion capture. Kinect's array of sensors have been put to an array of non-gaming uses, see for example http://www.theverge.com/2011/12/6/2616242/kinect-hacks accessed 24.3.2014.

procedural modifiers[221] to alter their geometry, turning the solid clay forms into fragile latice structures.

Padilla, chose the 3d model based on his 'cultural relation with it'. The exact origin of the Mexican mask is unknown to the National Museum Cardiff. It is also not clear how the mask ended up in the museum collections, this lack of information means that the mask has never been on display in the museum galleries. Padilla felt that by interacting with the 3D model of the mask he could 'reanimate it in some way'. He did his own background research with the help of Dr. Martha Carmona Macias from the National Museum of Anthropology, Mexico. 'I thought maybe I can find something out,' he explains. Padilla showed Dr. Macias photographs of the original artefact as well as the digital model of the Mexican mask. Dr. Macias suspects the object dates back to the first century and is from the Tehoticuacan culture. Tehoticuacan craftsmen mass-produced this kind of artefact for ceremonial use. Basic forms would be produced using moulds and were later decorated individually to create a more appealing and unique appearance.

Padilla based his concept for *Cantli* on this method of mass-production and embellishment. His working methods trace the ancient technique of producing these cerememonial masks. Padilla modelled basic form in clay, digitized and reproduced it with a homemade scanner and then used mathematical algorithms in order to digitally 'embelish' his figure. The procedural modifiers add an element of chance to the work; 'the parametres of modifiers are defined by the user but the final product is random' Padilla explained. 'Cantli' means 'cheek' in Nahuatl. 'Digital technology enables you to make something happen across the ocean' Padilla muses, through re-animating the Mexican mask he feels closer to its original makers; 'I feel like I am keeping something going'.

[221] A modifier is defined as the application of a 'process' or 'algorithm' upon objects, the results are not directly conrolled by the artist, but can be further modified manually. 3D modifiers can be applied in many 3D editing programmes.

Mohamed Hossam, 27.02.2014

Ushabti figures served as funerary figurines in Ancient Egypt. They were placed in tombs and were intended to carry out any tasks involving heavy manual labour required of the deceased in the afterlife. Originally produced in huge numbers, ushabtis are the most numerous of ancient Egyptian antiquities to survive.

Mohamed Hossam, an Egyptian digital artist and educator chose to work with the 3D model of an ancient Egyptian ushabti figure. “I am proud of my country’s heritage and culture” he explains, “I have also worked as a guide and educator at the Egyptian Museum Cairo”. For his *WSB-Transformer* pieces Hossam multiplied the digital model and formed the multiplied digital ushabtis into twisting spirals. “There are so many of these ushabtis,” Hossam explains “large numbers, not just one, so I wanted to work with multiples.” Hossam’s title *WSB-Transforma* is derived from the Egyptian word wSb (answer). Called ‘answerers’, ushabti figures carry inscriptions asserting their readiness to answer the summons to work. Hossam’s close contact with Egyptian antiquities and his insight into ancient Egyptian culture has inspired his creative approach to working with the digital model. The twisted paths of *WSB-Transforma* traces the ushabtis’ voyage from the land of the living into the land of the dead, where they will begin to answer to their master. As the pieces are flipped upside down they are symbolically transformed from one state to another. “I wanted to incorporate the idea of movement, continuation and transformation, the pieces also represents a balance between life and the afterlife”.

Initially Hossam tried to import the 3D model into Hemesh[222], however the size of the 3D model was too large to be imported into the library. Hossam then reduced the high polygon count[223] of the 3D scan, however he was not satisfied

[222] Hemesh is a processing library by Frederik Vanhoutte that can be used to create elaborate 3D shapes quickly. In computer science, a library is a collection of implementations of behavior. See http://www.wblut.com/2010/05/04/hemesh-a-3d-mesh-library-for-processing/ accessed 27.02.2014.

[223] 3D models used for video games usually have a low polygon count, much unlike the 3D scans created for this research. Polygons are two-dimensional shapes with multiple sides connected at

with the loss of detail that came with the decrease of polygons. Instead Hossam began to test other options “I tried out different libraries, but the file was too large, finally I edited the piece in CINEMA 4D[224].” Hossam describes searching solutions to these technical challenges as a learning experience; “I searched a lot of resources online, I even wrote to other artists asking for advice”.

Zachary Eastwood-Bloom, 29.03.2014

The work of artist Zachary Eastwood-Bloom explores the transformation of form and meaning as objects are translated from analog to digital. Eastwood-Bloom holds an MA in Ceramics and Glass from the Royal College of Art. Despite his background in crafts his work navigates the periphery of ceramics; “I still like clay” he explains “but my work breaks out of the ceramics world”. Eastwood-Bloom uses 3D scanning, 3D print, milling and laser cutting to capture, reproduce and transform physical forms. His approach includes physical as well as digital processes.

For (Im)material Artefacts Eastwood-Bloom chose to work with the 3D model of a bonbonniere[225], and the 3D model of a vase from the National Museum Cardiff. “I kept looking at the photograph of the original objects,” he recounts “and these are the two which I liked the most”. Eastwood-Bloom decreased the polygon mesh face count[226] of the 3D models on Rhino CAD, and printed them in nylon material. He then grew crystals on these nylon lattice structures in a Borax solution. “Borax is used in many ceramic glazes, ” Eastwood-Bloom explains, his use of borax references the original materials used in the production of ceramic

vertices to enclose the shape. In 3D animation, these polygons are connected along their sides and vertex points to build 3D models. More polygons in a model can mean more detail and smoother renders, but it can also mean longer render times and more problems caused by overlapping lines and vertices.

[224] CINEMA 4D is a 3D modeling, animation and rendering application developed by MAXON Computer GmbH, see http://www.maxon.net/en/products.html accessed 27.02.2014.

[225] A ceramic screw-lid box used to keep sweets.

[226] A polygon mesh is a collection of vertices, edges and faces that defines the shape of a 3D computer model. The faces usually consist of triangles, quadrilaterals or other simple convex polygons.

objects. The crystals also add complexity to the bare lattice structures. Crystals are formed from a regular repeated pattern of connected atoms or molecules, like the procedural modifiers[227] used in 3D editing the physical process of growing crystals transforms the surface of the object beyond the immediate control of the artist.

Eastwood-Bloom has used similar processes to recreate and transform a bust of Asclepius for the 2013 British Ceramics Biennial. Unlike the Asclepius bust the 3D models of ceramic artefacts are not "big and beautiful objects", instead Eastwood-Bloom sees "something personal and intimate" in the original domestic items. 3D scanning captures the X, Y and Z coordinates of physical objects, however there are qualities it fails to capture. The original vase and bonbonniere were both practical items, "you could see them in someone's living room," Eastwood-Bloom explains, "but the digital lens has its own filters, digital models do not always correspond to physical objects". The open lattice structures Eastwood-Bloom created have lost the practical and domestic nature of their original counterparts. Through stripping the forms back to their "minimal bones" and allowing physical processes to change their appearance Eastwood-Bloom has translated the objects into something new. It is this process-driven transformation, which Eastwood-Bloom seeks to explore; "these processes of translation put things through different filters".

Zack Dougherty. 31.03.2014

Zack Dougherty has captured everything from terrestrial bodies to man-made artefacts in his practice. 'I studied astrophotography for a while,' he explains; 'that is when I got into assisted, or mechanical photography. The camera is mounted on a robot which counteracts the rotation of the earth, so that it can take images as though it were floating in space itself.' A clouded sky in the Death Valley led Dougherty to look for motives elsewhere; 'I started taking pictures of

[227] A modifier is defined as the application of a 'process' or 'algorithm' upon objects. 3D modifiers can be applied in many 3D editing programmes.

things around me'. Dougherty began photographing from the tops of buildings, creating large panoramas, until Greek sculptures caught his eye in a museum. Dougherty's current practice involves capturing museum objects in 3D using photogrammetry[228] and re-imagining them in often surreal contexts as GIFs[229]. Monaghan goes into the museum 'like anyone else' to create his 3D models. 'I often find myself looking at other people taking pictures, seeing if they are doing the same,' he explains. To create photogrammetric 3D models images of an object are taken from all angles. Photography is allowed in most museums, but often there are no specific policies in place concerning the creation of 3D models. Dougherty is often self-conscious when he goes into museums to 'poach' 3D models. Dougherty uses his 3D models of museum artefacts to create GIF's, a highly popular medium on the Internet. 'GIF's have been around since 1987, they are quite an old medium, but only now people are beginning to talk about GIF-art,' he explains; 'ten years ago this would not have been taken seriously.
'

For the (Im)material Artefacts project Dougherty embraced the chance to use 3D printing; 'I wanted to get something out of the computer,' he explains, 'because so much of my work stays there.' Dougherty chose to work with the 3D scan of a teapot from the National Museum Cardiff. His choice of the teapot is a tongue-in-cheek reference to the Utah Teapot[230]. In the computer-graphics community the Utah Teapot is well known and has become something of an in-joke, appearing in animated movies such as *Toy Story* or the TV series *The Simpsons*. Dougherty describes the Utah Teapot as a 'historic 3D item.'

Dougherty was also drawn to the functional nature of the teapot; he transformed the form into a lattice and placed a cup inside this structure. The teapot remains

[228] Photogrammetry software produces 3D models from digital photographs through triangulation. By taking photographs from at least two different locations, so-called "lines of sight" can be developed from each camera to points on the object. These lines of sight are mathematically intersected to produce 3D coordinates of the photographed object.
[229] The Graphics Interchange Format (better known by its acronym GIF) is a bitmap image format that was introduced by CompuServe in 1987 and has since come into widespread usage on the Internet due to its wide support and portability. The format supports animations and allows a separate palette of up to 256 colours for each frame.
[230] The Utah teapot is a 3D computer model of an ordinary teapot of fairly simple shape, which has become a standard reference object in the computer graphics community. The teapot model was created in 1975 by early computer graphics researcher Martin Newell, a member of the pioneering graphics program at the University of Utah.

a container, but it would have to be dipped into liquid to be filled, and the lattice would make the act of pouring difficult, if not impossible. The practical teapot has been transformed into an impractical cup. 'It is a glorified teacup,' Dougherty explains; 'I really wanted it to be useable, but irony is often my go-to approach.' Despite his mischievous approach Dougherty recognizes the history of the objects he works with. His involvement with digital models of museum objects continues and extends their trajectory. 'Before they entered the museum these artefacts were used, cherished and looked after,' he explains; 'I take pleasure in the idea that these objects were made by hand a long time ago, now I continue them on another path.'

Museum staff

Ashley McAvoy 04.07.2014

Ashley McAvoy is an exhibitions and programs coordinator at the National Museum of Wales, he manages exhibitions at the National Museum Cardiff and all other 7 venues attached to the National Museum of Wales, including the Big Pitt and St. Fagans. McAvoy takes care of the logistics of museum displays; 'I am basically in charge of money and time,' he explains.

McAvoy is a musician, but found employment at the National Museum of Wales to supplement his income. He has now been working at the museum for 15 years and 'feels very lucky' to be employed in a job he clearly is passionate about. McAvoy's favourite piece from the *(Im)material Artefacts* exhibition is the *Teapot Trainfortress*. He likes the sense of humour the piece conveys; 'I like humour in art,' he explains, 'I believe there is truth in art, but when artists lack a sense of humour they can quickly come across as sanctimonious. Humour is a way to introduce truth without putting people on the back foot.' Although McAvoy sees museums as place where learning can take place he thinks this should not happen in a top-down, authoritative way. He knows that 'people don't like to be told what to think, but if you can make them laugh they are more open to suggestions.' McAvoy also liked the piece *Cupid Goat* and the *Cupid Goat – Interlude* animation; 'I am interested in esoteric art,' he explains, 'the original

cherub on the goat carries a hidden layer of mythology, which is reflected back in the new pieces.' 'What will stay with me is the copied, distorted and twisted face of the cherub,' he relates 'something happened between the objects and the video, it unsettled me slightly, but in a good way.' McAvoy thought there was a clear connection between the original figure, its 3D printed remixes and the animation 'the pieces are almost worth their own display'.
Although McAvoy also enjoyed watching the other videos displayed as part of *(Im)material Artefacts* he feels there was not enough background information on them for audiences to understand their context. He was not convinced by the labelling, and felt that the showcases, which were used for the exhibition, were not an ideal solution. However, he understands that these 'display problems' are down to a lack of time and resources. In his job he often has to balance the logistics of displaying artefacts in the most advantageous way with the need to save money and to work on a limited budget. This is not always an easy task; 'you can't fit oranges into square boxes,' he relates.

McAvoy works with all different departments of the museum; with curators who wish to create beautiful displays, with health and safety officials whose task it is to keep the public safe, and with technicians and IT staff. With every new exhibition he faces the task of balancing the diverging visions of all parties involved. 'Sometimes there is pressure to stick to the rules,' he relates, 'museums and galleries can be underpinned with very academic thinking. But personally I think breaking the rules is fun.' McAvoy admits that breaking established rules and going against set modes of gallery displays can be 'risky business', but he feels that experimenting with the boundaries of established practice is 'important for creativity' and allows the museum to be more innovative.
McAvoy believes that museums need to 'inspire new thoughts and feelings' (McAvoy). 'We are trying to unlock creativity in people who aren't necessarily used to thinking in a creative way,' he explains; 'not just artistic creativity, but also ways of independent thinking. Museums are not schools, churches, governments or councils, but they can tell people something about who they are and where they come from.' One way to foster engagement with museum displays is through engaging audiences on a personal level; 'all people are

slightly self-obsessed,' McAvoy relates, 'and at the same time desperate to communicate, to share feelings and thoughts.' He thinks that the *(Im)material Artefacts* display succeeds in 'bringing the individual in' by bringing old artefacts together with new and re-imagined objects. 'This gets people to think about the makers,' McAvoy explains 'it establishes a personal connection.'

Without the originals the new artworks would be 'just another thing on a shelf,' McAvoy argues; 'they serve no purpose, but then "form without function" is one definition of art, although not one I agree with. They are interesting enough as objects and perhaps a display without the originals would lead to a shift in focus and show them in a new light.' In the context of the *(Im)material Artefacts* display McAvoy thinks that the new artworks depend on the original artefacts for value and context; 'they are the source and provide a key to understanding the new work' (McAvoy). The new artworks have an effect on the original artefacts as well, McAvoy describes this as a 'feedback loop'. 'The new work made me re-evaluate the old objects,' he relates.

As a musician McAvoy is familiar with the concept of remixing; 'in music, when you mix lesser known genres together this is called a crossover,' he explains, 'it can make music more attractive to the mainstream, this is called "crossover appeal".' McAvoy identifies the creation of remixes, or 'mashups', as a strategy, which has begun to influence art across all disciplines since the digital revolution. 'It can be a way of reassessing and reshaping art,' he explains 'I like crowd sourced and open source collaborations. People are cherry-picking from different places and creating fusions. Museums should be a vital component in sustaining and improving this process. They can work as a repository. We are looking after the past, in the present, for the future.' *(Im)material Artefacts* brings the concept of remixing and open source sharing into the museum galleries. In a sense the display not only presents artefacts to the museum audience, but also introduces them to a concept, which has begun to gain ground within the arts and beyond. 'There has always been an interplay between technologies and art,' McAvoy relates, 'one leads the other forward like the

pedals on a bicycle. Artistic expression and technological advances have always chased each other, since the day of the first caveman paintings.'
McAvoy feels that experimental mashups need to be balanced with more factual displays; 'the trick is to realise what you are trying to get across,' he explains, 'and to present it not as a finger wagging teacher, but to say "let me tell you about something so you can make your mind up".' McAvoy knows, that 'very few people will be as interested in any exhibition as the curator'. 'There is no way of controlling how audiences react to displays,' he explains, 'people respond to objects in their own unique and personal way.' 'People sometimes don't know how to behave in the galleries, they feel like they are in church,' *(Im)material Artefacts* stands in contrast to the academic and sanctified view of museums; 'this display brings in some humour, I can imagine people thinking"yeah that's funny".'

Rachel Conroy 16.06.2014

'I like to see creative responses to museum collections,' Rachel Conroy relates; 'in a sense, artists working with museum collections have more freedom than we do as curators. It is interesting to see their creative and intellectual responses.' Conroy's historical background knowledge on the ceramic artefacts she works with feeds into her curatorial work and informs how she arranges displays and presents information to the public. 'I am also interested in the visual and aesthetic qualities of our objects' she explains 'sometimes I like to step out of the art and design historical context'.

'Creative responses tend to go down well with audiences,' she explains; 'people are very interested in 3D at the moment and this project offered us the chance to tap into this field. This is something we could not have done with our permanent collection.' Conroy thinks that (Im)material Artefacts provided an interesting insight into the creative responses of participating artists and made a clear connection between the original artefacts and the objects created in response to them. Her favorite piece is *Monkey Heaven*, she appreciates its minute detail and the collaged, playful juxtaposition of objects; 'the more you look the more you notice, there is the greyhound, the archaic figure, the shabti. You see the humor and the love of detail,' she explains, 'there is also a sense of narrative in it'. She also appreciates *Screwed Up*, for its 'clever reference of the action of twisting the lid of the original piece'. However Conroy would have liked to see some live 3D printing during the show. 'People are often very interested in process,' she explains. John Rainey's animation *Cupid Goat-Interlude* shows the process of transformation an object undergoes during digital editing. Conroy agrees that the video helps audiences to get an insight into the editing process, 'but 3D printing would have been great'. Do 3D printed reproductions appeal to her personally? Conroy shakes her head; 'Not really, there's something I like about the gesture of the hand, the contact an object has had with people during its making.' Conroy does not think facsimile 3D printed reproductions would be satisfactory. However she does see some potential uses and applications for these technologies; 'it allows people to be creative' she argues, 'and in people's homes where an object has been lost or broken perhaps the 3D model can be kept like the photograph of a loved one. It could help to continue the process of remembering.'

'The idea of downloading objects for 3D printing still seems quite futuristic,' Conroy relates, 'it brings new processes, new objects and new expressions of materiality to the museum. We will also face new challenges in the conservation of such objects.' And there are conceptual challenges 'should museums buy the 3D files with the objects? How do they relate? Are they like a preparatory sketch to a painting or like a design drawing, or is the data the artefact? And how could it be displayed?' But, although Conroy admits that these challenges make her feel 'slightly nervous' she is not too worried, 'there will be complications, but there always are. Museums have always had to deal with change.' 'Museums have engaged with digital technologies for a while, for example experimenting with digital access and social networking,' she explains, 'perhaps it would help if museums got together to discuss and set up guidelines for collecting and conserving digital 3D files and printed objects, it might make curators feel more prepared.'

Conroy was not directly involved in *(Im)material Artefacts*, but caught occasional glances as the project evolved towards the final display, 'it was fascinating to see it all come together,' she recounts 'this new group of objects popped up. Visitors seem to be enjoying it and it is always rewarding to see our collections used in new ways.' What does she think the museum-internal legacy of this project is? 'It has given us the impetus to broaden our horizons,' Conroy explains; 'it has introduced new technologies and new ways of thinking about the collections and what impact they can have.'

Visitors

Güler Oğuz, 11.06.2014

'I like the goats the most' Güler Oğuz exclaims after viewing the *(Im)material Artefacts* display; 'especially the one with the bubble heads and no faces.' Oğuz describes this pieces (*Cupid Goat* by John Rainey) as an 'amorphic, organic looking form' and argues, that it 'leaves things to the viewer's imagination' as the original object has been distorted and abstracted to a point where new associations become possible and the remixed piece begins to stand on its own. Oğuz argues that Rainey's animation, which shows the figurine undergoing digital transformations, shows the endless possibilities digital editing brings to the form-finding process; 'it is interesting to see at what point the artist stops. You get an insight into the artist's mind and the process.' Oğuz sees potential in 3D scanning, editing and print; 'it is not too time consuming and you can see variations of a form, this makes it easier to explore possibilities and find new designs.' However, as a finished product or artwork, Oğuz would still prefer hand-made objects, as she finds they carry more emotional and sensual value and can bring a feeling of closeness between the viewer and the artists who originally touched and moulded the artefacts by hand. Here, Oğuz is not speaking about mass-produced ceramic items, but rather about uniquely handcrafted artefacts.

Oğuz observes, that the digitally created remixes make the original pieces 'stronger'; 'they bring out their age'. Oğuz argues, that the contrast between the original pieces and the contemporary items and technologies give a strong impression of the time which has passed between then and now. Oğuz thinks that this type of project can help grab people's attention and draw them into the museum, perhaps even to help people 'learn about the connections between the old and the new, between history and present-day life'. She sees this effect as connected to the current popularity of digital 3D technologies and 3D print; 'it is interesting because it is new right now.' Oğuz sees the value of *(Im)material Artefacts*, and of all types of artist engagement with museum collections, in their contribution of reasons 'for people to visit museums, and to find beauty and experience embodied ideas'.

Michael Flynn 04.07.2014

Michael Flynn describes the *(Im)material Artefacts* display as 'quite nice', but felt it was more of an experiment with new technologies than an art exhibition. 'Fair enough,' he relates, 'you have to start somewhere. But it takes time to assimilate and digest the possibilities of new technologies.' Flynn is not against trying things out; 'I am not a Luddite' he jokes, 'and some of these objects are actually quite pretty. But nothing there really grabbed me.' While Flynn can appreciate artwork, which is based on reproductions he believes such work needs 'substance'; he finds most digital work stays at 'the first level'. Flynn found the two remixed teapots had the most substance to them, as they can be seen to fit into a long ceramic tradition of re-inventing the teapot as an art form. 'This is nothing new,' Flynn explains 'Kasimir Malevich was already doing the same thing with his Suprematist Teapot in 1923.' Flynn feels that the work exhibited in (Im)material Artefacts did not go 'beyond the level of experimentation.' 'But should we expect that?' he asks, 'these technologies are accelerating so fast, by the time a technology has become assimilated a new one comes along already.' Flynn sees this rapid pace of digital technologies as a 'fact of the times', one that many artists are perhaps a bit too keen to jump on board with. 'It is the big thing to do these days,' Flynn argues, 'but most of the results can be achieved using other means, I saw nothing earth shattering.' However, Flynn sees merit in the experimentation with emerging technologies; 'digital technologies caused a huge leap in photography,' he explains, 'it has become a lot easier to take images and to change them.' The possibility to edit objects unrestricted by gravity or material limitations could prove equally fruitful for ceramics and sculpture; 'the possibilities are endless,' Flynn argues, 'perhaps these technologies will make it easier for some to create work.' 'I like to make things with my hands,' Flynn relates, 'I make therefor I am. But I recently read an article about how digital technologies are leading us into a Abramovic situation, were art is supposed to exist without any objects. But with scanning and 3D print the focus is on objects again. People will always be into objects, perhaps scanning and 3D print are a way to bridge the digital gap.'

Tina Warnes 03.07.2014

Tina Warnes is currently busy with her MA studies; she is involved in a study on the human brain, and does not have much time to visit museums. "Last time I went to a museum was during the bank holiday in April,' she remembers 'I went to the Natural History Museum in London.' Warnes searches out things of interest inside museums and focuses on things, which she finds 'aesthetically pleasing'. She doesn't like to read a lot of signage, 'my attention spam isn't amazing,' she explains, 'unless my attention is grabbed I won't go to read the background information'.

Warnes likes the concept behind *(Im)material Artefacts*, she appreciates the 'mix of old and new and the re-imagination of things'. However, she does not care much for the videos included in the display; 'I would not stay to watch the whole video,' she explains, 'I like to view things in my own time.'

Monkey Heaven appealed to Warnes, she felt there was meaning behind the monkey holding antiques and antiquities. She also appreciated *Growing 1 and 2*; 'maybe it is my science background,' Warnes relates, 'I like the crystals and how they grew on top of the original structure'. Warnes did not enjoy the warped and twisted remixes, such as *Cupid Goat*. 'I can't quite pinpoint why,' she muses 'they are a bit like a hallucination'.

Warnes would have no interest in downloading 3D files, but thinks projects like *(Im)material Artefacts* hold potential as interactive teaching tools for schools. She says she is 'not so sure about the pieces themselves' as they are highly site specific and depend on the original artefacts 'for value'. Warnes suspects the remixed 3D models would lack content without the original artefacts. 'The originals just exist, they are the origin, the new ones can be changed,' she observes, 'the old ones are solid and the new ones are fluid.'

Paul Weston 03.06.2014

Paul Weston felt most drawn to the teapot and its 3D printed re-interpretations by Zack Dougherty and Ian Cooke Tilapia. He is a writer and musician, but has a lively interest in the wider field of art. 'If I had to choose an object to work with,' he speculates, 'it would be the teapot'. Weston describes the teapot's form as both intricate and simple. To him, the teapot is an 'approachable' item; it reminds him of his grandmother; 'my gran used to collect teapots. She had all kinds of different teapots (…) she would have loved this showcase.'
Weston is also interested in Rouse's videogame *Postcards from Mexico*. He describes the experience of watching the videogame walk through as an exploration of the 'topography' of a 'living organism' (the original mask). 'I feel like a fly,' he explains, likening the experience of the videogame to the vision of a fly, to whom all artefacts must seem like vast terrains. 'You can take a journey with the piece and enter into the imagination,' Weston relates; 'it allows viewers to have an experience'. 'This project ((*Im)material Artefacts*) makes art come alive,' Weston argues 'the artefacts become more than just aesthetic objects. They can be engaged with.'

Weston would download 3D files of museum artefacts and have them printed. He argues, that digital imaging and 3D print can enable viewers to have a closer look, from more angles, than is usually possible within the museum environment. If objects can be downloaded Weston feels this would 'make up for the fact that you can't have it (the original museum item) in your possession'.

Weston reasons, that access to 3D models would make the original even more 'beguiling' and attractive, because 'the original would still remain out of reach'. Weston views digital art with some reserve; 'digital technologies have enabled a lot of mediocrity," he argues, 'a certain feel for art can lack with computers, it sometimes lacks vision and life'. Weston is a musician; he argues that musical samples 'should only be accepted if they add to the piece, not to fill a hole'. Weston argues, that, similarly, 'digital models should capture the soul of the piece, they should not be a shape exercise.'

However, Weston thinks, that *(Im)material Artefacts* presents a 'good attempt at transferring static ceramic items into an accessible, living medium'. Weston could see this project appealing to a wider audience. This form of engagement 'takes nothing away from the original work, but spins it around and makes it more accessible' (Weston). Ceramic art often gets overlooked, 3D art projects can make artefacts more appealing, 'in line with our digital society' (Weston). He also sees digital imaging technologies as a way of 'dreaming about the past and projecting into the future'.

Weston sees the original artefacts as the core of the *(Im)material Artefacts* project, to him they seem to be saying 'look at me, I'm living and beautiful'.

Sarah Worgan, 03.04.2014

Mario Padilla's fragile lattice figure, a re-interpretation of the Mexican Mask most attracted Sarah Worgan; 'the plastic of 3D prints can be unappealing' she explains 'but this transparent, open form re-translates the mask and takes it further'. Initially Worgan was disinterested in the videogame visualisation, but when she learned, that the landscape of *Postcards from Mexico* was set on the 3D model of the Mexican mask her attention was caught. This knowledge made her feel like she was 'walking over ancient history,' Worgan explains, 'it was an almost bodily resonant response'. The video game visualisation together with original mask led Worgan to draw comparisons between the two, to try and negotiate which part of the mask the camera was flying over.

Worgan feels, that such 'new modes of being with the object' could open up new ways of learning about and examining artefacts. The too-and-fro between the real and the imaginary, the physical and the digital can make artefacts interesting to a wider audience, and inspire new ways of thinking about them. 'Too much specification and too many facts can close objects down,' Worgan argues, 'there is a danger of being spoon-fed information. Instead, this project encourages intrigue'. Worgan would however want a little more background information on the screen-based pieces. This was only provided in the form of QR codes. The QR codes link to an online blog with more information on the individual pieces, when scanned with a smart phone or mobile device. Worgan feels that providing this information in the form of wall signage might aid a part of the public who are not up-to-date on digital technologies, or who do not own a smartphone.

Sarah Worgan drew a strong connection between the *(Im)material Artefacts* display and her background in teaching. She has worked as a full-time primary teacher, specialising on teaching kids with behavioural and learning difficulties. Worgan is now enrolled on a full-time Ceramics Masters course, and still free-lances as a teacher. This has given her a wide insight into teaching methods. 'I am a passionate advocator of experiential learning,' Worgan relates, 'often very target-based teaching methods can leave children with learning difficulties behind'. Worgan sees a great potential for 3D models of museum artefacts as a teaching tool; 'this could give kids who can not easily approach textual information more confidence' (Worgan). She argues, that through the exploration of digital models and 3D prints experiential learning and meaningful, embodied experiences could be fostered. Access to digital models of museum artefacts could offer students more than 'just sentences, words and scripts' alone[231].

[231] As a spin-off of the (Im)material Artefacts project the researcher created an open-source lesson plan for the 3D printer company Ultimaker. This lesson plan was designed to use the 3D model of an ushabti figure from the National Museum Cardiff as an experiential tool for primary school teaching. See http://www.createeducation.co.uk/lessons/2014/05/08/egyptian-ushabti-history-lesson/ , accessed 03.06.2014.

Sarah Worgan also felt there was a 'political level' to the *(Im)material Artefacts* project; 'museums traditionally conserve objects and keep them precious,' she explains, 'the distribution and experimentation with 3D models goes against this, it also raises copyright questions'.

Overall Sarah Worgan felt 'excited about looking at museums in new ways'.

Tumi Williams, 04.06.2014

In the museum Tumi Williams' phone is instantly out of his pocket 'I haven't been here since uni' he comments as he snaps pictures of sculptures and looks for the best angles and filters[232].

To Williams the days when museums were quiet spaces, which commanded reverential silence and sedate contemplation of their collections are counted; 'the generation of people that saw museums in that light is dying off, our generation has a short attention span'. Instead, Williams argues, digital technologies enable different ways of accessing the museum; 'I've just taken photos and can have them on my computer,' he argues 'when I get back home, maybe that's when I'll look at them again and take more time'. Information can be stored digitally and returned to, additional details can easily be accessed over the Internet, and contemplation no longer necessarily takes place within the museum space. Williams agrees that this presents a challenge to museum practice; 'museums have to keep moving with the times'. He points to a large painting, installed behind the museum café counter, 'how long do you think this has hung there? Probably at least since the sixties'. Information and content should be able to move through the museum at a quicker pace he argues, allowing audiences to experience more change and variety when they step into the museum. Williams sees the *(Im)material Artefacts* display as moving in the right direction; 'it's not something I have seen before, it's a wicked concept'.

[232] Many mobile devices with inbuilt cameras today include various digital filters, which can be used to give photos a different appearance. The photography app Instagram, which allows users to upload and share photographs instantly, also offers a range of digital filters.

Tumi is an active musician, producing his own music and working with other performers. *(Im)material Artefacts* reminded him of a musical remix; 'if you take something, replicate it and alter it, technically it automatically becomes an original and begins to stand on its own. You could also just take a detail and zoom in on it, or maybe leave the form unchanged but blow it up to a huge scale. The fact that the new work is based on an old piece makes it no less creative, most things start in this way.'

Williams describes this form of digital engagement with heritage artefacts as 'passing on the baton'; 'it is an evolution, so to speak, digital media is just enabling another natural step in the evolution of the arts'. The imaginative nature of the *(Im)material Artefacts* artworks is 'suggestive to the public'; Williams suggests it allows 'personal interpretations' and 'invites people from any background'. However, Williams points out, in some cases this form of engagement could be problematic; 'if there was a piece with a difficult cultural background it would not be alright to just have a play with it'. At best, Williams argues, 3D imaging technologies could contribute towards restoring cultural artefacts to their original context, or even help to repatriate the original items to their original culture. 'You could let go of the originals but still pass on all the information'. But would this not destroy the authenticity of the museum experience? 'Authenticity is a construct, it is projected on to the object and has a lot to do with monetary value,' Williams argues, but he also asserts that not everything can be replaced by digital models; 'museums should still preserve that physical element'.

Digital access and digital remixes, like the *(Im)material Artefacts* project can help museums to negotiate between physical museum displays and digital access, between the authentic and the remixed, the old and the contemporary. And perhaps these areas can complement each other; 'because of the remixes I spent more time looking at the originals,' William recounts 'I was even looking for a seat'.

A.8.2. Lincoln 3D Scans

Users

Will Kendrick, 12.06.2014

Will Kendrick grew up in the Northern sea side town of Blackpool and is convinced the city left him with 'an obsession with colour and kitsch'; the 'neon lights, amusement arcades and nightclubs' of Blackpool have informed his aesthetic vision. Kendrick moved to Bath for his BA in Fine Art, during which he began using resin to cast sculptures. Kendrick used copying processes to reproduce and alter found objects; his process involved pouring resin over shop mannequins, letting it dry and removing the brightly coloured resin form.

Today, Kendrick's main source of found 'objects' and images is the Internet; 'I use Google as a palette,' he explains. Kendrick edits, layers and collages images, 3D models, films and Gifs found online to produce new visual material. 'A lot of my work is about copying and reproduction,' he explains 'in art education there is often a push for originality, but copying has always been a way of learning, and most art is derived from copies'. Kendrick sources his visual material from online 3D model repositories2, from YouTube and through Google. The resulting collages, prints, web-based pieces and installations 'blur the boundaries between disciplines, eras and media, referencing art history along with contemporary cinema in a way that any contemporary eye can immediately relate to' (Katie Tsouros). Through projects such as his collaborative practice MadeScapes3 and curatorial project Home-Platform4, Kendrick experiments with art that moves between the digital and the physical realm and curates collaborative exhibitions that take place partly in the real world, partly online; 'sometimes the browser is my canvas, but other work needs the gallery space'.

Kendrick feels privileged to witness the 'rise' of digital technologies and looks towards the progression of digital technologies with a lot of optimism; 'it is frustrating that I have a lifespan and can't see everything that will happen in the future.' Kendrick remembers playing Atari and Commodore 64 games as a boy.

Today, it is hard to think about a world without computers, smartphones, tablets and touchscreens. Kendrick recalls the fast commodification of digital technologies; 'everything moved so quickly, there was this huge jump in technology'. 'We are the crossover generation,' he explains, 'Wikipedia pages, images on the Internet, these are the artefacts we will leave behind, the whole thing is our legacy'. On the Web, it can seem virtually impossible to erase anything entirely, much to the dismay of people who regret posting misjudged status updates or uploading compromising images online. However this sense of permanence can be deceiving; rapid changes in the use of computer software and file formats mean that much digital information becomes lost or unreadable after some time. For example, artwork by Andy Warhol made on an Amiga computer in 1985 was recently re-discovered after it had been hidden away on defunct floppy disks for close to 30 years5. Researchers had to 'dig up' the lost images and convert them into useable file formats. Kendrick believes, that this form of 'digital archaeology' will become an important part of historical research in the future. 'The digging really begins when you look into the computer memory,' Kendrick explains, 'people will be unearthing the digital'.

Collaboration is an integral part of Kendrick's practice; he uploads his work online and shares it as open-source data; 'I have no problem with someone taking my work and making new stuff from it'. Kendrick sees this sharing and recontextualising of visual materials as a positive thing, a new way in which art is growing organically and collaboratively; 'I see it as a progression,' he explains, 'we are building on what is already there, and creating work on which the next generation will build. Art is an evolutionary progress, rather than a sequence of divine inspired moments.' Kendrick has recently used 3D models of museum objects, accessed via Oliver Laric's Lincoln 3D Scans website6 in his work. Instead of looking at the past with a sense of nostalgia Kendrick has used these 3D models to 're-imagine, re-contextualize and re-connect' artefacts from the past, collating them with contemporary material. Through this process of appropriation and re-appropriation old meanings are lost and new meanings begin to emerge. 'I am clinging to the past in a very progressive way,' Kendrick explains, 'pushing it forward, rather than dragging it behind'. He sees the 3D models 'like tourist objects'; they retain only some of their original connotations as they are carried forward towards new contexts. Kendrick did not look into the historical connections of the Lincoln 3D scans he used. He is more interested in their historical appearance, than in their actual histories.

To Kendrick the Internet is a 'sea of stuff', a repository that traditional institutions like libraries, museums and galleries have to keep abreast with. He sees no clear distinction between material and physical repositories; 'in the future I think people will switch between both realms quite naturally, there will hardly be any distinction, technologies like the oculus rift are already moving in this direction'. Kendrick does not see this as a threat to traditional institutions, such as museums 'in the end no-one wants to stare at a screen all day, museums are social physical spaces and we will always need such spaces'. Museums have changed and progressed continuously since their conception. Today, digital technologies present a new challenge. 'People want to curate their own experiences more,' Kendrick argues, 'they are not looking for linear experiences.' 3D models of museum artefacts can potentially open up museum collections; 'I feel like I can hold them (the museum objects) and play with them,' Kendrick relates, 'and that's never happened before, they have always been behind glass.'

Kendrick argues that museums now have a chance to contribute material towards the 'digital evolution' of art. Through 3D digitization collections of artefacts from the past can continue to inspire today's artists. 'This is the thing I love about art,' Kendrick explains, 'you can revive the dead branches, reconnect the forgotten to something new'.

Brit Bunkley, 20.03.2015

Brit Bunkley came cross the Lincoln 3D Scans project while he was reading Frieze art magazine; 'I was looking for 3D models at the time,' he explained, 'I was looking for classical style 3D models'. Bunkley has had an interest in the transformation of classical objects and ideas 'since about thirty years'; 'I have been trying to distort and change classical artefacts since around 1986,' he explained. Aside from digital 3D scans found on the Lincoln 3D Scans website Bunkley uses 3D models from the online repository and creates his own photogrammetric 3D models. Sometimes Bunkley 'is not sure' if the 3D models he finds online are born-digital models or 3D scans from real life; 'I was not always sure and I did not always care'. At present, he is becoming more interested in creating his own photogrammetric 3D models. 'I am looking at the imperfections, bumpy, scaly bits, the noise you can get in 3D scans,' he explained. Bunkley fears that his photogrammetric models are getting 'too perfect'; "I am interested in the imperfections that make scans appear a little bit odd,' he explained.

Bunkley uses digital image and video editing, as well as 3D editing and 3D print in his practise. From the Lincoln 3D Scans collection Bunkley used a 3D model of a bust of Napoleon and the 3D model of sculptures of a nymph and Venus and Cupid. Bunkley edited and 3D printed these models. He embedded a quote from Napoleon into the bust; "la révolution est terminé, je suis la revolution" (the revolution is over, I am the revolution). The quote is embedded twice on the cheeks of the bust; 'it's a bit like a Maori moko tattoo,' Bunkley explained, 'this quote shows how far he (Napoleon) betrayed the revolution'.
Bunkley distorted the 3D models of the nymph and Venus sculptures, he 'just stretched them about' to try and render the classical style figures in a new form. 'It's a test of creative capacity,' he explained, 'how many things can you do with a brick'. The compound distortions Bunkley applied to the 3D models have early precedents in 3D printed art; '15 years ago Lazzarini printed a famous prototype of one of The Ambassadors skulls (a skull from the painting by Holbein)' Bunkley explains. But, like Lazzarini, Bunkley is not someone who wants to be known just as an artist that uses 3D print, his use of the medium was motivated by practical reasons:

> *'I began working in 3D in the early 90's as a method to visualize public art proposals. When arriving here (in New Zealand) in 95, my public art "career" disappeared so I continued to work...."virtually". My first 3d print (rapid prototype) was in 1999, becoming part of the Intersculpt*

consortium. I am mostly self-taught. Sculpture takes a lot of space and resources. Virtual sculpture and video do not.'

Bunkley sees the 3D models he works with in context with their history and seeks to use them in a culturally informed way; 'I ask myself – am I going to offend anyone,' he explained, 'I was scanning Maori sculptures recently, but a Maori lady I spoke with explained that I should not use the 3D scans of these warrior monuments. I am very aware of how sensitive it could be. Taking pictures or 3D scans, it can be like capturing a soul.' During a recent trip to Europe Bunkley, who lives in New Zealand, 'went crazy in Europe'. He used photogrammetry to create models of Soviet Monuments in Berlin and Auschwitz architecture. Bunkley edits and 3D prints the 3D models he creates and collects. He remains conscious of the potentially problematic context of some of the 3D forms he works with; 'I asked a friend of mine what he thought,' he explained, 'he is Jewish and escaped from Germany when he was nine, most of his family died in Auschwitz, but he saw no problem with it.' Nonetheless, Bunkley thinks he should 'probably ask around more'.

Jonathan Beck *(Scan the World)*, 12.05.2015

Jonathan Beck is the mind behind *Scan the World*, an initiative funded by MyMiniFactory and iMakr[233]. Beck describes Scan the World as 'a global initiative between people across the world'; 'our aim is to build up an archive of heritage objects, sculptures and public monuments'. Although Scan the World's in-house designers create the majority of the 3D models featured on MyMiniFactory, the initiative supports active engagement and accepts contributions of user-generated (UG) content. 'We encourage people to send us their 3D models, we organise photogrammetry workshops and MyMiniFactory runs a 3D scanning and printing "academy". Sometimes people send us full 3D models, sometimes they just send us photographs and we then turn them into 3D

[233] See http://www.myminifactory.com/ and http://www.imakr.com/en/, both accessed 15.20.2015.

models,' Beck explains; 'we like to send 3D prints back to our contributors to say thank you'.

'Initially we began scanning public sculpture, but we boradened our approach and now also scan museum objects and heritage artefacts'. Scan the World have digitised museum objects from the Imperial War Museum, the British Museum, the V&A, the National Portrait Gallery, the Petit Palais, the Louvre, and the Metropolitan Museum of Art amongst others. Sometimes this takes the form of active collaborations and Scan the World are given access to storage facilities by museums. The Louvre, for example, will collaborate with Scan the World to digitise and make available their collection of plaster casts. At other times, Scan the World approach the museum as members of the audience, and create photogrammetric 3D models of freestanding sculptures and monuments in the museum galleries. 'We notifiy the museums afterwards,' Beck explains; few museums object, since the Scan the World initiative is an opportunity for them to atract new audiences and to 'get some free publicity' (Beck). Many museums are happy to collaborate with Scan the World, as they offer their digitisation services for free, unlike some commercial 3D scanning companies that are currently targeting heritage institutions. Furthermore, most heritage artefacts are 'out of copyright'; Beck explains; 'it is a bit of a grey area, but many of the old museum artefacts and sculptures in the public domain are no longer protected by copyright. Museums do not always own copyright, even when they own the object'.

'It is quite an exciting thing to be able to scan sculputres, and it is a good starting point for learning, they don't move about and people who are learning to do photogrammetry can practice'. Beck describes this 'learning' as a two-sided process; people learn how to use digital 3D scanning and printing technologies, but Scan the World also promote the distribution of historical knowledge and background information on the original artefacts. 'We put in descriptions and associated historical information as much as possible,' Beck explains; 'we take the information provided bu museums and sometimes also do our own background research'. Scan the World also marks the physical location of the original artefacts on a digital map accessible online; 'I can imagine people who print the 3D models being drawn to the originals,' Beck relates; 'one person left a comment on the website to say they came to London to visit the V&A and check out the sculptures from the website'.

Beck laid the foundation for Scan the World about a year ago, in 2014; 'I had graduated from a photo and fine art course, during which I'd played around with 3D scanning a bit', he explains; ' I had this idea to develop a collaborative archive and approached MyMiniFactory'. Things moved from there, and Scan the World continues to grow. Beck has ambitious plans for the future of his initiative; 'we would like to digitise the work of living and contemporary artists and include it in our archives for free downloading,' he explains; 'we also want to add more social content, such as forums to our website. Together with MyMiniFactory we are thinking about running artist residencies. We are also looking at virtual environments and have tested a walkthrough enviroment with some of our scupltures on the occulus rift recently; we are now working on a browser-based version'.

Although MyMiniFactory is mainly oriented towards 3D printing, users of the website who access Scan the World models are finding a variety of uses, including the combination of digital and craft processes, remixing of digital content and the resharing of 3D files. 'There is one guy who wants to print sculptures on a larger scale to sell them in Camden,' Beck recounts. In a way, Scan the World is encroaching on the territory of museums and museum gift shops, but so far they have not encountered adverse reactions by museums and other heritage institutions; 'so far, we are just going for it,' Beck explains; 'it is a new territory that we are exploring'.

Museum staff

Ashley Gallant 27.03.2015

Ashley Gallant is a Collections Access Officer at the Usher Gallery and The Collection in Lincoln. 'All our curators carry this title now,' he explained, this reflects the mission of the Usher Gallery and The Collection, to make their collections as accessible and useful to audiences as possible. 'We are quite open to the public as an institution'.

Oliver Laric's award-winning Lincoln 3D Scans project experiments with this notion of accessibility and use. Lincoln 3D Scans was undertaken in collaboration with the Usher Gallery and The Collection. The project involved the digitisation of museum artefacts from the museum collections. The resulting 3D scans were then uploaded to a website and made available for download without copyright restrictions. The website also features a gallery, where users are able to share the derivative work they create from the 3D scans.

Gallant invited Oliver Laric to propose an idea for the Contemporary Art Society's Annual Award for museums, after having previously exhibited another piece by the artists (ancient copies) at Nottingham Castle.

'We knew our proposal had to fit with the context of the museum. The collections of the Usher Gallery largely come from the private collection of James Usher. He was a Jeweller and clock maker in Lincoln, and built his fortune using an early form of copyright; Usher secured the permission to use the design of an imp from the cathedral in his work. The jewellery he created with this design made him rich and allowed him to build his collection.' This early use of copyright provides a clear link to Laric's artistic practice; the artist frequently explores ideas of reproduction, public access and remixes in his work. 'Oliver Laric came up with the 3D scanning idea,' Ashley explained. The proposal succesfully passed the different stages of the application and proved successful.

The museum now faced the challenge of weighing up the risks and benefits of providing open access to 3D models of objects from the collections. 'It's a whole minefield this area,' Gallant related, 'our lawyers told us that opyright law is lagging behind, there are no precedents for digital 3D reproductions'. It was decided to 'properly give the 3D scans away' without any copyright restrictions, in order to mitigate risks the museum ‘prepared seize and desist orders and apologies in case anything went wrong’.

The gamble appears to have payed off; Lincoln 3D Scans pioneers a new approach to the use of 3D technologies in a museum context. Gallant suspects, that digital 3D technologies are set to become more pervasive in everyday live. ‘A few years ago only specialists used image editing software,’ Gallant explained, ‘now everyone has editing applications on their mobile phone. Maybe in 15 years time everyone will have 3D tech on their phone. We did not have the skills to do much with the 3D files, we decided to give away the files for other people to use and are interested in seeing where this project goes.’

Lincoln 3D Scans was featured on the cover of Frieze art magazine, the project generated aufmerksamkeit for the Usher Gallery and The Collection. It also proved to be a significant learning experience for the institution. ‘We 3D printed some of the files and send them out to schools now,’ Gallant explains, ‘our archaeologist is using 3D scanning to research the marks on some of our sculptures, they can be seen a lot better on the 3D scans. We are also looking into digital restoration and want to make GIFs of the 3D models part of our archive web page.’ The project has also influenced museum-internal policies; ‘we have removed all restricitions on photography in our galleries,’ Gallant explained, ‘and we have changed our accession policies in order to be able to collect digital pieces. It was important to include the right to format-shift in our contracts with artists, to ensure we will be able to ensure digital work remains viewable.’

‘It has been quite a learning eperience’, one from which other institutions are now also looking to aquire knowledge. ‘A lot of museums now phone us for example to ask for advice in buying 3D scanners,’ Gallant explained, ‘we have received a lot of feedback from users and tech industries. One organisation used the scans to beta-test their projects. The forensic department even got in touch because they were interested in 3D scanning’.

The Lincoln 3D Scans website was promoted through press releases and Laric used social media and online 3D repositories to further public access to the 3D models. The website has now been accessioned into the permanent collection of the museum and the 3D scans are displayed on Ipads in the museum galleries. While it remains possible for users to share their work on the website gallery no more 3D scans will be added. 'I met Oliver several times during the project,' Gallant recounted, 'he sees the website as the artwork, but he is also very interested in removing the hierarchy of images. To him the original artefacts, the 3D scans and the remixed pieces all sit on one level. He sees the copy as equally interesting as the original.' Laric does not contextualise the 3D scans as a form of readymade; the files do not become artworks by designation, it is the concept behind Lincoln 3D Scans which makes the artwork. 'The files are just files, not an Oliver Laric,' Gallant explained.

The Usher Gallery and The Collection frequently use replicas in exhibition; 'we currate a-historically and present objects as cultural ideas, rather than unique artefacts,' Gallant explained. Staff at the museum were therefor not overly concerned regarding the authenticity and 'truth' of the digital scans. 'It was an art project and the scans are obvious copies, so the question of truth did not really arise,' Gallant recalled, 'we mostly discussed the project in terms of copyright. If we used 3D scans in different settings we might have to point out how their content has been edited.'

'Sometimes you have to take to move forward,' Gallant related. This can be easier for museums when it is done in the context of an art project. The Usher Gallery and The Collection are now considering taking the open approach of Lincoln 3D Scans forward. They are also interested in enabling more artistic experimentation; 'we are considering comissioning artists to work with the scans'.

A.9. *(Im)material Artefacts* exhibition

The following panel text was displayed during the *(Im)material Artefacts* exhibition:

(Im)material Artefacts

Mae'r technolegau digidol newydd yn rhoi ffyrdd newydd i gael ymdrin ag arteffactau ac mae datblygiadau diweddar mewn print 3D yn prysur gau'r bwlch rhwng gwrthrychau digidol a rhai ffisegol.

Ar gyfer y prosiect *(Im)material Artefacts*, cafodd arteffactau ceramig o'r casgliadau sydd wedi'u storio yn yr Amgueddfa Genedlaethol yng Nghaerdydd eu sganio mewn 3D. Mae'r sganiau 3D a sicrhawyd yn rhai y gellir eu newid, mae modd eu dosbarthu'n hawdd a gallant fynd i sefyllfaoedd sydd y tu hwnt i gyrraedd y gwreiddiol ei hunan. Cawsant eu rhannu â nifer o artistiaid Prydeinig a Rhyngwladol a gafodd eu gwahodd i greu gwaith celf newydd a oedd yn seiliedig ar y sganiau 3D digidol hyn.

Mae'r arddangosfa *(Im)material Artefacts* yn dangos yr ystod eclectig o weithiau celf a gafodd ei chreu yn sgil y prosiect hwn. Bydd *(Im)material Artefacts* yn sefydlu deialog rhwng yr hen a'r newydd, analog a dialog, hanes go iawn a phethau ffansïol digidol.

Mae *(Im)material Artefacts* yn ddyledus i grant gan Gyngor Celfyddydau Cymru. Rhoddodd Sefydliad Cymru ar gyfer Ymchwil mewn Celf a Dylunio, Cyngor Ymchwil y Celfyddydau a'r Dyniaethau, ac Prifysgol Metropolitan Caerdydd ychwanegol.

Emerging digital technologies provide new ways to engage with artefacts and recent developments in 3D print are rapidly bridging the gap between digital and physical objects.

For the (Im)material Artefacts project ceramic artefacts from the storage collections at the National Museum Cardiff were scanned in 3D. The resulting 3D scans are mutable, can be easily distributed and have the capacity to enter into situations beyond the reach of the original itself. They were shared with a number of British and international artists, who were invited to create new artworks based on these digital 3D scans.

The (Im)material Artefacts display showcases the eclectic range of artworks created as a result of this project. (Im)material Artefacts sets up a dialogue between the old and the new, analogue and dialogue, material history and digital flight of fancy.

(Im)material Artefacts was made possible by an award from the Arts Council of Wales. Additional support was provided by the Welsh Institute for Research in Art and Design, the Arts and Humanities Research Council, and Cardiff Metropolitan University.

A QR code on the panel was linked to a blog with more information on the project, see http://immaterialartefacts.blogspot.co.uk/, accessed 14.10.2015.

A.10. Analysis

During the analysis stage, coding categories were developed to analyse interviews undertaken during this study and visual inventories were created to analyse the visual materials produced during the *(Im)material Artefacts* study.

A.10.1. Coding categories

Category	**Definition**	**Example**
C1 Learning	Participants report learning experience in connection with *(Im)material Artefacts* or communicate an understanding of the project within an educational context.	Worgan sees a great potential for 3D models of museum artefacts as a teaching tool; 'this could give kids who can not easily approach textual information more confidence' (Worgan)
C2 Phantasy	Participants describe the inspirational impact of *(Im)material Artefacts* and give evidence of creative and loose association	'I feel like a fly,' he explains, likening the experience of the videogame to the vision of a fly, to whom all artefacts must seem like vast terrains. 'You can take a journey with the piece and enter into the imagination,' (Weston)
C3 Identity	Participants either report instances of personal identification with the object, or of an understaning of the 3D artefacts as somehow personified.	'Maybe I'm the monkey" Davis muses "and I'm in heaven, juggling with these objects, celebrating these things from the past.' (Davies)
C4 Historical	Participants understand the *(Im)material Artefacts* project within a historical context/refer to	Hossam's title *WSB-Transforma* is derived from the Egyptian word wSb (answer). Called 'answerers', ushabti figures carry inscriptions

	the history of the objects.	asserting their readiness to answer the summons to work.
C5 Memory	Participants report personal experiences and memories in connection with *(Im)material Artefacts*.	'It was almost like a flashback; as a kid I would always take old items or kitchen utensils, and make them into toys.' (Cooke-Tapia) 'My gran used to collect teapots. She had all kinds of different teapots (…) she would have loved this showcase.' (Weston)
C6 Technology	Participants are directly motivated by technological challenges/considerations.	Initially Rouse trialed turning the mask into a collectible game item, however the 3D model caused the crash of the first game engine he tried to feed it into. The high polygon count of the 3D scan moved him to "think big" and turn the mask itself into a digital landscape.
C7 Digital/Popular Culture	Partcipants refer to popular and/or digital culture when describing their experience with the project.	Dougherty chose to work with the 3D scan of a teapot from the National Museum Cardiff. His choice of the teapot is a tongue-in-cheek reference to the Utah Teapot. In the computer-graphics community the Utah Teapot is well known and has become something of an in-joke, appearing in animated movies such as Toy Story or the TV series The Simpsons. *(Im)material Artefacts* reminded him of a musical remix; 'if you take something, replicate it and alter it, technically it automatically becomes an original and begins to stand on its own. You could also just take a detail and zoom in on it, or maybe leave the form unchanged but blow it up to a huge scale. The fact that the new work is based on an old

		piece makes it no less creative, most things start in this way.' (Williams)
C8 Practical Use	Participants make mention of the practical use of the original artefacts/ 3D models.	From the museum archives Hansen learnt that this object had a screw-on lid. This information had been lost in the scanning process; as the original artefact was scanned with the lid screwed on. Hansen's work playfully references this loss of information and function between the original artefact and the 3D model. The original artefact would have been held and twisted to open it; Hansen's digital editing of the 3D scan mimics this physical action.

A.10.2. Visual inventories

Artworks and source objects


10
Bonbonnière (box for sweets or patches)
Leeds, 1780-90
Creamware
Purchased, 1904
Stirrup cup (the Pope and the Devil)
Staffordshire, 1780-90
Pearlware
15
Jwg hufen
Worcester, 1750-52
Porslen
Cream jug
Worcester, 1750-52
Porcelain
Given by W S de Winton, 1918


19
Mwgwd
Mecsico, diwylliant
Teotihuacan, OC 450-650
Terracotta
Tarddiad anhysbys NMW A 39266
Mask
Mexico, Teotihuacan
culture, 450-650 AD
Terracotta
Source unknown NMW A 39266

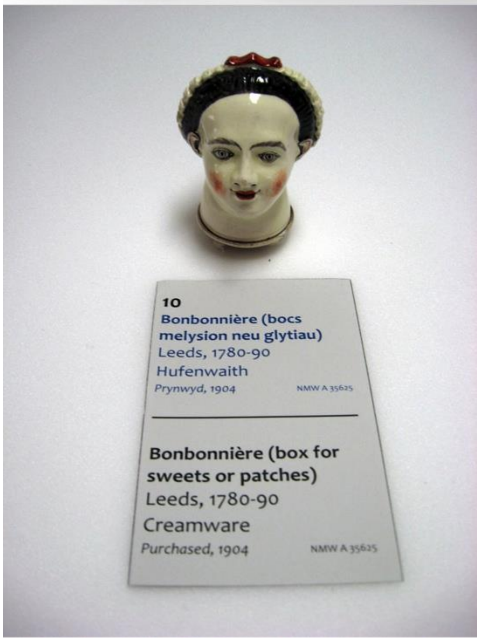

12
Ciwpid ar gefn gafr
Derby, 1775-85
Porslen
Cupid riding a goat
Derby, 1775-85
Porcelain

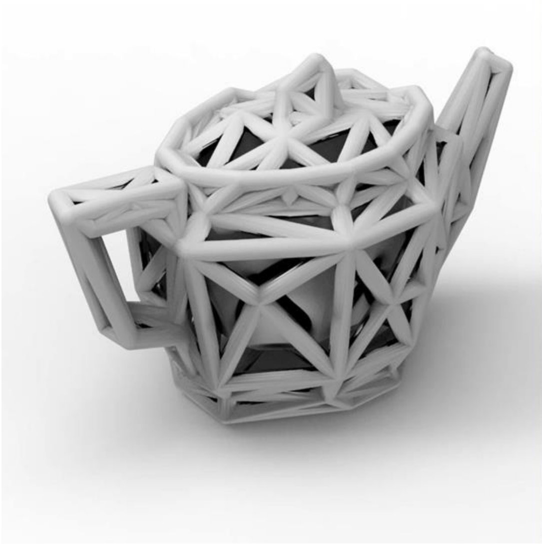

12
Ciwpid ar gefn gafr
Derby, 1775-85
Porslen
Rhoddwyd gan Miss Elizabeth
Humphreys-Owen, 1966
Cupid riding a goat
Derby, 1775-85
Porcelain
Given by Miss Elizabeth Humphreys-
Owen, 1966


7
Zachary Eastwood-Bloom
Growing 1-2, 2014
Print 3D neilon a
grisialau boracs |
Nylon 3D print and
borax crystals
10
Bonbonnière (bocs melysion neu glytiau)
Leeds, 1780-90
Hufenwaith
Prynwyd, 1904
Bonbonnière (box for sweets or patches)
Leeds, 1780-90
Creamware
Purchased, 1904
Vase
Coalport, 1825-45
Porcelain


Greyhound
Staffordshire, 1850-75
Earthenware

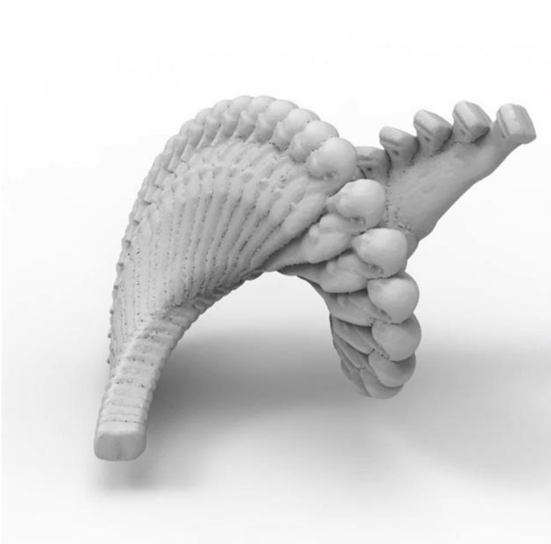

19
Mwgwd
Mecsico, diwylliant
Teotihuacan, OC 450-650
Terracotta
Tarddiad anhysbys
Mask
Mexico, Teotihuacan
culture, 450-650 AD
Terracotta
Source unknown


10
Bonbonnière (bocs
melysion neu glytiau)
Leeds, 1780-90
Hufenwaith
Prynwyd, 1904
NMW A 35625
Bonbonnière (box for
sweets or patches)
Leeds, 1780-90
Creamware
Purchased, 1904
NMW A 35625




16
Tebot
Lloegr, 1800-10
Priddwaith
Rhoddwyd gan W S de Winton, 1919
Teapot
England, 1800-10
Earthenware
Given by W S de Winton, 1919
NMW A 36158


16
Tebot
Lloegr, 1800-10
Priddwaith
Rhoddwyd gan W S de Winton, 1919
Teapot
England, 1800-10
Earthenware
Given by W S de Winton, 1919

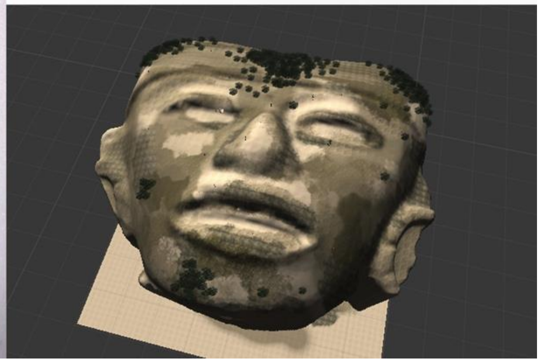


All images new artworks with original artefacts, various dimensions © Sarah Younan

Original artefacts and remixed artworks

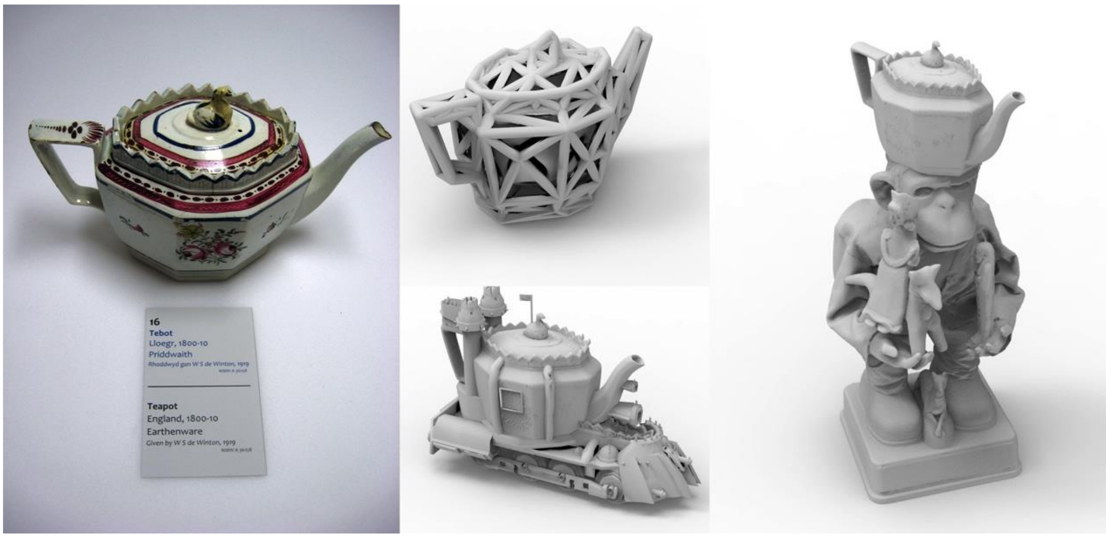

15
Jwg hufen
Worcester, 1750-52
Porslen
Rhoddwyd gan W S de Winton, 1918
NMW A 37643
Cream jug
Worcester, 1750-52
Porcelain
Given by W S de Winton, 1918
NMW A 37643


19
Mwgwd
Mecsico, diwylliant
Teotihuacan, OC 450-650
Terracotta
Tarddiad anhysbys
NMW A 39266
Mask
Mexico, Teotihuacan
culture, 450-650 AD
Terracotta
Source unknown
NMW A 39266




12
Ciwpid ar gefn gafr
Derby, 1775-85
Porslen
Rhoddwyd gan Miss Elizabeth
Humphreys-Owen, 1966
Cupid riding a goat
Derby, 1775-85
Porcelain
Given by Miss Elizabeth Humphreys-
Owen, 1966
NMW A 37476


18
Menyw ar gefn ceffyl
Cyprus yn ôl pob tebyg,
600-500 CC
Priddwaith
Tarddiad anhysbys
Woman riding a horse
Probably Cyprus,
600-500 BC
Earthenware
Source unknown



All images digital artworks with original artefacts, various dimensions © Sarah Younan

Appendix B Background

B.1. Introduction

The methodology used in this research arose from experiences gained during my MA studies and from pilot studies undertaken in preparation of my Master of Philosophy (MPhil). The focus of this research grew organically from a number of illuminating personal and professional events, which informed my understanding of museums and the artefacts they house, and motivated me to explore the concepts and questions addressed in this thesis. This section explores how personal and professional experiences as an artist and researcher informed the research.

In 2005 I interned in the field of restoration, during this time I first encountered the theoretical impossibility of restoring the past. When working on, for example, an oil painting the restorator is involved in an act of interpretation; although the aim is to make the painting reflect its former self as far as possible every dab of colour which is added to the canvas takes away traces of the painting's history and transforms it into something new. During my time working in restoration I first became aware of how restoration can transform an authentic artefact into a new object, hide the traces of its past, and thus interfere with the authenticity of an object. Furthermore my experience as a restorator gave me an understanding of historical artefacts as objects which are open to change, rather than frozen in time.

I worked as a museum guide at the Musée des Beaux Arts in Bordeaux, France in 2010. In one noteworthy instance I was tasked with guiding a group of British tourists through the galleries. Tours were usually delivered in French. Museum guides worked with a scripted presentation of the collections, much of this presentation was targeted towards a public with insight into French culture and art history. This information and a certain subtle humour in the original French presentation was lost on the British group and I found myself improvising, adding explanations and adjusting the presentation to better suit the target audience. This experience provided an eye opener on the subject of mediation of museum artefacts and the needs of different audiences.

During my ceramics masters course at Cardiff School of Art and Design I gained first hand experience of 3D scanning and print technologies while creating 3D models of museum artefacts for artistic purposes. During the MA course I first started woking with digital 3D technlogies and approached the National Museum Cardiff with a proposal to scan objects from their collections. I was given access to the museum's storage collections. A memorable moment in the ceramics storage collections at the National Museum Cardiff triggered the question of how the strands of technology, creativity, identity and history can run together during the creative engagement with digital models of museum artefacts;

> *'There was all these cabinets full of ceramics and there was so much stuff. And then I found this little head (…) it has a lady's features and she has got this kind of vacant smile on her face (…) she had been used to store sweets (…) she had no body and she was lying on her side. I identified with her so I picked her up (…) and I have got a little head now, so I can tell lots of stories, I can send her out into the real world in many variations.'*

(Interview with Wilbur and Lister, 2013, see https://www.youtube.com/watch?v=ZOI5IHnwc6I, accessed 15.10.2015)

These experiences and my background in ceramics and art had a strong influence on the way I approached this doctoral research. It provided a common ground for interviews with fellow artists and my artistic sensibility towards 3D forms, especially ceramic artefacts, played an important role in the analysis of artworks submitted for *(Im)material Artefacts*.
While undertaking the Critical Positions in Art and Design module in preparation of my MPhil I undertook pilot studies with Cardiff School of Art and Design students, which allowed me to trial and hone my skills as a project leader and researcher. During two subsequent pilot studies I led a student group in the

exploration of the Nantgarw Pottery heritage site[234] and in the creation of photogrammetric models of museum artefacts at the National Museum Cardiff. Experiences from these case studies, which included both researcher-led and student-led activities, informed the methodology used in this doctoral research.

I have found this area of inquiry to be engaging, inspirational and full of surprises. 3D scanning is 'radically changing the way we engage with material culture' and can bring about 'new ways of knowing and understanding the object' (Hess *et al.*, 2008:125). I hope to continue to navigate and map this field of enquiry through my artistic practice, through collaborations, experimental curation and research activities, both in the UK and abroad. This time as a doctoral researcher has enabled me to forge connections with museum practitioners, with artists, academics and activists. Following the completion of this doctoral study, it is my aim to continue to explore how digital 3D reproductions can function as memory objects through further artistic enquiries and collaborations with museums. I have been invited to undertake an artist residency at the Cer Modern Museum in Ankara[235] and will use this opportunity to work with people from different social and economic backgrounds in Ankara using digital 3D technologies. During this residency, I will digitally reproduce everyday artefacts that are meaningful to their owners, and use these 3D models as the basis of new work, which will tell their stories and those of their owners (see Appendix B.3. Proposal Cer Modern Museum). I sincerely hope this intervention at Cer Modern will be the first of many similar and related activities, as the digital exploration of the museum dream space is a rich and exciting area of research, which I feel I have only just begun to explore.

[234] See http://miscmouldings.blogspot.co.uk, for the blog dosumenting these explorations, accessed 15.10.2015.
[235] See http://www.cermodern.org/en/, accessed 22.06.2015.

B.2. Photogrammetry case study

The following paper was written after the researcher undertook a photogrammetry pilot study with students at the National Museum Cardiff, it was presented at the Digital Egypt Art Festival[236] in Cairo, Egypt in 2013:

Digital Three-Dimensional Copies of Museum Artefacts;

Dynamics of Access, Ownership, and Meaning

Sarah Younan, Steve Gill

Abstract: Museum visitors are increasingly beginning to discover digital ways of accessing museum artefacts.

Freely available photogrammetric software makes it possible to create digital 3D copies from photographs of museum artefacts without going through physical copying processes. Due to increasingly user-friendly software physical access and technological insight are no longer required to create digital three-dimensional copies. Furthermore recent developments in rapid prototyping are swiftly bridging the gap between digital and physical objects. Online service providers such as *Shapeways* have made 3d printed objects accessible to the private sector. Museum cases and curatorial signage no longer enshrine the historical artefact; museum objects can now be taken from the realm of display and purely visual consumption and re-introduced to functionality and touch. The museums' "enclosed nature and well-defined role" (vom Lehm et al. 2001:189) renders it a well-suited location to observe the impact of these technologies.

[236] See http://di-egyfest.com/, accessed 15.05.2015.

Recent research into 3D technologies in the museum context has focused mainly on their quantitative impact on preservation and documentation. Drawing on recent projects at the National Museum of Wales this paper investigates their qualitative impact on the dynamics of access, ownership and meaning.

Keywords: Appropriation; Intervention; Meaning; Museum; Photogrammetry

Introduction

Digital technologies provide new ways for an audience to engage with museum artefacts.
Museums are beginning to embrace the potential of these technologies and are taking steps to foster digital engagement with their collections. The Metropolitan Museum of Art staged its first *hackathon* in 2012. Digital artists and programmers where invited to create new work from the museums collections using photogrammetry and 3D print. This event was invitation-only and the attendants where guided through the collections by museum staff. Such a degree of exclusivity and supervision might soon be a thing of the past. Visitors increasingly expect a participative role in shaping their experiences. "In the past museum interpretation has largely been based on the perspectives of scholars (…) museums operate in a communicational mode: transmission of information to passive recipients" (McDonald, Alsford, 2010:77). These practises are rooted in nineteenth-century empiricist thought. Definitive meaning of objects was believed to lie within their physical form and descriptive data was seen as objective fact. Objects were thought to communicate perfectly by being what they are, this created the possibility for objects to be displayed "in and of themselves"' (Kirshenblatt-Gimblett, 1998: 17). With the advent of postmodern thought, however, the museum came to be regarded as a context capable of shaping the possible meanings of objects. Belief in the existence of an inherent objective truth has been replaced by an awareness of the discrete personal

meanings of objects and their continual transformation through interpretation and contextualization.

> The museum databank of objects (…) needs to be understood from a different standpoint, as much more than the raw materials of the historian's craft, but as part, a remainder and a reminder, of cultural expression and social signification where material can have multiple layers of meaning. (Kavanagh, 1990:63)

Outside the scope of the museums "slightly patronizing, intimidating atmosphere", which can "make people feel ignorant, and thus alienates them from the museum experience" (Walsh, 2010:229) visitors are increasingly beginning to discover digital ways of accessing and interacting with museum collections beyond the reach of museum authority. Free photogrammetry software enables viewers to access collections digitally. Tablets, smartphones, or cameras can be turned into digital scanners and used to create three-dimensional copies of museum objects. These digital 3D objects can be taken home, edited and 3D printed through online service providers such as *Shapeways.*

Historical artefacts are often expensive to acquire, store, preserve and keep safe. With 3D models of historical objects increasingly available on the Internet it is understandable that some curators feel uneasy about what can be seen as a loss of intellectual property, and as a threat to the museum's traditional focus on material objects. However Pachter argues that the realm of the digital is making viewers more enamoured of the physical:

> So the electronic will draw us more to the physical, the replicated will draw us more to the original, and we just need to be unembarrassed in our announcement of these qualities of availability in our precincts. (Pachter, 2010:334)

This paper seeks to investigate how the dynamics of access, ownership and meaning of museum artefacts are affected through the use of photogrammetry by museum visitors.

Background

Recent years have seen fundamental changes in photogrammetric theory and practice, due to technological changes such as the widespread adoption of digital imagery, and the emergence of software and applications that allow automated exploitation of the photogrammetric process insight into mathematical content, digital image processing, and algorithms is no longer required. Simple interfaces and applications have made 3D scanning an everyday reality, even for the non-specialist. Internet communities with the focus of sharing photogrammetric models are emerging and online collections house a diverse range of models, from sleeping cats to action toys and historical artifacts. The creation and collection of photogrammetric models is emerging as a new hobby, a new technical gimmick. However photogrammetry as an everyday practice has the potential to affect wide-ranging changes in our understanding of objects. Photogrammetric software applications look set to popularise the automatic production of three-dimensional models of objects. A parallel to this situation can be found in the rise of photography in the nineteenth century. In 1859 Oliver Wendell Holmes forewarned that, with their cameras "men will hunt all curious, beautiful, grand objects, as they hunt the cattle in South America, for their *skins*, and leave the carcasses as of little worth" (Holmes 1859:747). To take this analogy further, photogrammetry now allows us to prop up the photographic 'skin' and create digital taxidermies of our catch (Figure 1). But how much weight does this striking metaphor carry? The museum itself has often been criticized for 'deadening' objects by removing them from lived experience:

> The museum endangered artistic and cultural authenticity by removing artworks and artifacts from their original locations and placing them in

> galleries where they can only be gawked at, and never, so to speak, lived with. Loss of context, loss of cultural meaning, destruction of a direct connection with life, promotion of an esthetically
>
> alienated mode of observation, instigation of a passive attitude toward the past and of debilitating a mood of nostalgia (Maleuvre, 1999:1-2)

This is an issue artists are increasingly beginning to address within the framework of the museum. Whereas artist intervention in the past was mainly focused on exposing the hidden cultural agendas within museums, today artists are increasingly experimenting with strategies of intervention that question the museums will to preserve and 'deaden' objects. Again the analogy of taxidermy crops up:

> Vessels can be culturally symbolic, aesthetically moving, and personally expressive, but emphasis of these attributes at the expense of a functional vessel's immersion in life is surely akin to embalming an animal for display rather than permitting it to live out its existence in the wild, or even in captivity. (Brown, 2012:3)

Artist David Cushway's performance piece *Teatime at the Museum* explores the ceramics collections at the National Museum of Wales in terms of functionality. In the video of this intervention piece Cushway and Andrew Renton, Head of Applied Arts at the National Museum, remove teacups from their display cases inside the ceramics gallery and drink tea from them. Through photogrammetry the possibility of reaching into exhibitions and display cases is no longer reserved to collectors, artists and museum curators. Museum visitors are able to photograph and appropriate whatever catches their fancy. The shape of the original artefacts can be altered, extended and augmented, they become open to new paths of exploration. Museum artefacts are shifting from the public arena of the museum into the private possession of the viewer. The physical original remains unaltered by these activities, however photogrammetric models and 3D reprints extend the impact of museum objects beyond the realm and the control of the museum.

Research into true-to-material 3D printing systems is moving rapid prototyping closer to direct manufacturing. Museum objects accumulate value through their history, age and rarity. For every single object that has been elated to the status of museum artefact there where many others of the same kind that have disappeared (Pearce 1992:33). This is particularly true in the areas of ethnography and applied art; "though once multiple, in becoming ethnographic many objects become singular, and the more singular they become, the more readily are they reclassified and exhibited as art" (Kirshenblatt-Gimblett 1991:391). True to form and true to material reprints of museum objects effect a reversal of this process; the singular object becomes multiple again and the reprints are open to re-classification. The scope of materials that can be used in 3D print is still limited and synthetic materials, such as plastics, polymers, and resins, replace primary materials. Due to size restrictions and production costs of 3D printing, 3D printed physical reproductions of photogrammetric museum objects tend to be miniatures. The creation of photogrammetric objects is equally hampered by the technical limitations of photography. Photogrammetric models are influenced by the angle and light conditions as the photographs are taken. The positioning of objects within the museum's galleries restricts user access and defines the angles from which objects can be viewed, and hence photographed. Glass cases present an obstacle to the production of photogrammetric models. It is however possible to photograph into the glass case by adjusting the camera focus manually.

The objective effect of using technology to capture objects masks the subjective essence of the produced 3d models. "Historically the artist made a unique work within a particular medium. In this sense, the interface and the work where the same, i.e. the level of the interface did not exist. With new media the content of the work and the interface become separate. These interfaces might present different versions of the same work" (Manovich, 2010:69). Just as two photographs of the same object will defer no two 3D models are likely to be completely identical. If the photographs which models are produced from are shown in a

quick sequence they constitute a film, one that describes and documents the trajectory of the photographer around the object. Although the photographer is physically absent from his 3D model and no trace of his touch will mark 3D printed models, his gaze remains present within his creation. Photogrammetry not only documents the object itself but also the viewers gaze and the particular instance of perception, complete with any obstacles between the viewer and the object and other circumstances which affect photographic documentation.

Methodology

This study is concerned with how individuals use photogrammetry in the context of the museum; the focus lies with non-specialist users. Hence all photogrammetry and editing software used within the case study was taken from free online resources and is geared towards the non-specialist, hobbyist consumer. Participants where asked to provide their own computers, cameras, smartphones, or tablets. They where encouraged to download *Autodesk 123D Catch* photogrammetry software. This software was chosen since it is available free of charge for PCs, IPhones and Ipads*. Autodesk* also offers free 3D editing software and provides users with the possibility of ordering 3D prints through its website. It was hoped that this would provide an easy to use package and result in a uniform data-output format. Participants where all novice users of the software, and they where given the opportunity to familiarise themselves with the software prior to the study. The small focus group was formed from voluntary student participants from the Cardiff School of Art and Design third year ceramics bachelors course. This course focuses on the production of objects, teaching is mostly material-based but students have more recently been encouraged to investigate and embrace digital technologies in their work.

The project was undertaken at the National Museum of Wales. Non-flash photography for private use is permitted within the museum, however the use of tripods is not allowed and some paintings and objects within the collection cannot be photographed due to copyright, these are marked out within the galleries. Students chose to photograph pieces from the ceramics, natural history and fine arts collections. The project was undertaken in agreement with the National Museum of Wales, however the parameters of our interaction within the museum where akin to those of a normal museum visit. Participants entered the museum as members of the public and where given no special access to any of the displays. They where free to move about as they chose and explore the collections in groups, or as individuals. The researcher was present throughout the visit, to observe and document the participant's activities through photographs without intervening in their actions.

In immediate succession of the visit 3D objects where created from the participant's photographs using *123D Catch* and various purposes of the photogrammetric models where discussed in group-sessions. Participants where given the opportunity to present their photogrammetric models and discuss their experiences. These sessions where audio-recorded. The audio recordings enable repeated and detailed access to the contribution and interaction of participants during the sessions.

To address ethical issues the purpose of the project and the intended use of collected data for further analysis, research and publication was explained to the participants. They could refuse to be photographed during the event and the researcher offered participants the opportunity to have photographs of themselves destroyed if they had any reservations after the event. All images used in this paper have been reviewed and approved for public use by the National Museum of Wales.

Observations

After entering the museum as a group the students fanned out and explored the collections independently. A pattern of behaviour emerged amongst the participants; students would quickly scan the collections and then focus on pieces they felt suitable for their photogrammetry efforts. They would focus intensively on their chosen objects and spend quite some time photographing them (Figure 2). The unusual way in which students circled objects and photographed them from all angles created slight suspicion among some of the museum staff and it was felt by participants that gallery supervisors 'hovered about' more than usually.

Other objects on display, the close arrangement of objects within the display cases, other visitors in the galleries, the reflections on the glass of display cases, and shelf casings where felt to be problematic for the creation of clear and focused photographs from all angles. Bright lighting, intended to enhance the displays by amplifying the sparkle of shiny objects, and dampened lights, meant to make natural history panoramas more life-like also made taking photographs more difficult. Participants that chose to photograph larger artefacts became aware that in their attempts of photographing these objects other museum visitors came within the range of their camera. They felt uneasy about this side effect of photographing strangers.

In the students' choice of objects two contrary motivations emerged during later discussion. Some students picked objects for their accessibility; these students mainly chose freestanding sculptures, which they could easily walk around. Other students intentionally went for challenging objects that where difficult to capture, such as shiny surfaces and objects inside glass cases. Some participants employed both strategies, such as a student that firstly photographed freestanding sculptures by Rodin and then went on to photograph bird taxidermy in a dimly lit diorama because she ‘wanted to see how it would turn out’.

In the group discussion after the visit the students agreed that they had explored the National Museum of Wales differently than they normally would. Rather than visit the museum to view a particular piece or browse the entire collection it was felt that focus was much more on finding an appropriate object and photographing it. Although they employed a lot of time and attention on the observation of their chosen objects this took place mostly through the lens of their camera. Students took little note of signage and only one student chose to photograph the information provided by the museum along with the sculpture. The restrictions imposed on viewers through curatorial decisions within the museum displays where felt more intensively than during previous visits. Participants questioned why they could only see the front of some objects and expressed concerns that the museum chose how they where to see objects for them. One student expressed the wish to ‘liberate’ a teapot from its glass case.

Even though participants collected purely visual data of their chosen objects they reported an increased awareness of their own physicality. The students’ movement was affected by their attempts to document their chosen objects as closely as possible. One student remarked that she found herself on her knees in front of an exhibition case in the attempt to photograph the base of a teapot. Participants crouched and stretched to capture as many angles of the museum objects as possible and the students remarked feeling an augmented sense of their bodily presence within the museum space and in relation to the objects they were documenting. ‘Usually I just take everything in standing, but you don’t see everything that way’. (Figure 3)

All of the models created during this project needed editing to allow for 3D printing and some of the models showed blurry background rather than the object, which was being photographed (Figure 4). Students felt that the 3D models and the originals where very different things but agreed that they might view more accurate models in closer connection to the original objects. One student argued that a feeling of history, age and authenticity could not be transferred from the originals to the models because 'you only feel that inside the museum'.

The process of creating the photogrammetric models was enjoyed in its own right; it provided participants with a new way to interact with the museum. The students also enjoyed the suspense of waiting for the photogrammetric model to be calculated after uploading their photographs; "it's a bit like having ceramics in the kiln, you don't quite know what will come out'.

When asked how they might employ photogrammetry in the future students came up with a range of possibilities. These included re-scaling their own work and experimenting with forms digitally prior to producing them in clay. One student expressed interest in using texture-maps to print decals, which could be draped around different objects (Figure 5). A participant who had managed to capture parts of a shiny silver teapot from inside a glass case despite the poor quality of the photographic images expressed interest in further testing the limits of the software. Such activity might lead to the creation of a digital collection of objects of her choice, which would at the same time document her increasing skill in creating digital models. The photogrammetric models themselves provide a particular aesthetic which some of the students might experiment with through layering and collaging 3D models. It was felt that photogrammetry software offered a steep learning curve and could be put to use as a tool to document, collect and experiment with three-dimensional shapes.

Discussion

Photogrammetry is not only a process of reproduction but also of interpretation. The photogrammetric model is pieced together from available photographic data and missing parts have to be edited in. Unless complete photographic data is used to calculate the photogrammetric model some parts, such as the base and the interior of the object, will be missing from the digital copy. Moveable elements, such as lids, and taps, lose their functionality. Within the museum display the original might be impossible to photograph from some angles. Objects can be partially eclipsed by other artefacts within the exhibits. Only the angle of the object that the curator has chosen to display in plain sight is revealed fully to the eye of the viewer, and to the lens of his camera. In this way the curatorial voice retains authority over the museum object. What is obscured from view cannot be photographed and will leave faces of the 3D model empty. Digital objects can be manipulated with ease, and different versions of one object can be created from the same source. Subjective value judgements inform this process. While editing the author can only venture his best guess about the missing parts of the object, his solution is just one possibility of many. In the digital restoration of damaged historical artefacts heritage researchers have encountered similar problems:

> The problem is that advanced graphic systems that are used for computer reconstructions adopted by virtual museums may sometimes be too realistic. They are based on partial evidence, but they suggest an impression of good knowledge of the past. Sometimes advanced graphic systems present the 'image' as true, giving the sense of misleading accuracy. (Styliani, 2009:525)

The notion of a singular museum viewpoint is exposed as incomplete through the photogrammetric process.

Free photogrammetry software and applications are more suited to hobby pursuits than towards the functional reproduction of objects. Especially within the museum the creation of useable 3D models is difficult. This raises the question whether museums should take steps towards making 3D models of their collections available themselves, to allow viewers more complete access to the objects in their collections. On its website the British Museum Association defines museums as "institutions that collect, safeguard and make accessible artefacts and specimens, which they hold in trust for society". Research into the use of 3D models within the museum context has largely ignored this aspect of accessibility. 3D models of objects tend to be guarded from public access. Some museums, such as the V&A, allow users to download digital photographs of their collections, in contrast to this access to 3D models remains restricted (Hogsden & Poulter, 2012:274). Digital 3D copies of museum objects are usually created by museums for research purposes and internal use, to cater for reference or preservation needs.

If 3D models of museum objects were made accessible and the public was allowed to interact with them on their own terms, 3D models might soon pop up in video games and animated films, and 3D prints could make their way into private homes. This reinterpretation of museum artefacts would open the museum to different perspectives.

> The production of events and exhibitions as conjoint dynamic processes enables the incorporation into the museum of many voices and many perspectives. Knowledge is no longer unified and monolithic; it becomes fragmented and multivocal. There is no necessary unified perspective – rather a cacophony of voices may be heard that present a range of views, experiences and values. (Hooper-Greenhill, 2000:152)

At the same time museums would, to some degree, have to let go of their control over the display and interpretation of the objects they hold. Museum professionals may "need to shift from focusing on the user in the life of the museum to focusing on the museum in the life of the user" (Marty, 2007:97). Digital copies of museum artefacts challenge the nature of historical meanings attached to objects and create opportunities to express not only the expert knowledge of museum staff, but also individual viewpoints. "Reproductive technology, we might say in general terms, removes the thing reproduced from the realm of tradition" (Benjamin, 1936:7). Digital three-dimensional models allow us to rediscover museum objects devoid of context, with the patina of age and aura wiped away. Imagine the setting of a post-apocalyptic movie: After the great meltdown of society our attractively rugged hero strays into the museum and smashes glass cases in search of tools, which might be useful to him. His post-apocalyptic toolkit does not differentiate between cultures or eras; our hero is choosing objects solely by their suitability to his situation. In the same way, albeit without the drama of an apocalypse, 3D models enable viewers to contemplate museum objects through the lens of their potential application. Such activities could be seen to undermine the traditional focus of museums on material objects. The historical form runs the risk of being transformed into a gimmick, a disposable item while the original is forgotten; "matter in large masses must always be fixed and dear; form is cheap and transportable. We have got the fruit of creation now, and need not trouble ourselves with the core" (Holmes 1859:747). However this "cheap and transportable" quality of digital 3D models might equally add to, rather than detract from the experience of museum objects by allowing the digital copy to enter into "situations beyond the reach of the original itself" (Benjamin, 1936:6).

> When face-to-face encounters with physical objects are positioned as the most valuable and authentic of object–engagement experiences, opportunities may be lost to understand what happens when objects take on different forms that enable them to become connected in new and dynamic ways, to new con- texts and to each other. (Hogsden & Poulter, 2012:266)

If museums encouraged visitors to interact with digital three-dimensional models of historical objects this could result in a more frequent contemplation and discussion of their collections, and allow them to reach a wider audience. These developing technologies, which are already beginning to affect our everyday lives, will invariably shape our view of the past. Real life interaction with copies of historical objects might re-awaken us to some degree to a history from which we feel increasingly divorced.

Figures

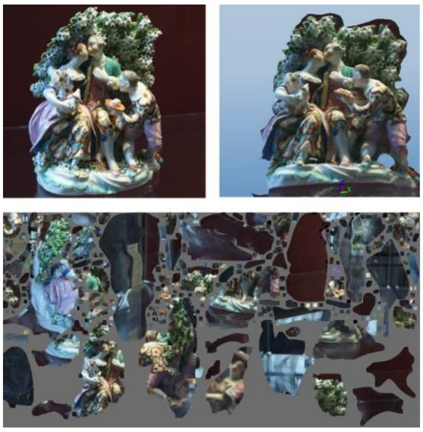


Figure 1.

Figure 2.

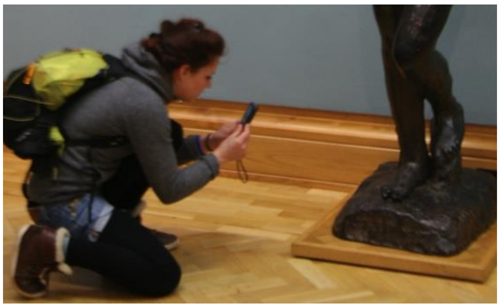


Figure 3.

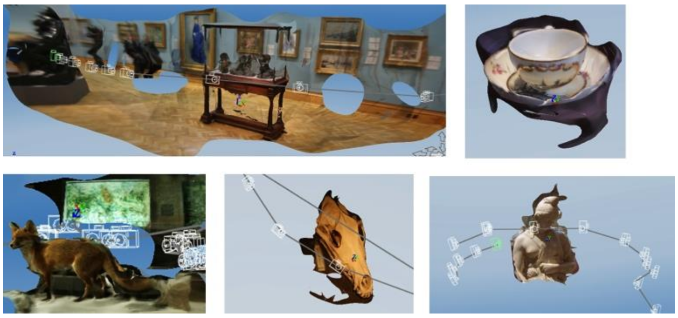


Figure 4.

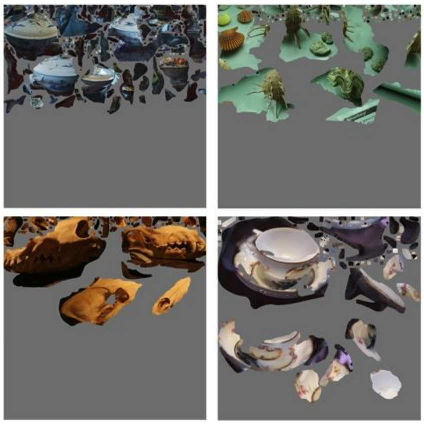


Figure 5.

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B.3. Proposal Cer Modern

The following project application was accepted by the Cer Modern Museum in Ankara, Turkey[237]. The residency is scheduled to commence in February 2016.

Artist in Residence Program Application

First name: Sarah

Last name: Younan

Address: 174 Albany Road, CF24 3RW, Cardiff, Wales, UK

Date of birth: 09.01.1986

Mobile: +44(0)7817873781

Website: http://vimeo.com/syounan

Email: younansarah@yahoo.com

Date: 08.01.2015

1. Briefly describe your residency proposal.

I am interested in how people and objects influence each other in a symbiotic relationship, and how identity, memory and gender can be expressed through artefacts. My primary interest is in low-culture items, such as souvenirs, decorative pieces and domestic artefacts. During the residency at Cern Modern I would like to continue to use digital technologies alongside traditional craft skills to re-imagine found objects.

2. What art form(s) does your work involve?

Ceramic, 3D digital editing and print, performance, film, mixed media, comissions from third parties

[237] See http://cermodern.org/, accessed 21.10.2015.

3. What are the aims of your residency?

After the completion of my PhD I intend to undertake a number of international residencies. I am particulairly interested in CerModern, as I enjoy working with museums, and am looking to develop stronger ties in Turkey. I have previously lectured as a guest speaker at the Hacetepe University and would like to spend more time in Turkey, to forge connections in the art scene and work together with local institutions and artists.

4. Why would you like to be a part of CerModern Residency Program?

I resently visited CarModern and was impressed by the quality of the displays and the atmosphere of the museum. I also had a chance to visit the residency studios and meet some of the current residency artists. I already have connections with some artists working in Ankara, as well as with staff from the ceramics department of the Hacetepe University. I would very much like to forge a lasting connection to Turkey through this residency.

5. Please describe the projects you would realize during the residency programme and how your residency will involve or interact with the community. Our goal is that artists in one way or another interact with the people of Ankara, which could be by giving a workshop, with an exhibition of work which give a reflection of the town and the people of Ankara, or in any form you suggest.

I would like to work with volunteers, from different social and economic backgrounds, who are willing to welcome me into their homes. Through visits, coffee and conversation, I would like to meet people and, together with them, choose a meaningful artefacts from their home. These objects and the stories connected to them will then function as the basis of new work; they will be reproduced as 3D models, and serve as the basis of new work. I will use both digital technologies and traditional craft skills to reproduce and re-imagine artefacts, to tell their stories and those of their owners.

6. What are your preferred dates? / The minimum stay is 4 weeks, the maximum is 6 months.)
Beginning around March 2016 for a duration of 3 months, with the possibility of extending the residency to its maximum length

Appendix C Papers

C.1. Digital 3D Models of Heritage Artefacts: Towards a digital dream space

The following paper was co-written with professor Cathy Treadaway and has been accepted for publishing by the Journal of Digital Applications in Archaeology and Cultural Heritage (DAACH)[238]:

Digital 3D Models of Heritage Artefacts: Towards a digital dream space

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Abstract

Digital data is fluid and malleable; there is no fixed cut-off point where it can be said that a digital three-dimensional (3D) model is complete; it can always be edited and transformed further. If actively embraced, the fluid qualities, digital

[238] See http://www.journals.elsevier.com/digital-applications-in-archaeology-and-cultural-heritage/, accessed 15.10.2015.

3D models of heritage artefacts can foster new forms of engagement with heritage. This paper follows the trajectories of digital 3D models of museum artefacts used in a creative context. It investigates how creative engagement with digital 3D models of heritage artefacts can stimulate learning and foster meaningful and personal experiences. This paper is illustrated with examples of creative works taken from a case study at the National Museum Cardiff and from the artist Oliver Laric's *Lincoln 3D Scans* art project.

Keywords: Museum; digital; 3D; hackathon; creative engagement; dream space

1. Institutional practice

Digital media are increasingly incorporated in museum exhibitions (Lovejoy, 2004) and an increasing number of museums and other heritage institutions are now undertaking 3D digitisation of parts of their collections. Digitisation is frequently used to support museums' core duties of collection, preservation and display. The collection and creation of digital objects is seldom a goal in its own right, but rather a consequence of other institutional activity. Digital 3D models of heritage artefacts are used in a continuation of the traditional activities, which scholars and professionals in cultural heritage institutions have been pursuing for centuries. 3D digitisation is used to document museum artefacts, heritage sites and archaeological finds, to study heritage materials without the need for physical access, to simulate real-world scenarios and to test restoration and hypothetical reconstructions. Furthermore, digital reconstruction from photographic data can 'restore' lost heritage; the Buddhas of Bamiyan, for example, were digitally reconstructed from photographic images by a team of researchers from the Swiss Federal Institute of Technology, following their destruction in 2009 (Gruen, Remondino, & Zhang, 2004). Whereas museum artefacts are perceived as a part of the past, 'digital historical objects are usually conceived as tools for understanding the past' (Newell, Lythberg, & Salmond, 2012:291). Within the context of documentation and restoration, it is of key importance that digital 3D models are as historically accurate as possible. At the same time, a certain amount of objectivity is unavoidable in the preparation of digital 3D models. There are on-going debates concerning the accuracy of digital heritage materials.

Many researchers and practitioners in the field of museums, heritage and archaeology see the creative use of digital 3D models of heritage materials as anathema to the established established uses of digital heritage materials to assist thinking in research and education. The open and creative use of digital copies continues to be seen as a threat to museum culture and practise, based on the long-held fear that simulations could render physical collections of authentic artefacts obsolete[239]. Another common fear in the heritage sector is that open engagement with digital heritage materials will distort the context and meaning of the original artefacts. These fears are heavily debated, with some arguing that multiplication of an object can increase its fame and lead to increased awareness and interest in the original item itself; 'the intensity of the search for the original depends on the amount of passion and the number of interests triggered by its copies' (Latour & Lowe, 2010:4).

2. Liminal 3D models

The digitisation of heritage artefacts is not as objective as the use of hands-free technologies might suggest. Digital 3D models have to be edited in many small and often imperceptible ways. There is no fixed point at which a digital model of a heritage artefact can be said to be 'complete'. Consequently, the choices and decisions of the editor play an important but often downplayed role in their creation. Digital 3D models look real, even though they are just a

[239] In his seminal piece The Work of Art in the Age of Mechanical Reproduction Walter Benjamin argued that the 'aura' of original objects would be lost through their reproduction and distribution. Jean Baudrillard further suggested that the shift from perceiving real objects to perceiving copies and simulations would result in a loss of reality.

hypothesis of an artefact or space. However, while digital copies are not necessarily 'truthful' to the original objects, they can be seen to posses a different kind of authenticity. In Languages of Art Goodman (1969) argues that any performance of a piece of art, which corresponds suitably to its notation (such as musical scores or code), can be counted as authentic. Digital 3D models are stored in bits, as ones and zeros. Bits lack intrinsic meaning until they are read and performed as, for example, a visual image or a physical print. Such performances exist as entry points to different perceptual planes, or interfaces, that render data into recognizable representations. Digital 3D models of museum artefacts are perceived 'in an unreal, virtual space that opens up behind the surface' of the computer screen (Foucault and Miskowiec, 1986:24). Every time we view a digital 3D model on the computer it is displayed for us by a software interface. Different software programmes present us with different versions of the same digital data.

Digital 3D models are not fixed; they remain open to exploration and transformation. Digital 3D models can be accessed online all over the world. In this way they exist in multiple locations and states at the same time. However, digital models of physical artefacts remain embedded in the physical world and continue to share a meaningful relationship to the physical originals. The relation between digital 3D models and physical objects is not a duality between virtual and real, as 'human activity takes part in both' virtual and real spaces (Dziekian, 2011). Digital reproductions can function as 'liminal' objects;

> '*Where the relationship between users and the medium is less physical or the controlling mechanism is established in the conventional sense of a controller, this type of interaction can be defined as liminal interaction.'*
> (Woo, Wohn, & Johnson, 2011:90)

Liminal objects provide a 'basis of symbolism and creativity'; people frequently use liminal objects to weave 'a continuing narrative of caring and relationships as well as self-identity' (Fitzpatrick, 2012:89). Liminal 3D models of heritage artefacts thus hold the potential to enable engagement with heritage artefacts that takes place on a personal and narrative level.

2.1. Fluid artefacts

Frequently museums and other heritage institutions respond with a certain alarm to the questions of interpretation and authenticity raised through 3D digitisation. However, heritage objects and museum artefacts can also be considered as a fluid medium. Without the knowledge and contextual material that give meaning to an object they possess little fixed content. Sheldon Annis (1986) identifies three conceptual spaces of meaning making in museums; the cognitive space, the social space and the dream space. The cognitive space engages with factual information, it is supported through museum signage and other contextual data. The social space describes the socially interactive nature of the museum visit. The dream space, on the other hand, describes personal and subrational responses to museum objects. In the museum dream space loose associations, memories and emotions, popular media, personal experiences and thoughts can all influence how we make sense of our cultural heritage. The thoughts and states of mind, which we carry into the museum influence how we see museum artefacts. 3D technologies create a liminal space, somewhere between the tangible and the imaginary, with the potential to enable us to creatively engage with the experiential realm of the dream space.

Artefacts are useful devices to facilitate creative processes and museums frequently provide artists with rich material to inspire their art making. Creative thinking involves a number of processes in which sensory and cognitive stimulation impacts on thought patterns in order to generate novel concepts (Treadaway, 2009). Access to museum objects provides them with cues that can, for example, inform the use of colour, texture or form in new artworks. Memories of personal or cultural stories that are linked to prior knowledge or experience can be stimulated by physical characteristics of objects. In this way museum objects can generate a wealth of associated ideas; these can be synthesised to produce completely new concepts (Smith et al., 1995). Digital 3D models of museum artefacts can inspire creative processes and promote the exchange of ideas in a similar fashion. Digital 3D models of heritage objects can provide a means of rapid interaction and translation from physical form to malleable virtual form that can help synthesise imaginative thought.

The creative engagement with digital heritage materials can be understood as a form of cultural 'poaching' (Certeau & Rendall, 2002). In his seminal work *The Practice of Everyday Life* De Certeau proposes, that human consumption is itself a creative act. During consumption, he argues, users recontextualise products, alter them and find unexpected uses for them. Certeau compares this to poaching; illegally hunting or catching game or fish on land that is not one's territory[240]. Poaching recontextualises digital cultural materials in ways that move beyond the control of the museum and other heritage institutions. It goes against the notion that there are appropriate and inappropriate ways of understanding and engaging with historical cultural materials.

3. From audience to users

For this research, a range of artists was given access to digital 3D models of artefacts from the National Museum Cardiff during a case study. Artists were invited to create new work from the digital 3D models and the resulting artworks were presented in the National Museum Cardiff and online[241]. Furthermore, the *Lincoln 3D Scans* project by the artist Oliver Laric was also investigated as part of this research. Laric undertook *Lincoln 3D Scans* in collaboration with the Usher Gallery and The Collection in Lincoln. For*Lincoln 3D Scans*, digital 3D models of objects from the Usher Gallery and The Collection in Lincoln were made freely available online. Users were invited to create new work and to share their digital remixes via an online gallery[242]. Data was gathered from these projects through interviews with artists and users, and

[240] This is an interesting analogy when applied to digital 3D reproduction; during 3D digitisation the 'skin' or surface information is reproduced and 'mounted' on a digital wireframe structure, much like a hunter takes the skin of his animals and mounts it on a taxydermy model.
[241] For more information see http://immaterialartefacts.blogspot.co.uk, accessed 09.04.2015.
[242] For more information see http://lincoln3dscans.co.uk/info/, accessed 09.04.2015.

through a visual analysis of the remixed artworks. The projects are illustrative of a larger trend; the digital 'poaching' of heritage artefacts (see Section 2.1. Fluid artefacts).

Increasingly, digital 3D models of museum artefacts, as well as digital tools and tutorials are available online. These resources enable larger audiences to engage creatively with digital 3D models of heritage objects. Online 3D repositories, such as Thingiverse[243] or Autodesk[244] allow users to share and download free and premium 3D models for further use. Some websites also offer software tools and cloud services, including free photogrammetry software, which allows users to create their own digital 3D models using digital cameras or smartphones. Hundreds of user-generated 3D models of museum and heritage artefacts can now be found online. Museums are beginning to embrace the creative use of digital material from their collections. Some museum institutions, primarily in the United States, and to an increasing extent in the UK and across Europe, have begun to foster creative digital engagement with their collections through hackathons[245] and similar projects. Museums are beginning to contribute digital 3D models to online repositories[246], and some museums offer access to 3D models from their collections on their own websites[247] or via shared databases[248]. Users of digital heritage content form interest groups, share materials and communicate online. 'The phrase "user-generated content" (…)

[243] See http://www.thingiverse.com, accessed 13.04.2015.
[244] See http://www.123dapp.com, accessed 13.04.2015.
[245] Hackathons (also referred to as hack days, hackfests or codefests) are events in which computer programmers, graphic designers, hackers, media artists and others involved in digital media develop intensive software collaborations, often in a short period of time.
[246] The Metropolitan Museum of Art, for example, shares digital 3D models from its collections via a Thingiverse profile, see http://www.thingiverse.com/met/about, accessed 09.04.2015.
[247] The Smithsonian museum, for example, provides access to digital 3D models from its collections on the museum website. See http://3d.si.edu/browser, accessed 09.04.2015.
[248] For example *Europeana*, a cultural foundation with the aim of disseminating digital content from museums and other cultural institutions across Europe. The Europeana website now provides access to digital 3D models from a number of European museums. See http://www.europeana.eu/portal/search.html?query=3d&rows=24&qf=TYPE%3A3D&qt=false, accessed 09.04.2015.

really describes not just personal but also social acts (…) the sharing, in fact is what makes the making fun' (Shirky, 2010:19). The independent sociologist Etienne Wenger coined the term 'communities of practice' to describe groups of people that voluntarily share knowledge, help members learn and practice skills and shape the identity of their members (Wenger, 2000). Digital 3D models of museum artefacts provide a way for users to share knowledge online and to teach and practice digital editing skills. For example, the 3D model of a nymph from the *Lincoln 3D Scans* project (Obj.1) was used to create a user-generated online 3D editing tutorial (Fig.1).

4. Memory objects

The chief personal use for digital 3D models of heritage artefacts, created by users or accessed online, is 3D printing. The size and material of 3D prints executed privately is usually limited by the capacity of home 3D printers. Most commonly, the 3D printed reproductions are plastic miniatures (Fig.2). Users, both prior to and after 3D printing, frequently customise the forms further. The closest comparable cultural artefacts that can help us to understand digital models of heritage objects are memory objects, such as keepsakes, heirlooms and souvenirs. Like the digital 3D model and they are portable reproductions of particular cultural, natural or historical objects or places. They are seen as low culture, as inauthentic and of little value. While most souvenirs are bought during a tourist visit, digital 3D models of heritage artefacts can increasingly be downloaded from the Internet. On the Internet digital 3D models are accessible anywhere at anytime and are no longer necessarily connected to the experience of visiting a place or seeing an original object. They are souvenirs of visits not experienced but substituted through surrogate engagement with the heritage models. In one sense they offer nothing but virtual superficiality, but in another sense they can artificially widen the user's experience of and engagement with heritage. After all, museum exhibitions are also simulations; substitutes for understanding and experiencing heritage in its original, historical context.

Unlike souvenirs, digital 3D models of heritage artefacts can be edited and personalised. The kind of digital souvenir users create depends on the experiences, associations or memories the heritage material triggers for them. With the necessary editing skill users are able to transform digital 3D models of heritage artefacts into souvenirs of the dream space. Users can leave a personal mark on digital 3D models of heritage artefacts and forge personal connections. New artworks created from digital models of heritage objects can function as synthetic memory objects; instead of simply reminding us of a place or time, as the traditional souvenir and other memory objects do, our memories can be integrated in the digital artefacts themselves. Jason Rouse's *Postcards from Mexico*, for example, blends the artist's personal responses with the digital 3D model that triggered them. *Postcards from Mexico* is a video game[249]. The field of vision of *Postcards from Mexico* resembles the style of popular first-person shooter games. However, in *Postcards from Mexico* there are no enemies to shoot. The only objective is to discover the landscape (Vid.1). The game map of *Postcards from Mexico* (Fig.3) is based on the 3D model of a pre-Hispanic Mexican mask from the National Museum Cardiff (Obj.2). Rouse visited Mexico the year before he created *Postcards from Mexico*, and he referred to his holiday photographs when he designed its landscape. Rouse described his mask island as an 'imaginary Mexico'; anyone can now visit his memories of Mexico through the digital artefact.

4.1. The influence of media

Present-day experiences, popular culture and media have become sources of information that feed into our historical imagination. Popular media, such as video games and movies have a great impact on younger generation's conceptualizations of the past. The work of American artist Jonathan Monaghan embraces the aesthetics of video games. Monaghan modelled a digital vessel from digital 3D models of ceramic museum artefacts (Obj.3-5). This cornucopia (Obj.6) is expelled from a spaceship in his animation *Alien Fanfare* (Fig.4). Monaghan's work contains many references to gaming culture, from its bleepy soundtrack to the inclusion of video game characters like Mega Man. The

[249] The game can be downloaded for Windows and Mac from the Rouse's website. See http://www.jasonrouse.co.uk/#/mex/, accessed 09.04.2015.

animation also carries a touch of consumerism and paranoia; behind a golden Mercedes star, the giant observation camera of the spaceship rolls in its socket like a roving eye.

The Irish artist John Rainey made the transformation and migration of digital data the theme of his work. Rainey remixed the digital 3D model of a ceramic figurine of cupid riding a goat from the National Museum Cardiff (Obj.7). Rainey used digital manipulation to render the sculpture into a series of individually distorted pieces (Fig.5) and created a digital animation film, which shows the 3D model twist and distort into new shapes (Vid.2). Rainey explained, that he was searching to navigate the 3D models as a new territory opened up by 3D technologies;

> *'When entering the virtual environment through 3D scanning, the traditionally static object makes certain compromises in terms of its colour and surface texture, but in return it is subsequently introduced to a catalogue of new possibilities. These include the transformative power of scaling, the ease of duplication, particularly relevant in the story of industrially mass produced objects, the potential of form manipulation, and the ability to behave in ways that are essentially anti-material.'*

Today, it is important that audiences and users are able to navigate the digital visual information they receive. Digital images, and increasingly also 3D objects are in a constant state of motion; they may migrate through different states and media and change in the process. Insight into these processes of migration and transmutation can be gained through the creative engagement with digital 3D models. The informed engagement with digital materials, competence known as 'digital literacy' is now a critical skill. Digitally literate audiences understand that digital materials are always a form of interpretation, rather than objectively accurate historical fact (see Section 2. Liminal models). Furthermore, digital literacy 'increases the size of the community that can make use of any given bit of knowledge' (Shirky, 2010:140) and allows wider audiences to engage with digital heritage materials.

4.2. Identity

In the dream space, museum objects function as evocative focal points, to which visitors connect personal memories, emotions and associations. Dream space experience can also shape the ways in which users experience digital 3D models of heritage artefacts. Furthermore, liminal digital 3D models are well suited to the articulation of liminal dream space experiences, 'where our inner experiences find a mesh with the outer experiences which museums provide (Kavanagh, 2000:175). Cooke Tapia created *Teapot Train Fortress* (Obj.8) from the 3D scan of a teapot from the National Museum Cardiff (Obj.9). The artist reported experiencing a 'flashback' to his childhood while editing the 3D model; 'It was almost like a flashback; as a kid I would always take old items or kitchen utensils, and make them into toys'. Personal memories and stories triggered by digital heritage models can lead people to engage with questions of identity. Frequently users of digital 3D models of museum artefacts identify with the digital materials to some degree. The artist duo Katie Parker and Guy Davis, who go under the name of Future Retrieval, created *Monkey Heaven* (Obj.12) from 3D models of museum artefacts from the National Museum Cardiff (Obj.9, 10, 13,14). They described a feeling of identification with the (digital) heritage artefacts they were working with;

> *'We have respect for the material and subject matter we work with (...) maybe I'm the monkey, and I'm in heaven, juggling with these objects, celebrating these things from the past.'*

Mohamed Hossam, an Egyptian artist, creatively expressed his cultural heritage and identity using the 3D model of an ushabti figurine from the National Museum Cardiff (Obj.10). Hossam saw his artwork (Fig.6) as a way of taking ownership of his cultural heritage;

> *'I am proud of my country's heritage and culture (...) I wanted to incorporate the idea of movement, continuation and transformation, the pieces also represents a balance between life and the afterlife.'*

The Mexican artist Mario Padilla, who remixed the 3D model of a Teotihuacan artefact from the National Museum Cardiff (Obj.2), expressed similar thoughts;

> *'I have a cultural relation with it (the artefact) I feel like I am keeping something going.'*

In times of rapid cultural change and increasing cultural diversity it is important to understand the processes of cultural change and development. Creativity, culture and identity are dynamically related. By enabling users to engage creatively with digital heritage materials museums can enable people to engage positively with cultural change and diversity.

5. Conclusion

Digitally remixed heritage artefacts can foster self-directed learning, reveal contemporary readings of museum artefacts, become vehicles for personal memories and identities and engage with museum dream space experience. Furthermore, digital technologies can be used to feed heritage materials into popular culture. Not every remixed version of a digital heritage artefact is an original masterpiece, but even the 'stupidest creative act is still a creative act' and can trigger new levels of interest in museum collections and heritage; 'the real gap is between doing nothing and doing something (Shirky, 2010:19). Digital media open up new ways of engaging with our shared cultural heritage, but they also raise questions about property, ownership, freedom of expression and the extend to which our view of the past is distorted by the tools that mediate our experience. We have to weigh up the gains and losses of encouraging public creative access to digital reproductions of heritage artefacts; museums and heritage institutions stand to loose some authority over their intellectual property and there is a risk that digital heritage content might be used in ways that are confusing or offensive. At the same time, our shared cultural heritage becomes more open to new interpretations and points of view. Popular culture and media have become a source of information that feeds into our historical imagination. If digital heritage materials are more widely used in digital and popular culture, they remain in the public eye and the public mind and thus inform public historical imagination. Users stand to learn from the creative interaction with digital heritage materials, to develop a more informed historical imagination and gain greater digital visual literacy. Communities of practice can emerge around digital content, and the creative engagement with digital 3D models of heritage artefacts can enable users to learn new skills, which will enable them to navigate history, culture and identity. It can lead to the sharing of ideas and knowledge. Furthermore, it can enable us to gain insight into contemporary experiences of heritage, to experiment with new digital materials and to find new uses for them, thus triggering refreshed interest in the heritage sector in general. Museum could potentially generate revenue from digital 3D models. More importantly, the heritage sector can inform historical imagination and promote digital literacy by providing access to digital heritage materials for further creative use.

There is growing public interest in access to digital 3D models of heritage artefacts and spaces. Digital media become ideological if they are withheld, simply because this is how things have always been done. While heritage artefacts are unique and valuable objects that need to be protected and kept safe, digital files are infinitely reproducible and can be shared without risk of loss or damage. 3D digitisation of heritage materials presents us with new opportunities to engage and inspire. Scientific progress and cultural understanding depend on access to data. Today, users expect 'access' to mean more than 'a view through the portal of a web-browser's window' (Blackwell & Blackwell, 2013:162); they want to be able to copy, manipulate and recontextualise data, and to share publicly the fruits of their labour.

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C.2. Towards a Digital Museum Dream Space

The following paper was presented at the Electronic Visualisation and the Arts conference (EVA London 2015)[250], it was published in the conference proceedings and is available online[251]:

Towards a Digital Museum Dream Space

1. INTRODUCTION

Digital three-dimensional (3D) scanning, editing and print technologies are giving rise to a number of unprecedented digital museum engagement practices, both fostered by museums and emerging outside the scope of these institutions. This paper examines how the creative engagement with digital 3D models of museum objects can link to the museum 'dream space' and reveal new possibilities in museums.

Figure 1: *WsB Transforma, Mohammed Hossam, made using digital 3D model of museum artefact.*

2. DIGITAL 3D MODELS

The emergence of inexpensive and flexible 3D digitization tools and technologies and of increasingly easy to use and intuitive 3D editing software, as well as affordable and accessible 3D printing, has lowered the bar for creative engagement with the museum through digital 3D activities. Museums are increasingly making 3D models from their collections available online[252] and a vast number of 3D digital models of museum artefacts

[250] See http://www.eva-london.org/, accessed 15.10.2015.
[251] See http://ewic.bcs.org/content/ConWebDoc/54870, accessed 15.10.2015.
[252] See for example the Petrie museum's 3D website, http://www.ucl.ac.uk/3dpetriemuseum, accessed 21.02.2015.

can be found on file sharing websites[253], where they are added as user generated content (UCG). 3D scanning of physical artefacts translates the form of physical objects into digital models with a new set of contexts and meanings. 'Models of museum objects can take on a creative life of their own through further derivation' (Neely and Langer, 2013 see also Lovejoy 2004). Digital 3d models can be edited, animated and rendered into new creative works.

2.1 Dream space

The encounter with museum artefacts can be informative and instructive, but it can also give rise to subrational thought and emotions, and can trigger the recollection of memories (Annis, 1986, Kavanagh, 2000). Annis terms this field of museum engagement the museum 'dream space'.

Digital 3D models of museum artefacts closely resemble the original museum artefacts. However, while original museum artefacts rest within the museum, digital 3D models can cross the threshold into the private sphere of individuals. They permit transformation, experimentation and play. Through 3D editing private thoughts, emotions and memories can be expressed and new cultural artefacts emerge, which engage with the museum dream space.

We make meaning of the past through an active and on going dynamic. Popular culture and the mass media feed into our historical imagination (Wallace, 1995). Museums can feed historical artefacts from their collections into this arena in the form of digital 3D models. Creative re-use of digital 3D models from museums can lead new audiences to engage with museums and to discover museum collections as sources of inspiration and creative content.

2.2 Digital visual literacy

However, digital 3D models can be seen as a threat to museums collections of authentic artefacts. Benjamin (1973) foresaw a depletion of the 'aura' of original objects through their automated reproduction and distribution. Baudrillard (1996) suggested that the shift from real objects to simulations would result in a loss of reality and lead to subsequent compensation through 'hyper reality'. This view identifies digital 3D models as a threat to museum culture and practise, 'based on a fear that as 3D simulations become more convincing, surrogates will merge in 'form' and affectual tome (…) with the physical object' (Eco, 1990:51). However 'multiplication of an icon, far from diluting its cultic power, rather increases its fame' (Cameron, 2007:38). Distribution of copies, reproductions and images of an artwork can lead to increased awareness and interest in the original item itself.

At the same time, the creative use of digital 3D models from museums risks taking the 3D forms out of context. It can reduce their likeness to the original museum artefacts and can

[253] For example*Thingiverse*, see http://www.thingiverse.com/thing:25369, accessed 21.02.2015.

mislead viewers. They can be altered without leaving traces of manipulation; therefor viewers need to be 'more critical of visual material than in the past' (van Dam and Spalter, 2008:95). Digital visual materials (DVM) are now ubiquitous in our everyday lives. The digital visual literacy necessary to critically engage with DVM can be learnt through creative engagement with and exposure to DVM.

3. CONCLUSION

Museums willing to make digital 3D models of their collections available for creative use face many hurdles and challenges, financial as well as legal, organisational and technical. However, museums can collaborate with target audiences and take steps to foster digital creative engagement with their collections without investing a large amount of resources[254].

The engagement and creative use of digital reproductions of museum artefacts can engage with the museum dream space and deal with the subjects of memory, culture and identity. While the creative use of digital reproductions of museum artefacts raises questions on authenticity and content there is no evidence to suggest they impact negatively on understandings of the original museum artefacts. Furthermore they can provide a way for users and viewers to engage with museum collections, to gain digital visual literacy and to create and share new cultural content that pays homage to the past and connects it to the present.

Figure 2: *Interlude, John Rainey, still from animated film made using digital 3D model of museum artefact.*

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C.3. Digital Artist Engagement as an Open Innovation Model

The following paper was co-written with Dr. Haitham Eid and has been accepted for publishing by the International Journal of the Inclusive Museum[255]:

How Digital Artist Engagement Can Function as an Open Innovation Model to Facilitate Audience Encounters with Museum Collections

Abstract: Today, digital technologies are encroaching on all areas of cultural life, including museums. The fast-paced development of digital technologies, including digital three-dimensional (3D) imaging and manufacturing technologies, and the perceived dichotomy between material artefacts and digital data pose a challenge to museums. How can digital strategies be developed and implemented in the museum realm? In the twentieth century museums have increasingly begun working with artists and other creative people to make new work inspired by their collections, or as guest curators (Putnam, 2012). Science and history museums, as well as other heritage institutions from a non-art background have now taken up collaborations with artists. Artist engagement in museums can be undertaken to experiment with different ways of engaging with museum collections. In this context, OI provides a framework that can be used to maximize the impact of digital technologies in museums. Through the discussion of a case study undertaken at the National Museum Cardiff, this paper presents ways in which collaboration with artists can be used as an OI model, to foster innovation in museums and promote new, digital forms of engagement with museum collections.
Keywords: Museum Collections, Open Innovation, Artist Intervention, Artist Engagement, Digital 3D, 3D Scanning, 3D Print

1. Introduction

This paper investigates how art projects using digital three-dimensional (3D) scanning and 3D printing technologies can foster new forms of engagement with museum collections, using the Open Innovation model.

3D scanning technologies offer the opportunity to capture the form of real objects, and to store them as digital files. Furthermore recent developments in 3D print are swiftly bridging the gap between digital and physical objects; it is now possible to print physical objects directly from digital files. More than seventy years ago, in his

[255] See http://onmuseums.com/journal, accessed 15.10.2015.

seminal work The Work of Art in the Age of Mechanical Reproduction German literary critic and philosopher Walter Benjamin foresaw a depletion of the ‘aura’ of original objects through their photographic reproduction and distribution. This view identifies copies and digital models as a threat to museum culture and practice, based on a fear that as 3D simulations become more convincing, surrogates will merge in ‘form and affectual tome […] with the physical object’. Museums are non-profit, permanent institutions in the service of society and its development, open to the public, which acquire, conserve, research, communicate and exhibit the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment . The perceived threat of digital technologies could be holding museums back from innovatively engaging with digital technologies. At the same time, museums are under pressure to embrace the digital revolution and re-invent themselves as institutions that both safeguard our material history and embrace digital strategies. Digital media can also be seen to present an opportunity, rather than a threat, to museums; recent studies of visitor numbers in museums and heritage institutions suggest that neither photography, nor digitization and mass media have diminished the fascination of the real . On the contrary, reproductive media has ‘the power […] to promote celebrity’ and to enhance the original object’s status . Digital technologies hold great potential for the dissemination and exploration of museum collections. Museums are beginning to recognize and embrace the potential of new technologies and are taking steps to foster digital engagement with their collections. Open Innovation (OI) theory provides a framework that could be used to maximize the impact of 3D technologies in museums and promote new forms of engagements with museum collections. OI refers to the paradigm in which organizations (such as museums) create channels for outside and inside ideas to be transmitted to and from the organization during the innovation process. Digital 3D models of artefacts can be widely disseminated without risk of damage to the original. In this way, digital 3D scanning, editing and print technologies can allow museums to reach a wider audience, and open new gates for innovation within the museum context. Furthermore digital 3D technologies open up possibilities and enable museum curators and professionals to experiment with collections in ways not previously possible; an essential requirement for innovation to take place.

In museums only a small proportion of artefacts are displayed, most are held in storage (Schaffner, 1998), and lay in stock for the future; ‘in a state of moribund exaltation, unredeemed until and unless a hand or eye from the real world touches them with the enchantment of new meaning’ . In an OI model searching for ‘re-enchanting’ their collections, museums have increasingly begun working with artists and other creative people to make new work inspired by their collections, or as guest curators . Such projects, known as artist interventions, have helped museums to cast off their conventional image. Artist interventions in museums can question the institutional framing of objects, attract new audiences, experiment with alternative perspectives, examine the museum’s relationship with visitors, and question practices traditionally associated with curatorship and exhibition design (Putnam, 2012).

For this research, a project was undertaken at the National Museum Cardiff. The aim of the project was to combine the innovative potentials of digital 3D technologies and artist museum engagement in an OI model. Artefacts from the ceramics collections at the National Museum Cardiff were 3D scanned, and the resulting digital 3D models were distributed among a number of artists. Participating artists were invited to create new artworks based on the digital 3D scans. This paper presents the outcomes of this project and discusses how this form of OI model can be conducive to innovation in museums.

2. What is Innovation?

The way we understand innovation now is largely influenced by business ideas where financial profit, competition, and marketplace are major factors. Innovation refers to the notion of doing something different (Lat. innovare: "to change"). The Australian Government’s Principal Business Resource defines innovation as ‘renewing, changing or creating more effective processes, products or ways of doing things’. Innovation in essence is about bringing ideas to life. However, ‘to be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need’ . Innovation is the engine that moves the economy forward and creates new opportunities. It is tightly linked to performance and growth through improvements in efficiency, productivity, quality and competitiveness. On the other hand, museums operate as non-profit organizations (or at least most of them) with social missions and the concepts of financial profit, competition, and marketplace are quite outlandish. Accordingly, positioning innovation within a museum context remains a challenging task. This challenge shows in a study by The Listening Post Project, Johns Hopkins University to explore innovation among American non-profits (including museums). The organizations were asked to report any implementation of innovative programs or services within the past five years. Museums were less likely than other non-profit organizations in the survey to introduce innovations (68% vs. 82%) and the highest to report incapability to adopt innovation in the previous two years of the survey (83%) .

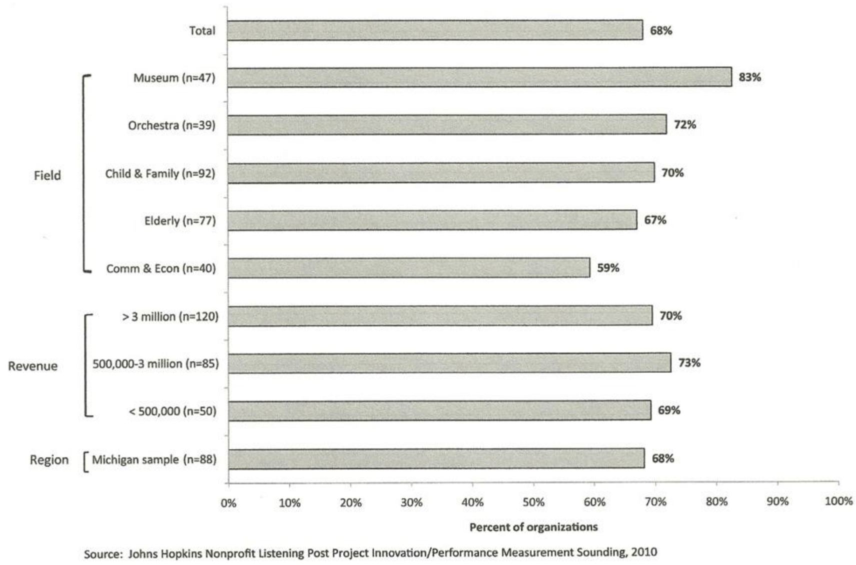


Figure 1: Share of non-profits unable to adopt an innovation in the past 2 years (n=340)

But the financial obscurity many museums are facing now due to the downturn in economy has probably pushed innovation to the forefront of museum discussions. Ed Vaizey, UK Minister of Culture, in his keynote speech at the 2010 Museum Association Conference asserted that; ‘Renaissance resources are going to be even tighter in the future and they will only be applied to efficient, imaginative and innovative museums’ . On the other hand, the American Alliance of Museums confirms that; ‘Museums need to innovate in order to successfully navigate the rapidly changing landscape of the 21st Century’. It is widely accepted that innovation is the legitimate pathway for growth in any field and the museum sector is not an exception. ‘Companies cannot grow through cost reduction and reengineering alone [...]. Innovation is the key element in providing aggressive top-line growth, and for increasing bottom-line results’ (Tony, Marc, & Robert, 2012).

Unfortunately, within the field of museum studies, there is a lack of frameworks to support innovation, which can be applied in museums in a sustainable fashion. This paper aims to exemplify a framework for innovation in museums using 3D technologies and artists' interventions.

2.1. Open Innovation

Artist engagement with museum collections has been identified as an Open Innovation model, which enables museums to experiment with new ways of engaging audiences with their collections. In this context, Open Innovation (OI) refers to the paradigm in which organizations (such as museums) create channels for outside and inside ideas to be transmitted to and from the organization during the innovation process. The Open Innovation theory was promoted Henry Chesbrough, Hass Business School professor, University of California Berkeley. Chesbrough explains;

> firms can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open Innovation assumes that internal ideas can also be taken to market through external channels, outside a firm's current businesses, to generate additional value .

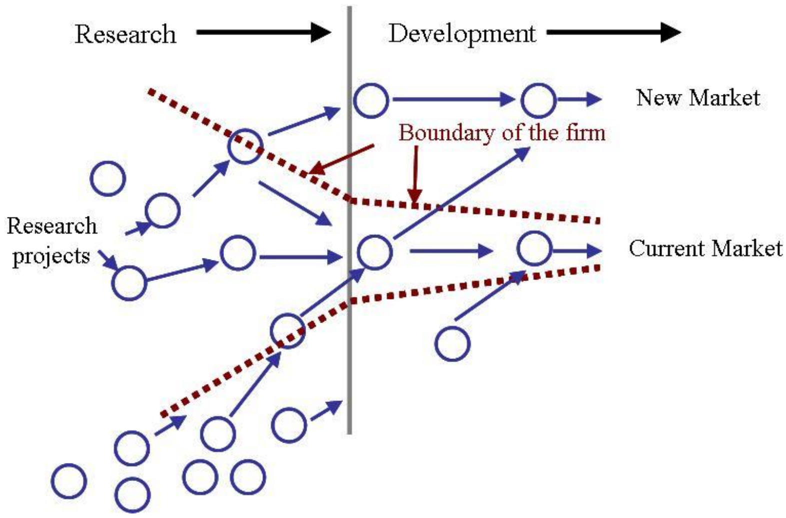
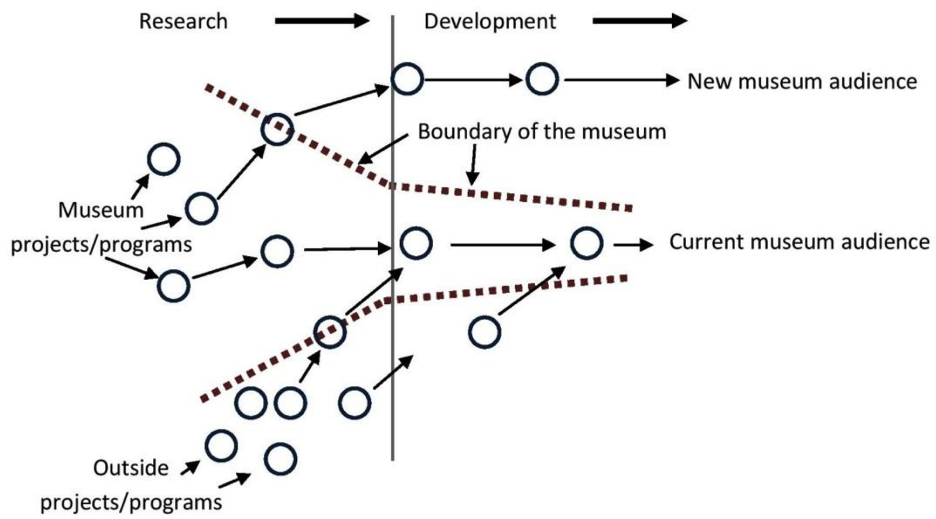


Figure 2: Open Innovation (Chesbrough, 2004)

Chesbrough argues that unused ideas sitting on the shelves of many universities, research centres, and companies can be used by other firms to accelerate innovation and help the whole economy to grow. He defines open innovation in his words:

Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology (Chesbrough, 2006).

OI may take different forms such as open source software, outsourcing, crowdsourcing, and patent trade. ‘The prevailing thought is that open innovation allows organizations to simultaneously expand their breadth of ideas, opportunities, and know-how while minimizing the technical and market risks associated with innovation’ . In the past few years OI became very popular and was strategically adopted in many fields such as energy, healthcare, and pharmacology.
OI can be conducive to museums in many different ways. This paper investigates how OI can enable museums to reach out to new audiences and explore innovative projects through artists’ intervention. Utilizing Chesbrough’s model we reconfigured the model illustrating how OI can possibly be used in museums (Figure 3).



Reconfiguration of Chesbrough’s Open Innovation Model (Eid and Younan, 2014)

Figure 3: Open Innovation in Museums

2.2. Open Innovation and Artistic Engagement with Museums

Although the concept of “opening up” seems to be revolutionary for the business sector, it is not necessary the case for museums. Museums have a long history of working with both individuals and organizations, for example, to collect new objects, care for their collections, promote educational programs, and create new exhibitions. Artists, makers, and other creatives have a particular relationship with museums and the artefacts they hold. They, and their artistic forbearers, are audiences as well as potential contributors to museum collections. Artists turn to museums to find inspiration, but museums are also institutions that collect and display artistic creations; museums play a role both in stimulating ideas and in displaying and acquiring the fruits of artistic inspiration. In the twentieth century artistic engagement with museums and their collections has increased , collaborations with artists have now been taken up by science and history museums, as well as other heritage institutions from a non-art background. Artists have been invited to interact with specialized collections such as archaeology, ethnography or natural history. Such projects enable museums to attract and engage with different audiences (Putnam, 2012).

Since the late 1980s politically engaged artists have used intervention as a tool to critique the institutional nature of museums, and to question the supposedly unbiased facts, which they represent. Recently, museum intervention has been described as a fading tool for institutional critique; ‘Once it had achieved its objective of exposing underlying dynamics of power in the apparently neutral spaces of preservation and display, it seemed destined to die out’ .

However, museums are multifaceted institutions, and artists continue to find varied angles from which to approach their creative engagement with museums. As museums increasingly embrace art projects interaction rather than intervention has become the norm. The objective of recent artistic engagement with museum collections has shifted from a critique of the museum institution towards the re-narration of museum collections. The critical question now is how museums can build upon their core duty of producing and sharing information to share knowledge and work with others specially artists in order to innovate? Robert Stein, Deputy Director of Dallas Museum of Art argues, that;

> Creating a culture in the museum that embraces risk is a prerequisite to allow significant innovation to take hold. Recognize that by attempting innovation you expose yourself to risk. The freedom to innovate can only happen when museum leaders remove the stigma of failure from the process. Instead, celebrate failure as a badge of honor and a key component needed to break old models and embrace innovation .

Seb Chan, Director of Digital & Emerging Media at Cooper-Hewitt, National Design Museum confirms Stein's view and adds;

> I'm a firm believer that failure is instructive. One of the reasons we invested so heavily in in-house expertise at Powerhouse (and now, increasingly at Cooper-Hewitt), is that it allowed for lots of small, inexpensive failures, and the cultivation of more of a culture of experimentation and continuous improvement .

Through collaboration with artists responsibility is shared between the museum and artists, which allows the museum to be less fearful of failure, to take more risks and to adopt essential enterprising values. Artists' collaborations provide a calculated risk. An artist's reputation is intrinsic to his success or failure and it is within the artists' self-interest to produce an engaging and successful museum intervention. The artist stands to lose face if his project fails, the museum, however can point to its openness and eagerness to embrace different voices and viewpoints, even if the artist intervention is not received well.

3. (Im)material Artefacts; OI Project at the National Museum Wales

For this research a project was undertaken at the National Museum Cardiff. (Im)material Artefacts, was undertaken in collaboration with the National Museum Cardiff and artists working in digital media. The enclosed nature and well-defined role of the ceramics galleries at the National Museum Cardiff renders it a well-suited location to observe the innovative potentials of emergent technologies. For this research the OI model of artist engagement with museum collections was applied to open the ceramics collections of the National Museum Cardiff to digital engagement.

This artist engagement with artefacts from the National Museum's ceramics collections was instigated with the aim to foster and observe creative digital engagement with museum artefacts. A number of artefacts from the ceramics collections at the National Museum Cardiff were selected for 3D scanning, and the resulting digital 3D models (Figure 4) were made accessible to participating artists online.

Figure 4: Digitally rendered image of 3D scans of museum artefacts from the National Museum Cardiff, © Sarah Younan

Participating artist were invited to create new artworks based on the digital 3D scans. The submissions of participating artists ranged from digital 3D models to animations and video games, these creations were displayed alongside the original artefacts inside the National Museum Cardiff ceramics galleries in the scope of a public exhibition. Through the artist-led conception of artworks this project illustrates how digital technologies can access the inherent creative potential of museum collections. For this project artists were selected for their proficiency in the use of digital editing technologies. However, as editing software develops and becomes more intuitive and easier to grasp, the manipulation of digital 3D files will soon be within the grasp of non-expert users.

All artefacts used for (Im)material Artefacts were selected from the National Museum's storage collections, partly because this made handling and digitization possible without interfering with the museum displays, but also in order to work with artefacts, which would otherwise not be seen by the public. The artefacts stem from different cultures and periods in history and include both functional and figurative ceramic pieces, they provide a diverse sample of ceramic objects held in store by the National Museum Cardiff. Thirteen ceramic objects were selected and digitized using a NextEngine laser scanner. 3D laser scanning captures the geometric structure of an object as X, Y and Z coordinates. In this way a 3D model of the original artefact, composed of thousands of coordinate points, is created. The digital models were exported as object files (.OBJ), a common 3D file format, and as stereo lithography files (.STL), a file format for 3D printing. Artists were given access to all 3D models via a shared Dropbox folder. The artists were also given access to archival information and digital photographs of the selected artefacts, and invited to select one or several of the digital models to use as the basis of creating new artwork. Artists were later asked to fill out a questionnaire, and further data was gathered through semi-structured interviews. Museum staff was also interviewed on their experiences with the project.

3.1. Findings

A stratified sample of British and International artists participated in (Im)material Artefacts. Eleven artists from the UK, America, Mexico, the Netherlands, Panama and Kenya submitted artworks for this project after discovering an open call for this project online. Artists were not promised any remuneration for their participation in this project; however they were motivated by the chance of showing their work in a museum gallery. After sending their digital submissions artists were asked to fill out online questionnaires and to participate in interviews with the researcher via Skype. Artists submitted a wide range of artworks for the (Im)material Artefacts project; submissions ranged from digital STL files for 3D printing (Figure 5) to animations (Figure 6), video games (Figure 7) and physical artefacts (Figure 8).

Figure 5: Monkey Heaven by Guy Michael Davis and Katie Parker (Future Retrieval), 3D print, © Sarah Younan

Figure 6: Scene from 3D animation film, Alien Fanfare by Jonathan Monaghan, © Jonathan Monaghan

Figure 7: Scene from first-person shooter video game, Postcards from Mexico by Jason Rouse, © Jason Rouse

Figure 8: hand-carved wooden sculpture, Curio Dog, submitted by Jeff Waweru, © Sarah Younan

Digital 3D editing proved to be the favoured production method, with 70% of the artists choosing to submit digital STL files for 3D printing. These files were then physically executed in 3D using Stereolithography (SLA). SLA is a 3D printing technology used for producing artefacts by curing a photo-reactive resin with a UV laser. The SLA process utilizes a vat of liquid photopolymer resin cured by ultraviolet laser to solidify layer by layer to create a 3D model. SLA offers high accuracy and good surface finish. SLA printing was undertaken in Cardiff, all artists' STL submissions were manufactured in bulk; the researcher in collaboration coordinated this with curators from the National Museum Cardiff.

The (Im)material Artefacts project was designed to foster new forms of artistic engagement with museum artefacts using OI model, however the outcomes of the project surpassed initial expectations. Digital 3D technologies were put to use to enable an unprecedented form of access and interaction with museum artefacts. The participating artists' responses provided examples of creative digital engagement and produced unexpected insights and surprising challenges to all parties involved in the project. The digital artworks submitted by participating artists presented the museum with new types of artefacts , which needed to be understood and conceptualized within the context of the museum. Through 3D editing some participating artists created new artworks from the digital 3D scans, these were shared with the museum in their digital format and shown on screens or 3D printed inside the museum galleries. This led to a new understanding of digital technologies for museum staff, many of whom had not previously considered digital technologies as a source of new forms of artefacts; born-digital objects. The term born-digital refers to materials that originate in a digital form. As Digital technologies, especially digital 3D print, develop such artefacts will become increasingly important; they merit collection as cultural artefacts in their own right. However, they also present conceptual and practical challenges to museums. Many artists sent in digital files without specifications to which material they should be 3D printed in, sometimes forms were too fragile for 3D printing and some meshes needed to be edited further to prepare the files for 3D printing. These cases forced museum professionals to communicate with artists, and to collaboratively find solutions; the curators became involved in the physical execution of the art pieces. Although the (Im)material Artefacts project was successfully completed through good communication between museum staff and participating artists it flagged up potential pitfalls. The opportunity of submitting digital files for 3D printing presented participating artists with an array of methodological and planning challenges; STL files do not include information on colour and materials. The size of some of the STL files submitted for the (Im)material Artefacts project was too large for available 3D printers and had to be adjusted. Too avoid misunderstandings and frustration it is important to agree on terms and conditions for the printing of 3D files when undertaking this form of project. A set number of reprints should also be agreed upon, as well as actions to be taken with the 3D files after printing. The artworks which participating artists contributed towards this project also presented a challenge to the museum in terms of copyright questions, which surfaced during this engagement with digital artworks. 90% of the artists participating in this case study stated, that they would be willing to include a copy of the digital file and specifications of the technology and materials used for 3D printing if a museum acquired one of their 3D printed pieces, provided a copyright agreement had been reached. Copyright is also important for museums that digitize their collections; the creation of 3D scans takes time and effort, and museums are responsible for how the resulting data is used. For the (Im)material Artefacts project the National Museum Cardiff agreed on an attribution non-commercial licence; artists had to credit the museum as a contributor to their artworks, and the 3D scans were not to be sold to any third party. The National Museum Cardiff takes a similar approach to photographic content, however it was agreed that 3D scans are dissimilar to digital photographs as they provide more information. A more specific solution targeted at digital 3D files will have to be agreed by the museum board in the future. The acquisition of 3D files was discussed as a potential approach to collecting contemporary artefacts, with the advantage of requiring no shipment and no additional physical storage space or conservation activities. Many of the materials used for 3D printing today are light sensitive and deteriorate quickly. 30% of the participating artists see this deterioration as part of the history of the object. Another 30% would like to see the museum respond to the deterioration of 3D prints by controlling light exposure and temperature to halt further discoloration. The remaining 40% would agree to replace the deteriorated artefact with a reprint using the same material and technologies. If the original software, technology or material were not available anymore 10% would not agree to have work reprinted, 70% would settle for a reprint using the closest matching material and technology available at the time, and 10% would agree that any print of the original file could be considered as authentic and as a valid replacement.

4. Discussion and Potential for Further Research

4.1. Practical and Technical Aspect

3D editing and print technologies are becoming more accessible and over the past 25 years have been increasingly used by artists and designers. As a result 3D prints are entering museum collections in ever increasing numbers, using a vast range of technologies and materials. Born-digital artefacts present museums with new conceptual and practical challenges. This research suggests that museums need to develop new approaches to the acquisition, display and conservation of 3D printed and digitally borne artefacts. Museums also need to address questions of access, ownership and copyright in relation to digital 3D content. Digital Art Projects such as the (Im)material Artefacts project allow museum to experiment, to discover the challenges of engaging with digital materials, and to trial possible solutions. In this way museums can prepare themselves with the necessary knowledge to begin to engage in the collection of digital cultural artefacts, or to undertake large-scale digitization of their collections.

4.2. Recommendations towards a new framework of innovation for digital museum engagement

Museums have been looking at innovation as a way to confirm their role in society and stay relevant in the new age. Although innovation is necessary within any field museum research on its own cannot provide a comprehensive framework for innovation, such as the strategic integration of new technologies, within the museum context. It has become almost inevitable for the museum community to examine how innovation is being conceptualized in other disciplines and how these approaches can be conducive to museums. Looking at OI, the concept has been originated mainly to maximize the use of knowledge and accelerate innovation. It has been academically researched, like most innovation theories, in the business studies discipline and rapidly changed the way many businesses operate now. This explains why the conceptualization of innovation in general and OI in particular is influenced by marketplace, competition, and generation of profit. These facts about innovation models and theories represent a huge challenge for the non-profit sector including museums which operate under a different set of values such as providing quality education, promoting social justice, and serving the public. It is suggested here that recognizing this divergence is probably crucial in order to build a museum perspective to innovation. Within this wider framework, this project tries to provide an example of the adaptation of a purely business innovation model (i.e. OI) to apply new technology (i.e. 3D scanning and printing) in a museum setting (i.e. artists engagement with museum collections). More research is desperately needed to define and model museum innovation. Ultimately, this is a cumulative task that requires different approaches and contributions. As museum researchers move towards this goal we envision that social enterprise and social innovation are key concepts in future discussions about museum innovation in order to reconcile the business studies conceptualization of innovation on one side and the social role museums have been elected to play in society on the other side.

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