From Analytical Investigation to Interpretive Product

Translating Heritage Science Based Analytical Investigation into Interpretive Product for a Museum

PhD Thesis

By

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From Analytical Investigation to Interpretive Product

Translating Heritage Science Based Analytical Investigation into Interpretive Product for a Museum

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Abstract

This research proposes that the analytical investigations conducted by heritage science can enhance the object biography of museum objects. If communicated effectively, this could be employed by museums to create interpretive products which could drive their core mission to engage the public in their collections. The research is focused on museums which have no facility to actively conduct these analytical investigations. It is proposed for such museums that this analytical capacity can be provided by a Higher Education Institution (HEI). Through literature review a case is made that heritage science and conservation have a stated desire to enhance their socio-political profile. Additionally, HEI's have a commitment to engage with stakeholders outside the academic sphere through their adherence to the Research Excellence Framework (REF) and the forthcoming Knowledge Exchange Framework (KEF) funded by UK Research and Innovation (UKRI). However, the literature review also caveats the successful funded collaboration of museum and HEI with phenomena such as 'cultural difference', 'power imbalance' and the existence of a 'rigour-relevance gap' that manifest between differing organisations such as an HEI and a museum. An understanding of how a rigour-relevance gap might manifest between heritage science and its end users is just emerging in the literature within the field. Through analysis of a collaboration between the ISAAC Lab heritage science research team from Nottingham Trent University and the Nottingham Castle Museum and Art Gallery, an analytical investigation is conducted, and an interpretive product is created from it in the form of 3D animation embedded in film. This research will evaluate the relationship between analytical investigation and the production of interpretive product and relate this to the current understanding of interpretation within museum studies. It develops new knowledge through the analysis of the nature of the transition from analytical investigation to interpretation. In so doing it enhances the understanding of a rigour-relevance gap within a heritage science context through practice.

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Introduction

This thesis presents a body of research that positions itself between the fields of museum studies, and heritage science and its embedded discipline of conservation science. It critically analyses the process of creating an *interpretive product* (Ham, 2013, p. 4) in the form of a suite of films from the results of an analytical investigation of a selection of museum objects. This generates the following research aims:

- How might a critical examination of literature and practice enhance an understanding of the current relationship between heritage science, its embedded specialism of conservation science and the wider museum sector?
- How might the creation of an interpretive product tailored for a museum setting make effective use of an analytical investigation?
- How might the creation of this interpretive product act as a bridge between the outcome of a heritage science analytical investigation and museum interpretation?

The overarching aim was to investigate how the output from heritage science and conservation research could be employed in developing content for interpretation material for museums without scientific research capacity. The literature review revealed that the fields of heritage science and conservation are seeking to develop their public and political profile (Bell, 2015; Brokerhof, 2015; Corbeil, 2015; Heritage and Golfomitsou, 2015; Lithgow, 2015). The Research Excellence Framework (REF) and the forthcoming Knowledge Exchange Framework (KEF) have sharpened the focus of Higher Education Institutions (HEIs) on how their research impacts on the economy and society. Consideration of this within the focus of this research creates two subsidiary questions. Can heritage science be a *proactive* creator of interpretation for museums and in doing so enhance its potential perception at a societal level? If so, then is this of mutual benefit to heritage science and to museums? Only a mutually beneficial relationship would have the potential to be sustainable.

The general format of a heritage science investigation would be to answer a scientific research question generated from a conservation or curatorial starting point as part of an ongoing museum investigation or conservation programme. Alternatively, the research question could be generated from an ongoing theme of heritage science research generated by the heritage scientists themselves. In the case of the heritage scientists being HEI based they might be seeking access to the Museum collection to pursue their research agenda. In the case of this PhD, the

Imaging & Sensing for Archaeology, Art History & Conservation Laboratory (ISAAC Lab) research group at Nottingham Trent University (NTU) was asked to do something different. Within the context of a case study, they were required to adopt a speculative approach employing a suite of their instrumentation and approaches to seek lines of investigation which could develop the *object biography* of selected museum objects (Gosden and Marshall, 1999). The case study was designed to ask the science to be a proactive creator of interpretation content for the Museum. The Museum in question was The Nottingham Castle Museum and Art Gallery (hereafter referred to as 'the Museum'). The Museum had no ongoing analytical investigation that it required heritage science assistance with. Indeed, it would not have had the staffing, funding structure or facility to conduct one. In addition, there were no clearly defined conservation issues that the scientists were being asked to address. They were tasked with exploring the objects presented by the Museum analytically. Their findings were to be expressed as filmic interpretive products, employing 3D animation to communicate the science and its implications for the object biography. This final interpretive product is directed by the Museum as a stakeholder in this relationship. The juxtaposition of what the analytical investigation reveals and how the manifestation of the interpretive product is managed by the museum is a significant aspect of this research. The final interpretive products from this research are available and can be viewed at my Heritage Imaging YouTube channel (appendix 5).

Through analysing the case study, an interaction between heritage science and a museum could be observed. Certain issues arise. Nottingham Castle Museum and Art Gallery are not enabled to carry out analytical investigations. This enablement came from the ISAAC team at NTU. However, museums with Independent Research Organisation (IRO) status or designated as a Public Sector Research Establishment (PSRE) are funded and remitted to conduct research programmes including scientific ones and will often employ heritage scientists. This creates a different dynamic when an HEI based heritage scientist works with them, as the museum is essentially a *scientifically specialised participant*. That is to say that both the museum and HEI heritage scientists share scientific specialism enabling them to negotiate the nature of the research (Markham *et al.*, 2019, p. 38) . This PhD research is focused on the relationship with a museum where the scientific enablement comes externally from an HEI without the museum enacting the role of a scientifically specialised participant.

A second issue is one of translating the outcome of a heritage science investigation into an interpretive product, in this case film and 3D animation. The common mode of scientific discourse is through peer reviewed publication and conference presentation within the respective scientific fields. The creation of an interpretive product for the consumption of a non-specialist museum audience presents a different challenge for the heritage scientist. This requires some investigation of the public understanding of science (PUS) and most importantly the nature of interpretation

itself in the form of *meaning making* as understood by the field of museum studies. The final issue is methodological. The practical first-hand experience of carrying out this research activity is central to its creation of new knowledge. Yet, recording that first-hand experience presents methodological challenges in how one observes and records the experience and then offers an evaluation of it. Approaches such as *participant observation* and *autoethnography* will be explored and these will have experimental connotations within the field of museum studies. To explore the issues described above a research structure was designed which could facilitate a triangulation enabling three aspects of the research experience to be juxtaposed (Yin, 2014, p. 119). The first aspect would be a case study experience using participant observation (Delamont, 2004; Saldana, 2011; Trent and Cho, 2014) to follow the development of the analytical investigation conducted by the scientists and observe its transition into an interpretive product. The second aspect being a literature review that comments on heritage science's desire to broaden their public and political profile and critically evaluate that within the context of literature exploring the relationship between museum and HEI. The third aspect of the triangulation would then be to review the responses from professionals within the museum sector to analytical investigation being a source material for interpretive products.

Certain practical considerations had to be managed. ISAAC Lab's engagement with the Museum came at a very specific time in the Museum's development. They had been successful in acquiring a Heritage Lottery Fund (HLF) bid for a major refurbishment. NTU had provided some financial assistance to aid that bid and in return had negotiated a memorandum of understanding for a level of engagement to pursue lines of academic research, of which this PhD was one. However, the timing of this meant that the ISAAC Lab engagement took place on the eve of the Museum moving their entire collection into storage for a protracted closure to enable the refurbishment. The Museum closed on the 1st of July 2018 with a prospected reopening in the summer of 2020. In reality the Museum finally opened on the 21st of June 2021 due to the Covid 19 pandemic. Additionally, during this time the Museum experienced considerable turnover with its CEO's and senior managers. This did impact on the progress of the research. The most pertinent of which was that the suite of films produced as an interpretive product for the Museum did not enter into any of the Museum's routine evaluation procedures and has still not been fully implemented as part of the Museum's interpretive offer.

The creation of an interpretive product also presented practical challenges. The employment of 3D animation within film as an integral part of the creation of an interpretive product brought technical challenges that had to be resolved through additional training when it became apparent that my original skill set would not be able to produce 3D animation sequences of sufficient professional quality. This training had to take place while the analytical investigation was underway. A second issue of concurrence was that of the professional discussions programme.

Due to the tight time scale of the PhD and the time it took the ISAAC Lab team to move through their analytical investigation, the professional discussions programme had to run concurrently alongside the analytical investigation and the 3D animation training rather than being able to employ the final outcomes of analytical results and interpretive product as part of the discussions. This creates a complicated picture for this thesis to describe, especially if aspects that were running concurrently have to be described as separate for clarity. Table 1 provides a Gantt chart showing all the major research elements and cross-references them with significant events within a timeline to equip the reader with an overview of the research activity before having each aspect described in greater detail. The issues surrounding this will be given greater attention in Chapter 3.

Key Concepts and Information

The Flawford Virgin

As the research progressed one object from the Museum's collection came to the fore. The Flawford Virgin is a medieval Christian sculpture of the Virgin Mother and Christ Child (Cheetham, 1962). It had a particularly interesting object biography. Originally carved circa 1380 it was re-discovered, along with two other religious sculptures, in 1779 under the chancel floor of Flawford Church during its demolition (Southwell and Nottingham Church History Project, no date). The contemporary report by Thoroton (1790) implies that much of the polychrome was still present at the time of the sculpture's discovery, of which very little survives today. The sculpture has clearly been broken into three pieces. During the conservation investigation for this PhD, apparent damage to the face is given further scrutiny in relation to this breakage. It is not clear from the contemporary report as to whether this damage was done pre or post 1779. The Museum's pre-existing historical research suggested that the sculpture had moved through several different owners since its discovery, even spending time as a garden ornament. Damage, repair, and the loss of polychrome could have occurred during this time. The ISAAC team's investigation into the original nature of the polychrome and the more speculative and hypothetical aspects of the investigation into the nature of the damage to the face, forms the core of the film and 3D animation content of this research (Chapters 7). It also is highly significant in the understanding of the issues surrounding the transition from analytical and conservation-based investigation to interpretive product (Chapter 8).

Overall Research Activity Sept 2016 -2021

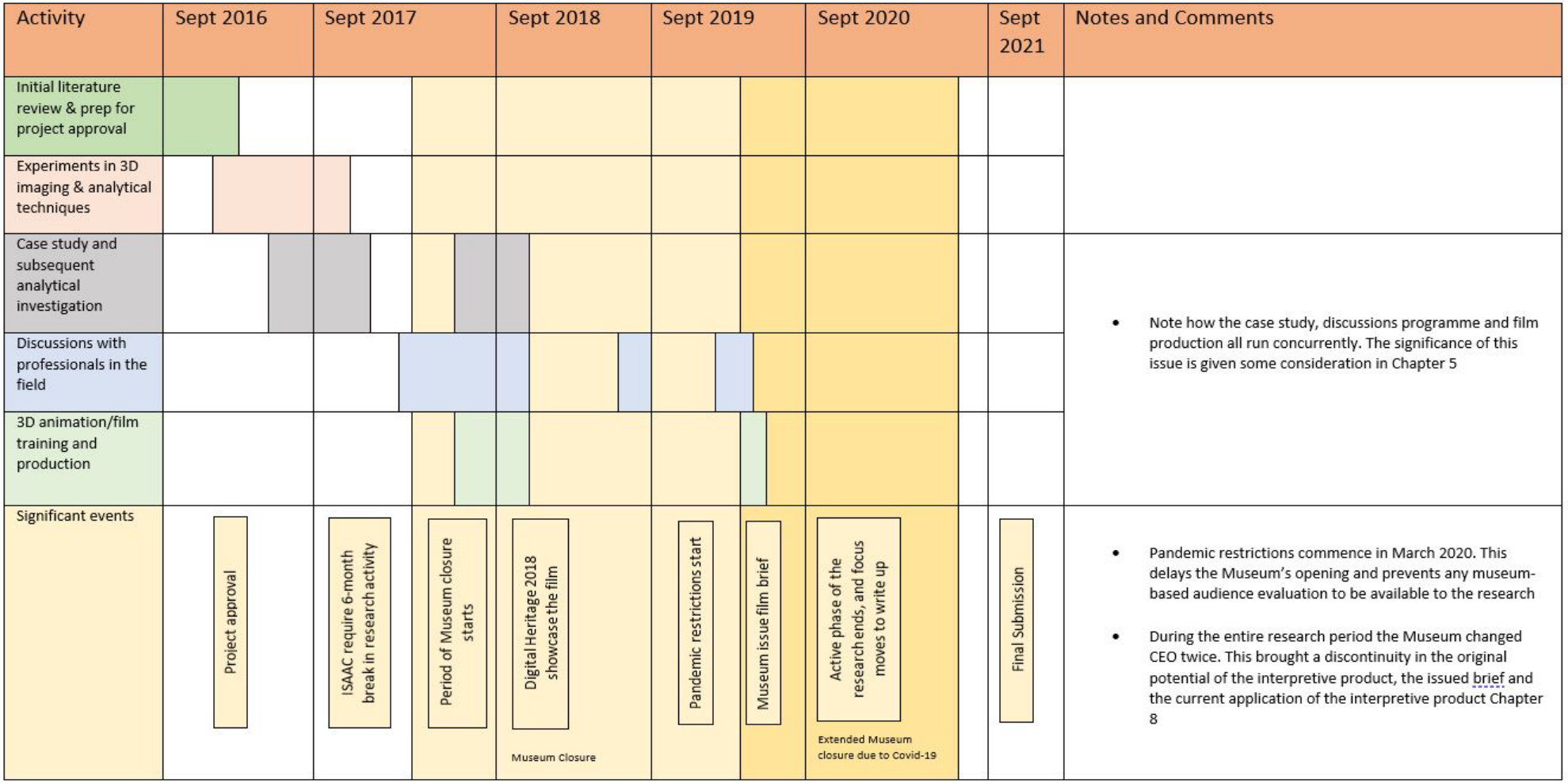

Table 1: Gantt chart showing the overview of the research activity from September 2016 through to September 2021. Note how some research activities run concurrently

Interpretation and Meaning Making

At the turn of the 20th century western museums had a didactic view as to what their visitors should think and know about the objects they presented and this reflected the western world view with an emphasis on educating 'large sections of society' (Hooper-Greenhill, 2000, p. 151). As the 20th century progressed this approach began to be moderated and an awareness grew that museum objects are interpreted by the visitor relative to the context in which they experience them (Stead, 2011). Sam Ham (2013, p. 1) provides a definition as to what interpretation is, stating; "Interpretation attempts to communicate in a thought provoking way to an audience that's completely free to ignore it". The need for interpretation to be thought provoking and the fact that they can ignore it acknowledges the audience's agency in how they respond to an *interpretive encounter* (Ham, 2013, p. 4). Ham cites Freedman Tilden from 1957, who is commonly considered as one of the original thinkers around interpretation, defining it as:

> "[A]n educational activity which aims to reveal meanings and relationships through the use of original objects, by first-hand experience, and by illustrative media, rather than simply to communicate factual information." (Tilden 1957 cited in Ham 2013, p. 7)

Note the terms here: 'reveal meanings and relationships' and 'rather than *simply* communicate factual information'. The relationship between factual information, the visitor and interpretation within a museum is a complex one which will be explored further in Chapter 1. For now, let us consider the revelation of meanings and relationships. The mistake here would be to consider the meaning of a museum object to be embodied within it. However, the meaning of an object can vary depending on who is looking at it and where it is being exhibited. Mason illustrates this well:

> "[D]epending on your point of view, an African mask could be viewed as an ethnographic exhibit, a tribal artefact, a piece of art, evidence of colonial looting, the subject of a repatriation case, or simply a commodity to sell. In each case it is still the same mask…"
>
> (Mason, 2005, p. 225)

In this sense it is the visitor who has agency in the act of interpreting what the meaning of the object is relative to them. This is given the term 'meaning making' (Mason, 2005). However, many factors can affect how those meanings are created. This might be the context of the visitor, the context of the museum, and how the curator has chosen to present the object, but in each case, interpretation is an interactive process. The essence is for an interpretive encounter to occur between the individual presenting the interpretation, the object being presented and the visitor. The visitor is being provoked into thinking more deeply about what they are looking at and it is

this provocation that is the interpretation experience (Ham, 2013, pp. 7-8). For the purpose of this introduction, interpretation is an interpretive encounter between visitor, museum object and the presenter of the interpretation. The outcome experienced by the visitor varies dependent on the context of the museum, the context the visitor brings to the object and the context within which the designer of the interpretation created it. This embodied nature of the process of meaning making is in juxtaposition with the more empirical nature of a heritage science investigation. As the final film and 3D animation work developed to become the interpretive product, issues around artists' reconstruction, the presentation of hypothesis, the detail in which factual information was presented, all became points of discussion, covered in Chapter 8.

SREO & N-SREO

Although museum types and definitions are numerous (Ambrose and Paine, 2018, pp. 8–10; Gray and McCall, 2018) these two acronyms will not be found within the literature of any of the fields represented in this thesis. They were created by me as a tool to aid the discursive process within the writing. They stand for: Scientifically Research Enabled Organisation (SREO) and Non-Scientifically Research Enabled Organisation (N-SREO). These acronyms will be used frequently in the following discussions. However, they are not just a writing device. They encapsulate my hypothesis that as heritage science enters into an engagement with the museum, the level to which that museum is able to respond as a scientifically specialised participant will directly affect the application that the heritage science has for that museum. Additionally, it will also affect how the science will be received within the museum environment. In an SREO the engagement might provide a piece of scientifically verifiable information, for example a pigment identification which may be a key to opening up an ongoing enquiry. I argue that within the N-SREO environment this type of application for heritage science would be much less common[1]. The emphasis for the collection would be one of dissemination and engagement with the varying demographics of the museum audience, rather than analytical investigation[2]. An N-SREO, by my definition, is not enabled to conduct its own analytical research. Therefore, an external heritage science provision would have to be available. A partnership with an HEI would be an obvious candidate. This research explores the creation of an interpretive product from the heritage science engagement and investigates its relevance to the N-SREO agenda of interpretation, public engagement, and dissemination.

[1] Chapter 2 will discuss the literature review that supports this statement.
[2] This is a central theme in the professional discussions which is presented in Chapter 5

I would propose that although the description of museums as being SREO or N-SREO would divide them in terms of their relationship with heritage science, I would not perceive it as binary. I envisage it presenting more as a sliding scale. A small folk museum in a tourist area would be deep in the N-SREO side of the scale and a national IRO/PSRE would be deep within the SREO end of the scale. However, a large regional or city museum or a university museum might cluster at the watershed between SREO and N-SREO. For me the defining factor at that watershed is, does the museum have a remit to pursue analytical investigation and is it staffed and funded to do so? The staffing is important as it is here that the scientifically specialised participant is encountered. However, this watershed is caveated. I envisage a situation whereby a museum might initially present as an N-SERO yet an individual curator's level of expertise in a particular area might rebalance the relationship further towards that of the SREO's scientifically specialist participant. The SREO/N-SREO watershed allows the reader to understand the nature of the museum that is being discussed. However, I suggest that the heritage scientist could use these definitions to gauge the reception that their science will receive and the relevance that their science will have for the museum they are working with. The discussion of this idea is a central element in this thesis.

Cultural Difference and the Rigour-relevance Gap

Since 2009 a body of literature has been produced looking at interrelationships between heritage science, HEIs and museums. The first investigates the state of play of heritage science provision within the UK (Williams, 2009a, 2009b, 2009c). Another body of literature investigating the nature of museum and university partnerships focused around the National Co-ordinating Centre for Public Engagement (NCCPE) in preparation for their Museum and University Partnership Initiative (MUPI) (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; National Co-ordinating Centre for Public Engagement, 2016). Also relevant to the debate is a small body of literature discussing how effectively heritage science serves the needs of the organisations it works with. (Bell *et al.*, 2014; Dillon *et al.*, 2014; Katratazis *et al.*, 2018; Curran and Zimmermann, 2021).

NCCPE's research on the interrelationship between museums and universities in partnership was significant. Understanding this relationship in broad terms was important as this PhD is focused on the heritage science research enablement for the museum coming from an HEI. Chapter 2 discusses issues arising from the analysis of these reports. They include concepts of '*cultural difference'* and *'power imbalance'* that the authors observe in the partnerships between museums and HEIs.

A small body of literature generated a significant concept for this PhD. This was the observation of a *rigour-relevance gap*. The concept pre-existed, outside the field of heritage science but a body of research produced two publications (Bell *et al.*, 2014; Dillon *et al.*, 2014) which sought to observe it within heritage science applications. The rigour-relevance gap observes a distance between an academic research outcome and how relevant that research outcome is to application by the end user for whom research is destined. This concept resonates with the core activity in the PhD of translating an analytical heritage science investigation (rigour) into an interpretive product for application by the museum (relevance). This phenomenon is observed at significant points in this thesis. Chapter 2 will enable a more in-depth critique of the literature surrounding the rigour-relevance concept. As the case study unfolds, I will illustrate how the positionalities of rigour and relevance will reflect the analytical and interpretive aspects of this research. My intention is to illustrate how the interpretive products, in filmic form, act as a bridge across this rigour-relevance gap. The current literature establishes the existence of the rigour-relevance gap in heritage science through statistical means. This PhD observes it manifest in practice in the field.

Chapter Structure

Part 1 of the thesis is focused on literature review. Chapter 1 fleshes out the current critical thinking behind the established fields of museum studies, heritage science, its embedded discipline of conservation science and its relationship with conservation. Chapter 2 is a literature review establishing the current socio-political and funding environment for heritage science investigations within the UK. It reviews the literature concerning museum and university partnerships, the rigour-relevance gap and considers the political and research funding landscape as an environment where this PhD research is positioned. These two chapters lay out the intention of the field of heritage science to raise its socio-political profile from an internal realisation, but also to meet the need of initiatives within research funding bodies for Knowledge Exchange (KE) and user engagement. It then puts this in the context of recent literature which explores the challenge heritage science faces in balancing the cultural differences between museum and HEI and bridging the identified rigour-relevance gap. Chapter 3 lays out the methodology with which the research will explore the above challenge and tackles some of the methodological approaches. These include the triangulation of case study, professional discussion groups analysis and literature review employing research methodologies such as participant observation and autoethnographical writing. Chapter 4 then employs the technique of autoethnographical writing to establish how I came to this research and establish my positionality within it.

Part 2 of the thesis focuses on the active phase of the research. It progresses through an analysis of the professional discussions programme and then moves to a description and analysis of the case study as defined by the methodology. Refer to table 1 which shows a Gantt chart illustrating the overall research activity. Note how the activities sometimes run concurrently even though they are described separately in the chapters. Chapter 5 analyses the responses to the professional discussions programme and finds that museums in the N-SREO sector could employ analytical investigation within their constitutional mission and funding structures, as long as it responded to their public engagement priority. Chapter 6 considers the practical application of analytical investigation within the N-SREO environment by describing the preparations for the investigation and the film and 3D imaging culminating in three site visits to the Museum. Within this chapter we start to see resonance within these practical applications of the cultural differences and the rigour-relevance gap described in the literature. Chapter 7 then looks at the analysis of the analytical data, how this informs the narrative of the films and describes the final iterations of the films as directed by the Museum's brief. It describes in practical terms the translation of an analytical investigation into an interpretive product.

Part 3 then takes a reflective look at the case study experience. Chapter 8 analyses the film making process as a translation from analytical investigation to interpretive product with reference to the concept of meaning making, documentary making and the public understanding of science. It explores the concept of bridging the rigour-relevance gap through the management of fact, hypothesis and artistic reconstruction to create the interpretive product. The final result of the suite of films produced as the interpretive product being available through this Heritage Imaging hyperlink. The thesis concludes with Chapter 9 drawing together the significance of the rigour-relevance gap when generating an interpretive product for the museum from a heritage science based analytical investigation. It concludes that one can formulate a '*theoretical proposition'*[3] that when analytical investigation is brought into the N-SREO museum, meaningful science and effective interpretive product can be produced.

[3] The use of this term will be given justification in Chapter 3

Part 1

Literature Review and Critical Thinking

The introduction to this thesis maps out the local environment and conditions under which the research was carried out. It furnishes the reader with an insight into the organisations involved in the research and the immediate environment in which they worked. In addition, it specifies certain key concepts that will be pertinent to the understanding of the research such as meaning making, cultural difference and power imbalance between museum and HEI, the rigour-relevance gap and the definitions of SREO and N-SREO museum. Part One is focused on a literature review and seeks to describe a broader landscape of relationships between academic fields, organisations and academic funders. A commonality of purpose appears which expresses a desire for heritage science to reach a wider audience and consider the requirements of an *end user* within the process of knowledge exchange between museum and HEI. However, literature is also presented that nuances the interplay between these two organisations and describes challenges to the prosperity of this relationship. This poses the question, how should one research the translation of an analytical investigation into an interpretive product within this landscape? A methodology is proposed that employs participant observation to observe this translation first-hand. However, with this methodology comes a consideration of the positionality of the participant themselves and the influence that this might have. The key issues are that a desire for greater socio-political profile for conservation and heritage science is identified, the caveats to bring this about are understood and a methodology that observes the bridging of a rigour-relevance gap in practice represents the new knowledge presented by this thesis.

Chapter 1: The Lie of the Land: Exploring the Wider Academic Fields

This chapter provides a literature review to map aspects of the academic fields of museum studies and heritage science pertinent to this research. It opens up the museum studies concepts of interpretation and meaning-making as outlined in the introduction, to establish a foundation for the understanding of the creation of an interpretive product. Within heritage science it explores the principles of conservation embedded in heritage science and discusses in detail a body of literature that seeks to understand how heritage science could interface with a wider audience and the potential socio-political advantages this presents. This foundation is required as this research will bring these two academic fields into alignment and explore how the creation of an interpretive product interrelates between them.

1.1 Museum Studies: Meaning Making, Objects and Our Relationship to Them

Quite a lot of the theory concerning how objects are interpreted revolves around this transience in the meanings that objects have and the process of meaning making intended by the curator and constructed by the visitor. Lidchi (2013, p. 121) tackles this exact problem with the employment of her 'constructionist' model, where the meaning of an object is constructed by the process of experiencing it. Here she explains how exhibitions designed to display museum objects have both 'poetics' and 'politics'. 'Poetics' refers to what the object signifies, the way in which the exhibition is designed and what meanings the design may have associated with it. These meanings are then constructed by the intentional interpretations of the curator but also augmented by the potentially unintended and unpredictable interpretations of the visitor (Mason, 2005, p. 226). 'Politics' refers to the cultural context of the exhibition environment and any clash there might be with the cultural context of the object and/or the visitor. Mason passes comment on this:

> "The key point is that just as visitors draw on their pre-existing knowledge to understand what they see in museums, galleries and heritage sites, so too will the museum, gallery and heritage professionals inevitably draw on, and be informed by, the various discourses circulating within society when they produce displays, or interpretation. Where ever possible, professionals should strive to recognize this and critically examine the paradigms and discourses within which they work."
>
> (Mason, 2005, p. 227)

MacDougal (2006) offers another perspective in describing objects as having a ‘knowledge of being’ focused on its physical presence and a ‘knowledge of meaning’ which relates to the ‘poetics’ described by Lidchi. In this context objects can form images and ideas around which meanings can be organised (Watson, 2010, p. 205). I will return to his concept of a knowledge of being and a knowledge of meaning when discussing the final iterations of the films in Chapter 8.

To what extent do museum visitors want facts about objects or to understand a story or biography that lies behind them in order to formulate their meanings? Wehner and Sear's preparations for the 'Australian Journeys' exhibition (2010) at the National Museum of Australia make some pertinent observations with regards to how objects are presented and experienced. They started by analysing 'object biographies' (Wehner & Sear 2010, p146). These would include: the physical form, style and materials of construction; associated values of the object but also how those values and meanings are enacted within the context of a culture. It is this 'object biography' approach which is standard practice in conservation prior to treatment (Pye and Sully, 2007, p. 23). The objects that had biographies that worked most effectively in exhibition were those that alluded to human experience, historical change or cultural context. In addition objects associated with known individuals were particularly effective (Wehner & Sear 2010, p. 146). What was interesting was that the Australian museum authorities were keen to see the curators tell a history of Australia through the presentation of facts. Yet the museum's focus groups suggested that the visitors wanted to know what it would have been like to experience the context of the objects rather than simply have information about them (Wehner & Sear 2010, p. 153). Clearly there was a desire to have something more engaging than simply the 'object and fact' approach. If we take the position that objects signify meaning and do not have meaning fixed within themselves (Stead, 2011, p. 39) then if provided, an object biography and cultural context could be the means by which we, the audience, position our interpretation of that object. This interest in narrative and context expressed by a potential audience is significant in how the Flawford Virgin film develops from its analytical fact-based starting point to an interpretive product enabling meaning making.

We have reached a point here where museum objects are transient in their meaning and dependant on context, and that curators have to manage the possible interpretations as they design an exhibition. How different this is from where they came from at the turn of the 19th century, what new challenges are presented as we move deeper into our digital age. Hein (2000) states: “…museums have descended from the heaven of authoritative certainty to inhabit the flatlands of doubt” (ibid pp. 142-151) . Hein describes how curators no longer have their traditional authority but are now “client orientated team players” (ibid, p. 143) with the visitor as ‘user’ or ‘consumer’ of their content (Mason, 2005, p. 221). In this role they are required to consider their own positionality and situated knowledge. Hein (2000, p. 146) appeals to museums

not to shy away from taking a specific point of view as "[p]rofessing a focused interest and a diluted story line does not discourage the expression of other, discordant positions…" and will not prevent visitors from their own interpretation of the exhibition. The model being proposed here is what Hooper-Greenhill describes as a 'transactional' communication model with meanings being exchanged between curators and visitors (Hooper-Greenhill, 1995, p. 9).

It might be considered that curators and visitors are in a relationship of equity in the exchange of ideas. However, above and beyond the influence of the 'politics' there is another set of societal factors that influence meaning making and not all of them leave the visitor on a level playing field (Mason, 2005). The interpretation a visitor generates is relative to their personal experience and this raises the issue of 'cultural capital'. This concept first identified by Pierre Bourdieu in 1966 suggests that individuals have varying degrees of capacity to interpret objects which is based in their personal experience and heavily influenced by social opportunity and socio-economic group. This might seem an outdated concept, but despite a significant rise in museum attendance in recent years a large proportion of museum audiences are still from those advantaged socio economic groups who have the cultural capital to engage (Mason, 2005, p. 232; Department for Culture Media & Sport, 2016, p. 20). The challenge that faces the curator is to open up the opportunity to interpret what is presented and allow in individuals with varying levels of cultural capital.

In order to achieve this level of cultural access the methodology of interpretation becomes significant. A simple fact should be considered at this point; outside its educative role, museum visiting is fundamentally a leisure activity. As Ham (2013, p. 1) pointed out the audience are at liberty to ignore the museum's attempt to communicate with them. Ham (2013, p. 12) reminds us that a museum audience is a 'noncaptive audience', unlike the 'captive audience' that a teacher faces. Captive audiences are incentivised by a desire to pass an exam, to enable the taught information to realise personal goals or just to stay out of trouble. Noncaptive audiences are incentivised by "their own intrinsic satisfaction with what they're hearing, seeing or reading. The only reward noncaptive audiences seek is internal." (Ham, 2013, p. 12). The core tenet of Ham's thinking is that interpretation should 'make a difference', that although enjoyment is vital to hold the noncaptive visitor's attention, as a means to its own ends it lacks real purpose producing what has been referred to as 'interpretainment' (Ham, 2013, p. 16). Ham suggests that there are a number of ways in which one might create the 'interpretive product' by considering the final proposed outcome of the interpretation or 'end game' (Ham, 2013, p. 53). He sees three basic approaches: teacher, provoker and entertainer. Teachers being focused on information transfer, ensuring that the visitor has the required information to understand the content. Provokers requiring their audience to think for themselves and formulate their own ideas and therefore engage in the process of meaning making. The entertainer's primary goal is to entertain,

generating incentive for the non-captive audience. Ham accepts that the three approaches are not mutually exclusive and a good interpreter will combine all three in varying amounts to reach their 'end game' (Ham, 2013, p. 60). However, he states that:

> "…it's the "provoker" who emerges as the most indispensable when it comes to interpretation's potential to make some kind [of] "difference" in the audience it reaches… A consistent finding is that the more communication provokes audience thinking, the stronger, more enduring, and more resilient are the attitudes that result."
>
> (Ham, 2013, p. 64)

What we draw from this is that the curator/interpreter has agency in how the visitor engages in the meaning making process and can be instrumental in enabling access for individuals with varying degrees of cultural capital. The manipulation of analytical outcomes for the Flawford Virgin film into an interpretive product that has the potential to provoke and engage is a central challenge of this research. This relationship would require a renegotiation as objects, contexts and potential audiences change. Mason comments:

> "…[I]t should be recognised that communication within museums, galleries and heritage sites will inevitably be complex and often unpredictable process, because it depends on so many variables. However, it is precisely this same variety and unpredictability which makes museums, galleries and heritage organisations such endlessly fascinating places within which to work, visit and study."
>
> (Mason, 2005, p. 234)

We have clearly reached a point where meaning making creates understanding relative to the visitor. However, objects do have information and stories, or object biographies associated with them sourced through research. It is now we should look at how objects and their associated information relate and give some consideration as to how embodied emotional experiences and new audio-visual and 3D imaging techniques are now influencing this relationship.

In the 19th Century museum the relationship between objects and information was straightforward. You saw the object and read the relevant information which told you what you should know. However, with visitors engaged in meaning making the relationship to an object is contextual. Dudley (2010) discusses objects within exhibitions as having two relationships. The first is 'Object' and 'Information' where objects are combined with their associated facts, usually in the format of textual information. The second takes a more phenomenological approach whereby the object is combined with the embodied experience of it. Here the emphasis is on how the object 'is', what one might describe as an 'emotive reaction'. Dudley attests that these two methodologies do not rest easily with each other. When objects become part of an 'information

package' the phenomenological experience can be lost (Dudley 2010, p. 3). She quotes Hein (2006, p. 2) as saying, 'Things dissolve into meanings'.

The exciting thing about a museum object is the experience of seeing it. As a young boy I have a clear memory of going to the Natural History Museum in London and standing below the blue whale in the whale hall. The fact that any living creature on this planet could be so vastly bigger than me was a profound experience. No amount of information about the migratory routes or feeding habits of blue whales could have generated that response. However, the presence of that information would not dilute that experience. One could question if Dudley's 'information package' is such a destructive thing.

Russel Staiff in his book *Re-imagining Heritage Interpretation: Enchanting the Past-Future* (2014) takes a close look at the relationship between how interpretation is presented and the emotive experience of it. Staiff acknowledges the power that modern audio-visual and 3D imaging techniques and the interconnectivity of the web have, to enable an immersive and emotive experience. Through a series of autoethnographical anecdotes Staiff (2014, pp. 15-26) observes how sound and imagery can convey information in a more phenomenological and embodied way, with more textual information being either complementary or ineffective in conveying the message. He describes an 'intensity' (Staiff 2014, p. 27) of experience built from both the choreography and expectation of the heritage site and the sights, sounds, smells, even food of the visit itself. In Chapter 8 I will return to these concepts and reflect upon how the Flawford Virgin film responds to them.

1.1.1 Film in the Museum

As film will occupy a central part of the research presented in this thesis some consideration of its relationship to the museum is important. Elisa Mandelli (2019, p. 85) describes documentary film as amongst the most widespread audio visual outputs shown in exhibitions. She points out that they are often commissioned for the exhibition with the common format being archival footage with voiceover. These images carry a connection to reality and have the power to be interpreted as direct access to the events of the past (Mandelli, 2019, p. 82). Mandelli also lists reconstructions and fictional films as genres of museum film. She describes them as "…mostly educational, as they aim to 'bring back' the past in a fictional but scientifically accurate form." (ibid, p.86). What is interesting in Mandelli's descriptions is that she separates the reconstruction film format from the documentary format. This research will bring these forms together with analytical accuracy being combined with reconstruction, hypothesis and speculation (Chapter 8).

Haidee Wasson (2015, p. 605) points out, film has the capacity to choreograph and manage the viewing experience, sometimes asking the visitor to "look at many things more quickly or fewer things more slowly". For this reason, film has to be part of the infrastructure of the exhibition experience. Wasson's analysis of the development and use of film at the Metropolitan Museum of Art, New York, from the 1920s onwards, showed that even early on it was seen that film could control time – it condensed thousands of years into seconds – or control the time spent by a visitor in looking, effectively training the visitor's eye in how to look and how long to look. Additionally, it was felt that film could provide an antidote to museum fatigue which (they thought), resulted from the "undisciplined eye" flitting from object to object. By controlling the viewing experience and pacing through editing it was felt that film offered an opportunity for visitors to learn more. This should be framed within the Met's then didactic approach to its audience where the "wandering eye and the wandering museum-goer were seen as a problem" (Wasson, 2015, p. 617). Within the modern context of meaning-making this would no longer be seen as problematic but the capacity of film to control chronological time, and the time the visitor spent focused on an aspect of the interpretation, would make it an appropriate tool to present known historical information alongside new scientific discovery.

Museums can take advantage of film's ability to communicate (Penz, 2012, p. 282). This is aided by their ability to combine 'text meaning and visual meaning' (Staiff, 2014, p. 75). They can: convey large quantities of information in comparison with other interpretive products; illustrate complex concepts and mechanical processes; display personal or witness accounts and when combined with museum exhibits and objects, can introduce movement which brings 'life' to the otherwise static (Mandelli, 2019, p. 79). Film can also hold the imagination and communicate in a common language. Film's capacity to employ visual and text meanings in the communication of scientific research concepts, which might be beyond the understanding of a non-specialist audience, is of significance to this research. Moreover, the interplay between text and visual meaning would be significant in managing the interplay between evidenced analytical fact and hypothesis, as Chapter 8 will explore.

The union of museum exhibition and cinema brings together two separate media genres. As Francesco Casetti (2015) pointed out, in their purest form they require the visitor to either move through a space with static objects or remain seated while the cinematic experience moves the viewer through the interpretive material. Film screening can bring a sense of movement to an otherwise static space (Mandelli, 2019, p. 6). On the other hand, it can interfere with the movement of the visitor. If the film is long, seating may be required. If the film has a narrative structure, then visitor movement at the beginning and end has to be managed. Darkened rooms for screenings intensify the experience but also can limit social interaction (Henning, 2007; Christie, 2012).

Russell Staiff (2014) in his book *Re-imagining Interpretation: Enchanting the Past-Future* takes this idea of film as ubiquitous media form and turns it back on the world of heritage. Staiff asserts that our visual construct of the past is generated by our consumption of film, media and gaming images:

> "When I say 'Ancient Rome' or 'Ancient Egypt' or 'Feudal China' or 'Medieval Europe' what images come to mind? And more importantly, what is the *source* of these memory images? These 'worlds' of the imagination, Ancient Rome, Feudal China and so on, exist in a mode that has never been so vivid or as detailed."
>
> (Staiff, 2014, p. 83)

Staiff (2014, p. 71) points out the difference between vision and visuality. Vision being a 'pre-epistemic' process that assists us in navigating the physical world, playing sports etc. and visuality which is 'epistemic'. As Staiff puts it: "looking what we do with a question in mind: 'seeing how', 'seeing why'; 'seeing that'. This type of looking is linked to knowledge, thus the term epistemic to describe it." Heritage cannot be viewed 'pre-epistemically' and each visitor brings with them a pre-existing 'knowledge' generated by a broader social and media culture (Staiff, 2014, p. 82). Indeed, if we see this in the context of meaning-making, the context we bring as visitors, the context of where we view and the context contributed by the designer of the interpretive product, all come into play (Mason, 2005; Lidchi, 2013). We see our western cultural history very much through the lens of the twenty first century and the broad genre of popular film (along with other media) is a major player in colouring and focusing that lens. The past is lost to us and can only be reconstructed through imaginative means. The process of reconstruction relative to our pre-epistemic understanding of the past, the artist's role within it, and the power that film and 3D animation has to present believable and convincing portrayal of the hypothetical, become of significance to this research.

1.1.2 Museum as Media

Eilean Hooper-Greenhill (1995, p. 7) comments on how museums are both mass communicators and interpersonal communicators. Their means of communicating beyond their walls are the internet enabled social media and broadcast platforms. A feature of these platforms is that they enable user generated content without editorial influence and are often grouped as 'new media'. Michelle Henning (2011, p. 648) comments that museums can be a form of media in more than a communicative role but also influence our perception. How the exhibition is designed can control movement and solicit 'different modes of attention and different viewing positions.' With respect

to new media, Henning (2011, p. 644) does not see new media as a means of communication or collection of devices, but a way to structure and organise knowledge, even challenging the hierarchies of knowledge in the museum.

Museum display can be seen in the wider context of its surrounding popular culture. Henning (2011) describes how, from the 1880s through to the 1940s in the USA, there was an interrelationship between design styles that encompassed department store displays and museums. Henning (2011, pp. 645–646) employs Bennett's (1995) concept of the 'exhibitionary complex' to relate how museums interrelate with a wider media culture of display and retail. One might regard the contemporary museum working within the 'exhibitionary complex' of gaming, online broadcast and social media in addition to more traditional platforms of TV, radio and print. Henning (2006a, pp. 46-47) notes a transition from research institute to institution responding to popular culture and public understanding in American museums as early as the late 19th century. The language of our wider media culture is what Thomas Elsaesser refers to as a 'Medienverbund' or media network (Elsaesser, 2004, p. 22; Mandelli, 2019, pp. 5-9). As such its potential demographic is large. This interlink with the wider media culture and its potential large demographic that new media can enable facilitates museums to employ the marketing potential of this interpretive material (Kidd, 2014, p. 48). This idea is significant in the development of this research as it represents a key issue in the translation of the analytical outcomes of the investigation into the interpretation and marketing tool that was required by the museum as 'end user'.

This communicative power of film was highly influential in the decision to employ film as the interpretive product. This enhances its role as a bridging activity to take the output of an analytical investigation and construct a narrative that enriches the object biography, which has the potential to create effective public engagement and effective marketing output. In a published discussion in 2009 between Neil MacGregor, the then director of the British Museum and Nicholas Serota, who was at that time director of the Tate (Higgins, 2009; Wilson, MacGregor and Serota, 2010) covered this concept of museum as broadcaster. Within this conversation both commentators predict a future from their position in 2009. MacGregor states " the future has to be, without question, the museum as a publisher and broadcaster" to which Serota adds " I am certain that in the next 10 to 15 years, there will be a limited number of people working in galleries, and more effectively working as commissioning editors working on material online" (Higgins, 2009).

What is unique about the museum as a form of media is that it is founded in objects and their exhibition. New media content can come from museums' initiatives and their visitors' interactions, not dissimilar to other forms of media. What is unique is that the museum collection

forms a ‘bank’ of reality from which the new media output can be generated. It is a re-interpretation of these real objects, ‘another reality’ (Pachter, 2010, p. 333). They are capable of autonomous existence through a social and web media presence, while remaining anchored in the collection, with the prospect of experiencing it for real (Hooper-Greenhill, 1995, p. 10; Henning, 2006, p. 71, 2011, pp. 650–51). The programme of analytical investigation in this research will focus on objects from the collection and as will be seen a new media output forms part of the final iterations of the films.

1.1.3 The Story is the Thing

Interpretation is how we access our material culture from the past. Our understanding of it is facilitated through interpretation and enables us, the visitor, to engage in an act of meaning making with the interpreter/curator and inspired by the museum object. The meanings we make are contextual to our own experience, the political environment in which we experience them and the cultural capital that we have obtained. Our engagement in this process is optional and so driven by our interest. The story of an object can assist us to reference it to our own experience and enhance the level of interest and engagement. The experience of the heritage visit creates a tension between our own phenomenological experience and that of the ordered presentation designed by the interpreter/curator. Film has substantive power to formulate a vision of the past, but how the film maker combines fact, hypothesis and supposition to create or encourage this vision will be influential. However, this tension can form part of the experience. Freedman Tilden has been quoted as saying “The story is the thing” (as cited in Ham 2013, p. 23) implying that the interpretation itself should be structured as a story. Interpretation is more than the presentation of information; when effective it is believed that it: has a theme; will make a difference; be sensuous and inspire new ideas and understanding that enrich our lives.

1.2 Heritage Science; The Science of Conservation

There is a close interrelationship between heritage science and conservation. As will be seen, heritage science, as a field, is a broad church encompassing many subdisciplines. The subdiscipline with the tightest correlation with conservation is conservation science. However, the relationship is broader than this. Heritage science, as an academic field, is a new discipline and has not yet established a deep theoretical and philosophical base within the academy (Strlič, 2015). Essentially, what makes heritage science specific within science is that it adheres to the philosophical and ethical constructs that guide conservation. It is also worth noting that within

these ethical constructs, there is a degree of interconnectivity with the museum studies concept of meaning making. For this reason, this section opens by mapping those fundamental concepts within the field of conservation. These concepts inform heritage science practice. Additionally, a commonality of purpose between heritage science and conservation is demonstrated through their desire to develop their respective socio-political profiles.

As with museum studies, conservation has a body of academic writing to help it define its role and purpose. This body of critical discussion tends to focus on the ethics of the interventions that a conservator might make upon a museum object and assists them in the vital decision-making processes as to the appropriacy of any one treatment. Elizabeth Pye (2001) offers the following:

> "Conservation is the action of safeguarding the objects and structures which compose the material remains of the past, and it aims to ensure that these remains are available to use and enjoy today and in the future."
>
> (Pye, 2001, p. 9)

This very pragmatic description encapsulates within it a significant role; a museum object is an agent of 'enjoyment', currently and for the future. Clearly 'enjoyment' is an embodied and emotional response. The choice of this word might imply that conservators would not consider the more complex relationship of object and viewer as the museum studies concept of meaning making. It does imply that a conservator has an understanding of the object as meaningful. Pye continues:

> "Just as there are many different views of, or interpretations of, the past so there are different possible views of, and uses for, objects. Conservation articulates with a range of different disciplines, and in elucidating meanings of objects conservators often work with different groups including artists, indigenous peoples, art historians, scientists and the public. Together these views should give conservators particular insight into the varied interpretations of objects from the conceptual to the material; from aesthetic to the historic or the scientific."
>
> (Pye, 2001, p. 24)

This description perhaps lacks the philosophical clarity of Lidchi's (2013) 'poetics and politics' but it does encompass how objects are varied in their interpretation. It is this contextual understanding that is the role of object biography within conservation. However, Pye suggests that the key role of the conservator is one of making objects displayable with their contribution focused on the material quality of the object (Pye, 2001). Chris Caple (2000, p. 32) supports this aim of displayability by saying that if preservation was the prime objective, then cryogenic storage would be the solution. Is a museum object in cryogenic storage engaged in meaning making? If it

cannot enact its role as meaning maker in an exhibited context then arguably not (Brooks, 2013). Within this lies an inherent tension within conservation as to what it is trying to achieve. On the one hand the preservation of our material culture is a primary objective (Caple, 2000, p. 18), the ultimate expression of which is the 'cryogenic chamber'. On the other hand, for a museum object to operate as a meaning maker it must reach its audience at some point. This 'public responsibility' that a museum object has can actually threaten it. As Caple (2000, p. 22) puts it 'people are bad for objects'. In the case of museum objects this is clearly mitigated by good preventative care and the actions of the museum case, but even the light required to view the object could be deleterious. Caple (2000, p. 33) sees this conundrum as a standoff between the conservational priorities of revelation, investigation and preservation (RIP). He defines them as follows:

> **'Revelation:** Cleaning and exposing the object, to reveal its original form at some point in its past…
>
> **Investigation:** All forms of analysis which uncover information about the object…
>
> **Preservation:** The act of seeking to maintain the object in its present form without any further deterioration…'
>
> (abridged from Caple 2000, pp. 33-36)

Within this model Caple suggests that conservators make decisions as to how to proceed depending on the priority revelation, investigation or preservation has for any individual object. He expresses this as the RIP triangle (Figure 1).

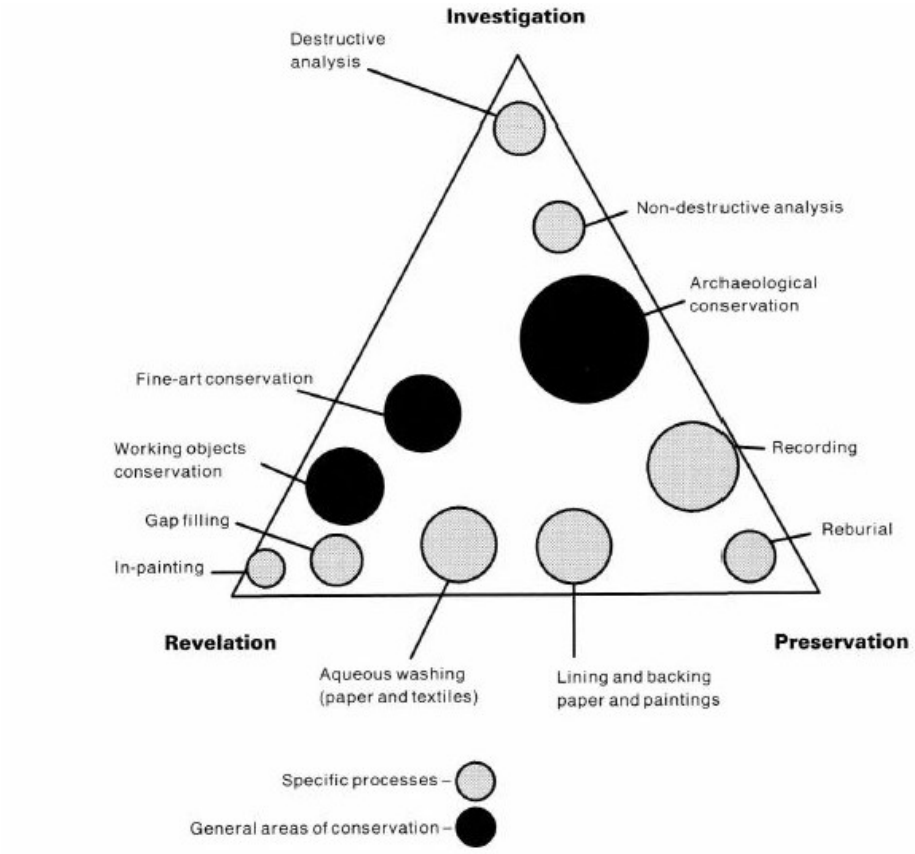

Figure 1: Chris Caple's RIP triangle showing different approaches to objects dependent on their nature and significance. (Caple, 2000, p. 34) - ©2000. Reproduced by permission of Taylor & Francis Group.

It could be argued that the object's significance would position it within the triangle. For example, a painting may undergo a quite invasive process of removing old varnish as the revelation of the true nature of the artist's intent would be seen as priority. On the other hand, one might rebury a mosaic to preserve it as other pre-exhibited mosaics within museums are already fulfilling the meaning maker role. However, large quantities of ceramic material from the same site may undergo destructive analysis as the information from that investigation is more powerful for the purposes of interpretation than the shattered ceramic remains themselves.

Hidden within Caple's 'revelation' is another complex conundrum. The removal of varnish from a painting strips away part of the physical history of that object, justified by the fact that the degraded varnish obscured the 'true nature' of the original artist's work. Eastop (2011) explores this concept a bit further. Here she describes the 'primacy' of the object (Eastop 2011, p. 439) whereby conservators have an interest in what the 'real thing' is, with less emphasis on subsequent changes brought about by interventions or reinterpretations. However, she points out that this concept is problematic and has to be renegotiated in the context of each individual object. In an extreme example she cites the conservation of a William Turnbull sculpture where, in consultation with the artist, large sections of the sculpture are thrown away and replaced. Here

the 'real thing' is the concept behind the work not the materiality of the object itself. Concepts of the 'real thing' are open to debate and the debate itself has the potential to be an interaction with an audience (Eastop 2011, p. 440). What is perceived as the 'real thing' and 'true nature' is subject to the positionalities of the conservator, curator, exhibition context and audience perception. Here we clearly parallel with museum studies theory as to the understanding of how objects are interpreted (Mason, 2005; Lidchi, 2013). Mary Brooks (2013, 2014) has written on the role of the conservation process as being one that is integral in the process of meaning making and defining the cultural value. She makes an interesting observation as to the bias towards the analysis of material culture via historical writing rather than a primary engagement with the object itself (Brooks 2013, p. 3).

Salvador Muñoz Viñas (2005) consolidates this concept in a Contemporary Theory of Conservation by moving the emphasis for conservation decision making away from concepts of 'the real thing' and 'truth' and move it to the role of object as significant to certain factions of society.

> "Contemporary Theory of Conservation calls for 'common sense', for gentle decisions, for sensible actions. What determines this? Not truth or science, but rather the uses, values and meanings that an object has for people. This is determined by people. Predicting the chemical alterations in an artwork, for instance, is perfectly valid, but in conservation, it is far more important to predict how people will be affected by a conservation process."
>
> (Muñoz Viñas, 2005, pp. 212-213)

1.2.1 Conservation 'in crisis': The Pragmatic Reality of Practice and Public Engagement

The financial crash of 2008 had a profound effect on funding levels within the heritage sector and that effect was felt keenly by conservation with many conservators losing salaried positions in museums and a general drop in employment level within the sector (Aitchison 2013, p. 11). London predominates as the area of employment for conservators (Aitchison, 2013, p. 23). Most of the employment offered outside London is part time or fixed contract, with the more substantial posts offered within London requiring high levels of experience and/or offered at salary rates unrealistic for relocation or cost of living in the capital. For a newly qualified conservator getting a job is not an easy thing to do (Panton and Plumbe, 2019). What does this say about how central the practice of conservation is to the contemporary heritage sector in the UK? Writing on the eve of the crash Pye and Sully (2007, p. 19) highlighted that many conservators were experiencing a 'crisis in confidence' stating: '…they may feel the traditional skills that define the identity of conservators are not valued by institutional managers or funding

agencies, or are no longer relevant'. Keene (2002, p. 22) and Brooks (2013, p. 2) point out that: "Conservation in museums is often perceived as being puritanical and restrictive, insisting on preservation at the expense of natural enjoyment and use" (Keene, 2002, p. 22). It does not require a huge leap of imagination to see how museums, now pressured by substantial funding cuts and needing to increase footfall and public engagement, might downgrade the role of the conservator. Bulow et al (2018) state:

> "Overall, there is an expectation that museums should demonstrate the responsible and sustainable use of public funds. This is particularly acute at a time of dramatic reductions in funding. Museums are therefore required to do more with less, in a measurable way."
>
> (Bulow, Stitt and Brokerhof, 2018, p. 37)

How clear is conservation about how to adapt to the current environment and plan for the future? These are challenging times for the conservator. As will be demonstrated later in this chapter, conservation science has published literature discussing how to move forward by encompassing other scientifically based heritage disciplines under the banner of heritage science to advance their socio-political profile (Heritage and Golfomitsou, 2015, pp. 3-4). Conservation is also aware of this agenda. As Chief Executive of The Institute of Conservation, Sara Crofts (2021) has suggested "… we need more conservators to emerge from behind the scenes and take their place on the public stage or, more probably, in front of the video camera."

Pye (2001) closes her book *Caring for the Past* with a lengthy discussion of methodologies of public engagement, conservation content in exhibitions, and public facing conservation events. She cites the Conservation Centre at the National Museums and Galleries on Merseyside as a shining example. However, since her time of writing this has closed due to lack of funds. Interestingly, she even suggested that controversy in conservation actions was an effective public engagement and was healthy as it indicates strong feelings about heritage (Pye, 2001, pp. 185-200). Bulow et al (2018) state:

> "In order to stay relevant conservators have to take on an active role in facilitating audience participation and increased access to collections, while at the same time improving their efficiency and accountability."
>
> (Bulow, Stitt and Brokerhof, 2018, p. 35)

The Institute of Conservation (ICON) published strategy (2017) clearly states 'advocacy' and 'engagement' as keystones of the strategy, with 'visibility' being seen as one of the 'big ideas' that will shape the ICON Strategy 2030 (Crofts, 2021). Within the US the 2011 'Playing to the Galleries and Engaging New Audiences' conference brought together numerous examples of live conservation and public access events. This was published as the '*Public Face of Conservation*'

(Williams, 2013). However, by Williams's own admission discussion on outreach remains underrepresented in the conservation literature: "Conservators may be increasingly comfortable talking to the public about what they do but, until recently, we have been reluctant to talk amongst ourselves…" (ibid, 2013, p. ix). The desire for conservators to become influencers, both politically and socially, is there but the challenge as to how to achieve this in the context of professional policy and leadership, appears still to be under development.

We see conservation as an academically and philosophically active field working in unison with the practice of conserving our material culture. This theoretical thinking is bound into the understanding of object biography and a museum object's significance in order to inform decisions about appropriate treatment. From an institutional perspective conservation has been experiencing pressures and challenges, which to a large extent are related to a perception of conservation within the heritage sector and levels of funding. These challenges conservation is aware of and is considering the role of a public engagement agenda. It is now interesting to juxtapose this approach with the one developing within conservation/heritage science.

1.3 Heritage Science: Background and Aspirations

The term 'heritage science' has been considered to come into common parlance after the House of Lords Science and Technology Committee's 2006 report Science and Heritage, where they describe a "…rich and diverse range of scientific challenges, which we have brought together under the heading 'heritage science' " (Science & Technology Committee, 2006). From this description it would be reasonable to assume that heritage science is quite a new thing. The term may be, and may not have been universally adopted as yet, but the practice of investigating our cultural and material heritage with scientific techniques is not. At the core of heritage science is a conglomerate of pre-existing scientific disciplines which aid the understanding and preservation of our material culture. These might draw from traditional scientific disciplines, for example, chemistry, physics, biology, material science, computer science, statistics etc. To enable a better understanding of this complex area of heritage it is helpful to have some detail around its three main pillars: conservation science, technical art history and archaeological science. These areas are not isolated disciplines but interact and cross over depending on the nature of the heritage asset that is under investigation. The collaborative and interactive nature of these specialisms is a feature of this field (Spring, 2001; Hermens, 2012, pp. 157–8). Its diversity of specialism is another. Most specialists who come under the banner of heritage science come from purer scientific specialisms and require this grounding as scientists to work effectively in the sector. The transition into a heritage area is more likely to be at Masters and PhD level (Davidson *et al.*, 2019, p. 12) and in some cases post-doctoral.

Conservation science focuses its role on analytical analysis to aid the processes of conservation. This may take the form of materials analysis to inform a conservation treatment, the development of new conservation treatments, and the study of mechanisms of degradation. It might also encompass assisting in the development of conservation processes and techniques, or with understanding the museum's environment and its implications for preventative conservation (Leona, 2009, p. 9; Tate Gallery, 2018). It may be instrumental in the development of new analytical techniques or even re-appropriate techniques from other fields such as medicine (Leona, 2009, p. 10).

Technical art history takes the collaborative ethic a stage further by encompassing the more curatorial practice of art history (Leona, 2009, p. 5; Hermens, 2012, p. 151). Curators, conservators and conservation scientists engaged in technical art history develop the knowledge of materials the artist used and their techniques. They begin to explore the meanings both of artistic intent and historical significance (Brokerhof, 2015, p. 10), and understand the provenance of an artwork. In this way the critical interpretation of an artwork can be informed by the investigations of technical art history (Hermens, 2012, p. 155). This has the potential to contribute to some more philosophical debate as to how one seeks authenticity in artworks, even considering multiple authenticities. Hermens (2012, pp. 151–152) discusses this with reference to a debate first triggered by William Hogarth in the eighteenth century. Hogarth's concern was with the contemporary taste for 'dark paintings' with discoloured varnish and accumulated pollution dirt that disguised the artist's true intent (or even their inadequacy). Technical art history has the capacity to reveal a chronology of authenticities, from the original artist's intent through the patination of the passage of time and the interventions and re-appropriations of other hands. In this instance curatorial decisions can be made as to where authenticity may lie. However, it may not be this complicated. Marco Leona (2009, pp. 7–10) describes the application of technical art history and conservation science analysis to inform the authentic reconstruction of the Islamic interior of the Nur al-Din rooms at the Metropolitan Museum of Art. He then goes on to discuss how these investigations can go on to bring about more far reaching discoveries of historical importance and establish provenance for museum objects.

Archaeological science is to archaeology what conservation science is to conservation and technical art history is to art history. It provides a scientific and investigative support for archaeology to interpret its findings. To what extent archaeology sees a subdivision between the two is a moot point. The various disciplines, methodologies and approaches within archaeology span the humanities and the sciences (Barker, 1999, p. xxxv) with some debate still open as to how archaeology defines itself (McGovern, 1995). This issue is not one for debate within the pages of this thesis. Suffice to say that scientific methodologies and techniques are central to the archaeological interpretation of our cultural heritage.

Outside these three main pillars there is some debate as to what else should be included under the banner of heritage science. Certain commentators have suggested that arts, humanities and social sciences should be included. It could be argued that subjects such as archaeology and art history are already arts and humanities subjects. Is the study of a museum audience through data analysis part of heritage science? Bell and Williams comment:

> "[Heritage Science] … is by definition cross-disciplinary, drawing from science in the broadest sense, as well as arts and humanities disciplines. Conservation science research, technical history research, and other areas of research including areas of digital and big data studies focused on cultural heritage fit neatly within a larger frame of heritage science, which includes science that is not exclusively conservation focused."
>
> (Bell, 2015, p. 20)

> "To help achieve this, heritage science needs to make greater use of economic and social science approaches to demonstrate the value of the work the sector undertakes in terms of wider public benefit."
>
> (Williams, 2009c, p. 32)

Should the social sciences be brought into the broad church of heritage science or is Williams simply suggesting the appropriation of some of their techniques? Can the 'heritage scientist' be scientific investigator, social scientist, economist, communicator and all round 'people person'?

> "They will have to adapt from scientist to knowledge manager, from reactive problem solver to proactive horizon scanner, and become an interpreter of material evidence in a social environment. Will they have become 'heritage scientists'? Probably not. Perhaps heritage science is too broad for a single person. Indeed, it may only exist in a network where many minds come together, including scientists, conservators and conservation scientists. This will be 'how' science and conservation can connect and contribute to the societal benefits from heritage. And those networks will need strategies to organise, direct and fund themselves."
>
> (Brokerhof, 2015, p. 12)

How 'neatly' these wider fields fit under the heritage science banner is a moot point. However, I would now like to direct the discussion towards how heritage science as a field might drive a public engagement agenda and what advantages it might bring both for societal benefit and socio-political profile. (Brokerhof, 2015, p. 10; Heritage and Golfomitsou, 2015)

1.3.1 Public Engagement for Heritage Science

A public engagement agenda is reflected by the Arts and Humanities Research Council's (AHRC) (2018a, pp. 4–5) stated aim of 'enhancing community and public engagement' through its strategic priorities. Cynically one could interpret a heritage science public engagement agenda as following the money. Indeed, as I aim to point out, this goal has not gone unnoticed within the field. However, communication with the public is something the general science community take very seriously (Lithgow, 2015, p. 59). It is worth noting at this point that archaeology has a long history of public facing output arguably starting with Sir Mortimer Wheeler in the 1950s. This legacy continued in programmes such as Time Team, Digging for Britain and numerous archaeological/historical documentaries screened on our televisions. For many involved in the pragmatics of analytical investigation of our cultural heritage this may appear somewhat superficial. However, alongside archaeology, conservation science and technical art history have begun to be represented in the media. The National Gallery's *Art in the Making* and *Making and Meaning* publication series is a good example of technical art history having an informative public engagement role and it is still maintained as a research theme on their website (The National Gallery, no date; Hermens, 2012, p. 158). Very recently the screening of the TV programme *Fake or Fortune* or the large multimedia immersive experience *Leonardo: Experience a Masterpiece* staged by the National Gallery show an awareness of heritage science's ability to develop narrative to engage a wider public. These outputs could be seen as indicative of a broader awareness of the value to the heritage science disciplines of an enhanced public and political profile. As this area is central to the main research focus of this thesis a closer inspection of the issues here is of interest.

By their very nature the disciplines within heritage science are scientific disciplines. As such the literature that they publish is focused within scientific practice and methodology in order to disseminate scientific knowledge in a peer reviewed context. This is essential to the maintenance of their activity as a science. As a result, within the literature, these disciplines are not self-reflective with regards to their collective position within the broader field of heritage science or within heritage science's position within the social or political landscape. Heritage science, being a very new concept (Science & Technology Committee, 2006) within the UK, has not formed an academic infrastructure that formally identifies itself as heritage science to help formulate theoretical concerns. Davidson et al (2019, p. 58) list twenty three academic institutions which were identified as offering courses with heritage science content in the UK. These range from PhD Analytical Chemistry at University of York to MA Buddhist Art History and Conservation at the Courtauld Institute of Art. Instead of a concise academic backdrop to heritage science, we see a pragmatic approach with researchers and practitioners responding to a political stimulus and

focusing on developing their political standing and funding proposition under the heritage science banner. This is reflected in the Science and Heritage report authored by the House of Lords (2006) which triggered the development of the Science and Heritage Programme (AHRC and EPSRC, 2009) to provide a funding structure to take its recommendations forward. A more socio-political agenda was addressed by the National Heritage Science Strategy (NHSS). This was a series of reports in 2009 authored by Jim Williams, the Strategy's coordinator. His first report is essentially a resume of the nature of the cultural heritage collections in the UK and the scientific issues surrounding their conservation (Williams, 2009a). Reports two and three start to take a closer look at the landscape of heritage science within the context of our cultural heritage establishments and some interesting observations come forward. He flags up a divide between what he describes as 'larger' institutions and by implication 'smaller' ones with regards to research capacity saying: "outside these larger institutions scientific analysis by museum staff is virtually non-existent" (Williams 2009b, p. 31). He then goes on to say that: "There has been a shift in emphasis from museum-based research by curators, to museums *encouraging* the use of their collections for research by universities and others" (Williams 2009b, p. 31 my emphasis). He points out there is very little private sector support for more routine analysis and if this does happen it tends to be part of a larger funded project where the museum is rarely the instigator but in receipt of an approach from the wider academic community. He acknowledges that research on museum collections has the potential to build collections knowledge and that such research can be an effective tool for public engagement:

> "The public is fascinated by science and forensic science, by the detective work involved in analysis of objects to learn more about the materials and the people who made them, and which are fakes and which are forgeries. People like to see the 'back room' activities that contribute to the generation of knowledge" (Williams, 2009b, p. 35)

He observes that the research could be communicated via web pages enhancing existing collections and then expresses the view that: "…museums and galleries could do more to foster collection research by external researchers by identifying outstanding questions or significant collections" (2009b, p. 35). Yet he feels that *no additional funding* would be required to achieve this advance in collections knowledge. He concludes that the generation of good research questions and the employment of heritage science in public engagement are the main areas for development. In this report Williams paints an insightful vision of a way that heritage science can develop but also makes some assumptions that this thesis will challenge in its later pages.

In his third report he deals with capacity in the heritage science sector and the availability of funding. He makes the following very pertinent observations with regards to museums and moveable heritage:

> "Funding for routine scientific analysis within the moveable heritage sub-sector is uncommon away from the major national and large institutions.
>
> - Outside their core budgets, there are very few sources of funding that museums, galleries, libraries and archives can apply to in order to carry out applied research that is essential to understanding collections and their contexts.
> - Unlike archaeology and historic built environment sector where funding may be available from national heritage agencies, there are no equivalent organisations for the moveable heritage sector.
> - Research council funding is not intended for routine analytical work, or the application of existing techniques to larger sets of objects.
> - Conservators can also find it hard to get scientific analysis recognised as an integral part of the conservation process by clients or museum managers."
>
> (Williams, 2009c, p. 29)

Williams then explains how the clarification of the role of heritage science can contribute to defining a public benefit and strengthen the position for procuring funding. He then closes with the observation that heritage science needs to encompass 'economic and social science approaches', including participant observation, to understand how the public engage with heritage. He comments that up to now this type of research has not been considered heritage science and therefore the benefits are underplayed (Williams 2009c, p. 32).

Williams's report set a socio-political agenda for heritage science to unify the various scientific fields that it encompassed under its banner and stressed the importance of public engagement and profile within the public realm to deliver relevance, impact and funding potential. The report was the foundation of the National Heritage Science Forum (NHSF) (2019). This organisation was established as a charity to move forward in a pragmatic way from the recommendations of the report. Simultaneously the Science and Heritage Programme provided funding support for heritage science practice. Within the literature one might assume that his report would then be followed by a critical debate and academic attention to the issues raised, much like the one ongoing in museum studies. As has been pointed out the vast majority of the literature is focused on scientific and technical aspects of its methodology as opposed to its purpose or direction (Munoz Vinas, 2005, pp. 78-79) and the theoretical aspects of the academic landscape behind it is thin and dispersed. Notable exceptions to this are the publication of the Ottens Report (2013) and a special supplement in *Studies in Conservation* of papers arising from the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) forum in October 2013. This special supplement (Vol 60, Sup2 2015) picks up on the themes that are raised in the NHSS reports and considers the implications. These few publications and the creation of the NHSF

signal a politicisation of the composite specialisms of heritage science. It could be argued that many of those motivated to engage in this discourse are from more managerial or strategic backgrounds, for whom the issues are most pertinent.

The supplement acknowledges the need to embed conservation science within the broader field of heritage science, but the writers appear to be primarily focused on the issues as they appertain to conservation science. The forum identified that conservation science does not exist for its own benefit but for the benefit it brings to cultural heritage. With this comes a responsibility to demonstrate the value of cultural heritage for people (Lithgow, 2015, p. 57). Within this supplement Heritage and Golfomitsou (2015, p. 3-4) lay out five key points for 'strengthening and strategically positioning the conservation science sector: Defining a shared vision and mission; strategy development; demonstrating benefit; influencing policy and improving communication. This is then cross-referenced with four recommendations: Assessing needs and outcomes; seeking sustainable solutions through collaboration and sharing; expanding and utilizing knowledge and enhancing quality. The rubric associated with these key points and recommendations goes into some length into their interpretation, however if one analyses key phases a managerial agenda of integrating and disseminating heritage science is strong:

> "Develop tools to analyse benefit and disseminate; …work with different audiences through multiple dissemination platforms; …solution orientated applied research developed in partnership with end users; …target audiences…at multiple levels from local groups to global networks.''.
>
> (Heritage and Golfomitsou, 2015, pp. 3–4)

I argue the creation of interpretive product from heritage science investigation on museum objects has the potential to contribute to these goals. The overriding tenet of these key points and recommendations is for conservation science to embrace a more collaborative role within the wider field of heritage science. Beyond that to be able to communicate on multiple levels with policy makers, funders, other disciplines and the public. It is the intention of this thesis to develop an understanding of the issues surrounding the creation of an interpretive product to aid its employment to reach the above aims.

A number of issues arise here, not least of which is that this broad skill set is a big ask of a community who are embedded in scientific practice and training, not the skills of media and communication (Reed, 2016, p. 3). In addition the conservation science community is not spread evenly across the range of heritage organisations nationally (Williams, 2009b, p. 31) and so the responsibilities would be focused within the research institutions who would be best positioned

to influence policymakers (Corbeil, 2015, p. 32). Would this leave the museums without scientific research capacity without access to that influence? Corbeil (2015, p. 33) goes further, citing the difficulty is the provision of interconnectivity for the conservation science community, as they are highly specialized and operating in small sub-specialist groups. However, this could be overcome with alignment with other scientifically based heritage fields under the banner of Heritage Science. The aim would be the creation of a 'critical mass' where the field becomes big enough and influential enough to influence policy (Corbeil 2015, p. 33). It would need to speak with one voice and the NHSF could play a critical role here. (Bell, 2015, p. 21). However, to what extent the socio-political and managerial agenda of the NHSF is representative of investigative science practice is debatable. Other sectors have been very successful in raising public profile and influencing policy makers. A good example is the environmental lobby who, with the help of high-profile media coverage, have engaged the public on an emotional level. Lithgow (2015, pp. 58-60) comments that by comparison the benefits of cultural heritage are usually expressed in economic terms from a perspective of tourism and local economy. However, she continues that conservation science can also communicate very human stories and make connections through to historical events. She cites the ICCROM definition: "helping tell the story of humanity through cultural heritage at global and local level". Bell states:

> 'If heritage science is to grow and be recognised beyond academia it needs to demonstrate the value of heritage science to policy makers, funding bodies and the public…in metrics and languages that have resonance with these audiences'
>
> (Bell, 2015, p. 21)

Metrics and languages are a pertinent issue here. The language of the policy maker and funding body is very different to that of the common parlance of the general public or the academic community. Michalski (2015 p. 31) states peer reviewed publication is the most accepted and easiest method to measure output. However, the content from these journals tends to remain within specialised communities and to not readily speak to a wider public, yet high quality publication is required to ensure scientific credibility (Corbeil, 2015, p. 34). Corbeil (2015, p. 37) states that there is a need for multiple levels of communication, detailed for conservation science peers and less detailed for end users. Communication skills make conservation science interesting but there is a need to 'avoid over-simplification in the interests of popularization' (Lithgow, 2015, p. 59). This represents a difficult conundrum as the language to achieve scientific recognition is very different to that which engages the general public. It is recognised that the use of social media has the power to engage communities locally and internationally (Bell, 2015, p. 21), but the skills required are specialist. It could not be assumed that these skills would be present in the conservation science community and seeking external expertise is required (Corbeil, 2015, p. 35).

Bell (2015, p. 21) identifies a broad spectrum of end users and a need to understand their interests to enable impact. There is a vision expressed that the field of Heritage Science as a whole should take place locally, regionally and globally and therefore sit within a wider cultural framework. She then identifies a need to encourage active engagement between researchers and the public which builds local support and demonstrates benefit to society. (Bell, 2015, pp. 20-21).

1.4 Conclusions

This body of literature suggests that Heritage Science as a field is extending the hand of engagement and cooperation with heritage organisations on all levels, academically and societally. By combining conservation science with other heritage related scientific disciplines under the banner of Heritage Science it is suggested that a critical mass could be created that would have the potential to influence political thinking and public opinion and access funding. Understanding the interests of the broad spectrum of end users will be critical in bringing this engagement about. However, the spectrum is very broad, and the variety of languages required to reach either end of it are very different. The creation of local hubs to embed heritage science locally is challenging, not least financially, and the pragmatic solutions to disseminate locally, regionally and globally are yet to be fully developed.

The heritage fields described in this chapter have an interconnectivity centred around objects and places which operate within our society as heritage. They share a concern for how objects and places are experienced and how the public engages with them. They are concerned with their positions in both a political and social context and aware that they have to promote their agendas with politicians, funders and the public through communicating their worth both financially and socially. However, their playing fields are not level and the sector is essentially divided; as Williams (2009c, p. 29) has pointed out, those ‘large’ establishments with facility and agency have more resilience in meeting the challenges of profile, funding and staffing. As previously proposed ‘largeness’ is not the defining issue but scientific research enablement. This research is focused on heritage science investigation within the N-SREO environment. For those organisations without scientific research enablement another institution would need to enable it. In the case of this research that is a Higher Education Institution (HEI).

The Research Excellence Framework (REF) first came into existence in 2014 and made the UK’s HEIs accountable for the extent to which their research activities create output and impact beyond academia. Additionally, the new developments within higher education to create a Knowledge Exchange Framework (KEF) will start to focus HEIs’ attention on how their research

creates relevant outputs for their collaborators outside academia. For those HEIs with heritage research interest this brings an invigorated player to the field. One with research capability, an academic understanding of the theoretical and philosophical aspects of heritage as well as pragmatic application. It is also one with a desire to seek funding and critically, a new imperative to seek public engagement and relevance for their research. This thesis presents film and 3D animation as a vehicle for analytical heritage science to reach an audience. Not only that but these organisations are strategically placed throughout the UK, enabling them to work at a local level. Williams (2009b, p. 31) claimed that museums were *encouraging* research from universities. As to whether that assertion is still the case will be challenged, but the potential for co-productive relationships between HEIs and heritage organisations and museums is apparent. However, in the context of heritage science, translating an analytically driven investigation with its well-established relationship with hypothesis, into an interpretive product presents challenges. In an interpretation context the audience engages in meaning making processes where the relationship between objects and facts is not linear. An understanding of the interface between these two positions of analytical and interpretive is key to the aims of this research. In the next chapter I would like to expand on the socio-political environment that the commentators in this chapter are seeking to influence and in which an HEI based heritage science investigation in an N-SREO museum would be set. In doing so I would like to map out some of the issues and challenges that face both museum and heritage science investigator.

Chapter 2: A Socio-Political Environment for the Research

Chapter 1 discusses how heritage science has identified within its literature a need to heighten its socio-political profile. Within this it sees advantage in terms of political and public profile and enhanced funding opportunity. The interaction between heritage science and external partners outside its field is just beginning to appear in the literature. (Bell *et al.*, 2014; Dillon *et al.*, 2014; Katratazis *et al.*, 2018; Curran and Zimmermann, 2021). This chapter, through literature review, seeks to create a backdrop for the socio-political and funding environment that heritage science needs to operate within. It maps a socio-political landscape and positions the research within it. The research presented in this thesis has a focus. It is that of the N-SREO museum employing heritage science from an HEI to create an interpretive product, which is of relevance to the N-SREO. The potential here is to serve heritage science's identified desire to enhance its socio-political profile. In return analytical investigation in the N-SREO environment could bring an enhancement of the interpretation offer for the N-SREO museum and potentially a greater level of analytical investigation to a larger section of our national collection.

Within an SREO, heritage science is embedded within the institution and dedicated to pursuing that organisation's scientific research agenda. In this scenario heritage science may manifest in its component parts of conservation science, technical art history and archaeological science etc. However, heritage scientists are also active within the academic environment with a small number of universities harbouring dedicated teams of researchers with specific heritage specialisms (Markham *et al.*, 2019, p. 41). Within the N-SREO environment the application of methodologies of public engagement through interpretation is a central feature of museums/heritage organisations. The presence of conservation however, would be variable, some institutions having conservation teams through to others who have no internal conservation provision and are entirely reliant on external contractors. By my definition of an N-SREO, heritage science provision would be absent and would have to be brought in externally. It is this N-SREO/ HEI based heritage science interaction that the research presented in this thesis seeks to observe from first-hand experience. For this reason, this literature review encompasses literature which gives some dimension to what commentary is available in understanding this relationship. The chapter attempts to correlate the literature assembled here; this correlation is not pre-existing in the literature, yet the case study experience that will be presented later in this thesis would suggest it is interrelated. A review of this literature assists the reader in contextualising the description of the case study in later chapters.

2.1 Museum and University Partnership: Who Interacts and How?

Museum and university partnership is highly advantageous to both stakeholders, with many pedagogical advantages and a case for success in this area is made (Boddington, Boys and Speight, 2013; Humphreys, 2015; Nottingham Trent University, 2020). For the purposes of this resume, I would like to focus on the debate around the analysis of four recent reports specifically focused on the pragmatics of the interaction of museums and universities. Three of them were published by the National Co-ordinating Centre for Public Engagement (NCCPE) (2018). The fourth report, Markham *et al* (2019), revisits and updates the NCCPE publications. This focus on four reports is for two reasons. Firstly, the reports themselves are literature reviews which correlate the broader landscape of literature in this area. The second is the significance of the NCCPE themselves. Three of the NCCPE reports were co-authored and published by the NCCPE and Share Academy (University College London, 2019), Share Academy having carried out a body of research into museum and university partnerships within the London area as a precursor to these reports. The Museum University Partnership Initiative (MUPI) was the result of this collaboration. The body of the reporting cited here was published from their pilot study. Since 2016 the NCCPE focused on the production of practical guides and tools for museum and university partnership. However, significantly they have subsequently authored the metrics to assess the first iteration of the Knowledge Exchange Framework (KEF) currently being developed by UKRI (UK Research and Innovation) (UKRI: Research England, 2020). The metrics the NCCPE have contributed are focused on public and community engagement and within that there is an identified focus on museums and galleries (ibid 2020, p. 8) . The fourth report (Markham *et al.*, 2019) was commissioned from Newcastle University by Heritage 2020 (The Heritage Alliance, 2016)[4] whose stated aim was to "...build stronger bridges between the heritage and higher education sectors." (Markham *et al.*, 2019, p. 3). The Markham report revisits the NCCPE/Share Academy research though a selective survey of 100 Research Excellence Framework (REF) impact case studies that reference heritage along with nine qualitative interviews (ibid, p. 8). The three MUPI reports (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; National Co-ordinating Centre for Public Engagement, 2016) form the reporting for the MUPI project and state:

> "The project aims to maximise the potential for museums and universities to work together to mutually beneficial aims. It explores how the Higher Education sector can be opened up to smaller and medium sized museums whose unique collections and engagement expertise are often an underutilised resource that could benefit academics,

[4] This report was co-funded buy Newcastle University and AHRC.

> teaching staff, and students within the Higher Education sector, whilst adding value to the work of the museums involved and contributing to their long-term resilience."
>
> (National Co-ordinating Centre for Public Engagement, 2016, p. 2)

The NCCPE authored report titled *Museum-university Partnership in REF Impact Case Studies* (2016) is a REF impact case study of considerably greater range than that of Markham et al. By coding across 6,640 impact case studies, they found 879 which featured the word 'museum' or 'museums'. From this a subset of 300 was created that formed the data for their analysis (ibid, p. 4). The second report authored by Dent and Wilcox (2016) synthesised pre-existing Share Academy and NCCPE knowledge and background research and referred this to 5 case studies from organisations identified as "researching, facilitating or advocating for collaborative activities between universities and museums in England" (ibid, p. 2). The final report by Bonacchi and Wilcox (2016) refers directly to an analysis of "…a pilot study involving a literature review, a survey and in-depth qualitative interviews." (ibid, p. 1). By cross referencing these four reports and other relevant literature a socio-political context, in which the research in this thesis is positioned, could be formed.

One of the common themes within these reports is that of the type of museums and universities that engage in partnership. Two of the four reports (Bonacchi and Willcocks, 2016, p. 2; National Co-ordinating Centre for Public Engagement, 2016, p. 7) pass comment that it was 'national' museums that predominated in university partnerships in their surveys. The NCCPE report (2016, pp. 7, 21) then goes on to conclude that 'national' and 'international' museums were the most likely to engage with universities, with 'smaller' museums being heavily under-represented and almost never initiating contact or collaboration. What they were also definitive about is that their REF impact survey was dominated by Russell Group universities. Markham et al (2019, p. 34) also notes a strong representation of the Russell Group universities, although they are keen to point out that this is not the 'full story' and so note an improvement in the range of universities involved in partnership. These museum categories of national, international, small and large would not have a direct alignment with my working definitions of SREO and N-SREO. However, this would indicate that, traditionally at least, partnership working between museum and university has been predominated by the most prestigious universities and 'large' nationals and internationals, these museums being far more likely to have research capacity. This trend appears to be breaking down now with more universities and museums outside these categories now entering into museum and university partnerships with a growing level of confidence (ibid 2019, p. 34). This does help position this research. Investigating how N-SREO might better employ HEI based heritage science engagement in partnership, indicates something of this research's potential to contribute to that trend.

Another common observation from this literature is one of cultural difference between the institutions of museum and university (Speight, Boddington and Boys, 2013; Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; Markham *et al.*, 2019). Bonacchi & Wilcox (2016, p. 14) couch this in terms of a misalignment of mission with "…different planning horizons, objectives and seasonality, budget constraints, language and ways of communicating". Even their national governance comes from different governmental departments (Speight, Boddington and Boys, 2013, p. 12). Additionally, language such as the words 'research' and 'impact' is cited has having varying meanings within the different institutions (Dawson and Gilmore, 2009, p. 12; Bonacchi and Willcocks, 2016, p. 23; Markham *et al.*, 2019, p. 40; Curran and Zimmermann, 2021). Curran and Zimmerman (2021) highlight the role that heritage scientists could play as 'conscious arbitrators' in the language they use in interdisciplinary research with other heritage professionals. Markham et al (2019, p. 38) highlight timescales as an element of cultural difference with commentators from their qualitative interviews stating that museum projects are funded for a maximum of three years at a time, with academics often requiring longer timescales. Obviously, this refers to large, funded projects rather than the smaller interactions generated by memoranda of understanding. Bonacchi & Wilcox (2016, p. 14) also comment on how museums don't always realise the potential they have to resource and enable research (Also see Dawson and Gilmore, 2009, p. 11). I suggest that the research presented in this thesis focuses on the potential for N-SREO museums to see that analytical research into their collection has a public engagement and interpretation potential, and if presented in terms relevant to the museum, can engage with their public in a meaningful way. Bonacchi & Wilcox (2016) also point out that administratively and structurally these organisations differ, giving different levels of flexibility. Museums do not always appreciate how complex university administration is (ibid, p. 14). They are also observed as 'mystified' by academia and don't know how to access it (Markham *et al.*, 2019, p. 39; Nottingham Trent University, 2020, p. 11). The existence of specialist heritage and heritage science groups such as ISAAC lab could provide a point of contact for museums to engage with a university[5]. On the other side universities are observed as not always understanding the precarious economic state of some museums. Universities were perceived as wealthier and less exposed to economic cuts (Dawson and Gilmore, 2009, p. 10; Bonacchi and Willcocks, 2016, pp. 14,23), and can have unrealistic expectations of, and not be fully conversant with, the workings of a museum (Dawson and Gilmore, 2009, p. 12; Markham *et al.*, 2019, p. 39). The focusing of projects was perceived as being much easier for academics than for curators who were often asked to fulfil multiple roles within their organisations. The role of co-researcher was commented on as being occluded by research journals being hidden behind pay walls and not accessible to the

[5] The Museum and University Partnership Initiative (MUPI), post publication of its reports, provided seed corn funding to actively encourage such contact.

museum (Bonacchi and Willcocks, 2016, pp. 14, 23). Again, heritage specialism within universities and open access publishing is a way of developing these empathies.

Motivations for partnerships between museums and universities were noted as being heterogeneous. Museums were seen to express a desire to open up access to large areas of their collection for interpretation with academics more interested in "thematically narrower and more focused research interest" (Bonacchi and Willcocks, 2016, p. 12). The approach of the research presented within this thesis has a contribution to make in this area. It seeks to demonstrate how this focused research interest can be harnessed to answer to a broader interpretation agenda. What these reports present is a museum-centric view of their perception of academia. The research presented in this thesis enables a first-hand description of an actual interaction of a more granular nature.

Many academics were observed as entering the partnership with the museum at the dissemination stage of their research seeking a public venue for the research via exhibition (National Co-ordinating Centre for Public Engagement, 2016, pp. 6, 10). The most frequent role being played by museum staff was to support academics in sharing their research through the museum as a public facing organisation (ibid. p. 6). Interestingly Markham et al (2019, p. 36) cited interviewed organisations as expressing "…a slight frustration at the idea of being regarded purely as research disseminators…" Markham et al (2019, pp. 35, 40) comment further on the historic feature of universities approaching heritage organisations late in the dissemination stage of a research project. They state:

> "We do not consider this as necessarily bad practice per se and there are probably always circumstances when this might happen (e.g. in responding to short window funding calls), but, on the one hand, it is evident that this sometimes *is poor practice*, with sector partners perceived as purely a resource to be mined by university researchers. On the other hand, we detect an encouraging shift of collaboration to more upstream, co-produced projects."
>
> (Markham *et al.*, 2019, p. 40 my emphasis)

The description of the early part of the case study in Chapter 6 will further discuss how ensuring that the requirements of an effective analytical investigation were met, meant the Museum had to play a supporting role in facilitating that investigation. However, as Chapters 7 and 8 will explore, the drive towards an interpretive product in communicating the analytical outcomes was informed by a brief defined by the Museum. This proposes that an understanding of the Museum's need was identified and met (Nottingham Trent University, 2020, p. 11). By being sufficiently 'upstream' and developing the analytical investigations over a period of three years,

co-ordinating the Museum-focused outcomes for the reopening of the Museum, a symbiotic relationship for both stakeholders is proposed.

Markham *et al* (2019) make some interesting observations as to the capacity for museums with IRO status to engage with research activity in partnership with universities. Although not specifically looking at scientific research, they comment on how museums with IRO status have the capacity to operate as principal and co-investigators on research themes and therefore take advantage of "…research benefits as they develop, rather than post-hoc." (ibid, p. 38). This does have a degree of alignment with my working definitions of SREO and N-SREO. I would push this further and say that an IRO was constitutionally mandated to pursue those research benefits. In a scientific context this could mean that they would have capacity to develop scientific research questions and have identified benefit in having them answered.

A feature of cultural difference that is reflected in this group of reports is expressed in terms of 'power imbalance' (Bonacchi and Willcocks, 2016, p. 30; Dent and Willcocks, 2016, p. 20). This phenomenon is identified in this literature as rooted in the funding structures that drive these partnerships. The funding structures directed at museums and universities have not been connected or aligned (Speight, Boddington and Boys, 2013, p. 12). A particular feature of museums that are outside of IRO status is that they cannot bid to the Research Councils for money directly to conduct their own research programmes. For this reason, the commentators point out that the financial flow is via a collaborating university. The university, as has already been stated, will often be the initiator of the collaboration. The difficulty then is that it is a university initiated project, the university will often drive the research agenda (Dawson and Gilmore, 2009, p. 11) and the university controls the funding of it (Bonacchi and Willcocks, 2016, p. 9) hence generating power imbalance. The solution here is seen as the creation of new funding streams:

> "National institutions seem to be playing a bigger role and to be preferred by universities that want to connect with their regional constituencies. This situation, together with the less privileged position of national authority and independent museums in accessing funding, creates strong power imbalances which could be corrected with the design of dedicated funding schemes for research and public engagement that can be accessed by both HEIs and museums."
>
> (Bonacchi and Willcocks, 2016, p. 30)

UKRI's recently published vision for public engagement declares a direct commitment to fostering public engagement (AHRC, 2018a, pp. 4–5). However, if channelled through universities or IROs this may not alleviate the power imbalance issue. However, what the reports don't appear to take

into account is that this is particular to research that is conducted through these funding streams. It does not account for more fluid interactions that might occur through memorandum of understanding agreements or through more pedagogical activities such as supporting PhD research. As will be discussed later, recent changes in UKRI funding strategy could also begin to level this playing field.

By looking at the suite of reports as a whole, another observation is apparent. The two reports that deal with this phenomenon of power imbalance directly, both draw data derived from the heritage organisations themselves (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016). The NCCPE (2016) REF impact case study does not pass comment on the issue. Markham *et al*. (2019), again a report focused on REF impact, does not report on any power imbalance but does reflect on potential bad practice where the HEI employs the museum as a research resource. However, the source of this information is their nine qualitative interviews. It is also worth pointing out that power imbalance is not universally observed in those studies that do seek the perspective of heritage organisations. Dawson and Gilmore's (2009) study of established collaborations between HEIs and museums, galleries and visual arts organisations in the North West, does not make any specific reference to power imbalance. I would argue from this that any 'power imbalance' is a phenomenon that is experienced within the museum sector and an awareness of it is limited in HEIs. Further to this, in interview, Dr Rebecca Bridgeman[6] (2019) from *Birmingham Museums Trust* states that other funding streams are available to museums which could be used to fund research. Additionally, again in interview, Scott Furlong, *Director of Collections and Cultural Property* and Isabel Wilson, *Senior Manager Museum Development* both of *Arts Council England (ACE)* felt that an analytical investigation that generated interpretation and public engagement potential could be considered for funding under the ACE funding structures available to museums. The key issue with regards to the research presented in this thesis is the link to interpretation and public engagement that is generated from the heritage science starting point. This raises the possibility of enabling access to a more expansive range of funding structures. By conducting the heritage science investigation 'upstream' and ensuring that an interpretive product relevant to the museum's need is proposed, any actual power imbalance could be negated. However, the indicators that it is perceived within the museum sector means that it should not be ignored.

There are observations within this literature of disparity in type of museum that predominates in museum and university partnerships, cultural differences in how museums and universities interact and perceptions of power imbalance. This generates a description of an environment where HEI based heritage science/N-SREO interactions take place. However, the most pertinent is

[6] As discussed in Chapter 8 Bridgeman also cites personal experience of the poor practice highlighted by Markham.

the observation that a REF impact study, surveying an initial sample of over 6,000 case studies, found scientific investigation in museum and university partnerships to be a very rare event. When the NCCPE (2016) analysed their sub sample they divided them into four panels: Panel A, Medical Sciences and Health; Panel B, Physical Sciences and Engineering; Panel C, Social Sciences; and Panel D, Arts and Humanities. It was Arts and Humanities that dominated the sample (39.5%). Physical Sciences represented only 5.2% of the REF impact studies analysed. On closer analysis of the Arts and Humanities panel it was seen that art and design, English and history were notably stronger responses than the other Arts and Humanities subjects (National Co-ordinating Centre for Public Engagement, 2016, p. 4). This quantifies a phenomenon that is not particularly surprising. One might argue that the majority of museums would view themselves as broadly arts and humanities organisations. This is certainly reflected in current ACE funding for museums. However, Markham *et al.* (2019, p. 42) also note a concentration of cases across the arts and humanities and alert to what they refer to as 'cold spots' in their REF impact study which include the physical sciences. They comment that this was against expectation with the prominence of the Science and Heritage Programme (AHRC and EPSRC, 2009) but felt this would be addressed in the AHRC's heritage strategy (AHRC, 2018a, pp. 4–5). I will discuss this issue a little further later in this chapter as I look at the funding landscape, as it does have implications for the predominance of IRO and Russell Group interactions.

The affiliation between art and design, English, history and the museum, is again not particularly surprising. One might consider history to be the core interest of the museum and both art and design and English, in a museum context, would both produce public facing outputs, for example: artworks; exhibitions; productions; poetry performance and related workshops. One might consider how the outcome of scientific analysis has a greater disparity with this type of public engagement. NCCPE (2016,) REF impact study noted from their case studies that exhibition was frequently a driver for museum-university partnerships (National Co-ordinating Centre for Public Engagement, 2016, p. 12). With regards to assessment of impact[7] and benefit, outreach and visitor experience were notably strong responses (ibid, pp. 14-15) and within an analysis of measurable impact (e.g. visitor numbers), collectively those constituting visitor interactions were the most common (ibid, p. 16). Engaging audiences was also identified as the primary academic benefit to museum-university collaborations enabling dissemination of research. It is proposed by the research in this thesis that the creation of interpretive product from a heritage science starting point has the potential to define the value of such an investigation for the N-SREO

[7] It should be pointed out that term 'impact' has been defined in museum terms within this report. It is not the specific definition given to the term within REF assessment.

environment. It asks the question: could this be influential in seeing a greater presence of analytical investigation within museum and university partnerships?

To inform an understanding of how such an analytical investigation may succeed, the NCCPE (2016) REF impact study identified four main ways that museum staff contribute to research collaborations (ibid, pp. 19-20): 'Sharing' – where museum staff support academic dissemination; 'Applying' – ensuring that academic research feeds into their own practice; 'Consulting/Informing' – here the expertise/knowledge of museum staff feeds into the academic research and skill set; and finally 'Creating' - where museum staff are joint partners actively involved in the process of the creation of new knowledge as well as products and resources of dissemination. These were coded within the data set and by far sharing was predominant with the other contributions evenly distributed at a much lower level. To what extent the above may inform any metrics from the NCCPE to assess public and community engagement with respect to museums and galleries for the Knowledge Exchange Framework (KEF) is under consideration (UKRI: Research England, 2020, p. 8). It does, however, appear to quantify the level of knowledge exchange that has taken place. In Chapter 5 The SREO and N-SREO environments will be given voice as to their experience of these interactions. At this stage I suggest that an upstream project, developed from the outset alongside the museum, which employs heritage science to create new knowledge, and then generates from this an interpretive product that is designed to be relevant to the museum application, would have the potential for more than 'sharing'.

2.2 The Rigour-relevance Gap

> "Rigour and excellence has always been – and will continue to be – a priority for researchers in academia. Yet relevance comes from addressing the bigger questions – those that reflect the needs and hopes of people, questions that promote shared stewardship [of heritage] and put the research to work for the benefit of the end user."
>
> (M Cazar as cited in Katratazis *et al.*, 2018, p. 2)

The previous section discussed aspects of museum and university partnership as reflected in a body of literature focused on the pragmatic interface between these two organisations. Although undoubtedly a positive and beneficial activity for both partners, it did analyse some of the more challenging aspects. It highlighted a propensity for Russell Group universities and research enabled IRO museums to be the main collaborators in these partnerships. It identified a cultural difference that existed between museums and universities with regards to the working methodologies and outcomes. Finally, it points out that the presence of material science within museum and university partnerships is very small.

The forthcoming description of the research in this thesis will describe the interaction of a museum and a university in a research project of mutual benefit. In order to explore the differing positionalities of these organisations a little further, I would like to refer to peer reviewed research surrounding the phenomenon that has been referred to as the 'rigour-relevance gap'. The phenomenon grows in significance within critical debate in management studies in the late 1980s and into the 1990s. It describes a tension that exists between the rigour that is required for successful scientific research, which produces a research output that does not effectively communicate to those who might apply it in practice. What Kieser and Leiner (2009, p. 517) refer to as 'lost in translation'. Some debate exists as to the degree to which this phenomenon manifests and how bridgeable it is (Fincham and Clark, 2009; Hodgkinson and Rousseau, 2009; Kieser and Leiner, 2009). Martensson and Martensson (2007, p. 1331) suggest that all 'good' research should be 'credible, contributory and communicable'. Outside management studies, the basic concept of a distance between a pure research starting point and the practical application appears in a medical context. The initial concept was one of 'bench to bedside' where a frustration was expressed in the last decades of the 20th Century when spending drastically increased in medical science yet its translation into improved health outcomes was very slow to be realised (Davidson, 2011, p. 909). This formed the original meaning of what is now termed 'translational research' which encompasses '…the problem of translating research into practice…'(ibid 2011, p. 909). Kieser and Leiner's (2009) argument is that this rigour-relevance gap is unbridgeable. This is not just because the language that is used in both science and business management are different, but they actually belong to different systems. They state that "…[f]rom a system theory perspective, social systems are self-referential or autopoietic, which means that communication elements of one system, such as science, cannot be authentically integrated into communication of other systems, such as the system of a business organization." (ibid 2009, p. 516). For this reason Kieser and Leiner claim that an attempt to do this will result in the science results being 'lost *in* and *before* translation' due to their inappropriacy for application (ibid 2009, p. 517). Within the field of management research, the debate becomes centred around opposing this view. Hodgkinson and Rousseau (2009, pp. 534–535) claim Kieser and Leiner's analysis to be false, citing a number of researcher/practitioner collaborations. They acknowledge a gap between research and practice but describe this as "a challenge that many of us prefer to rise to, not reject." (Ibid 2009, p. 535). The 'two system' dichotomy is also seen by Fincham and Clark (2009, p. 512) as an advantage in that universities can focus on the production of new knowledge and free critical thinking outside the restraints of commercial or business requirements. However, they provide solutions for the 'lost in' and 'lost before' barriers in the form of publications and outlets attractive to, and accessible by practitioners, along with better collaborative practices at key stages of the research process (ibid 2009, p. 510). Martensson and Martensson (2007, p.

1328) point out that to increase the relevance of research one needs to add the questions “why?” and “for whom?” to the research base of “what?” and “how?”. The argument that develops does not deny the existence of a rigour-relevance gap but simply acknowledges its presence and espouses strategies to bridge it. The key issue is how far apart are the research outcome and the practical application (Fincham and Clark, 2009, p. 511; Kieser and Leiner, 2009, p. 523) . To put this in the context of the research presented in this thesis, this would be influenced by the difference between SREO and N-SREO. In their context Kieser and Leiner (2009, p. 528) suggest that fruitful exchange between researchers and practitioners can take place as long as research is not the intended output. They precondition this with the need for “…bilingual and ‘bi-competent’ facilitators…” who can “…transmit implications of scientific analysis for practical problems…”. What is also notable is that Kieser and Leiner point out that collaboration can be achieved when it produces separate outputs for the research and practice systems (ibid 2009, p. 525). Although the research that will be presented in this thesis will challenge Kieser and Leiner’s basic claim that the rigour-relevance gap is unbridgeable, the bridge building process, as will be described in practice in this thesis, would support many of Kieser and Leiner’s observations. The analytical and the museum interpretation aspects of this research will manifest as separate systems and although the analytical content will not be lost, it will be seen to have to be translated and my role in this research will increasingly identify as the ‘bilingual’ and ‘bi-competent’ facilitator. A more detailed critique of how, will be described in Chapter 8.

The rigour-relevance gap has just begun to enter the field of heritage science as an issue in relationships between heritage scientists and non-specialist end users (Bell et al. 2014; Dillon et al. 2014). It forms part of a very niche area of research which is beginning to explore, in practical terms, the interface between heritage science and the organisations it works with and for (Katratazis *et al.*, 2018; Curran and Zimmermann, 2021). This is essentially in response to the literature described in Chapter 1, identifying the need for heritage science to raise its socio-political profile. However, the approach to date has relied heavily on statistical analysis and observation from pre-existing completed projects. The research presented in this thesis offers an opportunity to seek the rigour-relevance gap in the creation of an interpretive product from a heritage science starting point and observe its manifestation in practice.

The museum, as an interface with the public, is an obvious conduit to communicate heritage science issues and the museum and university partnerships and collaborations offer a means by which this could be achieved. The literature dealing with the phenomenon of rigour-relevance, specifically in the context of heritage science, is not extensive. Dillon *et al.* (2014) titled their paper ‘*Mind the Gap: rigour and relevance in collaborative heritage science research*’. Dillon *et al* is a technical paper describing the methodology of analysing a quantitative attitudes questionnaire distributed amongst the heritage science community. Alongside the Dillon *et al*

paper a parallel report by the same name was also published by the AHRC under the auspices of the Science and Heritage Programme (Bell *et al.*, 2014). This is in fact from the same authorship and describes the same body of research. However, the Bell *et al* report is designed to encapsulate the main findings of the Dillon *et al* paper but be accessible to a broader field of heritage professionals, hence aiding dissemination.

Dillon *et al* summarised how their 210 respondents were approached:

> "They were asked about their personal goals in relation to the project and whether these were achieved, satisfaction levels in relation to project outcomes and impact, level of agreement with a series of attitude statements to ascertain what helped and hindered projects, personal characteristics and project characteristics. The questionnaire was analysed using a factor analytic, segmentation and profiling approach."
>
> (Dillon *et al.*, 2014, p. 1)

A separate paper, 'Enhancing Research Impact in Heritage Conservation' (Katratazis *et al.*, 2018) shares an author in Cath Dillon. This paper is focused on developing a pathway to 'Impact' within heritage conservation and is focused on a conservation science role in enhancing it. However, it does have some resonance with the rigour-relevance gap concept and the interaction between heritage science and a museum.

Overall the findings from the authors of the Dillon paper and the Bell report paint a positive picture of interaction between heritage science 'researchers' and what are termed 'users,' "who use research evidence in practice" (Bell *et al.*, 2014, p. 2). What the authors of both paper and report are attempting to do is to see heritage science researchers and the resultant research outcomes as an output. Then, through statistical analysis, assess these outcomes for efficacy within those organisations that are employing that research in practice. They concluded that a rigour-relevance gap did exist. Although not profound, it was considered statistically significant. Dillon *et al.* (2014) cite four key pieces of evidence for this. They noted that "most respondents were satisfied that the aims of their project were achieved…they were less satisfied that the impact of the project would be realised." Secondly, they noted that "practice-focussed goals…were associated with lower self-rated achievement than academic goals." They then went on to observe that certain types of practice-focused goals, namely management goals, were not widely held within their survey cohort. Their final piece of evidence was that "a sizeable minority of respondents reported that they had encountered challenges in collaboration or were shown to be less interested or skilled in collaboration than other respondents" (ibid, p. 19). In addition to these four key evidences they offered an overview:

> "Users had higher expectations than academic researchers that research would improve practice, but gave lower achievement ratings for their goals than academic researchers, were less satisfied with the outcomes of collaborative research and gave lower ratings of research quality."
>
> (Dillon *et al.*, 2014, p. 19)

Although the conclusion is that a rigour-relevance gap is manifest between researchers and users, the analysis indicated that many respondents sought both rigour and relevance in their responses to the survey and it was felt that this could be due to many of these respondents having dual roles as both researcher and user.

Essentially, the research described above tries to reach an understanding of interactions of organisations and individuals of potential cultural difference (Bell *et al.*, 2014, p. 20). It speaks in terms of 'goals' as 'practice focused' or 'academic' and attempts to assess 'achievement ratings'. It then muddies the water by explaining that many of the respondents have dual roles of both researcher and user. One might consider how this combination of paper and report actually enable one to understand the nature of rigour-relevance in practice and how one might negotiate it. However, the research is peer reviewed and the source and authors credible; the research was supported by AHRC via the Science and Heritage Programme. The conclusion of both paper and report is that a rigour-relevance gap is identified, and the concept of rigour-relevance has already been established within the academy outside the field of heritage science. The research presented in this thesis is positioned to revisit the concept of a rigour-relevance gap with a very different methodology. By seeking to observe its manifestation in practice a more granular understanding of its nature could be deduced.

Katratazis *et al.* (2018) is another contributor to the niche area of heritage science's interface with user organisations. They look specifically to evaluate how research impact is defined, measured and generated within the context of heritage conservation. Statistical analysis from the literature is augmented by interview material with relevant professionals to form the research methodology. Within the literature they searched for co-authorship and took note of the nature of the organisations that were co-authoring. Their observations focused on different types or 'mandate' of organisation and noted differences including those of a non-academic mandate. They observed that co-authorship between institutions of different mandate has risen, yet still only represents the smaller proportion incidences of co-authorship, with three out of five being institutes of similar mandate. They conclude; "This indicates that although inter-institutional collaborative publishing is increasing, proportionally the participation of non-academic partners is not." (ibid, p. 6). They go on to observe "…this illustrates an output focused evaluation system

with limited formal connection to the research beneficiaries." (ibid, p.8). Katratazis *et al.* (2018) propose the following:

> "…reappraisal of the true goals of research: moving from an emphasis on academic impact achieved through publications towards a non-academic impact achieved through working closely with research beneficiaries. This can only be realised through the active contribution of individuals who are prepared to step out of established ways of working, devote time and energy to building creative partnerships outside academia, and take risks." (ibid, pp. 13–14).

They go on to suggest that diversity of engaged partners and the quality of knowledge exchange should have parity with journal impact factors and citation counts. Again, the research is conducted post-hoc of any observable projects or case studies and reliant on statistical analysis. The research presented in this thesis enables a first-hand account of an example of how knowledge exchange occurs in an N-SREO/heritage science interrelationship. The KEF initiative is gaining momentum and crystallising how it will operate within the HEI environment. It would indicate at this early stage that the metrics for knowledge exchange begin to move the focus of heritage science investigations in non-academic environments to the efficacy of knowledge exchange itself, rather than a peer reviewed quality assessment of the research through publication. This PhD research seeks to formulate a theoretical proposition that heritage science investigation can effectively deliver a contribution to the core mission of the N-SREO museum of interpretation and public engagement. This theoretical proposition could represent a contribution to the small but developing area of research exploring heritage science's outreach and be contributory to developing an understanding of its capacity for knowledge exchange in the heritage environment.

The implications of bridging the rigour-relevance gap and bringing organisations together in creative partnerships have resonance with the body of literature around museum and university partnerships in managing any perceived power imbalance and negotiating cultural differences between organisations. Bell *et al.* (2014) and Dillon *et al.* (2014) were written before the MUPI publications yet Katratazis *et al.* (2018) postdates this literature by two years, yet no connection seems to have been made with the MUPI literature. Similarly, Markham *et al* (2019) makes no reference to Bell *et al.* (2014), Dillon *et al.* (2014) or Katratazis *et al.* (2018). Both bodies of research seek to understand a disparity between the academic research culture and that of non-academia, yet do not appear to cross relate with each other. This disparity has been expressed in terms of rigour and relevance or assessment of research outputs, cultural differences or power imbalances. By seeking to correlate these bodies of research together for the first time in this thesis, a broader and more informed picture could develop. This answers to Dawson and

Gilmore's (2009) critique that "these differences are not explored and better understood by the partners" (ibid, p. 13).

As we look back over this body of literature, we find the commentators identifying misalignments of goals and outputs and identifying cultural differences and being mindful of power imbalances. There is also a lack of cross reference across this literature. The theoretical proposition encapsulated in this thesis seeks to bridge the rigour-relevance gap. It seeks to acknowledge the cultural differences and allow both stakeholders to arrive at outputs natural to their working methodology. It seeks to enable the agency of the scientists to create the conditions for good analytical investigation. In return it looks to meet the need of the museum for the final output of an interpretive product for public engagement and interpretation. The theoretical proposition could be viewed as an investigation in translational research which has the potential to generate knowledge exchange.

2.3 The Socio-Political Climate

In the last two years an intensity has grown around the significance of heritage to the nation's socio-economic health. This is a move away from the austerity agenda of earlier years and relevant to heritage science's stated desire to heighten its political profile. The DCMS report Culture is Digital (2018a) was presented as a "call to action" (ibid, p. 17):

> "Here, we propose an approach to support the whole digital culture ecology: our audience is both the world-leading and the small, voluntary led organisations in communities; technology companies ranging from start-ups and scale-ups to large and multinational tech companies; those working at the cutting edge of technology development and those using more basic digital tools. We encourage cultural and tech sector organisations to support the proposals set out here and work together to unlock the opportunities for Digital Culture."
>
> (DCMS, 2018a, p. 17)

The implication from this report is that cultural heritage, as embedded in the cultural landscape, would be encouraged and potentially funded to develop its digital offer. Within this is a strong theme of the employment of new media and digital output. The report describes 'us', as "…no longer passive receivers of culture", (ibid, p. 9). It describes how "[t]echnology can also allow for a more meaningful or deeper relationship with audiences, including more interactivity, with users able to curate their own experiences and generate their own content." (ibid, p. 18). Throughout the report there is a strong theme for the development of audience engagement and diversity

and the enhancement of digital maturity within cultural organisations (DCMS, 2018a, pp. 9–10, 2018b, pp. 15–16). An exemplar illustration given is that of the Natural History Museum who reach more people in a month through the use of social media platforms than physical visits in a year (DCMS, 2018a, p. 19). However, behind the altruistic desire to engage us all, lies a harder economic driver. The government sees a private sector input into the cultural sector from "…cultural and tech organisations of all sizes…" (DCMS, 2018a, p. 14). The concept that heritage, as embedded within culture and tourism, is a contributing economic driver is more apparent within the published Industrial Strategies namely the Tourism Sector Deal (HM Government, 2019) and the Creative Industries Sector Deal (HM Government, 2018). Directly relevant to the research presented within this thesis is the Creative Industries Sector Deal's creation of the Cultural Development Fund to benefit the creation of "…world-class creative clusters…" taking the form of "…local partnerships of businesses, museums and galleries, universities and local government…"(HM Government, 2018, p. 14).

Where does this leave analytical investigations in N-SREO museums? The above climate has reflected itself in the development of attitudes towards heritage-based research and in particular the funding of that research. In the context of heritage science, the National Heritage Science Forum (2019) (NHSF) published their Strategic Framework for Heritage Science in the UK 2018-2023 (National Heritage Science Forum, 2018). They identify in their vision that heritage "…will be enhanced by better use of science and technology for the benefit of society." (ibid, p. 2). Through this framework they envisage enabling the heritage science community to work together to realise a series of goals which include to "…articulate the value of heritage science to society and the economy." (ibid, p. 2). What is also notable is who the framework is for. They acknowledge that the core users will be the heritage sector; however, they also target "…opinion-formers, policy-makers, aligned sectors and partners as groups that the heritage sector will work with on delivery." (ibid, p. 2). NHSF assertions of the value of heritage science to society and the economy actually hark back to the original Williams reports (2009a, 2009b, 2009c) on which the formation of the NHSF is based. Around the same time (2009) the AHRC and EPSRC (Engineering and Physical Sciences Research Council) established the Science and Heritage Programme (AHRC and EPSRC, 2009). Within its programme framework it describes "…interdisciplinary collaborations among and beyond universities." (ibid, p. 5) and seeking to bring together:

> "…academic researchers and a wide range of individuals and organisations outside academia with an interest in the research and its outcomes, including but not limited to those in cultural heritage, museums, galleries, archives and libraries but also public policy and legal sectors, media, industry and commerce." (ibid, p. 6).

It is worth noting that it is stated further on in the document that the programme is designed to "…attract researchers and practitioners from a number of different types of *research* organisations." (ibid, p.7, my emphasis). What they qualify as a research organisation might be a matter of semantics, but ten years later Markham *et al* (2019) are still noting a heavy representation of IRO and Russell Group universities in museum and university partnerships. It would not be unreasonable for research councils to fund research establishments, but the overall effect could have been one of siloing this initiative within the SREO environment as Markham *et al* (2019) observed. They also note that despite that programme having a five-to-six-year tenure the presence of science within museum and university partnerships is proportionally very low. A recent initiative from IPERION HS offers the facility for heritage organisations to bid for high level heritage science analytical capacity and expertise in both fixed and mobile laboratory formats. This facility is free to successful applicants. However, it is accessed by competitive tender and the emphasis in the assessment criteria weighted towards 'scientific excellence', 'advancements of the field' and 'expertise of user group' (IPERION HS, 2021) would imply that an unsupported N-SREO would find it very difficult to submit a competitive application. This initiative, albeit a harbinger of research excellence in heritage science, will be focused in the SREO environment.

Recently, UK Research and Innovation (UKRI), who are the co-ordinating body across the research councils, published their report on the UK's research and innovation infrastructure (UK Research & Innovation, 2020). The report covers all research interests but devotes a chapter to the social sciences, arts and humanities sector. It highlights an awareness of the communicative aspect of heritage science investigation.

> "Heritage science infrastructures can act as bridges between the humanities and sciences by using scientific analysis and technological innovation to understand, manage and communicate the human story, expressed through landscape, buildings and artefacts."
>
> (UK Research & Innovation, 2020, p. 65)

Within one of the report's subthemes, focused on digital humanities, it highlights an interest in making digital artefact more accessible to users, the importance of digital reconstruction and visual modelling with a mind to "…the creation of more socially embedded and responsive technologies that are able to balance the needs of researchers, industry, the third sector and the public." (ibid, p. 77). For the interpretation of the relevance of the research presented in this thesis, this has broad scope, but it does position it with the potential to respond to the defined AHRC aims. Take note of the description of heritage science acting as a bridge between the humanities and sciences. This research takes as its focus the nature of that bridge and questions whether heritage science can build it on its own.

However, two more specific AHRC strategy documents focus this in a more heritage centred way. The AHRC's Heritage Strategic Priority Area Future Directions Update (2018a) celebrates the contribution of IROs funded by AHRC in the last 10 years. It recognises heritage science as a major new research field and the cross disciplinary nature of heritage research (ibid, p. 1-2). It acknowledges co-design and co-production with institutions and practitioners being part of 'heritage ecosystems' and growing opportunities for pathways to research impact and societal benefit (ibid, p. 2). As the document moves to lay out its future strategic objectives and framework, it highlights "strengthening cross-disciplinary links between the arts and humanities and the sciences." (ibid, p. 4). It seeks to widen collaboration beyond the IRO to other "…key organisations in the heritage sector and wider cultural ecosystem … ensuring that research agendas are informed by organisational and *user* need…" (ibid, pp. 4-5 my emphasis). In addition, enhancing community and public engagement is identified as a priority (ibid pp. 4-5). It goes on to ask some pertinent questions around community and public engagement such as: "[h]ow can academic research be better connected with public heritage activities…?" and "[h]ow can research most effectively inform the ways that collections and heritage are used in public settings so as to enable the most effective public dialogue, learning and knowledge exchange?". In addition to this the AHRC identifies a Science in Culture theme as a focus for research funding (AHRC, 2018c, 2018b). The theme's rubric cites "…[t]he public understanding of, and engagement with, science – in the sense of our ability to integrate the findings of the sciences within our overall worldview – is one in which the arts and humanities play an essential role." (AHRC, 2018b). It then goes on to pose some interesting questions for its funding applicants to ponder, for example "[w]hat roles do culture, imagination, argumentation, creativity, discovery and curiosity play in scientific enquiry?" In addition, highlighting the potential for research on "…the role of narrative, imagery, artefacts and cultural institutions (including museums and galleries) to inform ways of enhancing public engagement with science and technology." Much of what is suggested here is encapsulated in the recent project funding call from UKRI & AHRC titled Towards a National Collection: Opening UK Heritage to the World (2020). The call aims to develop methodologies to develop a digitally-based national collection which coordinates online collections and catalogues in numerous heritage collections for both the advancement of research and public engagement (ibid, p. 2). It clearly states that developing IRO and HEI partnership is on the agenda for this research (ibid, p. 2), and sees its public engagement agenda being met by "major research-driven public facing outputs…" (ibid, p. 3). Within the objectives of this project call is the requirement to have a stakeholder involvement from collections outside the IRO environment and beyond the metropolitan centres (ibid, p. 4). I argue that the research presented within this thesis is positioned within these objectives.

2.4 Conclusion

The last two chapters have mapped out a landscape into which the research presented in this thesis can be positioned. Chapter 1 described the nature of interpretation and the significance of meaning making as defined by museum studies. This is an essential understanding to the central remit of this research which is to create an interpretive product from a heritage science investigation. Within the field of heritage science, a move towards the development of a higher social and political profile for the field is being sought and is seen as advantageous. The political climate is currently conducive and sees economic gain in developing the approaches to public engagement in heritage through digital means as its way forward. This is reflected in UKRI and AHRC funding policy. However, this chapter identifies certain features of the landscape that have to be negotiated. This research assembles a theoretical proposition that the N-SREO sector can engage with heritage science investigation by enabling the investigation to create the interpretive product. Within the N-SREO sector both the analytical facility and ability would have to come in from a partnership with an HEI. Quite possibly the facility to create the interpretive product may also be resident within the HEI. For this reason, understanding the dynamic of museum and university partnership is a valid precursor to this interrelationship. How any partnership might manage, and even embrace, the cultural difference that exists between these organisations, and how any perceived power imbalance might be negated through the design of activity and output, are worthy considerations. This poses the question, what role does the theoretical proposition presented by this research play in assisting in managing this dynamic? A rigour-relevance gap has been identified, albeit tenuously, between heritage science and the users of its findings. The research presented in this thesis takes the principle of rigour-relevance in the context of heritage science working with an end user and seeks to observe it first-hand and understand its nature. As these observations unfold, the significance of the literature from outside the context of heritage will become apparent. Concepts such as the 'two systems' model, the bilingual/bi-competent facilitator and the systems being 'dynamic' rather than 'closed' will receive critical discussion. Both research on museum and university partnership and heritage science's interface with those who receive its findings are represented in the literature. Until now the connection between them has not been strong. The research presented in this thesis seeks a connectivity here and strives to enrich the understanding as to how they are interrelated.

Heritage science is still a rare participant in museum and university partnerships despite over ten years of focused funding to develop its influence. Could a greater understanding of the interface between the two be employed in the new round of funding strategy presented by UKRI and AHRC? From the description in the previous section one can see a close alignment with the research presented here and UKRI and AHRC funding aims, namely: the creation of heritage

ecosystems; cross-disciplinary links between arts, humanities and the sciences; research informed by user need; a public engagement agenda met by “major research-driven public facing outputs…” (UKRI and AHRC, 2020, p. 3). It could be argued that as answers to these funding calls are accepted these issues will be dealt with by application. What is unique about the research presented in this thesis is it seeks to gain a greater understanding of the process of how this is achieved. This will involve a more granular inspection of the translation of heritage science investigation into interpretive product and expose some of the embedded issues for museum studies, museum practice, heritage science and the practitioner engaged in the process of translation. The challenge that now faces this research is how to create a methodology to observe, record and analyse this process.

Chapter 3: Methodology, Practical Application and Positionality

This PhD examines the relationships between heritage science and museum interpretation and explores the issues surrounding the creation of an interpretive product from an analytical heritage science-based investigation. It seeks to achieve this by using film with embedded 3D animation to describe that analytical investigation. Chapter 2 summarised how the research presented in this thesis is positioned within a developing area of research within the field of heritage science, exploring how it interacts with those who employ its research capacity. It is also positioned in the context of funding priorities being specified by UKRI and AHRC. By exploring what heritage science offers the N-SREO environment one could start to understand how heritage science might develop that influence. One could suggest methodologies of pure observation or further literature review of pre-existing interactions, perhaps further statistical analysis to consolidate patterns and trends. Where this research differs is it proposes exploring the issues of potential interconnectivity in practice and through first-hand experience. This interconnectivity and its practical implications are not represented in the literature. I explore how concepts such as the rigour-relevance gap or cultural difference might manifest when one takes a real heritage science research group from an HEI into a real N-SREO museum. This could inform an understanding of those concepts and provide a richer and more nuanced understanding of practical application. What is the nature of the transition from heritage science investigation to interpretive product? What is the nature of the application that a museum might have for that interpretive product? Achieving this understanding poses a methodological challenge. One has to experience it, one has to record that experience and one has to be able to evaluate it. To experience it you have to do it and for this reason case study is a main pillar of the research methodology. Recording first-hand experience requires the consideration of participant observation and autoethnography and associated writing styles as research methodology and with this comes the consideration of positionality within the research. The case study will produce an interpretive product and within this research that will be film(s). Therefore, a creative product has to be produced which could be evaluated for its efficacy in the N-SREO environment. A single case study has an environment and circumstances in which it takes place and therefore could be an isolated experience. The research methodology presented here is designed to reduce this isolation through employing a discussion programme with heritage professionals.

3.1 Research Structure

The overall research structure employs a triangulation of the case study experience, literature review and analysis and observations taken from the professional discussions (Yin, 2014, p. 119).

This takes the form of a participant observation from within the case study, observing the progress of the analytical investigation and analysing how this investigation is translated into an interpretive product. The professional discussions and the literature review then enable a critical analysis of this process enabling the case study to position itself in a wider professional practice.

The case study for this research spans a number of phases. It encompasses: the preparations for a analytical intervention in a museum; a series of site visits where analytical data, 3D imaging material and film footage were gathered; and a period of post-site analysis which was highly influential in the production of content for the final interpretive products in the form of film. Robert Yin offers the following advice:

> "Case study research is one of several forms of social science research. Others include experiments, surveys, histories and archival analysis such as economic or statistical modelling. Doing case study research would be the preferred method, compared to others, in situations when (1) the main research questions are "how" or "why" questions; (2) a researcher has little or no control over behavioural events; and (3) the focus of the study is a contemporary (as opposed to entirely historical) phenomenon."
>
> (Yin, 2014, p. 2)

I argue that this body of research fundamentally fulfils the basic requirements that Yin lays out. With regards to the research questions: 'How might the creation of an interpretive product tailored for a museum setting make effective use of an analytical investigation?' and 'How might the creation of this interpretive product act as a bridge between the outcome of a heritage science analytical investigation and museum interpretation? These questions could be answered with a practice-based approach. I could not control the behaviours of the stakeholders as I brought them into contact. Although it could be argued that I influenced them. In addition, the issues form part of a current debate as to how public engagement and interpretation interrelate across the HEI and heritage sectors. Yin's advice would indicate that to investigate these issues by employing a case study is appropriate. From a common sense perspective, how else would one really understand how an analytical investigation mounted by an HEI within an N-SREO would manifest without seeing it first-hand? Without this experience how could one contextualise the observations existing within the literature and investigate the wider attitudes in the field?

Johnny Saldaña (2011, p. 9) points out that there are a number of reasons that one might select a particular case study: 'Deliberately' as it is a stand out case; 'strategically' as it is highly typical of the phenomenon you wish to observe; or purely 'conveniently' as the infrastructure to carry out the case study is readily available to you. In this case 'convenience' is a primary reason for the case study being carried out where it was. The Museum and NTU have a memorandum of

understanding to work together in a research relationship, enabling an infrastructure to pre-exist the research activity, this being greatly enhanced by the university having a specialist heritage science investigation unit in the ISAAC Lab team. To have a museum undergoing a major refurbishment being receptive to research activity and it being in the locality where I live was a serendipity that could not be ignored.

Robert Yin (2014, pp. 20–22) points out that case study is not beyond criticism as a research methodology. A common one is how can one generalise from a single case study? Yin's response is that they are:

> "[G]eneralizable to theoretical propositions and not to populations or universes … in doing case study research, your goal will be to expand and generalize theories (analytical generalizations) and not to extrapolate probabilities (statistical generalizations)."
>
> (Yin, 2014, p. 21)

He then goes on to point out that there is also an issue around 'comparative advantage'. Yin states (2014, p. 21) that this issue gains momentum during the early 21st century with the preference for randomised controlled trials (RCTs) which produced comparative data. However, as Yin points out RCTs are limited in their ability to answer "how" or "why" questions. It is the more nuanced and rich nature of case study research that can enhance research material coming from other sources and it is this role that the case study fulfils within this thesis.

Within the memorandum of understanding was a predisposition to support research activity proposed by the university. This does create a different dynamic to a heritage science group within a university approaching a museum to pursue a research agenda. In essence, the museum would have a greater disposition to a partner than to an external approach. It is also not particularly likely that the ISAAC Lab group would have approached the museum at this time had it not been for the catalyst of supporting my PhD. It would also be extremely unlikely that the museum would instigate this research collaboration. This is partly because of the workload associated with the refurbishment but also because no pre-existing research programme was running that the scientists were required to contribute to. Additionally, N-SREO museums don't tend to instigate these collaborations (National Co-ordinating Centre for Public Engagement, 2016, pp. 7, 21). As Saldaña (2011, p. 9) has pointed out, sometimes case studies are selected from convenience. In this research this should be noted. The circumstances through which this case study and stakeholders were brought together should be seen as a conditional lens through which this research should be viewed. To what extent do circumstances under which the case study presented itself and was carried out remove it from a routine or mutually generated analytical interaction between museum and HEI? Although the behaviours within the case study

would have been influenced by the way it was constructed, this should be likened to running a laboratory experiment. Experimental outcomes from laboratory conditions are valid in creating theoretical propositions which can be used to observe and understand real-world scenarios. It is in this way that the case study, strengthened through the triangulation of multiple sources of evidence from the literature review and professional discussions (Yin, 2014, p. 119) enable a theoretical proposition for the understanding of potential practice.

An initial literature review in Chapter 1 was conducted to map out the wider fields of heritage science, its relationship with conservation and the field of museum studies. This enables an understanding of the issues appertaining to film and new media in museum interpretation. It also generated an identified need in heritage science to develop its socio-political profile. This part of the literature review provided a background of understanding in the fields of heritage science and museum studies, which I had not studied academically in the past. An understanding of the conceptual constructs of the stakeholder areas was required so that, although my position was one of 'non-expert' in those areas, it was informed.

Moving from the case study the next consideration in understanding the research structure is literature review. The literature review in Chapter 2 provided a context within which the research was carried out. This was to understand the socio-political landscape that backdrops heritage with its emphasis on the development of digital methodologies and new media as a means of expanding and developing new heritage audiences (Black, 2018; DCMS, 2018a). It brought to light pre-existing research into museum and university partnerships (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; National Co-ordinating Centre for Public Engagement, 2016). It also brought to light the genesis, within heritage science peer reviewed literature, of an exploration of heritage science's interrelationships with other fields and institutions (Bell *et al.*, 2014; Dillon *et al.*, 2014; Katratazis *et al.*, 2018; Curran and Zimmermann, 2021). The broad scope of this literature review not only enabled an understanding of the academic fields as stakeholders but also the context in which these stakeholders operate. Additionally, more literature review was carried out to inform the methodology to analyse the content of the discussions (Appendix 2 and Chapter 5). The breadth of this literature review was a requirement to see patterns of interconnectivity, but it also posed a methodological challenge in that each of the fields presented deep and complex specialisms. One could not become specialist in each of these areas but could assemble core concepts to observe the interconnectivity between them. This research does not inhabit one field but contributes to an understanding between them. As such it could be described as 'trans-disciplinary' (Crowley *et al.*, 2014).

The final aspect of the triad of investigation within the research structure is that of the professional discussions. The aim of the professional discussions programme was to seek

resonance, within professional practice, with the case study concepts of translating analytical content into interpretive product. It is then possible to 'triangulate' this experience with the literature review (Saldaña, 2011, p. 76; Yin, 2014, p. 119). This is done firstly through seeking resonance with the findings of the literature review and juxtaposing these with experiences of the case study as it progressed. It would then be possible to interrelate this with commentary from a small cohort of heritage professionals. This critical reflection explores how my singular experience of the case study might interrelate with the existing literature. Additionally, it reflects on whether my personal observations and experiences might resonate with heritage professionals working across interpretation, conservation and heritage science, in both SREO and N-SREO museums. From this process of triangulation, it is postulated that one could draw observations and evaluations to formulate a theoretical proposition. This would be drawn from the interrelationship between HEI and museum during an analytical investigation and then postulate how that interrelationship might inform further research to enact this interaction within the political climate for heritage delivery.

The discussions with heritage professionals had to have a tailor-made methodology and literature review. This methodology drew on social science techniques for interview analysis and employed an application of 'coding' (Kvale, 2007, p. 125) in order to draw comparative, albeit qualitative data, from the discursive responses. This data set was used to identify common themes that were expressed by the cohort and allow these themes to be opened up to critical analysis. In this way a resonance could be sought with my own experiences within the case study and aspects of the literature. The professional discussions programme encompassed a total of thirteen organisations and thirty-five individuals from both SREO and N-SREO organisations[8]. The organisation types were museums, national heritage organisations, an HEI, a conservation advisory service and a business archive. The discussions were conducted in an open-ended format (Silverman, 2006, pp. 109-113), where the interviewer facilitates the discussion allowing ideas and views to be formulated and expressed. The audio recordings were transcribed in an abridged form and a short resume of the key issues was written for each transcript. Each member or convener of the discussion group was then sent their transcript and allowed time to respond if they felt the transcript was not an accurate portrayal of the views of those present. These 'member validated' transcripts (Kvale, 2007, p. 125) were then used to enable more detailed understanding of the issues raised and views expressed. These individuals were speaking from personal experience and expressing views that would not necessarily represent those of their host organisations. Therefore, the methodology required that the analysis anonymised the participants and the

[8] See Appendix 2 for a detailed breakdown of the nature of the thirteen organisations and professional demographics.

organisations. A basic coding technique (Kvale, 2007, p. 105) was adopted where issues were identified and counted across the data set. It was felt a threshold had to be set to identify issues which had commonality across the data set. Hence, an issue raised once would be simply a personal opinion, twice perhaps a coincidence, however issues that appeared three times within the data set prompted the start of the coding process. From that point onwards, these issues were identified in the resumes and counted to measure frequency with which they occurred across the data set. The raw analysis of this data produced by this methodology is available in Appendix 2. Chapter 5 opens up a more holistic discussion of the common themes identified in this data set and sets them in the context of the literature review.

It should be stated at this stage, that the professional discussion programme was not designed to stand on its own as a definitive or representative analysis of opinion within the professions appertaining to analytical investigations in museums. Additionally, it does not attempt to give a national picture. Instead, it enabled the experiences that I had in the case study to be reflected upon by a wider group of heritage professionals to enrich and support the significance of the observations made and to help inform a theoretical proposition. Again, certain methodological challenges are presented here. The time required to conduct the discussions within the time scale of the PhD meant that the programme began in early 2018 and runs concurrently with the post site visit analytical investigation and the production of the films (refer to Table 1 in the introduction). Issues arising from that investigation and the films began to inform the discussion content as the programme progressed. The implications of this will be discussed in more detail in Chapter 5

3.2 Approaches

3.2.1 The Employment of Film

When the research was first proposed there was no clear methodology defined as to how the research outcome, and imaging generated by the analytics, was to be delivered to the museum as interpretative product. 3D documentation, however, was seen as significant in the early stages of the methodological development. It was thought that 3D models with embedded information displayed online and via an in-gallery interactive kiosk could be the most likely outcome. In the very early stages of the development of this research, film gains credence methodologically. It is easy to adapt to in-gallery, online and social media platforms and can be re-edited to suit these outputs and hence is highly adaptable in the museum environment. In addition, it does not

require specific computer coding or technical expertise to make it available as does an interactive kiosk. As a result, film has a resilience as an approach to interpretation.

Although the skills to generate this film had to be acquired, the creative decision-making processes were pre-existing from my previous professional life as a creative practitioner. I could visualise my film both mentally and in storyboard form to communicate what I wanted. I understood how to generate mood, pace, and narrative to consciously control the character of the film. I understood that many of the complex scientific concepts would need to be handled with care, both in image and text, to provide sufficient understanding to carry the narrative without cluttering with extraneous detail.

The initial approach was that any films were to encapsulate the analytical research experience as it unfolded; in this respect this film could be understood as documentary in format. It would then present the findings alongside additional pre-existing historical information provided by the museum. However, film would also need to be a research outcome. The process of making it would explore the issues around transitioning analytical research findings into interpretive product and the implications this has for museum studies concepts of interpretation and meaning making. It is also interesting to observe how this research process would be different to the normal working relationship of filmmaker in a museum who would be fulfilling the museum's brief, driven from the curatorial and design process (Mandelli, 2019, p. 85). This might seem a moot point at this stage but later in this narrative the museum does issue a precise design brief and how it is responded to is significant. My response was an initial film produced as a research outcome which was twelve minutes long and focused in a documentary format on the analytical investigation. This film was presented at Digital Heritage 2018 in San Francisco. In response to this original film the Museum presented a brief for re-edits which encapsulated their relevant application for the film. The actual brief negotiated with the Museum is in Appendix 1, however, in essence what they required was four films. The first two were to be social media outputs no more than thirty and ninety seconds in length. They posed questions to their audience which a visit to the museum had the potential to answer. As such, in a social media context, they had a marketing role. The third film was to encapsulate the entire narrative of the analytical investigation and yet compress it into three minutes. To achieve this most of the content describing the analytical elements of the investigation were edited out. It was this film that was regarded by the Museum as the central interpretive product. The fourth film was to be ten minutes in length and could contain a much more detailed description of the analytical process. However, from the Museum's perspective this was a special interest film focused more at heritage professionals. These films were not pre-considered in the early manifestations of the methodology although it was deemed likely that the Museum would require an input. However, they do have methodological significance as they represent the point at which the transition from

analytical investigation into interpretive product occurs. Chapter 8 will revisit this and consider the implications of this transition.

The final decision to employ film as the interpretive product within this methodology is based on an understanding of the role film plays as an interpretive product within the museum environment sourced from the literature review. The original methodology for evaluation of the film in a museum context was to produce film as a research outcome and then work with the Museum as they reopened and employed the film as an interpretive product. The rationale behind this methodology was the Museum would evaluate the film through its normal programme of front end, formative and summative evaluation (Grewcock, 2014a, pp. 34–35; Ambrose and Paine, 2018, pp. 184–187) and be able to feedback final analysis to inform the final conclusions. As has been pointed out in the introduction the unforeseen circumstances of the delayed closure due to the Covid-19 pandemic and the extensive changes in the management structure meant that the suite of films described in the brief above was never actually implemented as intended by that brief and no evaluation processes were carried out by the Museum. However, as Grewcock (2014, pp. 34–35) points out the purpose of a front-end evaluation is to define goals for the interpretive product and identify the intended audience. In turn this then informs the nature of subsequent evaluations. Although this was not formally carried out in conjunction with the Museum, clear goals were set for the film work to encapsulate the analytical content of the investigation and communicate it to a mainstream audience. The formative stage (ibid 2014a, p. 35) is developmental, where tests and trials prototype interpretive products to ascertain their capacity to meet the requirements identified at the front-end stage. The use of focus groups in the evaluation process is not uncommon (Soren and Armstrong, 2014, pp. 44–45). I did not have access to the Museum's potential focus groups due to my positionality as researcher. However, there was a formative developmental process with consultation with the ISAAC research team as to how their research should be presented and through the reiteration of the original Digital Heritage 2018 film into the four films defined by the Museum's brief. Although this did not involve a focus group it did involve consultation with the Museum who knew what they wanted and the nature of their audience. The final summative stage did not take place for the reasons stated above. However, as some degree of front-end and formative evaluation has taken place then a summative evaluation could be conducted post hoc. A proposed methodology for evaluation is discussed in the context of further research in Chapter 9.

3.2.2 Participant Observation

Another significant observation is that in order to produce the films as a research outcome I was a participant in the case study with a role, yet the methodology required me to observe the

interactions and outcomes I was participant in. For this reason issues around participant observation and positionality now need to be considered. My adopted roles within this research were numerous. In some cases, I was required to step back to observe the expertise of the scientists carrying out the analytical investigation and yet in other respects I was highly proactive, such as in the creation of the film content. In this sense I was both participant and observer. The role of participant observer is well established in qualitative research (Delamont, 2004; Saldaña, 2011; Trent and Cho, 2014) However, Delamont (2004, p. 206) suggests that participant observation does not actually mean participation but merely sufficient engagement to observe. One could also deduce from Delamont's comment that the requirement for observation indicates the position of the researcher could be one of non-expert outside the activity being observed. However, other commentators have a broader view, describing participant observation to be part of a continuum in which the researcher places themselves somewhere on a scale from distanced impassionate observer to proactively engaged participant (Saldaña, 2011, p. 47; Trent and Cho, 2014, pp. 644–645). For example, action research is regarded as being heavily biased towards the participant end of the participant observer continuum (Trent and Cho, 2014, p. 641; Emerald Publishing, 2020). In this form of participant observation experts are engaged in cross referenced self-analysis to improve an aspect of their practice. Here the detachment of the non-expert is replaced by a peer review process. Clearly the methodology of participant observation is broadly defined and where one places oneself in the continuum often will alter the positionality of the researcher. Saldaña (2011, p. 48) likens this to the difference between watching a film and being an actor in it. Needless to say, the perspective from which these two positions see the film are drastically different. Saldaña goes on to point out that, realistically, the researcher as participant observer will find a midrange where participation is active but selective and this position could alter as the research progresses. Philips (2014, p. 544) points out that there are advantages and disadvantages to these varying positionalities, the impartial observer having detachment as opposed to the 'insider' proactively engaged and so able to experience people's interactions. However, in this situation the participant observer has the potential to influence what happens. Chapter 6 describes this interaction and the altering of this position at the start of the case study.

The application of participant observation brings with it considerations of positionality. Although I have professional training and limited professional practice in conservation, I do not feel I could claim to be an expert in the field of conservation. Therefore, I define my initial positionality as non-expert within this research. This positionality allowed a certain distance from the specialisms which were integral to the research. The majority of my working life experience is within the creative arts and teaching. Therefore, I come at this research from the position of being a heritage professional trained in conservation of historic objects. This enabled me to engage with the objects presented by the Museum in an investigative manner. However, this is not based in years

of professional experience, but it is informed by a degree of professional practice. One could argue that I have not had time to consolidate my positionality within this practice. However, it also means I do not have that practical real-world view of the experienced conservation practitioner. I am trained and experienced as a creative practitioner and this heavily influences my approach to the outputs that I have pursued to answer my research questions. However, I have no specific specialism in film. Within the fields of museum studies and heritage science I have no pre-existing experience and my knowledge of these areas has been gathered in an introductory form as part of my conservation training and developed through this research project. I am therefore quite uniquely placed with overview, yet this is caveated by a lack of focused expertise in any one of the specialisms embodied in this research. As the narrative of the case study progresses, this description of having insight into specialist areas without specialism and yet overview of them all, could be considered in light of the concept of the bilingual and bi-competent facilitator (Kieser and Leiner, 2009, p. 528).

The adoption of participant observation as a methodology creates a situation where the knowledge that is gained is specific to the positionality of the observer (consider Saldaña's film viewer and film actor). In addition, my roles within the case study presented me with different levels of applicable knowledge. As a filmmaker I was acquiring knowledge yet knew more than my co-researchers. As a creative practitioner I was highly experienced yet did not have the level of agency or relationship with my 'client' that was familiar to me. As a PhD student I had little or no agency to effectively project manage as I would have done as a creative practitioner. Where I would be allowed that agency, my lack of heritage science knowledge could impede my ability to manage effectively.

There is an academic position that there is no universal truth to be discovered and that knowledge is framed within a sphere of experience and is therefore partial or 'situated' (Grewcock, 2014b, p. 188; McHugh, 2014, p. 149). Ian Cook sees his own knowledge as so situated that his writing is a composite of his knowledge and that of others who influenced his understanding. For this reason, Cook writes as 'Cook *et al*' - the '*et al*' in italics indicating the existence of other situated knowledges that contribute to his own (Grewcock, 2014b, p. 189). Therefore, as researcher, I am positioned as a non-expert observing the interactions of other areas of expertise. Yet the requirements of the research demanded that we (myself and the stakeholders) actually did a piece of analytical investigation and then produced an interpretive product. This pushed my positionality within the research towards the participant end of the participant observer continuum in varying degrees. As my positionality of active participant became greater so did the potential impact I was having on the outcome of the research. The

knowledge that I brought to the research as a creative practitioner from outside academia, the knowledges that I was acquiring, and the knowledges that I had to defer to in order to conduct the research, all create a unique sphere of situated knowledge. Some consideration will be given to the impact of this on the early part of the case study in Chapter 6. Positionality and situated knowledge have an interrelationship yet they are separated. As Cook (2005, p. 19) explains that positionality is "…more social", whereas situated knowledge is "…about material-semiotic relations." Your positionality is who you are. Your situated knowledge is created by frameworks of thinking and methodologies created from a professional context. By acknowledging positionality and situated knowledge in the research process one can create tension within the thinking and methodologies created from a professional context. However, as Grewcock states:

> "…[T]his introduces a wider range of experience, materials and associations into research than might otherwise be admitted. It also embraces the serendipity of research and the problems and pitfalls that one can experience as productive, creative opportunities rather than encounters to be lost and glossed over in polished accounts of fieldwork."
>
> (Grewcock, 2014b, p. 189)

As one progresses through a research process one acquires and develops knowledge. The techniques of filmmaking; enhanced understanding of heritage science's investigative technologies and methodologies; an enhanced understanding of museum studies concepts of interpretation and meaning making, and an enhanced understanding of the museum as an end user of an interpreted product, were all knowledge acquisitions. However, these are all enhancements and do not constitute expertise in their own right. Expertise comes in the knowledge of their orchestration within a specific environment: the understanding of the process of translating a heritage science investigation in the N-SREO environment into an interpretive product relevant to that environment, and understanding the resonance this has for heritage science, museum studies and museum practice. In this research this is how the non-expert positionality acquires expertise.

3.2.3 Autoethnography

A fundamental methodological challenge presented by research that is centred on an actual practical experience is how one records that experience and with what voice one communicates that experience. The rationale behind this being to record the 'productive, creative opportunities' that Grewcock refers to and not 'polish' them out. For this reason, an autoethnographical

approach has been piloted within the context of this research. The term autoethnography itself is a composite word: 'auto', meaning personal experience; 'ethno', referring to the understanding of cultural experience and 'graphy', being to describe systematically and analyse. (Adams, Holman-Jones and Ellis, 2015, p. 1). Many examples of autoethnography are within the field of the social sciences, with many writers using it to analyse aspects of the human condition often carrying substantial emotional charge (Rambo, 2005; Tillmann, 2009). Autoethnography is a hybrid of autobiography and ethnography. Ellis et al (2011) make the key point that autobiographers write about epiphanies as significant moments or events that alter the trajectory of one's life. This can require a choice of first-, second- or third-person narrative as an authorial voice. It is the personal experience of such epiphanies within a research context that are relevant to autoethnography. Ethnographers often become participant observers within their chosen culture. They attempt to write what are described as 'thick descriptions' (Ellis, Adams and Bochner, 2011, p. 4) of the culture, hence achieving an understanding of the culture's practice that enables both members of that culture and outsiders to better understand how it functions. Autoethnography employs engaging and personal creative writing styles to articulate and represent epiphanies and create an immersive narrative that follows the researcher through the progress of their research. These can then be subject to critical reflection and contextualised through reference to other research literature and methodologies.

Autoethnography within museum studies is not a commonly used methodology. However, in my view, one of the notable exponents is Russell Staiff. Staiff does not self-identify as an autoethnographer; however, in his book *'Re-imagining Heritage Interpretation: Enchanting the Future Past*' (2014), Chapter 1 provides 'anecdotes' and observations from his international travels to provide context to the following discussion on approaches and critical thinking around heritage interpretation. Staiff states that:

> "The anecdotes are presented, in the first instance, with little commentary. Each of them is suggestive and each of them illuminates something of the complexity of the interaction between people and heritage places and objects or, in a less binary tone, the embodied engagement of places, objects, monuments and landscapes."
>
> (Staiff, 2014, p. 14)

Museum scholars rarely reflect on their personal lived experiences (Grewcock, 2014b, p. 190). However, participant observation, as a research methodology, does occur on occasion within museum studies. Good examples are Sharon Macdonald (2002) and Hannah Paddon (2016). In Macdonald's book '*Behind the Scenes in the Science Museum'*, through a process of ethnography, she charts the Science Museum's development and opening of a major exhibition. Although she leaves the 'auto' off the front of the word and her authorial voice remains that of the participant

observer throughout (hence ethnography as opposed to autoethnography), she does recount dialogue and personal experiences to illustrate the personal interactions. Paddon's book '*Redisplaying Museum Collections'* (2016) uses three British museums as case studies to explore in depth the process of redisplay and reinterpretation of museums with respect to the Heritage Lottery Fund as a catalyst. As part of this the internal relationships of the exhibition teams themselves are observed as the process progresses. There is precedent for autoethnography being used as a research process. Duncan Grewcock (2014b) juxtaposes his personal experience of witnessing the Lord Mayor's Show (London, UK, 2011) simultaneously with the Occupy London Stock Exchange protest camped outside St Paul's Cathedral. Here he feels "a more performative sense of doing heritage studies emerges that attends to the lived process and actions of heritage" (Grewcock, 2014c). Grewcock's book *Doing Museology Differently* (2014b) consolidates this concept for the field of museum studies. It is within the context of these commentators that this methodology has been employed.

Autoethnography has its own defined ethical framework. Adams et al (2015, pp. 57–62) give a good resume of the pillars of this framework; from Adams et al (2015) I summarise as follows: *Process Consent*: This requires the autoethnographer to check at various stages through the research process that it is still acceptable to continue with the participants' involvement. *Ethics of Consequences*: Here one should look beyond the short-term goal of the research outcome and consider the consequences of the research for the participant and the researcher. *Protecting Privacy and Identity*: It would be normal practice to maintain the anonymity of those involved in the research as it is the modes and patterns of behaviour within the context of the research that are of significance, not the individuals themselves. *Relational Ethics*: This is the maintenance of mutual respect and dignity common to healthy human interactions. *Caring for Self*: This is related to the 'ethics of consequences' – one should consider the impact of this research on oneself. Autoethnography often requires the autoethnographer to become part of the research and to look at one's own actions, emotional states, interrelationships and positionality within the research. For some this can bring them close to uncomfortable problems and experiences within their own lives (Tillmann, 2009). Alternatively, their writings may influence their professional standing or relationships. Therefore, one should always consider the impact of one's research on oneself.

When autoethnography is situated within the social sciences, it can often be dealing with highly sensitive material such as mental health, substance addictions and other issues surrounding social deprivation. This may be inspired by the personal experiences of the autoethnographer from earlier periods in their own lives. Clearly the attention to ethical considerations such as 'ethics of consequences' and 'caring for self' are highly pertinent. In the context of this research, it is professional relationships that are under the spotlight not a range of highly personal and

emotionally difficult issues. However, professional relationships can also be personal and emotional and the requirement for anonymity is an issue. Although individuals would not be named, both NTU's ISAAC lab team and Nottingham Castle Museum and Art Gallery are clearly identifiable. For this reason autoethnography is not used to describe the actual interchange between these two institutions but focused purely where a greater insight into my own experience and positionality can be gained. Where my descriptions handle the interaction between myself, NTU's ISAAC lab team and Nottingham Castle Museum and Art Gallery then the focus is moved to actual events, decisions made and the cause and effect of those decisions. This information is sourced from employing research journals, email transcripts and supervision records as an archive of events to ensure their chronological accuracy.

3.2.4 Conclusion

At the beginning of this chapter I described how, methodologically, one had to observe, record and evaluate the process of converting a heritage science investigation into an interpretive product. It is a requirement of the methodology to record an actual first-hand experience of this process, as this is not represented in the current literature. This first-hand experience would be brought about by proactive engagement. Research within any field inevitably comes from a particular perspective. Who you are, your level of expertise, your cultural background all have a bearing on how you interpret the research findings. The approach to research can be influenced by experiences that have gone before and that have brought one to carry out the research. This perspective is the positionality one brings to the research. Within the case study I needed to fulfil the role of filmmaker and conservator-investigator. Yet at the same time I would need to observe and evaluate the interactions of the ISAAC lab team and the Museum. Additionally, I would need to observe the impact my filmmaking was having on that interaction. In this way, within the case study, the different roles required would also present as different positionalities. To employ Saldaña's example I was acting in the film whilst observing the other actors and then would need to watch the film after it was made to evaluate and critique it.

The recording of these shifts of role and positionality presents a methodological challenge. Through autoethnography I could express how I felt and demonstrate the more embodied experiences of those whose anonymity I could preserve. This left me free to employ a descriptive 'creative writing' style. These 'thick descriptions' allow an insight into thoughts and feelings above and beyond the first person descriptive narrative used for the majority of this thesis. In the next chapter I will use a first person autoethnographical voice employing a creative writing style to establish my personal positionality: who I am and how I come to this research. As has been

pointed out, the ethics of autoethnography require a different writing style or voice to manage the recording of professional and institutional interactions as part of the case study descriptions and evaluations in Chapters 6, 7 and 8. This writing style needs to be descriptive and has to effectively record observations, and the cause and effect of events. However, I would need to step back from the emotive content of the creative writing style as I cannot assure the participants of anonymity. I do employ it at the start of Chapter 5 to juxtapose a personal embodied experience of visiting museums and museum professionals with the more discursive analysis of the discussions programme. I then employ it again at the start of Chapter 8 to illuminate a set of issues I wish to discuss. Autoethnography in this research is being employed as a methodology of observation. However, it is also being employed as a method of writing and recording. In both respects its employment is experimental within the sphere of museum studies and some evaluation of its efficacy will be made in Chapter 9.

Chapter 4: Personal Positionality

This chapter deals with my own positionality within this research, defining who I am and what my perspective is. It will look at my prior knowledge and workplace experience to position myself relative to the research activities to be described in later chapters. It hopes to demonstrate a transition in my own life that brought me to the research and establish a perspective through which I would view the unfolding case study activity. In this section I would like to explore autoethnography's power to capture embodied and emotive experience. As autoethnography is an experimental methodology within this research I would like to present first a 'narrative curriculum vitae', which represents the distanced but descriptive voice that will be employed to describe the case study activity. I follow this with a series of autoethnographical vignettes which work through the narrative CV chronologically and 'colour' certain minor epiphanies that take place. After Russell Staiff (2014, p. 14) I present them without commentary and will conclude with some evaluation as to their significance. I also invite the reader to compare the two descriptions and how their respective economy and precision and descriptive emotive contents are juxtaposed.

4.1 Narrative and Autoethnographical CVs

I originally trained in Fine Art Sculpture and was productive as an artist. I trained as an art teacher to earn a living, and for 10 years I didn't produce any artwork. I then stepped back from full-time teaching and began producing artwork again. This time I put together a modest portfolio of exhibition, community arts work, private and public commission. This went on for another 10 years until I came 'to the end of the road' with teaching. I took a voluntary redundancy and left. I didn't dive full time into being an artist, partly because there was not enough work to earn a living and partly because a cynicism had crept in here too. Instead, I enrolled for two years' retraining as a conservator of historic objects. This I loved, but the harsh reality of employment within my local area meant little opportunity to work. Why is this relevant? Because over this time a set of skills and experiences had coalesced to direct and influence my proposed doctoral research and shape an approach to it.

As part of my training as a conservator I became aware of object biography and the ability an object has to reveal a story, potentially a very human one, through investigation. This, coupled with a developing interest in the conservation potential of 3D documentation, led me to consider how conservation practice could contribute to museum interpretation. After the completion of my Master's in the Conservation of Historic Objects I began a search for work. Regionally this proved very difficult, with only very occasional periods of freelance work. This left me faced with a choice of applying for a part-time post as a conservator with an unachievable job description (for

which I had been short listed) and massive commute or the possibility of studying a fully funded PhD at Nottingham Trent University. I chose the latter. Constructing my PhD proposal began to bring together threads of previous learning and experience that informed that proposal. As an artist I had gained experience of managing projects including commissions and public funded work. I had experience of a client/contractor relationship and enjoyed autonomy within these projects as 'the artist'. I understood the power of imagery to construct narrative and communicate ideas and I had a developed sense of aesthetic decision making. As a teacher, I realised that the secret to teaching was not the amount of knowledge you had, but an understanding of why others don't understand. I understood how to break down knowledge so that 'keys' could be identified to enable my learner through a 'door' to the next level of understanding. I also spent 20 years experiencing how the rigorous canon of academic education theory did not always reach the teacher in a relevant, classroom-useable format.

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Throughout the winter I arrive at an artist's studio that is barely above freezing but my three bar Calor Gas fire, set close in to where I am working, makes for a degree of comfort and will eventually warm the room. I sit back from my artwork illuminated in a pool of warm halogen light, mounted on my drawing board. I have strip lights in the studio but don't always use them, preferring the window's natural light or the focused light of my work lamp. The rest of the studio, cluttered, dusty and industrious, is now getting dark, lit only by the vigorous orange glow of the heater.

I look back at the artwork in front of me and find myself asking a question I have never asked before: "Who is this artwork for?" A few months back I had completed a large tryptic to be mounted across an entire wall of a London educational establishment. I had enjoyed the focused and purposeful nature of this project. It had filled me with a sense that things were 'now on the up' after the bleak years following the 2008 financial crash. Even so, when I calculated the respectable four figure sum I had been paid into an hourly rate required to create the piece I would have been better off stacking shelves in a supermarket.

Since that commission a familiar pattern had established itself: prospective tenders for further commissions politely declined and returned. This self-motivated piece was destined to follow a familiar pattern. A curator would advertise an 'opportunity to raise my profile' through an exhibition. I would submit images of the piece. It would be accepted. I would then deliver this work to another provincial city at my own expense. It would be exhibited. I would attend a private view and a month or so later I would return to collect my artwork,

again at my own expense. From that point onwards this work would be added to the growing stack of other artworks which accumulated against the walls of the studio.

I returned to my artistic labours. I wanted to enjoy the moment. The immersive activity. The music I was listening to. The onset of a winter evening in a now warming studio. A studio day was a precious thing. I was back in the classroom tomorrow. However, the question still lingered: “Who is this artwork for?” The answer was clearly ‘me’! But, was it part of the progression of an artistic career or a coping mechanism?

***

I can’t remember what the indiscretion was. Probably testament to its triviality. Nevertheless, the four boys sat at the table as the break time bell rang. I needed to know which one was responsible.

“Right! If you want a break time then I want an answer, who is responsible?”

The boys sit facing down into their laps, fists clenched between their thighs, lips pursed. But it is not contrition that they are showing. Faces redden as a desperate fight not to snigger builds within them. I explode and shock them from their mirth.

“I am sick of this, SICK OF IT! This is the third week now….”

My rant gathers volume and aggression fuelled by my frustration. The torrent of impassioned words startles me. Its insistence has brought my head of department out of the departmental office into my classroom to support me. She maintains an authoritative glare on the boys, punctuated with concerned, flashed glances at me, silently willing me to stop but not wanting to undermine my authority. Her presence brings me a kind of closure.

“Expect to pay with your break EVERY TIME YOU DO THIS!”

The boys leave, and their laughter is audible on the corridor.

“What was that about?”

I describe the minor yet repetitive act that has come under my skin so effectively.

“You shouldn’t have sworn when you spoke to them.”

I stare at her startled: “I didn’t!”

“You did.”

I stare at the vacant table where the boys had sat, trying to recall my tirade. My breath comes in short gasps, my neck pounds with the beat of my heart and my ears are filled with the scream of my own tinnitus.

“Are you OK?”

My gaze snatches back to her: “No…No I am really not OK”.

***

An INSET day is a mixed blessing. It is a break from the rhythmic beat of classroom teaching: bell, kids in, bell, kids out. Repeat. However, a day away from the classroom could so easily be filled with a hundred things that hover in a backlog, yet INSET days are normally dominated by a managerial agenda.

The tables are arranged in groups and, as per normal, in the centre of the tables are four sheets of A2 sugar paper and a clutch of large marker pens in varying colours. We will be creating mind maps and spider diagrams and then be ‘reporting back’ from our tables. The first slide of a PowerPoint presentation is already illuminated on the school hall’s pull-down screen as a besuited senior manager takes the stage, marker pen in hand, to stand by a flip chart. The PowerPoint slide says, ‘Learning Styles: VARK’. [9]

We ‘explored the concept’ through mind mapping and spider diagrams. Mercifully we were not required to ‘stand up, make eye contact with someone we had not spoken to that day and explain the concept to them’. I managed to avoid having to write anything with the marker pens but chipped in ideas willingly enough. We got the drama teacher on our table to ‘report back’. A bit of typecasting really.

The concept is that children fall into one of four potential learning styles: visual; auditory; read & write and kinaesthetic. The school has gone to great length to analyse the learning styles of our students and can now issue to us an encoding for each student as to their preferred style. I am left to ponder how I am to enable the children to get on with their artwork, in a mixed ability class of over 30, in under an hour, in four different ways. I resolve to let them get on with their artwork and think about it.

Lunch was nice.

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[9] For more information on VARK learning styles see (Teach, 2019)

I have two free periods on a Friday. At morning briefing I pick up a note in my pigeonhole that I am to make an appointment to see the Head Teacher during the first of them. I know what this is about. At the beginning of the year a programme of redundancy was announced. My Head of Department, Anna, took this opportunity to announce that she was taking early retirement. I could see how this was going to work in the Head Teacher's mind. Anna would leave, the art timetable would be compressed to one full-time equivalent post and Alysa and I as the two part-time art teachers would cover it with one of us acting up to Head of Department. The spanner I put in the workings of this was that I had also put in for voluntary redundancy. With Anna going it was likely that this would be denied and if it was, I had secretly resolved to resign. My redundancy application had caused considerable tension between us; if I went Alysa would be left to run the show alone, possibly being put under considerable pressure to go full-time. She had discussed this with Anna numerous times, on one occasion tearfully.

Teachers contractually can only resign at certain staging points in the term. This was the Friday of the final deadline to make a September departure, the spring bank half term. I had an unconditional offer to study the conservation of historic objects at a university and I intended to take it. In this meeting with the Head, I would be given the decision about my redundancy, and I fully expected that my reply would be my resignation. After 20 years of teaching, the redundancy represented a significant amount of money! After 20 years of teaching this was a significant moment!

"Go straight in Chris, the head is expecting you" the secretary chirped over her PC screen. I push open the plain, pale pine laminate door and walk into the Head's carpeted office. The Head is a small woman in a pencil skirted pinstripe suit. She is attending to her PC screen. Eyebrows and eyes are raised over reading glasses as she glances up.

"Take a seat Chris, I will be with you in a moment" she says and continues at her PC screen. I sit and wait on the standard minimalist staffroom chair that she provides for her guests.

"OK, so you put in for a voluntary redundancy?"

"I did" I reply.

"Well we have made a final decision now and we have decided to let you go."

My initial reaction is shock. How did she know that I was going to resign? Then the reality of what she has said sinks in.

"Oh…oh right. Wow. Thank you." The head is clearly disapproving of my enthusiasm to leave her school. I rise and thank her again as I walk out but she has returned to her PC screen.

Back in the departmental office Anna is waiting for me.

"Well how did it go?" she asks as I arrive through the door.

"I got the redundancy". I pause. "You've said something to the Head haven't you? You have had a hand in this?" The expression on Anna's face is difficult to read. Relief? Regret?

"I couldn't tell you before and I didn't know how she would react, but I didn't think you would make another year."

I should be annoyed that my mental health was being discussed without my approval but instead I am grateful. Alysa comes in and I tell her I got the redundancy. She feigns congratulation and stands for a while as I bluster on, elated. Then she remembers that she needs to collect something from her pigeonhole in the staffroom, and leaves.

***

It is late September, 8.30 am and I am on a train. It has pulled into a village station just outside my home city. I see a gathering of school children by a bus stop. An ageing dark blue double decker school bus has just pulled up and the children are filing on. They are wearing the uniform of my old school. I recognise some of them. Children I know, children I have taught. They are unaware of my presence a few yards away. There is a jolt and the train begins to move, taking me forward to my induction day at my new university. The children continue to file on to the bus and our futures diverge.

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Figure 2: The author at work in the conservation laboratory.

A conservation laboratory is a very particular type of work area. On arrival first thing in the morning it presents as a blank space awaiting activity. Unlike the cluttered, indulgent space of my art studio, it is a shared space and so protocols exist that mean no one can leave anything of the previous day's activity out. All objects, equipment and chemicals are to be returned to storage or placed in 'project boxes' on shelves and brought back out again the next morning.

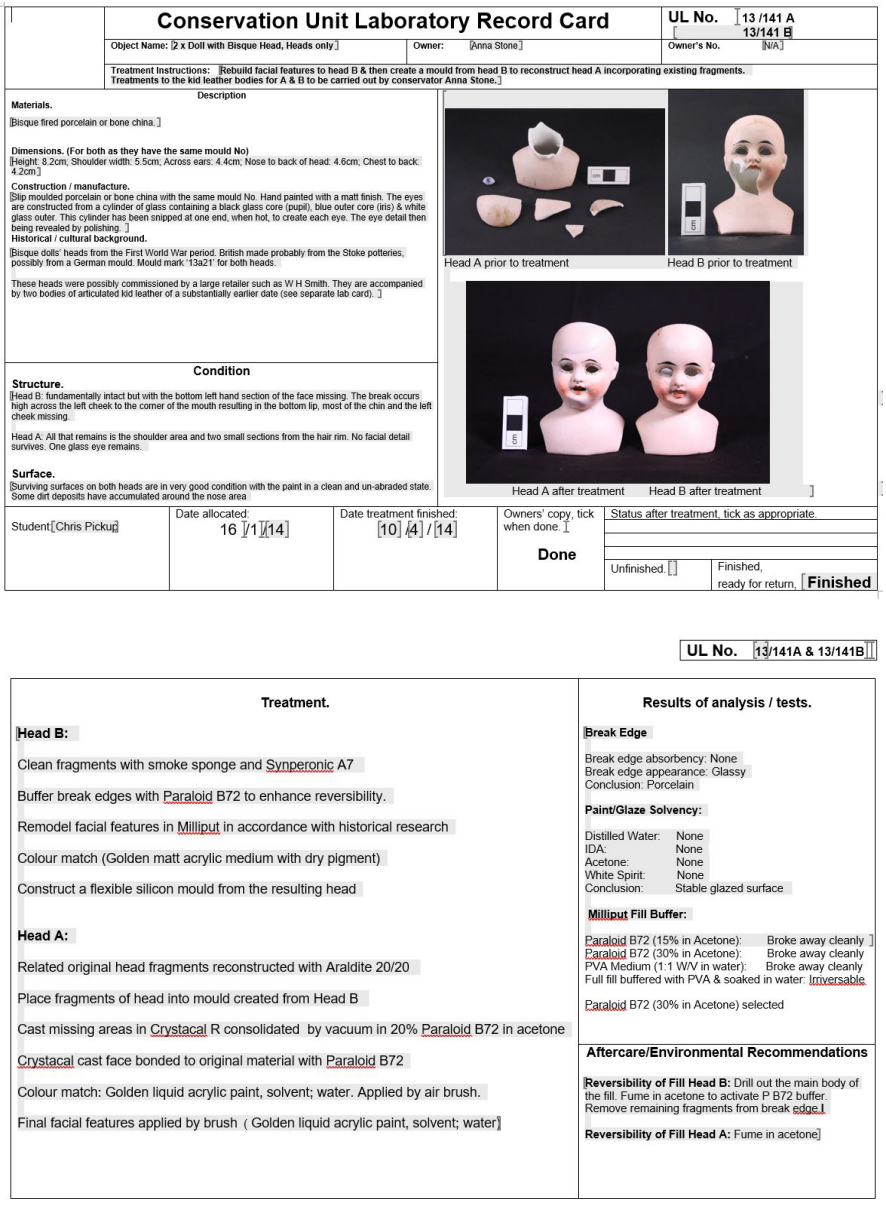
The light in the lab is even, bright, fluorescent and insistent. The walls are white. Floor and worktops, grey. Chemical and equipment cupboards, grey. There is a mandatory requirement to wear a lab coat (white) at all times when one is in the lab. This bright, clinical, protocol driven space is a hospital for museum objects (Figure 2).

The lab begins to fill with its white coated inhabitants and one by one the objects, like patients, are laid out on the worktops. Forlorn furry toys are being groomed and inspected for pests inhabiting their fur. Grotesque over-glazed baroque ceramic and dull surfaced archaeological pottery lay shattered, yet systematically arranged, on large sheets of white paper, their inspected edges being brought together tentatively in blue nitrile gloved hands to seek a possible union.

On my worktop that day lay two fragmentary ceramic dolls' heads. One was shattered beyond recognition. The other had the bottom right hand quarter of her face missing. These trauma-stricken faces enforce the hospital analogy very well. Both dolls' heads had the same mould number, which indicated they would have been identical.

My treatment plan was to employ an already existing skill set as a sculptor to reconstruct the more complete of the two heads and then use a casting technique to create a replacement face for the second head. This conservation process was technical, complex and rewarding. However, this is not the reason this project was seminal in the development of my ideas. These two dolls' heads were owned by another conservation student and they were accompanied by two rag doll bodies. What was interesting was that through her research (she was conserving the bodies) she found them to be of German manufacture from approximately 1870. The heads I was working on would probably have been cast in Stoke (UK) and dated from the First World War period. They were clearly replacements and had been inexpertly stuck on to the bodies with a thick yellow animal glue.

Conservation students are generally encouraged to use and familiarise themselves with all of the analytical equipment and, as I was in the first year of my training, this presented quite a novelty. Animal glue fluoresces under UV light, so we placed the bodies in a UV light cabinet to see how the glue was distributed. This revealed a final element of an unfolding story. In the centre of the chest of one of the rag bodies a thumb print fluoresced with a green/yellow light. We had unravelled elements of an object biography, but more than that, we had made a very human connection, which suggested a narrative. A father, during the First World War, inexpertly replaces the heads of German made dolls with English ones for his daughter to play with. Were the dolls passed down through his family? Were the original heads broken or was he just hiding their provenance? The facts from an investigation, for the purposes of a conservation treatment, had opened up a much more speculative story. A narrative with a human dimension. A direct link between conservation practice and museum interpretation. However, I propose that in many conservation scenarios, the destiny of this revelation would be the lab card and the filing cabinet (Figure 3). A stark contrast between a successful completion of a conservation process and a story of war and love of one's children placed within a social and historical context.



Conservation Unit Laboratory Record Card

UL No. 13 /141 A
13/141 B

Object Name: 2 x Doll with Bisque Head, Heads only
Owner: Anna Stone
Owner's No. N/A

Treatment Instructions: Rebuild facial features to head B & then create a mould from head B to reconstruct head A incorporating existing fragments.
Treatments to the kid leather bodies for A & B to be carried out by conservator Anna Stone.

Description

Materials.
Bisque fired porcelain or bone china.

Dimensions. (For both as they have the same mould No)
Height: 8.2cm; Shoulder width: 5.5cm; Across ears: 4.4cm; Nose to back of head: 4.6cm; Chest to back: 4.2cm.

Construction / manufacture.
Slip moulded porcelain or bone china with the same mould No. Hand painted with a matt finish. The eyes are constructed from a cylinder of glass containing a black glass core (pupil), blue outer core (iris) & white glass outer. This cylinder has been snipped at one end, when hot, to create each eye. The eye detail then being revealed by polishing.

Historical / cultural background.
Bisque dolls' heads from the First World War period. British made probably from the Stoke potteries, possibly from a German mould. Mould mark '13a21' for both heads.

These heads were possibly commissioned by a large retailer such as W H Smith. They are accompanied by two bodies of articulated kid leather of a substantially earlier date (see separate lab card).

Head A prior to treatment
Head B prior to treatment
Head A after treatment
Head B after treatment

Condition

Structure.
Head B: fundamentally intact but with the bottom left hand section of the face missing. The break occurs high across the left cheek to the corner of the mouth resulting in the bottom lip, most of the chin and the left cheek missing.

Head A: All that remains is the shoulder area and two small sections from the hair rim. No facial detail survives. One glass eye remains.

Surface.
Surviving surfaces on both heads are in very good condition with the paint in a clean and un-abraded state. Some dirt deposits have accumulated around the nose area

Student: Chris Pickup	Date allocated: 16 /1/14	Date treatment finished: 10 /4 / 14	Owners' copy, tick when done. Done	Status after treatment, tick as appropriate. Unfinished. / Finished, ready for return, Finished

UL No. 13/141A & 13/141B

Treatment.

Head B:

Clean fragments with smoke sponge and Synperonic A7

Buffer break edges with Paraloid B72 to enhance reversibility.

Remodel facial features in Milliput in accordance with historical research

Colour match (Golden matt acrylic medium with dry pigment)

Construct a flexible silicon mould from the resulting head

Head A:

Related original head fragments reconstructed with Araldite 20/20

Place fragments of head into mould created from Head B

Cast missing areas in Crystacal R consolidated by vacuum in 20% Paraloid B72 in acetone

Crystacal cast face bonded to original material with Paraloid B72

Colour match: Golden liquid acrylic paint, solvent; water. Applied by air brush.

Final facial features applied by brush (Golden liquid acrylic paint, solvent; water)

Results of analysis / tests.

Break Edge

Break edge absorbency: None
Break edge appearance: Glassy
Conclusion: Porcelain

Paint/Glaze Solvency:

Distilled Water:	None
IDA:	None
Acetone:	None
White Spirit:	None
Conclusion:	Stable glazed surface

Milliput Fill Buffer:

Paraloid B72 (15% in Acetone): Broke away cleanly
Paraloid B72 (30% in Acetone): Broke away cleanly
PVA Medium (1:1 W/V in water): Broke away cleanly
Full fill buffered with PVA & soaked in water: Irriversable

Paraloid B72 (30% in Acetone) selected

Aftercare/Environmental Recommendations

Reversibility of Fill Head B: Drill out the main body of the fill. Fume in acetone to activate P B72 buffer. Remove remaining fragments from break edge.

Reversibility of Fill Head A: Fume in acetone

Figure 3: The lab card for the doll's heads destined for the filing cabinet. What interpretation activity might be lost here?

***

Summer 2016: I had officially left secondary teaching just three years ago and in that time had qualified with a Master's in conservation of historic objects. My PhD was due to start in late September and I had been invited to a preliminary meeting with my Director of Studies simply to discuss some initial ideas. The tram stopped a little way downhill from the city centre campus of my new university. On the hill above me were buildings of white and honey coloured stone and concrete, blending Victorian architecture with art-deco styling and the modern. I entered ten minutes early, through green-grey glass into a contemporary space linking the older parts of the building. It had the demeanour of a semi-deserted airport concourse. I descended a steel and glass staircase from a mezzanine floor to the main atrium and hurried to a café I knew from previous visits.

It was ten minutes after our arranged meeting time, and I was still alone in the café. Maybe academics were casual about time keeping? I checked my phone and realised that I had not exchanged mobile numbers with my new supervisor. A check of my email brought the realisation that he had been waiting for me in a café, which was on the mezzanine floor and had escaped my attention on my arrival. I flustered off to meet him.

My apologies were accepted congenially, and enquiries were made as to what I had been doing since we formulated my PhD proposal. He described some work he had been doing for a local heritage trust. We even exchanged summer holiday plans. Eventually our conversation became more purposeful. My Director of Studies began:

"So, as you probably know the museum has been successful in obtaining its HLF bid and will now be going ahead with its major redevelopment. This will mean a redesign of most of the major galleries which would include the museum's lace collection. The University has a 'compact' with the museum which essentially means we have put some money in and in a reciprocal agreement they will assist and support MA and PhD research projects. How do you feel about lace as the subject matter for your investigation?"

I felt great! I had transitioned from school teacher to researcher. The conceptual premise of my original PhD proposal was now a real research project in a real place. Lace, why not? As I look back now, I had no concept of the complexity of the body of research I was about to embark on.

***

I had arrived early for my PhD project approval meeting. The presentation room was still locked so I sat on a chair in the corridor outside. My internal organs suddenly clenched. Had I put the hard drive with the presentation on it in my bag? My short-term memory only gave me a picture of it on my desk at home. I scrabbled through my bag where I expected to find it, hissing out whispered expletives, but to no avail. It finally appeared in the third zipper pocket that was opened. I was nervous. More nervous than I had expected to be. This surprised me; I had twenty years' teaching experience. Standing at the front and talking to gazing eyes had been my stock in trade, yet this felt very different. I suppose as a teacher your subject knowledge is so much greater than those in front of you. Here it was completely the opposite; my ideas were on trial, not old well-established ones but raw and new ones and that made me feel vulnerable.

My audience gathered inside the room: the three members of my supervision team and two internal assessors. My first breath out had a slight tremor in it as I began. The faces remained fixed and full of intensity. Heads turned down to leaf rapidly through the accompanying materials I had handed out, only to flick back up again to resume their

scrutiny of me over the tops of their reading glasses. These were not the smiling, nodding faces that I had encountered in my previous exchanges. I crescendoed to my 'interpretive conservator' finish. There were a few moments of silence while handouts were tidied and reading glasses returned to tables.

"It sounds to me that you are writing your own job description!"

I was taken aback but twenty years in the secondary teaching arena had enabled me to think on my feet. I parried: "One would assume that doing a PhD would improve one's employment prospects."

"But you have defined a role to manage the various aspects that you have described, and I quote you from your research statement 'I am proposing that this professional is the interpretive conservator'!"

The issue was that I had prejudged the research output and I had to let the development of the research define the most appropriate outcome. It was agreed that I would soften the concept to 'interpretive conservation' as a working title and allow the research to define what this meant and what form it would take. One of the internal assessors gave me one last passing shot: "So, you intend to make lace interesting?" I affirmed that I did. "Right! Good luck with that".

When the internal assessors had left, my supervision team gathered round me. "Well that was a bit tougher than we were expecting" my Director of Studies comforted. "Yeah…" I said "Still not as tough as Year Eight period five on a Friday."

On reflection I realised that this was the first time in my professional life that I had been criticised for having a clear idea what I intended to do and how I was going to achieve it. I had never given a presentation where the final outcome of the project was not clearly defined.

***

4.2 Conclusion

The epiphanies described in these vignettes help add weight to the description of events given in the first narrative CV. Career change was not a casual decision in response to a mid-life crisis but a necessity to maintain my mental health. The realisation that investigation of museum objects authored stories that stepped outside the materiality of the object itself and became more speculative and fictitious in nature is central to seeing this potential in heritage science. The writing above also charts a transition between two worlds of work, one outside and one within

academia. The juxtaposition of a working world that had clear aims, objectives and targets, with the outcomes defined. In this world one often plans by working back from the defined outcome to identify 'milestones' (Brown, 1992, p. 40) in order to signpost one's progress towards achieving it. This feels different to the world where aims are defined by questions and the answers are reached by a process that should not be prejudged. Here lie the seeds of the concept of there being a cultural difference between these two worlds. This resonates with Kieser and Leiner's (2009, p. 516) two system model. The 'thick description' of these events does help to enrich their understanding and significance. It allows the reader to position me in relation to the experiences I have and the observations I make.

It is also worth noting from a methodological perspective how much more efficient the detached but descriptive voice is at moving through chronological events. Putting aside the ethical justifications for employing this voice to describe the bulk of the narrative in this PhD, it also represents the most efficient descriptive methodology to meet the research requirements. However, where the ethics allow, the juxtaposition of the two voices can bring about a mutual enrichment of understanding. Albeit relatively minimally, this is how the autoethnographic creative writing style is employed in this PhD thesis.

Part 2

The Case Study

Part One establishes a broad landscape within which this research is positioned. It maps the literature which justifies the desire for heritage science to raise its socio-political profile and interrelates this with the recent publications from the research funding bodies. These bodies see merit in HEI's reaching wider audiences and identifying the needs of the end user of research, in order to facilitate knowledge exchange. A challenge is presented to the prosperity of the relationship between HEI and museum through cultural differences, perceived power imbalance and the influence of a rigour-relevance gap. Specifically, the rigour-relevance gap in a heritage science context is explored statistically within the existing literature. This research is positioned to investigate the interplay between an analytical investigation conducted by an HEI and the Museum's end user need for an interpretive product. Inherently this requires an engagement with the concept of the rigour-relevance gap and offers the opportunity to experience it first-hand. The methodology presented in Part One is designed to record and analyse this experience, employing participant observation and autoethnographical writing. The focus of Part Two is a narrative that describes the active part of the research. It opens with an analysis of the observations made from the professional discussions. This analysis seeks to provide a context from the attitudes towards the role of analytical investigation and its relationship with interpretation as perceived by SREO and N-SREO museums. Against this context the reader can then follow the narrative of the case study from initial analytical investigation through to the analysis of the results. The issues surrounding the influence that the findings have on object biography and how those findings are translated into the interpretive product of film will become apparent as will their resonance with concepts such as cultural difference and the rigour-relevance gap.

Chapter 5: Perspectives from the Field

This chapter is designed as a juxtaposition on the research to be presented in this thesis. Its purpose is to colour and contextualise the presented material with views and experiences from cohorts of conservators, heritage scientists and curators from within the museum sector in discussion with myself. Both SREO and N-SREOs are represented. These opinions are snapshots of their museum experience, but there is resonance with the findings in the literature in Chapter 2. We hear about other examples of interaction between these professionals outside those to be presented in the Flawford Virgin film case study and get a more intimate insight into their working procedures. Within this thesis I endeavour to explore through both praxis and published literature the interplay between the museum and HEI, an interplay between creative filmmaker/visualiser and scientist and explored the potential for heritage science to generate interpretation. Through this process I have sought resonance with the rigour-relevance gap (Martensson and Martensson, 2007; Fincham and Clark, 2009; Hodgkinson and Rousseau, 2009; Kieser and Leiner, 2009), and observed some of the practical manifestations of the cultural differences that exist between HEI and museum (Speight, Boddington and Boys, 2013; Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; Markham *et al.*, 2019).

Methodologically the ideal would have been to have completed all analytical investigations and filmmaking processes and then present the outcomes for review by a body of professionals. However as previously stated the restraints of the PhD research period meant that they had to run concurrently with other research processes. For this reason, the programme of professional discussions was commenced just after the site visit part of the case study finished[10]. The programme then developed and matured in understanding as the other research strands came to fruition. However, the analysis of their views was done collectively on the completion of all the discussions so that their opinions could be balanced and cross referenced as a group. This process was conducted towards the closure of the case study and so added a more reflective tone.

As described in Chapter 3 Methodology, this chapter analyses a body of qualitative data from discussions with thirty-five individual heritage professionals, spread across thirteen organisations, categorised as SREO and N-SREO. Transcripts of the audio discussions were validated (Kvale, 2007, p. 125) and then analysed using a basic coding technique (ibid 2007, p. 105). The data was then anonymised to enable individuals to speak freely. However, it should be noted that these individuals were expressing personal views that were not representative of the organisations they

[10] See introduction, Table 1 and Chapter 3.1

worked for. A full description of the data set, its demographics and a detailed discussion of the outcomes of the coding are given in Appendix 2. However, the histogram in Table 2 shows the main elements identified by the coding.

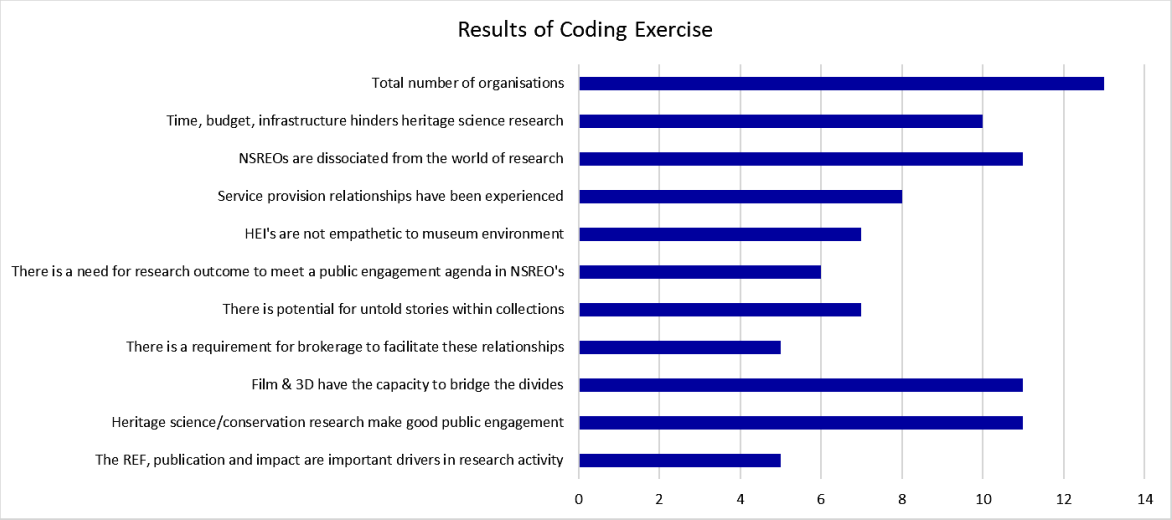


Table 2: Details of each identified issue with the total number of responses to each issue across the cohorts.

The aim of this chapter is not to discuss the individual elements of the coding exercise, as this is done in Appendix 2, but to take a more holistic view of the implications. However, what does resonate in the discussion below, and is not immediately apparent from the analysis of Table 2, is a sense of the cultural difference between museums and HEI's. This is reflected in the desire for any analytical research to serve a public engagement agenda within the N-SREO and how the N-SREO might feel a sense of dissociation with the world of academic research.

The anonymisation and coding protocol above was the case for the main cohort of discussion participants. However, after the main programme of discussions and analysis was completed two more discussions took place. The first was with Scott Furlong, *Director of Collections and Cultural Property* and Isabel Wilson, *Senior Manager Museum Development* both of *Arts Council England (ACE)* (Wilson and Furlong, 2020). The focus of this discussion was to respond to issues raised within the anonymised discussion programme concerning ACE funding policy for museums as related to science. The second was with Dr Rebecca Bridgeman (2019) from *Birmingham Museums Trust*. This discussion was triggered by one of my conference presentations of the initial observations from the anonymised discussions programme. Bridgeman is an academic who transitioned to the museum environment. She is instrumental in developing Birmingham Museum Trust's research programme and memoranda of understanding with outside academic institutions. As such her overview of the anonymised discussion programme was felt to be of

value. These three commentators were outside the anonymised programme and agreed to be quoted on their views.

The organisations in the anonymised discussion programme were separated into SREO and N-SREO. To maintain anonymity N-SREOs are numbered 1 to 5, SREOs numbered 1 to 8. Each individual professional, curator, conservator or heritage scientist has been given an arbitrary number. To organise the transcripts for my own understanding the basic coding technique (Kvale, 2007, p. 105) was adopted where issues were identified and counted across the data set (Appendix 2). This assisted me in identifying commonalities of view as expressed in the discussion cohort. For this reason, the discussion here is not heavily reliant on quotes from individuals but expresses more consistent issues and views that appeared to have commonality across the cohort[11].

The discussion's content and direction developed and matured over the programme. This generated a highly qualitative body of data. The advantage of this methodology is that it raises and develops the issues themselves, allowing them to evolve over time as the discussion programme progresses. The obverse of this is that the nature, quality and content of the discussions changed as the programme progressed and as I became increasingly informed as to what those issues were. For this reason, the data set does not have the comparability that a pre-set questionnaire applied consistently would have. It is also important to note that as chairman and convener of the discussions I was framing questions and guiding the discussion to explore issues dictated by my own research agenda. As a result of the continuous development of the open-ended format of discussion (Silverman, 2006, pp. 109–113) my own positionality in the way in which the interviews were conducted was constantly being reaffirmed and developed. As a result, the body of material assembled does not represent a statistical or quantitative analysis. They are discussions and perspectives relevant to how heritage science is perceived to interact with museum practice in both the SREO and N-SREO environment. However, some discussion is given on the potential wider implications for how HEIs and museums interact. To open this discussion two short excerpts of autoethnographical writing are included. They allow us to sense a more emotive response to the issues presented. They help the reader to visualise a physical and emotional environment where the discussions were enacted and contextualise the views expressed.

[11] The nature of the coding, the issues identified and their level of commonality to the cohort are explained in appendix 2

5.1 Hearing the Voices: An Autoethnographical Window into the Museum

The dialogues described in these autoethnographic pieces are heavily abridged to enable readability and creative flow. The '…' insertions indicate where the abridgements have taken place in the dialogue. However, the dialogue that has been written in the piece is quoted directly from the audio transcript. The names of the participants have been changed to protect their anonymity. The first piece is a conversation with Conservators 17 and 18 and Curator 11 from N-SREO 5. The second piece is Conservators 2 and 3 and Curators 3 and 4 from N-SREO 2.

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I wasn't going to the museum itself but its off-site store, buried in an industrial estate on the edge of the city. I made my way down the service road between discount stores and industrial units, turning left at the burger van attended by men in overalls. I arrived at locked gates as per my instructions but hesitated to ring the bell. There was no signage, no indication of what or who was in this building. I buzzed, "Hi, it's Chris Pickup, I am here for the interviews…" An electronic voice said they would be straight down.

A casually dressed woman pushed a key into a heavy steel padlock. "Hello, are you Rebecca?" I said. "No, I'm Heather" she replied. "Bring your car in, I will need to lock the gate again. Some of the members of the local traveller community thought our grassed area was a good place to stay last summer."

The room we entered was themed in grey, not brightened by the colourless pallor of the rain spattered windows. It was adorned with functional worksurfaces, grey Formica topped tables with square section metal legs, surrounded by a cluster of grey moulded plastic chairs. The colour in the room came from my interviewees. Heather introduced herself as a collections officer and introduced me to Rebecca, the museum's conservation officer and Aneka, a conservator with regional developmental responsibility. It was Aneka's energy and support that was instrumental in setting up this interview and a number of others within the region.

The interview was energetic. We discussed: 'T' shaped staff skill sets with staff working outside their comfort zone and as 'jacks of all trades'; the role of serendipity in creating research opportunity and concerns that the methodology suggested by my research might suppress it; the haemorrhage of knowledge and specialism through the turnover of staff; and of course the lack of funding. Then Heather chose her moment: "While I have got the opportunity, I am going to jump on my soap box about two things…" Her first point was that the main barrier to research was an inability to access research journals even though they had a memorandum of understanding with their local university. She said, "A researcher mentioned our collection in a research paper, didn't tell us, I was doing some

Googling, came across the paper … I had to ask the university to let me into it, to see that our museum had even been mentioned … yet they use our collections for their research!"

Heather now has the floor and is on a roll:

"Ok that's soap box number one … the other one is museums like us, the money comes from the Arts Council … I am getting a little bit fed up with having to dress science up as art … Getting research done on science collections under Arts Council remit is really hard unless I can attach it to a diversity agenda … Their answer to me, to meet their agenda, is to engage a contemporary artist. For me, my science collections cannot stand for their scientific worth alone." Aneka jumps in at this point, enjoying the revolutionary flavour of the conversation, "Yeah! If you sewed them [the scientific specimens] into a dress, they would start to get interested!"

The interview rolled on into what stories could be told from a scientific collection and continued for another half hour, segueing through other points and issues until the conversation reached its natural conclusion. At the end, I thanked Aneka in the car park for the time and effort she had put into organising this part of the interview programme. As I reached my car the sun came out.

***

I had just made one of my favourite transitions in the museum world. One that is particular to the museums of our regions. You are escorted through the planned, lighting controlled, public facing space of the museum gallery. You see yourself reflected as you pass the final cluster of sharp edged, structural glass cases to reach the transitional door. This door is often the same matt white of the gallery walls or an unassuming grey that indicates nothing of its purpose other than what is implied by the sign 'Private. Staff Only'. A different museum lies behind it, a cluttered, worn, shabby one, known only to the staff. This part of the museum is dedicated to the pragmatics of museum life, storage, preparation and planning and defies the need to look good while it is doing it.

After welcoming greetings, I was led through to a room which served as a common room/kitchen, which nevertheless still had a short-term storage role to fulfil. As I set up my recording equipment the room began to fill. Nine conservators and curators had come to be involved. However, as the discussion progressed it became apparent that many were happy to be observers. I moved the discussion through its gears, seeking affirmations and denials of the basic tenets of my research. Two individuals engaging with my concepts of 'facilitating relationships between museums and universities' made comments that were revealing. The first to speak was May, their senior curator of visual arts. "I've heard a lot recently of the university saying, 'what we really need to do is to take on extra staff to be the liaison with museums', and you think, we could have hundreds of liaison officers in…

the university but that still does not give any more time to really respond." At this point Cathy, the museum's conservation and documentation manager chips in "...It's like having students. We always want to take student placements but actually we struggle with our capacity to be able to provide good quality supervision…The want to do it is there but it's having the capacity with everything else that is the challenge." May's final comment was significant. "I think one thing we have all realised is the lack of understanding of what the other is trying to get out of this … the university is often looking for impact and student opportunities, we are looking for used ten-pound notes! We want cash, we want capacity."

As the discussion drew to a close some of the participants began to leave to attend to their duties that day. Cathy remained happy to continue our conversation. By the time the others had left she raised an issue that she was not so keen to voice in front of her colleagues. "You're preaching to the converted in a way here … we all really get what the science behind the objects can tell us … but there are certain groups … I want to be fairly delicate about this … they would feel that this is not accessible … the Engagement and Participation groups … they will see it as 'high-brow'…" She went on to explain the great work Engagement and Participation do within the museum and how the arts were their preferred vehicle.

Back through the transitional door I stood for a short time alone in the manicured hall of glass cases. I pondered on museums that 'dressed science up as art' that didn't need liaison officers but 'used ten-pound notes' and that were concerned about being 'too high-brow'. There would be plenty of time to consider in the motorway hours ahead.

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5.2 Relationships and Interactions

The above texts add colour and human dimension to the following section, which considers a number of broader themes arising from the discussions conducted. This section gives a holistic view of the interrelationships described between individual professional disciplines and their respective institutions within the museum sector. Relationships and the role of relationships in the serendipitous alignment of money, academic interest and public engagement potential, has existed as a theme throughout the discussions. It also considers institutional relationships and the motivations of those organisations. As we listen to these voices we are reminded of the concept of cultural difference as highlighted in Chapter 2 (Speight, Boddington and Boys, 2013; Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; Markham *et al.*, 2019). They express degrees of misalignment in their relationship with their respective HEI's. Heather's 'soap box' comments

even illustrating an incidence of power imbalance as raised in Chapter 2 (Bonacchi and Willcocks, 2016, p. 30; Dent and Willcocks, 2016, p. 20). Heather's comments also raise an interesting debate about an arts bias in the ACE funding of National Portfolio Organisations (NPO) N-SREO museums. Within this chapter I shall invite comment on this matter from Scott Furlong and Isabel Wilson from an ACE perspective. In Chapter 1 I present a body of literature which explores heritage science's role in the heritage sector and how it might develop its public and political profile (Bell, 2015; Brokerhof, 2015; Corbeil, 2015; Heritage and Golfomitsou, 2015; Lithgow, 2015). I assert that it is the voices heard in this chapter that allow a window into the practicalities of how this could be achieved.

5.2.1 Cultural Difference Between Museums & HEIs

N-SREO 1 (Curators 1 and 2) had engaged in a conservation and research project with their regional HEI. They commented on how they lost control over this research as the academics involved covered many academic specialisms to service the multidisciplinary approach required by Arts and Humanities Research Council. This resulted in them not getting the outputs they wanted. However, they did concede they got more done than they would have been able to fund themselves. They felt that many 'non-academic' museum professionals would be intimidated by academia and would not know what was available to them for scientific research. The lack of confidence identified by this participant in managing the potential of academia is worth noting. It was also observed that the academics they worked with were not heritage specialists, and this raised issues in terms of how the object was managed and handled (this observation was supported by SREO 5). However, from their experience they could see merit in relationships with academia to access funding.

N-SREO 2's (Conservators 2 and 3, Curators 3 and 4) commentary raised the issue of a mismatch of time scale between museum exhibition programme and desired academic output, with the academic output's being much shorter. They voiced a desire for academics and students to understand the museum environment[12]. This does resonate somewhat with the cultural differences identified in the reports cited above. Another interesting observation was that N-SREO 2 commissioned data analysis which was presented to them in a 'non user-friendly' format. Interestingly it was these themes of empathy, lack of understanding of time scales and the difficulty in interpreting data generated outside their organisation that Heritage Scientists 4 and 5 (SREO 6) empathised with. This being notable as they were heritage scientists from a SREO. N-

[12] The second autoethnographical piece at the start of this chapter illustrates this very well.

SREO 5 (Conservators 17 and 18 and Curator 11) described a pre-existing relationship with their local HEI as somewhat distanced, especially in terms of working practice, although they have realised its potential. They cite a memorandum of understanding with their HEI but describe it as 'fairly far apart'. A liaison existed but was not actioned although they saw an improving situation. They stated that academics do not understand museum function. Serendipity is an important factor for this museum. N-SREO 5 believe it is the best way to identify potential research and co-ordinate with academia. For them, the serendipitous coordination of money, manpower and narrative were the ingredients to create public engagement through scientific research. An observation that is hardly surprising. It is worth stressing that not all of the 'scientific research' experiences these organisations would have had would be 'heritage science research' experiences. A specialist HEI heritage science team could have a much greater empathy with heritage related issues and potentially a better understanding of museum culture. My research presents a theoretical proposition that a heritage science team coupled with the capacity to generate interpretation outputs from the analytical findings would push an empathetic response a stage further. This would create an output which was museum centric, especially if the museum was in control of the final iteration of that interpretation. Heritage science's potential to generate interpretation would need to be seen and understood and the creation of that interpretation material would need to be facilitated by the HEI. Could this create a potential where heritage science is actively sought for its interpretation and something less serendipitous might develop? As the following chapters unfold we shall see the interplay between HEI and museum and gain a more granular understanding of the nature of this relationship and how it might relate to Kieser and Leiner's (2009, p. 516) concept of there being two systems at play.

N-SREO 1 (Curator 1) commented on a mismatch of methodology in research practice and the design of heritage projects. They stated, "Research drives forward to see where it might go, heritage projects start with the final output/engagement and work back to achieve it." What Curator 1 is observing is that research cannot be prejudged, arriving at its conclusions through an ongoing research process. Whereas much of the planning in a heritage organisation would be done to a project management methodology, with a pre-set outcome and working back from it to plan its preparation (Brown, 1992, p. 41; Ambrose and Paine, 2006, pp. 254–257). This is an interesting observation. It was also highlighted by Isabel Wilson (2020) that an effective ACE bid would need to be quite developed in terms of milestones and defined outcome. As the description of the case study between the ISAAC Team and the Museum unfolds the reader is encouraged to note how the analytical research activity and its research outcomes relate to the film production focused on an interpretation output. This will raise some interesting issues around how research outcome is portrayed in an interpretation context but also observe the role

played by hypothesis and speculation within interpretation. The research and project management methodologies of analytical investigation and film production will be seen to separate into their respective 'logics' supporting the 'two system' hypothesis.

Members of the discussion cohorts were receptive to a collaborative relationship between museum and HEI. However, cultural differences manifested in terms of mismatched timescales, ambitions and output[13]. Some of the N-SREOs describe having a 'memorandum of understanding' with their regional HEI. From their descriptions the relationship appears to be closer to an amicable 'service provider' agreement. For example, N-SREO 2 described a positive relationship with their local HEI. However, when asked to describe in detail how they worked together the 'service provider' relationship began to surface. Conservator 3 stated: "When you contrasted the idea of being a scientist … interested in new discoveries as being a service provider … [then] that is what I would use them [the scientists] for …" Conservator 2 adds; "We don't have access to … [a heritage scientist in house] … so if we have something we would like to … [research] … we would ask the university if we could borrow their equipment … or they could do it for us, or get them to do it …" One would assume that when a conservator 'borrows' equipment they have the expertise to use it and interpret the data. Alternatively, they would need to 'borrow' a scientist with it to operate it. In this scenario the scientist's role could be one of technician. Doubtlessly this is done out of good will and other activities with research advantages to their HEI would be facilitated by the museum at a later date. We are reminded here of Conservator 17 in N-SREO 5's 'fairly far apart' comment with regard to their memorandum of understanding. This exchange of services should have the potential to be a perfectly sustainable relationship if well balanced, but to what extent it is the basis for meaningful analytical investigation is debateable. As the narrative of the case study unfolds the reader should note how far apart the level of specialism required to draw meaningful data from the analytical instrumentation is from the Museum and indeed myself. Markham *et al*. (2019, p. 40) actually identify bad practice from some HEIs when the relationship becomes one-sided and the HEI uses the museum to achieve its research goals without a stakeholder return. N-SREO 5's Curator 11 gives an example of this[14] and this had actually been experienced by Rebecca Bridgeman in professional practice (2019). In the context of analytical investigation, creating interpretation, in this case with film and 3D animation, I suggest there is a potential enrichment of this relationship possible. By identifying purposeful investigations into objects in the collection, driven initially by conservation or historical investigations, research questions could be established. By the museum seeing these questions as potential interpretation

[13] Heritage 2020 (Markham *et al.*, 2019, p. 39) also identify linguistic and cultural barriers and lack of empathy with museum culture.
[14] Featured in the autoethnographical piece at the start of this chapter.

and enlisting heritage science to pursue them, a much richer and mutually beneficial relationship could develop.

The field of heritage science encompasses researchers within HEIs and those embedded within SREO museums. However, within their institutions they do have different roles. Within the HEI a heritage scientist would be a proactive researcher developing lines of research in keeping with their institution's philosophy. I think it is unlikely they would regard themselves as service providers. One might imagine that heritage scientists embedded in a SREO would, as part of their work, be pursuing active research. However, amongst the eight SREOs in the discussion programme an acceptance of service provision as an aspect of the heritage scientist's work was more sanguine. SREO 3 provide a museum and conservation advisory service, and accepted their role as service provider and have good relationships with academia who they frequently employ in turn as service providers. Conservator 6 (SREO 3) commented that they have not experienced tension within this relationship. Heritage Scientist 2 from SREO 4 took a similar position and considered the role of conservation/heritage scientist as one of 'service provider' within the context of their organisation. Heritage Scientist 3 (SREO 5) pushed this a little further, offering that they were not 'career scientists' and with their qualifications would have greater earning potential outside heritage. The implication was that their decision to employ their qualification in heritage was driven by passion. They accepted that their role was research and service provision for their organisation. This does raise the issue of motivation of scientists employed within heritage who are driven by a passion for the sector rather than more financially focused scientific career paths. It was only SREO 6 (Heritage Scientists 4 and 5) who stepped outside the model of comfortable acceptance. Tensions around the 'service provider' issue were well recognised as a longstanding problem and were identified within the organisation as well as outside it. In this SREO, it is the curators who are generators of exhibition content and they generally "don't look at what is on offer" from within heritage science (Heritage Scientist 4). This raises the question, to what extent would HEI-based heritage scientists need to see how their work on the collection within an N-SREO is in pursuance of an active research or pedagogical agenda, in keeping with their personal and institutional interests, and not simply a service provision activity? Within the case study this appeared to be possible with the N-SREO's interests of interpretation and marketing being met by the final suite of Flawford Virgin films.

5.2.2 Public Engagement

The need to enact public engagement is not a factor that divides museums. All museums must engage their public or they are little more than inaccessible archives. However, an SREO can separate out public engagement activities from its remit to conduct research and specifically analytical research programmes on its collection. An N-SREO's focus would be weighted on its public engagement agenda. NPO's funded by ACE (as many of The UK's larger N-SREOs are) this public engagement agenda would be a condition of funding (Wilson and Furlong, 2020) and museums would be required to identify the demographics of their audiences and target them. It is here that the rigour-relevance gap (Bell *et al.*, 2014) manifests itself in the observed N-SREO/HEI relationship. There is a need to translate the outcome of a successful analytical investigation of a museum object into a relevant outcome which has interpretation and public engagement application. This disparity is reflected on in the discussions.

If one refers to the histogram in Table 2, and Appendix 2, there was a predominant view that heritage science and conservation research make good public engagement. In contrast the recognition of the requirement to translate analytical investigation into relevant interpretation only solicited six responses, which could be interpreted as it being a weakly supported issue. However, with only five N-SREOs in the sample, four of them responded confirming this statement quite adamantly. The one that didn't (N-SREO 1) is an archive and not a public-facing museum. From this small sample the view supported is that, for those organisations focused solely on public engagement, any analytical research within an N-SREO would need to contribute to a public engagement agenda. N-SREO 2 (Conservators 2 and 3 and Curator 4) stated that research that meets their public engagement need or that brings funding/staffing resource via academia is the research which could develop. N-SREO 3 (Curators 5, 6 and 7) commented that they did have a research strategy, but this is again interlinked with a public engagement agenda. They confirmed that the criteria for the selection of objects for analytical research would also be driven by this agenda. N-SREO 4's contribution was enlightening (Curators 8 and 9 and Conservator 7). They stated that, if approached to engage in analytical research, it would be considered, but the criteria would be that it would have to be specifically tailored to their exhibition programme (18-24 months in advance), understand their ethos and meet their business aims and objectives. What might appear a good project to Curators 8 & 9, may be blocked at management level due to its failure to meet these criteria. They would want to see the funding procured supporting their exhibition as well as the research activity[15]. Comment was made that procuring funding was a very time-consuming business. They could not see this being a mode of operation, but possibly as an intervention, maybe with a science intervention being an

[15] See chapter 2 (2.2.3 Bonacchi and Willcocks, 2016, p. 30) where such a funding structure is suggested.

occasional 'add in' to the existing or planned programme, much like an artist intervention. The case study will demonstrate that a heritage science investigation could operate with this level of flexibility running alongside and beyond exhibition commitments. As the case study will suggest film and 3D animation, web and social media content, podcast, and blog could broadcast findings, create opportunities for meaning-making and pose as yet unanswered questions. However, the brief that was issued by the Museum ensured that the business aims and objectives were met by all the broadcast outputs.

N-SREO 5's (Conservators 17 and 18 and Curator 11) contribution was equally informative as to the nature of opinions held within the small cohort of N-SREOs[16]. The 'public engagement need' theme was strong throughout their discussion, as was the funding implication of this. They could not devote staff time to anything that did not meet this need or be 'bought out' from their main task by external funding for any protracted length of time. Academics would have to come with both money and staffing to carry out research and in this circumstance, they would happily adopt a 'service provider' role. It is interesting to hear these N-SREOs defining their need in an assertive way and pushing back against the power imbalances observed in the literature (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016). N-SREO 5 also pointed out that within their internal structure, managerial functions and the public engagement role is given priority over curatorial concerns and this was reflected in their pay scales. Staff are required to be 'jacks of all trades' described as 'T' shaped, encompassing more than one role within any one job description. This more granular understanding of what a heritage science investigation would need to deliver to the museum to be comfortably accepted is of great significance when developing interpretations materials to meet a more managerial agenda described by the curators in N-SREO 4. From outside the N-SREO cohort, Heritage scientist 2 from SREO 4, (a large national heritage organisation), felt there may be some development in their approach to public engagement with their 'new research strategy' and the requirement of 'inspiration' as a pillar of their charitable status. They foresaw that their remit for public engagement would rise.

Although the N-SREO cohort discussing this issue is small (approximately five museums in this sample), it was very consistent in its view. Analytical research activity in an N-SREO would need to have a strong public engagement output to justify the curatorial input to facilitate it. Analysis of this sample would suggest that a needs analysis would be needed to identify the managerial priorities, ethos, aims and objectives and ensure that the museum-centric output is designed to meet it. Within the case study this role was performed by developing the brief for the four films. The interpretation of the analytical research data would need to be translated into a publicly accessible format and presented appropriately to bridge the rigour-relevance gap. As Isabel

[16] See the autoethnographic piece at the beginning of the chapter.

Wilson (2020) pointed out this would also be a requirement for ACE funding within the NPO funding structure.

5.2.3 N-SREO Dissociation from the World of Scientific Research

I proposed during the discussions that N-SREOs would be dissociated from the world of scientific research and this potentially makes a relationship with a heritage science investigation more challenging. Within the literature this has been couched in terms of there being two systems of science and management (Kieser and Leiner, 2009, p. 516). This assertion was widely supported by the discussion group but for them it manifested in pragmatics. One of these manifestations was the inaccessibility of research literature within their organisation. This was noted particularly within the commentaries provided by members of N-SREOs 1 and 5 and SREOs 7 and 6. N-SREO 5 (Conservators 17 and 18 and Curator 11) previously stated that liaison exists with their local HEI but was 'fairly far apart'. They commented that they are denied access to journals which the HEI could enable for them and yet academics wanted access to their museum for their research[17]. This assertion bears a little consideration as journal and database conditions would have to be negotiated to enable a museum access; however, it is negotiable. Within the well-developed relationship that Birmingham Museums Trust have with the University of Birmingham, curatorial staff have research associate status and can access University of Birmingham library services (Bridgeman, 2019). Bridgeman (2019) sees this as part of a policy to seek a level playing field with academia with an 'active collaborator' role. This access to and appropriacy of literature is identified by Fincham and Clark (2009, p. 510) as one of the effective bridging strategies for the transcendence of the rigour-relevance gap. I believe this approach could go a long way to dispersing any perceptions of power imbalance resident in the museum environment. Embedded in this approach Bridgeman identifies a need to 're-train' academics as part of a maintained relationship but also a need to build confidence in the museum staff in their specialisms of collections knowledge and engagement. This echoes Kieser and Leiner's promotion of the bilingual bi-competent facilitator. Scott Furlong (2020) reiterated this point that museums don't value their own communication and interpretation expertise sufficiently and equate it with that of the university. SREO 7 (Conservator 13) accepted the N-SREOs' difficulties in accessing literature as an issue and regarded open access publishing as the way forward, as promoted by National Heritage Science Forum (NHSF, 2019) and required for UK and EU research funding (European Commission, 2017; UK Research & Innovation, 2021). Interestingly SREO 6 (Heritage Scientists 4 and 5), as a scientifically research enabled museum, felt they were not as research enabled as one

[17] See the autoethnographic piece at the beginning of the chapter.

might assume. They had problems accessing equipment and journals for literature review. They found supporting PhD students in collaboration with HEIs helpful here, giving indirect access to the literature databases. With regard to accessing technology, The *European Research Infrastructure for Heritage Science* (E-RIHS) (2018) will soon enable SREOs to apply, via competitive tender, for access to expertise, data and technologies to pursue heritage science research. The infrastructure is planned to be fully operational by 2022. However, it is designed to service the research community with its application criteria focused on scientific excellence, advancement in the field and expertise of the user group; it is unlikely to provide a resource that the N-SREO cohort could access.

N-SREO 5 (Conservators 17 and 18 and Curator 11) made some very pertinent comments about their funding structure. They had engaged in research projects but expressed frustration that as an NPO with funding coming from Arts Council England (ACE), they cannot progress scientific agendas unless they 'dress it up as art'.[18] The cancellation of the PRISM[19] fund is cited as a loss here and as an NPO they cannot access STEM[20] funding. Again, this bears a deeper investigation as, on the face of it, what the conservators and curators at N-SREO 5 are suggesting is that their ACE funding is actively obstructing scientific investigation in the museum. This was challenged effectively by Isabel Wilson and Scott Furlong (2020) from ACE. Their first observation was that the PRISM fund shut down as it was underclaimed and the bids declined in quality. It was felt that there was a better facility to cover non art interest within the other funding schemes that were available. However, the need to identify public engagement outputs would be a condition of funding. Funding streams to support a heritage science investigation with a public engagement/interpretation output built in would be eligible for funding under the terms of the new ACE funding strategy (2020). However, Furlong felt that articulating and communicating this breadth of application through the wording of the strategy was a challenge. The making of an interpretation output, in this case film and 3D animation from heritage science investigations, could be a viable fundable proposition within the NPO museum and one that maintains the integrity of the science. Bridgeman (2019) suggests that other funding streams are available outside ACE especially if partnered with an HEI. As Martensson and Martensson (2007, p. 1328) point out, to increase the relevance of research one needs to add the questions "why?" and "for whom?" to the research base of "what?" and "how?" to bridge the rigour-relevance gap. However, even with why and for whom questions addressed, navigating the pragmatics of the funding system can still present barriers.

[18] See the autoethnographic piece at the beginning of the chapter.
[19] The Preservation of Industrial and Scientific Material (PRISM) fund was an ACE fund to acquire and conserve items or collections which are important in the history and development of science, technology, industry and related fields.
[20] Funding streams related to Science, Technology, Engineering and Mathematics (STEM)

N-SREO 5 had engaged in research activity and requested academic engagement through their website. However, again, this would have to be supported by the public engagement potential of any academic approach. At their museum they have had a major scientific research-based exhibition. This was developed from a research question raised from a preventative conservation starting point, which serendipitously attracted academic interest. N-SREO 2 (Conservators 2 and 3 and Curators 3 and 4) also reported a similar successful research-driven exhibition resulting in a digital interactive and animatronic. In this case they had sufficient specialism in house to interpret the fossil material and engage the academics at the university with which they had a memorandum of understanding. Kieser and Leiner (2009, p. 528) do suggest a bilingual bi-competent facilitator as a catalyst to this interaction. The final ingredient was a successful funding bid. The object biography driven 'life story' element of the final outcome did a great deal to service the public engagement element of this exhibition.

The above observations within the discussion group suggest a picture of N-SREOs having an inconsistent relationship with scientific research. They are hindered by their interpretation of the funding structures and the need for the output to deliver to their public engagement agenda. Yet, when serendipity delivers research question, academic knowhow and funding in alignment, this agenda can be met very successfully. It would appear that a third 'system', that of accessible and identifiable funding, is in operation in the transcendence of the rigour-relevance gap. Curator 7 (N-SREO 3) makes a pertinent comment here: "…we know we do not have time to do the research ourselves and therefore we are very much beholden to the research community … that means we don't control it …" It is interesting that 'control' is the word selected. 'Control' in the interrelationship between N-SREO and HEI is an issue cited in regard to power imbalance (Bonacchi and Willcocks, 2016, p. 30; Dent and Willcocks, 2016, p. 20). However, it could be argued that what is required here, when collaborating with an HEI, is a greater confidence on behalf of the museum as to what their role is, what they bring to the table in terms of knowledge and specialism and what they need to get out of the collaboration in terms of their own organisational need. It is quite possible that this assertive attitude might be the only level of control required. Within the discussions in the N-SREO cohort they did appear to be able to define organisational need quite effectively. The final ingredient then is a conducive funding environment (Facer and Enright, 2016, pp. 4–5). The disconnect between the N-SREO and analytical research could be mediated by heritage science research that delivers a public engagement requirement. If heritage science and museum could engage in this relationship proactively, they may not have to wait for serendipity to bring them into alignment. As pointed out in Chapter 2 the funding climate is increasingly conducive to this collaboration (AHRC, 2018c, 2018a, 2018b; UKRI and AHRC, 2020).

5.2.4 Curator, Conservator, Heritage Scientist: An Interactive Triad Within the Museum?

It might be interesting at this point to allow the discussion group's comments to influence our reflections on the nature of conservators and heritage scientists in museums, and how they might interact with curators:

> "… as a conservator we have objects here, and we are looking at them very closely … probably more closely than anyone else, curators, scientists; scientists don't even look at objects really until you ask them to … As a conservator I often, or we, will pick up things that no one else has seen." (Conservator 4, SREO 2).

This comment indicates how this conservator sees themselves placed, with a level of intimacy with a museum object. They are allowed an intimate experience of that object. They are asking the question: what is it that this object can tell me that might influence an understanding of its object biography or its physical condition? It is interesting to note a degree of parallel here with the act of meaning-making. Admittedly, the conservator's process has a more forensic application but the first stage is a sensory experience. We can then contrast this with a need for a heritage scientist to structure an investigation with a clearly defined research question. Remember the definition of 'conservation science' as a scientific methodology to aid the processes of conservation[21]. Here I suggest an idea of conservator as 'explorer', allowing their investigations to develop an understanding and pose questions. The scientist then acts as 'investigator' deepening the exploration by taking the questions posed and designing specific methodologies to answer them. However, other commentators expose an insecurity in this relationship that I have mooted here. Conservator 6 from SREO 3 felt conservators often identified as 'pseudo scientists' without the authority of a scientific background. Conservator 5 (SREO 5) felt that a prejudice of 'conservator as craftsman' still existed, implying a subordinate role to the 'academic' disciplines of curation and science. This is despite conservators having the ability to qualify to Masters level and beyond for many years now. Within the interview with SREO 5 other interesting attitudes surfaced. Curator 10 commented "… what is a heritage scientist?" to which Heritage Scientist 3 replied "Me!" Curator 10 then passed comment later in the interview making a distinction between 'intellectual' content and 'conservation' content in exhibition interpretation. This could be interpreted as 'conservation content' being, in the curator's mind, 'technical content' which does not take into account the conservator's ability to create object biography. Conservator 10

[21] Conservation science now being defined as a constituent of the broader field of heritage science See Chapter 1 – 1.3.

commented on how rare crossover conferences are, and that how, when they do occur, different disciplines would not visit each other's papers. We are seeing a manifestation of Corbeil's (2015, p. 32) comments about the segregation of heritage science into sub-specialist groups reflected in a broader picture of conservation and curatorial interaction. What we could take from the discussions presented here is a sense of how segregation between these fields manifests itself with little proactive, institutional interconnection. In this environment it is personal interrelationships and serendipity that enable the collaborations to form. It is also worth noting in fairness to SREO 5, that within their interview they felt that this siloed approach was a legacy and that the tide was changing. It was Curator 10 who expressed the view that they would hope that the boundaries between the fields would be flexible. Successful examples of the integration of academic, curatorial and public engagement interest certainly do exist when this integration is seen as policy (Cooper, 2013). If one was engaged in the process of converting the exploratory findings of the conservator into investigatory heritage science and then take the outcome from the heritage science to develop interpretation, then in theory at least, this triad could operate with a degree of synchronicity.

This interaction between curatorial staff and heritage science was picked up by SREO 2's Heritage Scientist 1. It was felt by this commentator that heritage science content within interpretation was essentially a curatorial requirement. Although an interaction between heritage science and curatorial practice was encouraged there is no policy driving it. Personal relationships were important in developing this, as is an intimacy with the collection. At times heritage science input in SREO 2 could be subtle. However, curators do not see heritage science as a resource for exhibition development, although Heritage Scientist 1 would like it if they did. Heritage scientists would not see it as their role to suggest exhibitions, this would be by invitation only. Research was normally driven by individuals working alone. Conservators 4 and 5 from the same organisation contributed to this debate. Overall, within SREO 2, they felt, as conservators, that they had good personal relationships with curatorial/heritage science staff and felt that these relationships were important in developing research driven interpretation projects. However, this would occur on a case-by-case basis, always restrained by time and resource and be infrequent (a number of years apart). It was conceded that this was a very small part of the overall output from the museum. A slightly different perspective was offered by SREO 6 with regards to this matter. When questioned on curators seeking scientific research content for exhibition, Heritage Scientists 4 and 5 considered that this was done to a very minor extent, usually to seek 'added value' to make exhibition proposals more competitive within the museum's programme selection process. This would normally be done within pre-existing relationships. On the whole curators would not look at what was on offer within the conservation department. Overall, they felt that their organisation had started to see potential in this science and conservation collaborative content

with efforts to communicate behind the scenes activity growing within SREO-6, and elsewhere. Because of the size of SREO 6 it had the facility to create film content in house; learning engagement being the main drivers here. However, also because of its size, it had a considerable inertia for the intention to become practice.

The contributors to this discussion give a sense that the relationships between heritage science and curators and conservators can be symbiotic and yet it is not driven by any institutional policy. It is also worth noting that our commentators are exclusively from the SREO part of the discussion group, where curators, conservators and heritage scientists co-exist within the same organisation. One might even suggest that it would merely be a matter of booking a meeting room or walking down a corridor to realise this potential, should the institutional impetus be there. I propose that the case study to be presented in this thesis indicates that film, as a potential interpretive product disseminating heritage science findings in the N-SREO environment, could motivate an interrelationship between N-SREO and heritage scientist. In the N-SREO environment, the desire to seek purpose in heritage science investigation to generate interpretation, which can be broadcast across different media platforms, would require a relationship to be formed with an external heritage science researcher. The expertise to create an interpretive product may also need to be sought and the HEI could potentially provide both. Within the SREO the same approach may have the potential to be a catalyst to develop already existing relationships. Is it possible that in both environments a purposeful pursuance this approach could reduce the amount of serendipity required to make it happen?

5.2.5 The Position of the Conservator

If one accepts the level of intimacy that the conservator has with the museum object, and how they allow the object to generate questions about its materiality and object biography, then this places the conservator at a central point in a potential relationship. If the conservator could be a creator of content for the interpretive product then this might enhance their contribution to "meaning making and enabling social engagement" (Brooks, 2013, p. 4). Let us consider a hypothetical concept: that it is the conservator who reveals the questions that require answers and the heritage scientist who has the facility to answer those questions. As those questions are answered the object biography develops, enriching the interpretation potential for the creation of an interpretive product to be employed by the museum. One could imagine a continuous loop of exploration, investigation, and interpretation. In principle this potential relationship could be symbiotic but actioning it within a large SREO or co-ordinating across N-SREO and HEI is where the challenges to it lie. SREO 5's Conservator 13 was concerned that the above hypothetical scenario

placed an increased burden on the conservator to be at this central point. They pointed out that conservators already have a justified role and this co-ordinating position would distract them from their core tasks. In reality this is a fair point and is particularly pertinent of a conservator in an N-SREO. Within a potential environment of low staffing level and limited resource, the conservator would have to work with an HEI as an external organisation in order to provide heritage science enablement. All of which assumes a conservator is even employed by the N-SREO (Brooks, 2013, p. 4).

In the context of the N-SREO/HEI collaboration, the challenge of the conservator being centrally placed to mediate in this relationship between these two organisations would appear daunting and its symbiotic nature highly hypothetical, had it not been for the comments of Conservator 6 from SREO 3. SREO 3 is not a museum or a national heritage organisation, but a conservation and museum advisory service. What is interesting is that they have actioned the scenario above from the position of conservators. What Conservator 6 described was longstanding relationships with some museums where the conservation service could be involved very early on in the exhibition planning process. This enabled the conservation service to have agency by enabling the curatorial team to understand the interpretive potential of the objects to be included in the exhibition and inform them as to how heritage science and conservation could be employed to develop object biography. This in turn could inform the nature of the interpretation approach and potential funding bids. When this occurred, it was regarded as a very successful formula. However, many museums would often come to the conservation service late in the exhibition development process with a small budget. When this happened the museum's options were greatly limited, with object stabilisation for exhibition being the usual outcome. Here we see an issue of timing and co-ordination. When the stakeholders are co-ordinating at the outset of the project the potential of heritage science to develop that project could be realised. When the conservation service was brought late to the development a less productive service provider relationship was all that was viable. This phenomenon was noted by Markham *et al.* (2019, p. 8), however, they felt there were 'promising signs' that collaboration is 'more frequently occurring upstream'. The production of the Flawford Virgin films will be shown to have a strong 'upstream' element with all the stakeholders involved from the outset. The interpretation, public engagement and marketing potential of the films grows out of the analytical investigation. It could also be postulated that recent developments in the Knowledge Exchange Framework could fuel this interrelationship.

5.3 Reflections on the Professional Conversations

If we look back over the collective comments and observations of the participants, they create a snapshot of the interactions between conservators, heritage scientists and curators within the museum environment and stress the differences that exist between the SREO and N-SREO organisations. Many of the patterns that are observed by the discussion cohorts are reflected in the literature which surrounds museum and HEI partnerships and the concept of the rigour-relevance gap. The crux issue appears to be the requirement for N-SREO museums to justify any analytical investigations of their collections from an interpretation and public engagement perspective. This is reflected in both available staff resource and the ACE funding structures immediately available to them. For the N-SREO this analytical capacity could be available through HEI's but we observe that this relationship can have a degree of distance within it. Within the literature this has been couched in terms of cultural difference or that interpretation and analytics are different systems which do not share a common logic.

N-SREOs commented that they cannot institutionally interconnect with the processes of analytical research unless available funding and well-established relationships between academia and museum are in alignment. In addition, the avenues to justify and fund these investigations do not appear to be immediately apparent to curators within the N-SREO discussion cohort. This possibly leads to a reliance on the agency of an HEI to initiate projects, as observed in the literature (National Co-ordinating Centre for Public Engagement, 2016, pp. 7, 21). If one bears in mind that N-SREOs in the discussion cohort could not dedicate staffing resource to analytical investigations unless there was a clear public engagement output or vehicle, funded and supported by the project. Then Interpretive product, such as the Flawford Virgin films, could be employed to help develop a confidence within the N-SREO environment that heritage science investigation can deliver interpretation which can answer to their mission statements and managerial agenda. I suggest that less serendipitous and service provider based relationships between N-SREO and HEI could be developed, with stakeholders acquiring a greater empathy for the different institutional cultures that operate within the museum and HEI (Cooper, 2013, p. 487). The Flawford Virgin case study seeks to provide an indication that the creation of interpretive product, in this case 3D animation within film, can allow these two cultures to work in unison without undue reliance on each other's outcomes. However, the respective outputs would have to be pre-negotiated and clearly identified at the outset. Additionally, the museum would need to accept the facilitation role to enable the scientists to investigate and have the confidence to define its outputs and be given the agency to see them met. In the next two chapters, through the case study, I will take a close look at the interface between museum and HEI to enable a reflection on how the literature review and discussions programme resonate in practice.

Chapter 6: Case Study Part 1: Taking Science to the Museum

The focus of this chapter is to chart the early challenges and decision-making processes of instigating and enabling the production of an interpretive product from a heritage science investigation in an N-SREO museum. As has been pointed out, my participation in these events is at the proactive end of the participant observer scale (Saldaña, 2011, p. 47; Trent and Cho, 2014, pp. 644–645). This chapter describes this interplay between participation and observation and reflects on its implications. It then observes the working practices of the two institutions as they engage with each other in the early production process. Throughout this description resonance will be sought with the established concepts of cultural difference, power imbalance, the 'two systems' hypothesis and the actions of the 'bilingual, bi-competent facilitator'. A decision had been made to create film with embedded 3D animated content and this film material should perform a dual role as a production process to create an interpretive product, but also as a research process to understand the nature of the transition from analytical investigation to interpretive product.

The events that unfold in this narrative took place between the spring and winter of 2017. They are recounted here using the research journals, supervision forms and email threads employed as an archive (Yin, 2014, pp. 105–107). A chronological list was constructed for my analysis from these sources to tie together the interplay of events. Two points come from this. It is written from the perspective of having completed the active phase of the research and having produced a suite of films that ultimately focused on the Flawford Virgin. It is also written in the light of the completion of the literature reviews and the resultant reflections. The second issue is one of chronology. A number of filmic requirements and analytical research strands ran concurrently and to attempt a diaristic approach for this account would bring considerable problems for the reader to track the trajectory of each strand. For this reason, these narrative strands are separated from their actual chronology to see their significance and conclusion.

The preparation for a visit to a site where an intensive analytical investigation, initial filming, photography and the 3D imaging process are to be carried out all form part of the early film production process and it has to be done before one reaches the site. The preparations to carry out the initial investigations on museum objects at the Nottingham Castle Museum and Art Gallery by the ISAAC Lab from NTU would involve: identifying museum objects; developing research questions; planning which analytical instruments were appropriate to answer those questions; solving specific 3D imaging and film making problems associated with the chosen objects and all of this would have to be applied in a limited number of visits to the Museum's sites

in a pre-planned and choreographed way. Site Visit 1 was at Newstead Abbey. This was me alone working with the keeper of the Museum's lace collection to create imaging of lace at high magnification. Site Visit 2 was a week-long at the Museum, with four different analytical instruments on site: Optical Coherence Tomography (OCT) for analysing subsurface structures; X-Ray Fluorescence (XRF) for detecting elements; UV/Visible Reflectance Spectroscopy for identifying pigments and Raman Spectroscopy for identifying molecular compounds. Although Raman was represented in the original suite of instruments the data it produced did not form a significant part of the subsequent investigation. For a more detailed description of the operational characteristics of these instruments see Appendix 3. These instruments were manned by PhD colleagues with specialism in their operation. Four object types including lace were brought to these instruments and rotated through the instrument stations for analysis. This site visit was also the only opportunity to film scientists in action and gather sufficient photography for filmic and 3D imaging purposes. Finally, six months after the first two site visits, I returned alone for Site Visit 3, with the focus on the Flawford Virgin to obtain more photographic material for filmic purposes and to aid the analytical investigation. It was at this site visit that I carried out an investigation with a more analytical photographic technique. The results of this suggests an interesting hypothesis about an aspect of the Flawford Virgin's past.

Table 3 is a Gantt chart showing a timeline of the lengthy planning and preparation period culminating in the specific site visits. This is included to help the reader map the events described. What is shown are the four selected research themes associated with objects from the Museum collection, mapped over a period of months of preparation time. Each theme culminates with its associated site visit. Significant meetings and events are also marked enabling their chronology to be understood. Table 4 shows the research questions that were submitted by the Museum to initiate the research process. Each set of questions is attributed to objects aligned with the research themes and is important in understanding the issues arising in negotiating research questions appropriate to frame an analytical investigation.

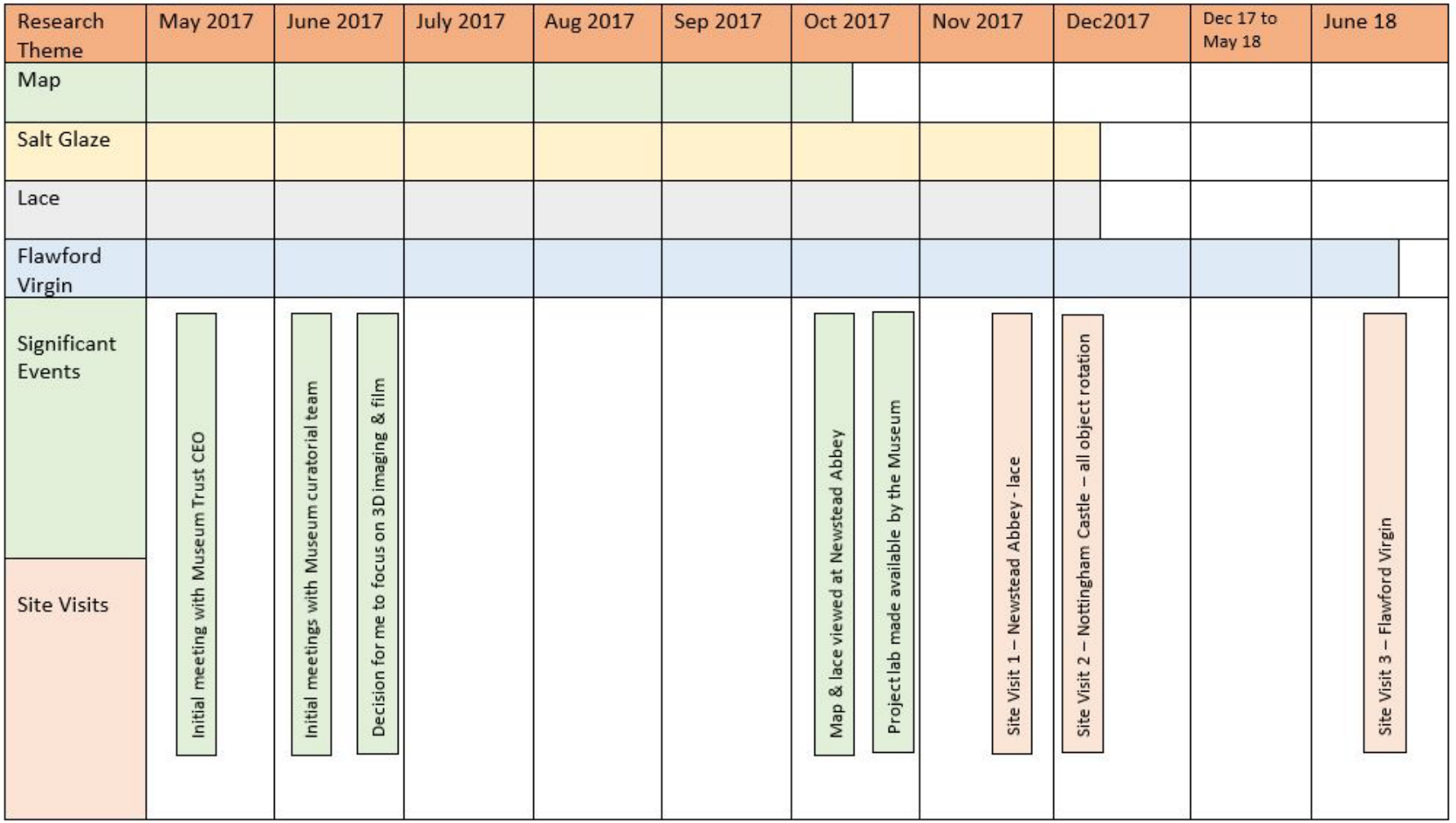

Table 3: Gantt chart showing progress of the four research themes in relation to the site visits and significant events.

Object Type	Research Questions/Issues Presented by Nottingham Castle Museum and Art Gallery
Lace	• Illustrate the difference between machine and handmade lace • Investigation into the shawl's gimp • Textile identification?
Maps	• Recording • Textile identification? • Dye identification? • Does the object show physical signs of its biography (further investigation into the historic damage/repair)
Salt Glaze	• Glaze analysis (how does the salt behave in the firing process) • There is potential for a conservation process (traditional technique or 3D imaged). Could this be recorded and presented in exhibition?
Flawford Virgin	• What are the nature of the two cracks? • When was the backing added? • Is the base original? • What were the original colours/pigments? • What does this add to the object biography? • Geographical provenance of the alabaster

Table 4: The range of research questions raised by the Museum in association with objects within the research

It was known from early on that the lace collection was going to be a subject of investigation. Initial meetings with the Museum raised a new set of possibilities. Along with lace, other possible lines of investigation were offered. The city had been a centre for the production of salt glazed stoneware and during the medieval period had been a centre for alabaster carving. The museum held significant, if not internationally significant, collections of both[22]. These included a salt glaze bear and a 'posset' pot [23] dating from the mid eighteenth century and the Flawford Virgin, the fourteenth century alabaster carving of the Virgin Mary with a complex object biography (Figure 4).[24] These objects were stored at the Nottingham Castle site. In addition to these objects were two huge seventeenth century textile maps of North and South Nottinghamshire (Figure 4). These

[22] The alabaster collection was peer reviewed and deemed of international significance by Professor Richard Marks of the University of Cambridge in his peer review of the collection, 2013.
[23] Posset is a desert made primarily of cream, sugar and citrus flavourings. The pot was specifically designed for its service.
[24] This object biography is described in detail in the introduction.

objects were stored, along with the lace collection, at the Museum's Newstead Abbey site. Through discussion a decision was made to initiate analytical investigations on all of these objects.

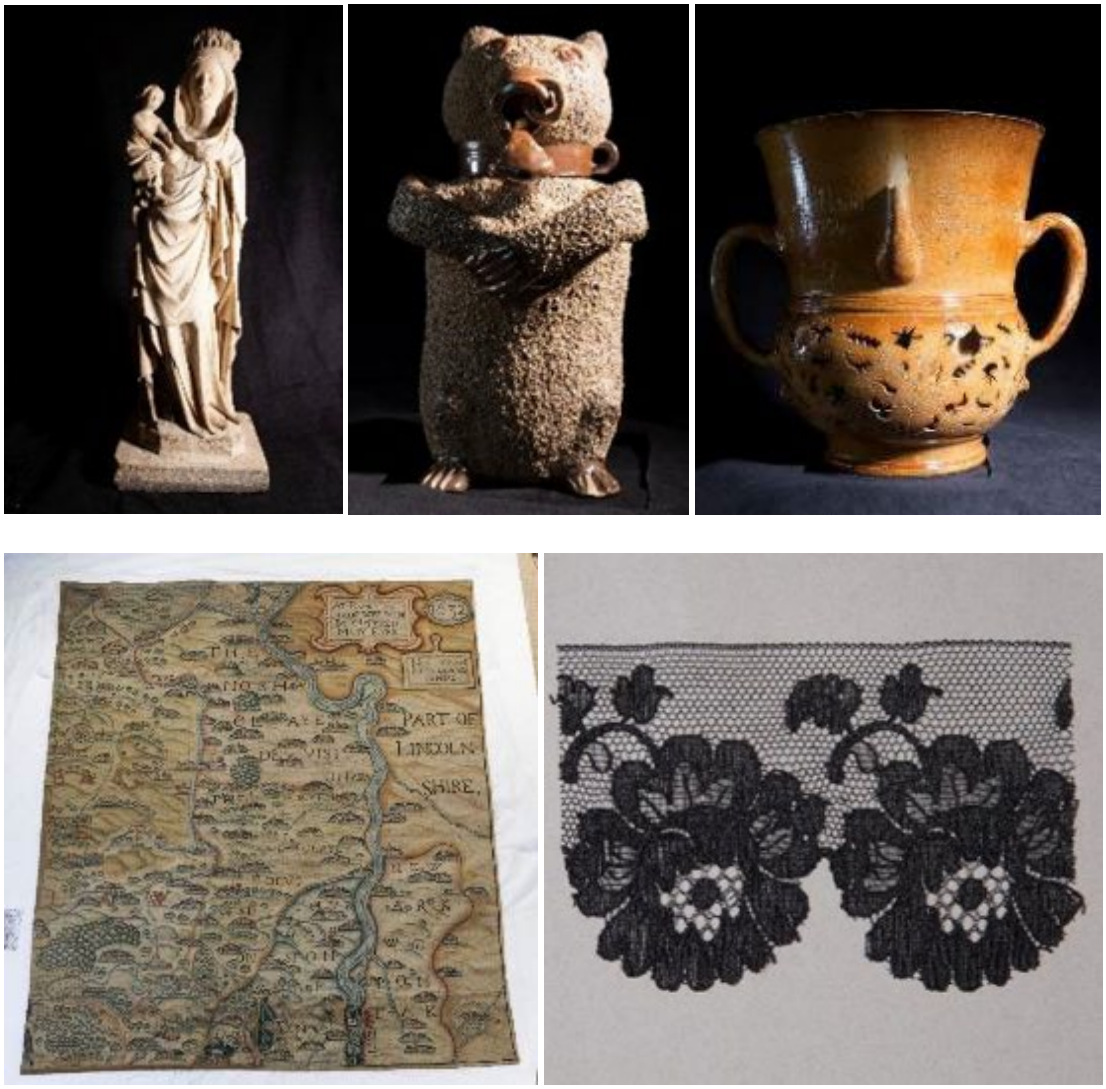

Figure 4: Objects initially presented by the Museum that were to be considered for scientific analysis. From top left: The Flawford Virgin; salt glaze bear; posset pot; one of the two 17th Century maps; machine lace (example).

The next stage was to convene a meeting with museum managers, curators and my supervision team to start to consider how to progress with access to these objects and start to design the analytical investigations required. As result of the Museum's HLF funded redevelopment, their entire collection was to be packed and removed to a secure site of storage. Some of the object types that had been offered for investigation were to be packed and moved to storage very soon, others had already been packed. Therefore, the availability of objects for research was juxtaposed with the Museum's need to prepare for redevelopment. A significant effect of this was that the conservation provision within the museum was focused on preparation for redevelopment as a priority and would not be available to assist me in any investigation of the chosen objects. As a result, access to a conservation lab or the expertise of the onsite conservator was not available. A

list of four object types was identified by the Museum's curatorial team. This list contained background information for each object and suggested research questions that the scientists could pursue, establishing the research themes of lace, alabaster, salt glaze and the maps (Table 4). The arrival of the list with the research questions revealed the varying perspectives of heritage scientist and museum curator. This will be explored in relation to each one of the object research themes later in this chapter.

The initial planning stages focused on movements and logistics of objects and instrumentation. The Museum is an N-SREO and the conservation capacity was entirely dedicated to packing and moving the collection off site for the temporary closure. This did influence the dynamic of the investigation. One result of this was that for a large proportion of the time in preparation for the site visits no actual dedicated facility existed to conduct the analytical investigation. This was resolved by the Museum making an education room available. This enabled the science to have dedicated space which was secure, had power and the light levels could be controlled. This room at the Nottingham Castle Museum site became the on-site 'project lab'. The Museum succeeded in enabling this room four weeks before going on site and this triggered an intense period of logistical planning. This had implications for the management and care of the objects under investigation and the logistics of their movement and created an object rotation system adopted in Site Visit 2. The analytical instrumentation's measurements are sensitive to ambient light condition and vibration. They require a substantial period of stabilisation and calibration. To use the instruments most efficiently, once set up and calibrated they are best maintained in position. As the museum objects were essentially moveable then the methodology was to rotate the objects under investigation around the instrument stations. This meant that Site Visit 2 was the only opportunity for the analytical instrumentation, its specialist operators, and the chosen objects to be in the same place at the same time to make efficient use of the scientists' time. For the salt glaze this was straightforward. However, for the Flawford Virgin this was a considerable problem. The object was heavy enough to require at least two people to lift it. It had been broken into three pieces and had been repaired in antiquity. The break at the neck had subsequently been conserved by the museum with an appropriate conservation adhesive which prioritised reversibility over strength. The conservation perspective on this was that every move of this object threatened its safety. The scientific perspective was that to move and recalibrate the instruments would create a drastic increase in the time and commitment required to gather the data. The arrangements for the scientific analysis had already expanded from an initial estimate of two or three days to a full week. A rota was designed to minimise the movement of the sculpture, but this still required it to be moved three times. Conservation decisions such as this are managed through Capel's RIP triangle (Caple, 2000, p. 34). Here the scientific goal of 'investigation' is given priority over 'preservation' (see Chapter 1, Figure 1).

The challenge for lace was slightly different in that it had to be moved from its storage at Newstead Abbey to the Nottingham Castle site and such movements were subject to the Museum's object handling policies. The movement of the map was impossible for Site Visit 2 and if it was to be analysed this would require a completely separate site visit. No conservator was available to supervise during the first two site visits so the Museum adopted a policy that only staff employed by the Museum could handle the objects. Although understandable from the point of view of their duty of care, the first two site visits would be highly impactful on museum staff time. As the research strands play out these considerations have effect. In these interchanges we see the first distance in approach and priority that manifested between the two organisations.

In the early stages of planning this research I had envisaged I would be involved in the operation of the analytical equipment. As a result of this I undertook to gain as much experience of the investigative equipment as I could. Certain equipment available to the ISAAC Lab did not find application in the case study. Other equipment required externally certified training to enable its safe use. The technical operation of all of this equipment was potentially trainable. However, I quickly became aware of the fact that this was not the crux issue. It was not the ability to operate the instrument but the ability to interpret the data it produced that was critical. Moreover, it was an ability to manipulate the operation of the instrument in such a way as to ensure the data collected was appropriate to the analysis. This realisation was noted through the supervision process quite early on in the progress of the research. I was clearly competent with the photographically based imaging processes and could control them to drive my research need, but the control of the analytical equipment was driven by a scientific knowledge that I did not have. This is the root of the decision to have PhD heritage science colleagues operating the analytical instrumentation and gathering the data, with my focus being to gather the 3D imaging and film sequences (Table 3). It is worth noting this observation in the context of the 'service provider' relationships established through memorandum of understanding described in the last chapter. It will also form part of the discussion on the manifestation of the bilingual, bi-competent facilitator.

Another consideration was the integration of filming and 3D imaging processes with the analytical investigation. Site Visit 1 was conducted independently of the on-site scientific support. By Site Visit 3 I was again working independently and by this time the museum had assured themselves of my capacity as a conservator and I was left unsupervised. However, within Site Visit 2 not only was the rotation system being managed by scientists and museum staff to facilitate the analytical investigation, but the rotation also had to absorb the needs of film making and 3D imaging. Considerable planning and negotiation went into integrating these two aspects of the research. Concerns were expressed by the ISAAC Lab team around set up and calibration times and limited time to gather quality data, this being balanced against an understanding that film and 3D content was also 'data' that had to be gathered within that week and leaving without it would have

compromised the research. Establishing this understanding between scientist and myself as filmmaker was critical to the success of the site visit.

Although the fine detail and challenges of how each object was imaged and analysed will be dealt with in the following descriptions of the research themes, it should be pointed out that the series of site visits was successful. The filming and 3D imaging requirements were met over the suite of visits and meaningful data was either gathered on site or obtained through post site visit arrangements. Chapter 7 will chart how that data was analysed and the subsequent observations, analytical conclusions and narratives that created the Flawford Virgin films were developed. However, this is not to say that every research theme produced analytical and interpretation outputs, far from it. An important observation here is that although the Flawford Virgin became the significant output, at this stage in the development of the research there was no way of prejudging which was going to be the most successful line of investigation.

6.1 The Research Themes

6.1.1 Lace

From the very start of this PhD lace was considered to be a subject for investigation given the significance of the Museum's lace collection. Consideration had to be given to how I was going to present this delicate object type in film, photography and 3D modelling either as images for interpretation or a vehicle to explain any scientific discovery. Under investigation lace reveals two sides to its character. The first is the appearance of it as a fabric with complex design and the use of pattern. The second reveals itself at high magnification where the complexity of the craft becomes apparent, the twisting and knotting of the threads carefully choreographed to create the effect of the finished fabric (Figure 5).

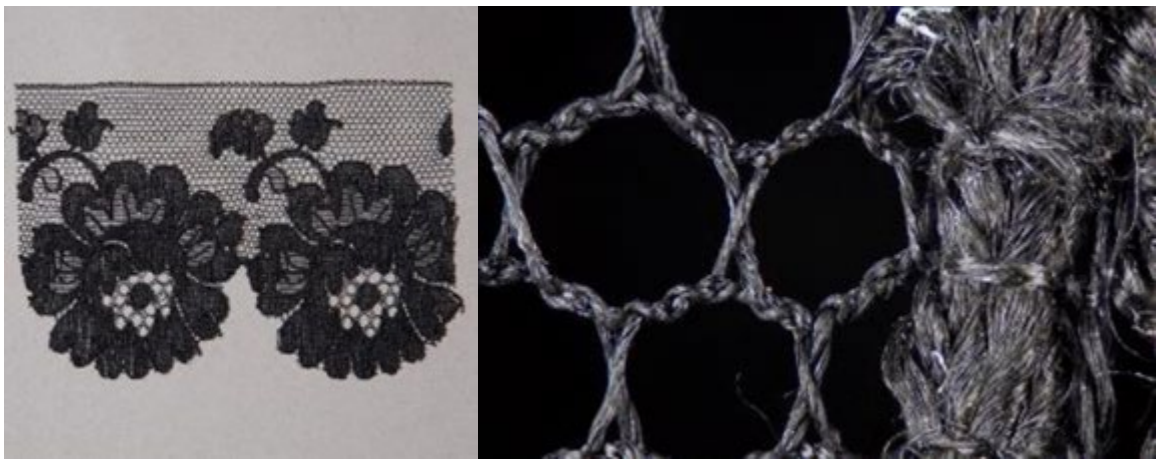

Figure 5: Left, machine lace created by a lace machine. Right, the same lace at high magnification.

The research questions posed by the Museum around lace were focused on issues that were pertinent to them with regards to interpretation: "Illustrate the difference between machine and handmade lace"; "Investigation into the shawl's 'gimp threads'" [25]; and "Textile identification" (Table 4). As the Museum is an N-SREO quite reasonably these questions were not framed in a scientific context. Words such as 'illustrate' and terms such as 'investigation' are broad in terms of how they would be interpreted analytically. 'Textile identification' was specific but there are methodologies within conservation to do this visually by microscopic means. Additionally, a historical investigation of the archives of the manufacturers could also have gone a long way to answering this question without recourse to analytics. The shawl referred to with regards to gimp threads was a large handmade object and delicate. Manoeuvring it under the focal stacking equipment to image gimp threads presented logistical problems and a risk to the object. As a result, a decision was made to focus on illustrating the differences between machine and handmade lace. These research questions reflected the fact that the Museum had no pre-existing issue that science could answer with regards to lace. In fact, the questions were driven towards the possibility of a 'micro-documentary' film which was under consideration to be screened within the 'Making of Nottingham' museum case planned for the refurbished Lace Gallery. The analytical approach was to be speculative. There was some possibility of using the instruments in the identification of the textile type and this might throw some light on the capacity of the instrument itself from a research and development perspective. Additionally, some consideration was given to dye identification although this was thought to be problematic as only black was represented within the final selection of laces. It was indicated that some of the analysis might throw light on textile machines used. There was also merit in using the OCT equipment to study lace as this instrument had the capacity to create a 3D image. Although this speculative approach bore no fruit for lace in this programme of research[26], it did advance the analytical enquiry for both the Flawford Virgin and salt glaze as will be explained in the following chapter.

My main focus was to develop a methodology for creating high magnification images, and 3D models of lace, in order to see the intricate structural qualities. My first task was to attempt to create a 3D model of this complex fabric. The first chosen technique was photogrammetry (Luhmann *et al.*, 2014; Cultural Heritage Imaging, 2017). This is because it can be achieved by taking multiple photographs with a regular DSLR camera and affordable software and does not require any specialist equipment. Appendix 4 gives a detailed description of the photogrammetric

[25] The shawl was a garment made from black Leavers machine lace (date - 1855-1870). It did not get selected for the final analysis due to its fragility and size. Gimp threads are thicker threads employed in lacemaking to outline detail and add pattern. These were evident on the shawl.
[26] The ISAAC Lab team are embarking on a body of research related to the lace collection held at NTU.

process. However, although 3D models were successfully created there were difficulties cleaning the models effectively as they are lattice structures. There were also difficulties joining two sides of the flat plane of the lace to create a truly 3D model. The models produced with this methodology lacked the detail and clarity to really explore the complex structure of lace at microscopic level (figures 6 & 7). Appendix 4 gives a detailed description of the challenges that this technique presented.

A second technique of focal stacking was explored. However, this relied on being able to create microscopic magnifications from a DSLR camera lens. The technical aspects of this are described in detail in Appendix 4. At high magnification a camera lens will only have part of the subject in focus. This is a very shallow 'depth of field' (Langford, Fox and Sawdon Smith, 2007, pp. 45–46). In the case of a lace sample this would have been just the uppermost threads closest to the lens. As the lens is moved towards the lace sample the uppermost threads slip out of focus and a thin slice of threads just below them comes in to focus (Figure 8). By repeating this slicing process and accurately recording the incremental movement of the lens it is possible to measure the distance between the threads that are in focus at the top of the lace sample and the threads that are in focus at the bottom. The focal stack technique was explored by the ISAAC Lab team using the data analysis software MATLAB (MathWorks, 2021). It produced an accurately measured image but was visually very difficult to interpret by a mainstream museum audience. I then turned to more photographic based software. By processing using Helicon 6 software to select in-focus pixels from each one of the images and then aligning and combining them together it was possible to combine all of the sliced images in the focal stack into one in-focus image (Helicon Soft, 2017). Additionally, because depth measurements have been taken, a 3D model can be created (Figure 9). This image, although lacking the measured accuracy, had a much greater visual eloquence. The Helicon software (2017) allowed the focal stack images to be processed into short sequences of film where the 3D model could be animated to illustrate its structure (Figure 9) (Pickup, 2020)

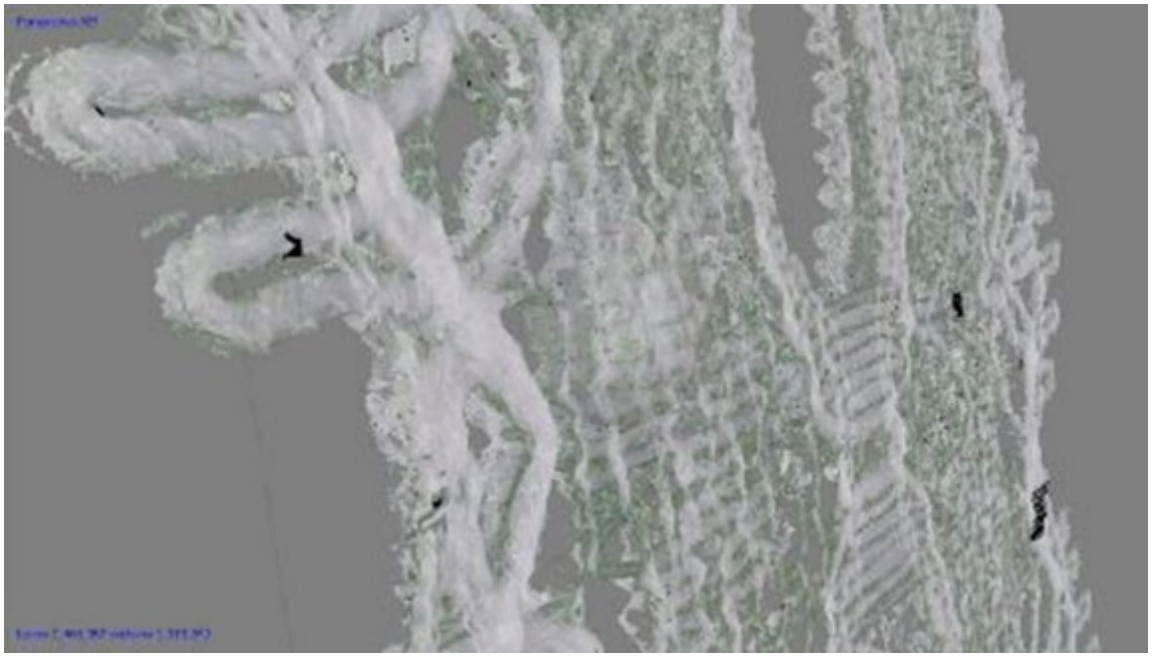

Figure 6: The ragged effect of trying to join two single side lace models together. Note the green 'residue' from using a green screen to remove the background from in and around the lace structure.

Figure 7: The best quality lace model produced using photogrammetry. This is the model at its maximum magnification before the problems in figure 6 become apparent

Figure 8: Left, an image of lace from the top of the focal stack. Right, an image of lace from the bottom of the focal stack.

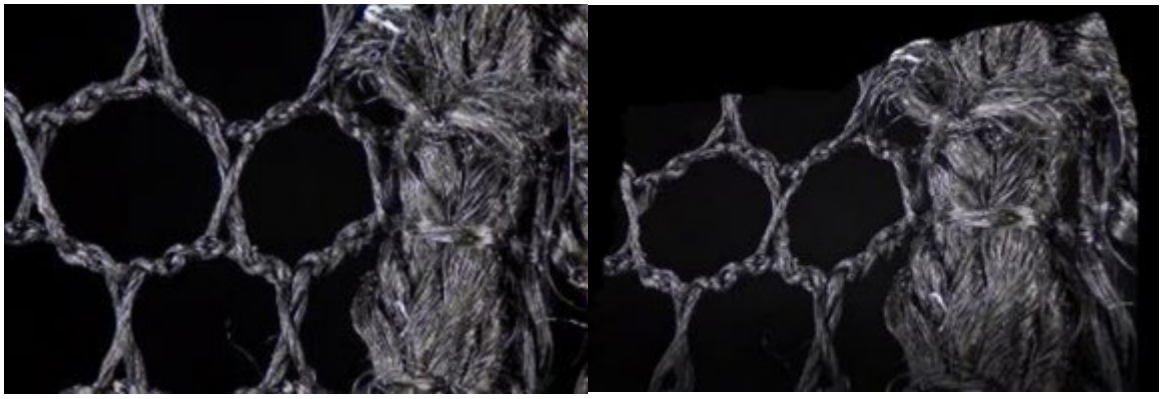

Figure 9: Left, focal stack image of machine-made lace from a Levers Lace machine. Right, 3D model of same from which the software can produce a short animation sequence.

The analytical instrumentation also presented an imaging option for lace with Optical Coherence Tomography (OCT) (Cheung, Spring and Liang, 2015). The instrument's laser could penetrate a light permeable material such as lace and also had the capacity to create an animated 3D model (detail of how this is achieved is available in Appendix 4). If one looks at figure 10 one can see the visual characteristics are very different to those in figure 9. Figure 10 represents an image which is analytical in its intent and retains measurable qualities which are imbued from the use of an analytical instrument. The photographically produced image in figure 9 prioritises visual eloquence to communicate with its target audience in the Museum. I will return to this discussion of scientific images and images from science in Chapter 8 where I will be exploring the resonance of the concept of the rigour-relevance gap and its manifestation as two systems, in translating the outcomes of analytical investigation into interpretive product.

I required considerable support to operate the OCT equipment and creating an image by this methodology required me to do little analytical work. The final technique to produce the 3D model was similar to focal stacking and therefore familiar to me. However, this instrument has considerable analytical capacity, but the level of specialist knowledge required to access it was

that of the heritage scientist. The final decision was that the focal stacked image and 3D model produced with Helicon software were the most appropriate for an interpretation application.

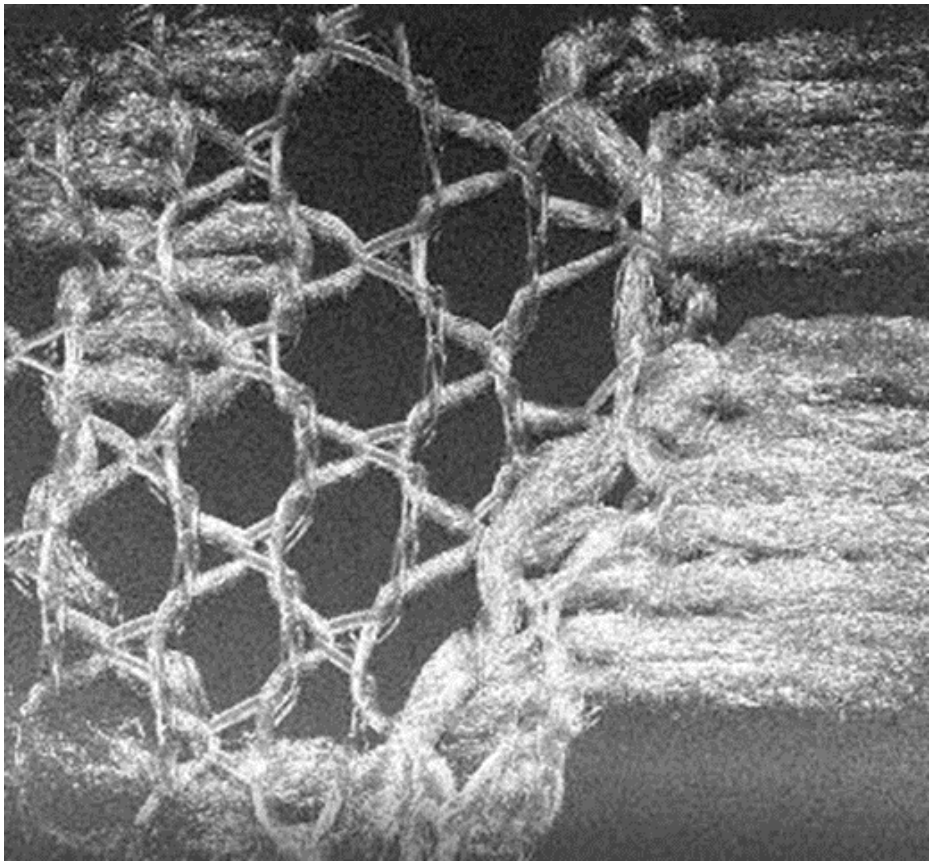

Figure 10: Image of lace created using the OCT equipment supplied by ISAAC Lab.

With the imaging for lace resolved the next consideration was one of logistics. The lace collection held by Nottingham Castle Museum & Art Gallery is stored at Newstead Abbey. It was here that the first site visit would take place. Originally planned in early November 2017, it was rescheduled for nearly a month later to absorb the technical challenges being dealt with to prepare for it (Table 3). This site visit was specifically to work alone with the curator to employ focal stack photography to create the high magnification images and 3D models that would become the interpretive product for lace. Despite the postponement of this event by a month the technical challenges of creating satisfactory imaging for lace still made this deadline challenging. I arrived on site with the equipment to create the images and a request for examples of lace from the collection which represented examples of each of the lace machine types and one example of handmade lace. The curator delivered each sample in good time to create the focal stacks for each of the lace types. It was not until much later that I discovered that I had contravened museum protocol by not requesting these samples days in advance. I had quite innocently exercised a level of agency that I would with a research librarian without truly understanding the culture of the organisation I was working with (Bonacchi and Willcocks, 2016). Lace also had to go to the project lab on the Nottingham Castle site for analytical analysis. Again, what on the surface

might seem a straightforward transfer of a museum object from one site to the other for the duration of a day generated considerable challenge in achieving this within the confines of object handling guidelines and staffing rotas. These issues might be considered minor but viewed in the context of the existence of cultural difference as identified by the literature it has resonance.

Analysis of the data collected from Site Visit 2 did not suggest any significant ongoing analytical enquiry. Lace remained under consideration as a subject for film until late 2018. The first iteration of the Flawford Virgin film contained an introduction which pre-empted films on lace and salt glaze. However, the Museum's considerations for the micro-documentary for the Making of Nottingham museum case were reviewed and a decision was made that film no longer had a role within the developing plans for the lace exhibition. However, the focal stack images along with their short 3D animation sequences were felt at the time to have interpretation potential. In the initial discussions it was proposed this would take the form of an interactive cafe wall where the lace images would be linked via 'Artcodes'[27] (2016) to their 3D animated sequences. The Artcodes operate much in the way a QR code does. It was proposed that these Artcodes would link to photographic and 3D animation material on the Museum web site. This would allow the photographs and 3D model animations to be viewed on visitors' handheld devices while in the cafe[28].

[27] Artcode is very similar to QR code, the difference being that the hyperlink to online content is triggered by a picture.

[28] A final resume of the developments the Museum have made towards this goal will be given in Chapter 9

6.1.2 The 17th Century Textile Maps

Figure 11: One of the two 17th Century textile maps demonstrating its scale.

To view the two seventeenth century textile maps I was accompanied by my scientific supervisor and the Curator of Textiles at Newstead Abbey. Once laid out on the floor of the main hall of Newstead Abbey the map was nearly nine square metres in area (Figure 11). It is an impressive object, and my initial reaction was that it could form a centre piece to any interpretation output. The research questions posed by the Museum spanned across historical research, the object biography implications of the various visible repairs and textile and dye identification (Table 4). Again, these questions did not focus on the resolution of an analytically framed question. However, dye identification would lie within the remit of the instrumentation available at ISAAC Lab. The problem presented here was one of sheer scale and accessibility. Transporting this object to the project lab for Site Visit 2 was not viable both for conservation and handling reasons relative to assisting in PhD research. Additionally, the project lab was not big enough. The Museum expressed concern about the risk posed to this delicate object by the analytical techniques. There were also challenges in conducting analytical research in what was a public space. The floor of the main hall of the Abbey was the only place on site that was big enough to lay it out. Closing this public access space for the scientists to work undisturbed was again not realistically viable. Certain avenues were explored for a fourth site visit but the logistical and

conservation issues meant that it was not a good candidate for further investigation and was suspended as a research theme by mutual consent by early 2018.

6.1.3 Salt Glaze

The formulation of the research questions for salt glaze developed over a period of time, with the initial questions having an emphasis on the construction of the ceramic. However, the question 'how does the salt behave in the firing process?' could be framed in analytical terms. Background research revealed that a previous investigation had been carried out which came to light during literature review (Henstock, Hildyard and Wood, 2010). This was research that had not been published but was included as part of an exhibition catalogue for an earlier salt glaze exhibition at the Museum. This single page entry considered how during the firing process iron was drawn from the clay body up into the glaze to give it its characteristic brown colour and creating a white layer against the surface of the clay. This research suggested there could be implications for determining the provenance of salt glaze ceramic. As the Museum is an N-SREO it is interesting to note that the research question presented by the Museum had not been framed as a continuation of this pre-existing research but as a parallel or independent research. However, this did trigger the interest of a scientist at ISAAC Lab, a specialist in ceramics, based on the scientist's previous research. A research question developed around the possibility that analysis may be able to reveal markers to identify ceramic from the different potteries that had been operating regionally. This was of interest to the Museum as a significant proportion of their salt glaze collection was unprovenanced. This was clearly framed as a scientific research question but to achieve the analysis the scientist would require multiple samples of known provenance from each of the potteries in order to identify characteristics common to them. They would also require samples with exposed break edges as the instrumentation would need to be able to take readings from both the clay body and the glaze layer. In the rotation planned for Site Visit 2 only two items of salt glaze were available, the posset pot and the salt glaze bear. Hence a request was made to draw more samples from the Museum's collection with known provenance, in sufficient quantity to analyse common characteristics. This request from the scientists came three weeks before going on site. This was a scientific requirement but would impact the Museum as the process of packing and moving the collection to its new storage site had already begun. The outcome of this was that the body of analytical study on salt glaze could not take place during Site Visit 2. However, suitable samples of shattered sherds of salt glaze did exist, held within the Museum's archaeological collection (not subject to being moved to the offsite store). Although held in the Museum store it was in fact owned by private individuals who now occupied the sites where the original salt glaze potteries had been. Once permission had been obtained it was possible to move

these samples to the ISAAC Lab after the site visit had been completed. However, what had not been decided was which of the instruments would be the most appropriate to investigate this provenance and by which methodology. For this reason, there was merit in taking the salt glaze objects available for Site Visit 2 through the different instruments to obtain a baseline set of data to inform that decision. A discussion of the results, subsequent analytical findings and implications for the creation of narrative will be discussed in Chapters 7 and 8.

The next task was to formulate a methodology to image items of salt glaze in order to manipulate them in a film context. Like the challenges of the 3D modelling of lace, salt glaze also presented specific problems in the creation of a 3D model that could be animated. Although as previously described, rounded 3D objects often make good subjects for photogrammetry there is a caveat with salt glaze; it has a shiny surface. Photogrammetric subjects have to be evenly lit and the content of the photograph is what the software uses to map the camera position in relation to the surface of the object. Recognisable features on the surface moving to different positions in subsequent photographs allows the software to combine the overlapping images. Shine and highlights on the surface reposition themselves as the object is moved into different orientations. It confuses the mapping process and often manifests in the final model as a fog or bloom on the surface or an organic white shape attached to the model (Figure 12). As with lace, attempts to overcome this problem were very time consuming and in the run up to Site Visit 2 this technical problem was not resolved. No satisfactory methodology was available to create 3D models of the salt glaze objects. More traditional photographic and filmic solutions would be required to tell any story arising from the analysis of salt glaze.

Figure 12: 3D model of a salt glaze pot used for trialling photogrammetry showing white extension on the rim, caused by shine.

6.1.4 Flawford Virgin

The Flawford Virgin presented handling challenges in the form of its weight and vulnerability so an initial inspection within the case was made available. In retrospect I reflected on my time as a conservation student where a dedicated conservation laboratory was available. In this scenario museum objects were brought into the laboratory and presented at your workstation, where they would be under your care. Intimate inspection would be carried out to gather information that could be discerned from the physical condition of the object. Small programmes of testing might be carried out to confirm or question the identity of certain materials. Background research would enrich context and potential object biography. None of this would be driven by one specific research question but a more holistic gathering of information to build a picture, ultimately to inform a treatment. However, in this scenario I presented as an HEI researcher. The initial encounter with the Flawford Virgin had to be much more modest. On my arrival one glass panel was removed so that I could view the sculpture. I photographed tiny stains of colour and fragmentary remains of gilding (Figure 13). It is worth noting at this point that as the site visits proceed my opportunity to have a more in-depth investigation follows and with it a deeper understanding of the issues surrounding this sculpture that begin to inform the film narrative.

Figure 13: The Flawford Virgin as seen in its display case. Visible are the break at the neck, remains of gilt on the drapery and traces of colour in the crown.

As with salt glaze the research questions surrounding the Flawford Virgin, as framed by the Museum, manifested in two different ways: those that the analytical equipment was best suited to tackle and those that informed the object biography with potential interpretation outputs. The question 'What were the original colours/pigments?' was perfectly framed for the scientific team. ISAAC Lab specialises in non-invasive pigment analysis and they felt confident that by using complementary data obtained using different techniques they could answer this question. A second question requested the 'geographical provenance of the alabaster'. This was considered by the scientific team to present a complex scientific challenge; however, they did feel it offered the potential of a scientific outcome. The progress of these two lines of investigation would become significant in developing an understanding of the contribution science can make to object biography and how that narrative is expressed as an interpretation output in film. The implications of this will be explored in greater detail in Chapters 7 and 8.

The questions: 'What is the nature of the two cracks?', 'When was the backing added?' and 'Is the base original?' fall into a category of information to inform the object biography with potential interpretation outputs. These questions were not given direct attention through the scientific analytical techniques but were considered by myself from observation rooted in my training as a conservator. Initial observations were made in Site Visit 2 but in Site Visit 3 I had time to observe and consider what physical evidence there was to approach these questions. From observation one could see that neither the backing nor the base was alabaster. The alabaster was only a few centimetres thick, and the carved detail aligned with a flat plane suggesting it was carved from a narrow slab. The break at the middle of the sculpture stopped at the plaster backing. The break at the neck continued through the backing, but the museum had reported that this had been conserved. This would imply that the plaster backing was added post breakage to hold the sculpture together and the repair had failed later at the neck. The plaster backing appeared to bulge out at a point roughly in anatomical line with the buttocks and to mimic a Victorian bustle. The base was proportionately positioned to accommodate this plaster backing and the base had visible fittings (Figures 14 & 15). The known object biography provided by the Museum said that the sculpture had passed through a number of owners and had spent time as a garden ornament. The three pieces of the sculpture being reassembled and repaired with a plaster backing and attached to a base to make it stand up would fit this known biography and would be presented as a reasonable hypothesis in the films.

A second line of investigation I carried out for the Flawford Virgin was a Reflectance Transformation Imaging (RTI) survey of the damage on the sculpture's face. Unlike photogrammetry, where the camera moves to different positions, RTI employs a series of multiple photographs taken from the same position, each lit from a different light direction rotating

through 360 degrees[29]. The result is a digital rendering of the surface that reveals 'topographical' detail that would be difficult or occasionally impossible to see with the naked eye. A more detailed description of this technique is available in Appendix 4. This technique was one that would be within the remit of a conservation investigation and represents the potential the conservator has to frame scientific research questions. Through this technique, I observed that the damage to the face had a flat planed quality on the cheek that came to a halt in a straight cut line. There was also a small amount of damage on the eye lid and the top lip (Figure 16). The pre-existing object biography supplied by the Museum suggested that the sculpture was of medieval origin and present in Flawford Church at the time of The Reformation (Thoroton, 1790). In addition, it was found hidden under the floor during the 18th Century demolition of the Church.

Figure 14: Left, Area of the original alabaster highlighted showing the addition of the base and plaster backing

Figure 15: Right, The base of the Flawford Virgin showing fittings. Also note the repair to the 3D model on the back edge of the base that had to be hidden in the animation.

[29] For more information on RTI see Cultural Heritage Imaging (2017)

Figure 16: Still from the Flawford Virgin 3- and 10-minute films illustrating a light effect to mimic a potential sword blow.

However, what is unclear from the historical accounts is if the two breaks were pre- or post-concealment of the sculpture. If one looked at the plane of this damage and considered the possibility of it being pre-concealment, then an intriguing hypothesis arises: was this a glancing blow from a bladed weapon? Could this be an attempt to destroy the sculpture during The Reformation followed by the clergy hiding it to prevent further damage or destruction? (Thoroton, 1790). This would be presented as a hypothesis within the final films. In theory the Flawford Virgin should be a perfect subject for photogrammetry. It is a solid 3D object with a matt surface and plenty of surface detail for the software to map. However, to model the Flawford Virgin was problematic. Due to its weight and the fact that it had two major breaks through the alabaster, it was at great risk of damage through movement. For this reason, it was limited to standing on its base or lying on its back where there was no carved detail. Other orientations would not be possible. When this was rehearsed prior to going on site with a sculpture of my own, it proved very problematic, leaving the rear bottom edge of the base unmodelled. Numerous attempts were made to overcome this problem, and all proved unsuccessful. During Site Visit 2 the best possible model was made within the movement restrictions placed on the object. The model was repaired using MeshLab (Visual Computing Lab, 2017) and in the final films

the model of the Flawford Virgin would be animated in such a way that this repair was never seen (Figure 15).

The strategy of obtaining film footage appropriate to any narrative surrounding the analytical investigation of the sculpture had to be pre-planned and shot within the week of Site Visit 2 when the sculpture was available. Experiments were carried out trying to create panning and zooming effects with the Canon 6D DSLR camera I was using for filming. The camera itself was very capable but the photographic tripod didn't allow camera movement without vibration. Rather than attempting to source a film tripod the problem was overcome by using a carefully planned lighting system and shooting still photography of the sculpture. The still images could then be processed in the film-making software by panning and zooming across and into the image. This technique is commonly referred to as the Ken Burns Effect and its application will be describe in greater detail in Chapter 7.

6.2 The Site Visits: An Overview

Site Visit 1 (Newstead Abbey: lace), Site Visit 2 (Nottingham Castle site: lace, salt glaze and the Flawford Virgin) and Site Visit 3 (the Flawford Virgin) produced a body of conservation-based observations and analytical data that was to be analysed and developed into scientific outcomes by the scientists and interpretation outcomes by myself. The descriptions of that analysis and development of the films forms the content of Chapters 7 and 8. However, at this point it is worth reflecting on the commonalities of experience across the site visits to have a more granular understanding of how these two institutions interrelated, especially in the light of the published literature with regards to museum and university partnerships and that of the rigour-relevance gap.

It should be reiterated that the programme of site visits was successful. The analytical data gathered then went on to fuel scientific outcomes and develop interpretive product. However, I did not fully appreciate how invasive the film making process was to the smooth running of the analytical data gathering. In many cases it was not possible to simply film over the shoulder of the scientists as they worked. This meant that analytical processes had to be filmed after the event by mocking up that process after its completion. This they did with good grace, with an appreciation that film was an integral part of the 'data' that required gathering. However, it had to come from the time budget they had for analysis. The complexity of Site Visit 2 and the time pressured way in which the rotation system was designed was a concern before going on site. Yet it was effective. The curatorial staff, after the challenge of accommodating the science, appeared excited and engaged in the activity. However, I did observe that I had not successfully communicated the

nature of the analytical investigation, the capability of the instruments and the scientific methodology, to the Museum's curatorial staff. Although requested by the Museum, it was not possible for the scientists to give any initial feedback on their investigations until their data had been processed. A few weeks after Site Visit 2 I was asked to produce a resume of what each of the instruments analysed in non-technical terms, so the curators had a reference to understand the analytical investigation that had taken place in their museum. The Museum could not be expected to present as a scientifically specialised participant (Bonacchi and Willcocks, 2016, p. 14). However, I would argue that this expression of cultural difference highlights the challenge of positioning oneself as bilingual and bi-competent facilitator between what are potentially two systems of knowledge and understanding. A defined strategy to overcome this distance would need to be developed in future interactions.

6.2.1 The Question of Research Questions

An early part of the process in preparation for all of the site visits was to establish research questions for the scientists to select appropriate instrumentation and analytical methodology to answer them. What I noted was a misalignment for the framing of these questions. The Museum had no pre-existing programme of scientific investigation for which they were seeking assistance from the ISAAC Lab at NTU. Hence the starting point for the Museum was to raise questions that would have application to the interpretation narratives that might be useful to them. The transition of these questions into those that were appropriate for the scientists to answer meant that the Museum had to relinquish a degree of agency over them and allow them to be framed in scientific terms, with some remaining unanswered. We can reflect here on the commentary from the discussions with curators concerning control of research processes and the requirement for them to meet exhibition programme requirements, museum ethos and business aims and objectives. It would seem that the negotiation of the research questions is highly significant in this translational process. We see a distance between what scientists need to function effectively in an analytical system and what the museum actually requires from within their interpretation based system. Through my training as a conservator, I felt I had an understanding of what was required from the research questions. However, as the preparations for the site visits progressed it became apparent that my understanding was not in alignment with that of the scientists. This misalignment was not within the questions themselves but me not fully appreciating what information was required to inform the analytical methodology. What was needed was a mapping of the debates surrounding heritage science and conservation issues relating to an object and an analysis of what the science can contribute. In this sense the scientific research question has to be developed not only relative to the object but within a context of scientific research in that area.

This also needs to be framed within the facility of the investigative capacities within any one heritage science group. Research questions could be raised that are perfectly valid but not answerable with the suite of instrumentation and expertise available. As has been explained, the analytical processes were to be carried out by other PhD students and research fellows with specialism in the specific instrumentation. My lack of expertise in gathering and interpreting the analytical data had moved my focus to 3D imaging and photography and managing film content. As has been demonstrated, the management of this content was proving more challenging than was anticipated and therefore absorbing a lot of my time. I had not appreciated how much more background information and fine tuning of the research questions was required for the scientists to operate effectively. This was magnified by the fact that the other PhD students were not actively pursuing this as it was not their programme of research, they were simply helping by gathering data. If Kieser and Leiner's concept of the bilingual and bi-competent facilitator was to be enacted to full potential, then the knowledge of the two systems they were facilitating would have to be very broad.

The Museum facilitating a room for a project lab a few weeks before the site visits were planned brought this disparity into sharp focus. I embarked on literature review and background research on the scientists' behalf but in the holistic way a conservator would rather than driven by an understanding of the needs of the instrumentation and the data outputs. In this case study the scientists are working with research questions that were not generated from an ongoing analytical investigation or research programme from within the Museum but were directed towards an interpretation outcome. I propose that the concept of the rigour-relevance gap is manifest here. If we consider the two systems suggested by Kieser and Leiner (2009, p. 516) then the scientists were being pulled from their analytical system into an interpretation based system. Negotiating questions the Museum generated from an interpretation perspective to those that science could frame and had facility to answer was, in retrospect, a big part of the challenge that this phase of the case study had to overcome. The ideal would be to reach a point of synergy where the question was well framed in scientific terms and yet had substantial implications for the object biography and potential for interpretation. The question regarding the Flawford Virgin's original colours did just that.

6.2.2 Agency and Roles: Power Imbalance and the Role of Participant Observer

In order to carry out an effective analytical investigation, the requirements the scientists have to operate their equipment and the availability of the subject matter for analysis, have to be facilitated. The role of operations facilitator was carried out by the Museum. ISAAC Lab are specialists in on-site analysis and are contributors to the European Research Infrastructure for Heritage Science mobile lab facility MOLAB (2018). Working in this way was familiar to them. Fine tuning the skills of managing analytical investigation in an onsite context was a justification for the other PhD heritage science researchers to assist me on site. As the research questions developed, the scientific team were clear and purposeful about what they needed to be effective in gathering the analytical data and in so doing demonstrated a high level of agency. During the late developments in planning the analysis for the Flawford Virgin, a request was made to gain access to other alabasters from the collection. The scientific rationale was a greater breadth of comparative data from different alabasters from the collection, from which one could identify patterns. When a similar request was made for salt glaze this was possible as it effectively meant collecting a box of bagged ceramic sherds from the archaeological store. For alabaster sculpture, the practical collection management issues and conservation concerns and the lack of time, made this request untenable. I was aware that the ISAAC team were agile in how they could approach the challenges presented. Even under considerable time pressure they appeared to be flexible and responsive in approach and application. For the Museum I observed that facilitating the requirements of the analytical investigation was much more challenging. However, they met those requirements despite these challenges. This idea of the museum being a facilitator of analytical research activity does appear in the literature (National Co-ordinating Centre for Public Engagement, 2016, pp. 19–20; Markham *et al.*, 2019, p. 36) and was observed by the discussion cohort with varying degrees of amicability. I would suggest this is a manifestation of the cultural difference that existed between these two institutions. However, within this case study this shift in agency, with the scientists in ascendancy, could not be interpreted as manifestation of power imbalance as described in the literature (Bonacchi and Willcocks, 2016, p. 30; Dent and Willcocks, 2016, p. 20) but a necessary fluctuation to facilitate this part of the project. As I will demonstrate later in the narrative that agency comes back into the hands of the Museum as they issue their brief (Appendix 1) and the final interpretive product is created.

ISAAC interaction with the Museum is one observation. However, my own interaction with both parties as participant observer also requires analysis. I was the designer of the research methodology and the catalyst for this research to take place. However, as a PhD student I had restricted agency as the project manager. The ISAAC Lab had clear requirements that had to be met, the Museum also had requirements that had to be met in terms of the management and

care of collections. I had no decision-making power on behalf of the scientists or the Museum. My role was to take requests for facilitation in one direction and issues affecting the meeting of those requests back in the other. On reflection it is arguable that simply stepping back and focusing on making a 3D animated film with the Museum and the scientific team negotiating directly might have been more efficient and could well have brought about a swifter understanding of the issues surrounding the research questions. I suggest that a scientific team with a pre-existing concept of the rigour-relevance gap would have been enabled to do this. The difficulty was that I was the catalyst; I was initiating the reaction between these two organisations as it was my PhD. My position of participant observer was being shifted into the participant end of the scale and yet what I was observing was being influenced by my participation. Paradoxically my presence was both productive in driving the activity forward and obstructive in the interaction between them. This does beg the question of how a bilingual and bi-competent facilitator should interact. Because of the breadth of knowledge required this case study suggests that there are limitations to when this facilitator should be proactive and when to defer to greater expertise. An interplay will need to take place managing stakeholder outcomes and cultural difference, while managing levels of agency to allow separate systems to function unhindered. What it did do is allow me to experience the rigour-relevance gap that opened up between these two organisations and the fluctuations of agency at this stage of the research to be redressed at a later stage in the case study. This did inform a more granular understanding of the issues identified by the literature, of cultural difference and rigour-relevance in the context of heritage science as a representative of an HEI working in a museum.

Within this chapter one observes an interaction between two organisations where a cultural difference manifests and is managed. The logistics of making lace, alabaster and salt glaze available for analysis challenge the priorities and systems that the museum has in place. One sees research questions which have to be negotiated from interpretation centred to analytically appropriate. Within this lie issues around the level of agency the analytical process requires within the Museum to operate effectively. Considering which, one is mindful of the comments from the discussions cohort like, ‘academics don’t understand museum function’ and talk in terms of being intimidated by academia, or ‘far apart’ in their relationship. What is also evident is to see the role of bilingual/bi-competent facilitator being stretched to the limit of that ‘linguistic’ capacity.

Chapter 7: Case Study Part 2: The Story of Developing the Data into a Narrative for the Films

Chapter 6 focused on the preparation for and completion of the site visits and observes the interaction between the two organisations with reference to the literature and the discussions programme. This chapter describes the post site visit scientific analysis and how the research themes reach their conclusions. Again, there is resonance here with the issues raised in the literature. There were now only two research themes of the original four that the ISAAC Lab team were actively investigating. As will be seen, salt glaze did not reach a filmic conclusion. However, the Flawford Virgin research theme became a suite of films manifested as a research outcome and a response to the brief set by the Museum. Table 5 shows how the main body of the active phase of the analytical research took place during 2018. Pressing academic commitments for the ISAAC Lab team meant that they were not available to pursue the research themes until my third site visit in June 2018. This restarted the analytical investigation phase of the research. The analytical investigations, their findings, and the implications of those findings, came to completion at the end of October 2018 in the form of a film entitled 'The Flawford Virgin' to be presented on behalf of NTU at the Digital Heritage 2018 conference in San Francisco. This film was the first iteration created from the outcomes of the analytical investigation. The next iterations were not created until April 2020 when the Museum presented a brief to deliver a series of interpretive films.

7.1 The Analytical Investigation Writes the Script

The script and storyboard for a non-fiction film can be created at different stages of the production process dependent on how the content is created (Young, 2002, pp. 21–22). In this case, although the production had started, the narrative created by the analytical investigation post site had to be completed before decisions could be made as to how the story revealed by the science was presented as interpretation. Not all lines of analytical investigation produced noteworthy stories. Some analytical investigation had output relevant to peer review publication rather than film narrative. All of this had to play out before the film narrative could be defined. As the research themes developed the Flawford Virgin research theme would present as the best candidate for an interpretive product in the form of film. As with Chapter 6 these research threads ran concurrently, interwoven with each other. For clarity they are described here separately and taken to their scientific and/or filmic conclusion.

Research Theme	Jan 2018 to May 2018	June 2018	July 2018	Aug 2018	Sept 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019 to March 2020	April 2020
Lace										
Flawford Virgin Polychromy										
Flawford Virgin Alabaster Provenance										
Flawford Virgin Sword Blow										
Salt Glaze										On going...
Significant Events	ISAAC Lab team take 6-month break from pursuing the research themes due to pressing academic commitments	Site Visit 3 – Flawford Virgin	Geologist indicates OCT results do not indicate provenance		Film about lace no longer required by the Museum	Screening of the first iteration of the Flawford Virgin film at Digital Heritage 2018				The Museum issues their brief for the Flawford Virgin Films
Film Course: Cinema 4D, After Effects & Premier Pro										

Table 5: Gantt chart of significant events affecting the research themes after the site visits.

The only film shot at the start of 2018 was a small amount of onsite footage of scientists operating their equipment and some scenes from the site of where Flawford Church once stood. Therefore, the story of the investigation would need to be told through 3D animation. This posed a technical challenge which had to be met by procuring bespoke training in Adobe After Effects software (Adobe, 2017) and its embedded light version of Cinema 4D software. This enabled me to animate the photogrammetrically created Flawford Virgin model as a film and manage film effects to enhance its interpretation potential. However, at the start of the course the Digital Heritage 2018 conference scheduled for October in San Francisco was only a few months away. This represented an exciting opportunity but also an absolute and immoveable deadline for completion.

What lay ahead in the subsequent months was to pursue lines of investigation related to salt glaze and the Flawford Virgin. As described in Chapter 6 the post-site analysis of lace produced little of scientific interest and the final outcome presented to the Museum was the focal stacked images and short animated sequences. However, I will return to lace in Chapter 8 as a discussion of the nature of the images created during the lace investigation have significance in understanding the transition from analytical investigation to interpretive product. This has resonance with these two approaches operating as separate systems. The analytical investigation on the Flawford Virgin had shown potential to identify the position and nature of its original polychrome. In addition, the analysis had raised the possibility that characteristics of the alabaster's grain structure could indicate where the sculpture's alabaster had been quarried from. The research presented well-framed scientific research questions and could be resolved with the equipment and expertise that the ISAAC Lab team had at their disposal. However, and perhaps more significantly, answering these questions could enhance the object biography of the sculpture and produce outcomes that had real potential as revelations to serve the purposes of interpretation. In a very real sense what the scientists found dictated the content of the final interpretive product produced.

7.2 The Research Themes

7.2.1 Salt Glaze

During Site Visit 2 only two examples of salt glaze could be made available. The sherds of salt glaze held by the Museum were privately owned. Only when they were cleared to be taken to ISAAC Lab could the real analysis begin. The shattered sherds were from known salt glaze pottery sites (Figure 17). The Museum collection had examples of salt glaze pottery which were more complete pots but did not know in every case which potteries these examples had come from. If

the sherds of known provenance could be seen to have subtle chemical differences which were attributable to specific potteries, then analytical techniques could be used to provenance other items in the collection. This would be done by seeking a match in the unprovenanced salt glaze collection with the known chemical markers. The chosen technique was X-ray Fluorescence Spectroscopy (XRF). This instrument has the capacity to identify specific elements. By being able to group the sherds into known potteries and look for the amounts of certain elements which one would expect to find as a result of the raw material and the ceramic production process, particular patterns began to emerge. Distinctive markers for two of the potteries outside Nottingham city were observable, with a third pottery within the city potentially identifiable by cross reference. Two other pottery sites were less definitive, but were both within the city of Nottingham. These results meant that the XRF analysis could be used to ascertain where unprovenanced salt glazed pottery from the Museum collection was made. The caveat was that the successful identification results came from the exposed ceramic body not from the surface glaze. This means that a chip or break edge on the pot under examination would be required for an analysis to take place. This research was completed and was considered to be significant enough by the ISAAC Lab team to be written up and presented for peer review for publication. Additionally, a second salt glaze research theme was being considered. A scientific understanding of how the salt glaze effect was created appeared to be thinly represented in the literature and a second paper was considered here. The potential of this research came too late to become a film in the context of this PhD. However, it is significant. By bringing about speculative analytical research within a museum collection, meaningful and potentially publishable science has been produced that has the capacity to reveal further insights into the Museum's collection. Some possibilities arise here. This opens the possibility for the Museum to investigate the unknown provenances of its salt glaze collection. New insights into this collection could create new interpretation opportunities, hence encouraging an interplay between analytical investigation and interpretation. The other significance is that if one views both the ISAAC Lab team and the Museum as stakeholders, then this output from their interaction is one from which the ISAAC Lab team also gain.

Figure 17: Example of salt glaze fragments taken to ISAAC Lab for XRF analysis. Copyright: by kind permission of Yu Li, ISAAC Lab Team

7.2.2 Flawford Virgin Alabaster

A line of research was pursued using Optical Coherence Tomography (OCT) analysis on the alabaster the Flawford Virgin was carved from. The scattering of the laser light from the OCT equipment can create an image of the changes in the subsurface structure or 'tomography' creating a picture of structures that lie just below the surface. The Flawford Virgin's alabaster tomogram had been recorded on Site Visit 2. The historical information suggested that the alabaster from which the sculpture was made was local, and most likely from an identified medieval quarry at Chellaston near Derby (Cannan, 2010). It was felt that there was merit in using the OCT equipment to analyse regional alabaster to confirm or question this historical understanding. Alabaster quarrying was still active at Fauld near the original Chellaston quarry as well as in the Newark area where it was believed medieval alabaster quarrying took place (Kloppmann *et al.*, 2014, p. 209). Samples were sought from the two different locations from British Gypsum. What came to light early on was that there were noticeable differences between these samples. Additionally, there was a close correlation between the grain structure of the Flawford Virgin and a sample that was not from the area thought to be the original medieval quarry. This raised the intriguing possibility that the investigation could enrich the historical

understanding that had been presented. If we look at three images for comparison, figure 18 shows an image generated by the OCT laser. The thick white line at the top is the alabaster surface. The texture below the white line is the grain structure below that surface. This sample is from the quarry at Fauld close to the Chellaston medieval quarry thought to be the source of the alabaster for the Flawford Virgin. Figure 19 shows a different grain structure. The large black voids are clear crystals in the grain structure. This sample is from a quarry near Newark. Now look at figure 20. Similar clear crystals appear in the grain structure, albeit different sizes. This sample is from the forehead of the Flawford Virgin. Was the Flawford Virgin carved from Newark alabaster not Chellaston as originally thought?

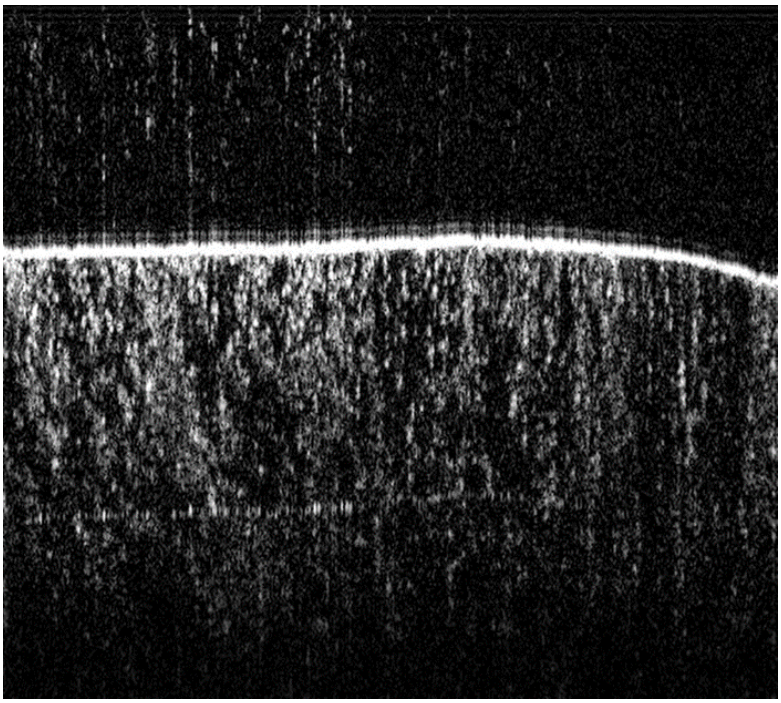

Figure 18: OCT image of a sample of alabaster from the Fauld Quarry near Chellaston.

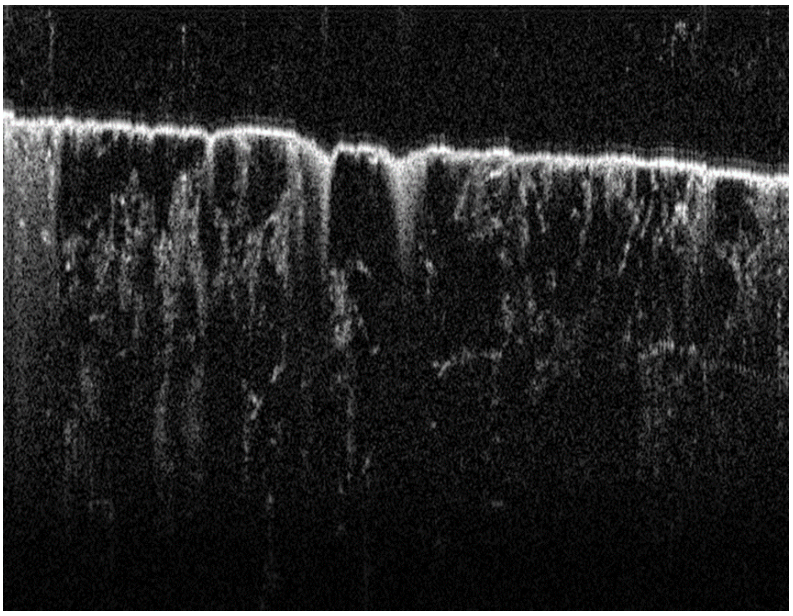

Figure 19: OCT image of a sample of alabaster from the Newark Quarry.

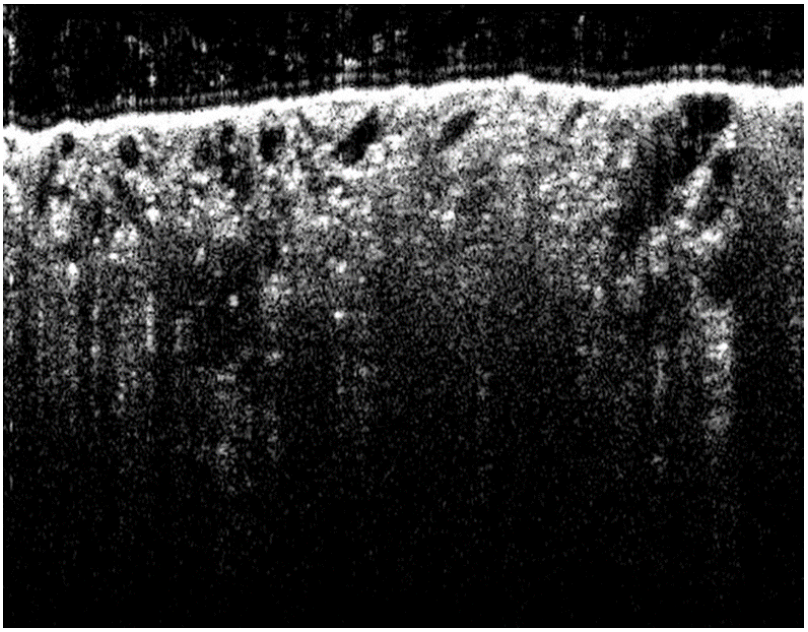

Figure 20: OCT image of a sample of alabaster from the forehead of the Flawford Virgin.

However, these initial observations would not satisfy the rigour of an analytical investigation. No geological expertise was available within the ISAAC Lab team and so it was felt prudent that commentary was invited from an expert in this field. British Gypsum advised on this and an eminent geologist, Dr Noel Worley was approached. Our caution was well placed. The geologist recognised the changes in grain structure. However, they were not indicators of geographical location but depth in the alabaster seam. The geologist explained that the alabaster seam in this area was inclined west to east. The original medieval quarry at Chellaston would have been in the west and the upper layers of this seam quarried away in antiquity (Ramsay, 1991). The modern quarrying operation in the west, at Fauld, was therefore exploiting a much deeper part of that seam. The sample that came from the east at Newark, which appeared to correlate with the alabaster from the Flawford Virgin, came from later quarrying activity exploiting a higher section of the seam. Therefore, the correlation was alabasters that were high in the seam not any indication of geographical location. It would have been possible to confirm the geographical location of the alabaster using an isotope analysis (Kloppmann *et al.*, 2014). However, this lay outside the funding remit of my PhD. This sub-theme in the research associated with the Flawford Virgin was suspended from my PhD and did not contribute to the final suite of films. However, this is significant to note. If one is integrating analytical research, for which the outcome cannot be prejudged, into an exhibition programme that requires predefined content then the relationship between the two requires a degree of independence.

7.2.3 Flawford Virgin Polychrome

A second line of investigation with the Flawford Virgin was to seek evidence of the original polychrome. This was done by cross referencing XRF and UV/Visible Reflectance Spectroscopy. The XRF & UV/Visible Reflectance Spectroscopy data began to give a clear picture of the polychrome of the original Flawford Virgin sculpture. It showed the main body of her clothing, hair and crown was gilt. The Virgin had an over-garment of vermillion red and her gilt crown had indigo inserts. She also had a hooded cowl over her head, down onto her shoulders that went under her crown. However, the analytical instrumentation gave no indication of a colouration on that cowl. It had been agreed with the ISAAC Lab team that I would be given the freedom to attempt an artist's reconstruction of her face. This is because the instrumentation had picked up evidence of vermillion on her lips and historical research would indicate that the faces of these 14th Century Madonna and Child sculptures would have had areas of open skin left as clean white alabaster with features such as eyes and eyebrows painted in (Cheetham, 1984, p. 27). However, the cowl colour presented a dilemma of both scientific integrity and interpretation. An image search of 14th century Madonna and Child sculptures in collections worldwide and within the online collection of the British Museum, revealed blue as a consistent clothing colour associated with the virgin[30]. In fact, the Flawford Virgin with a predominately red clothing colour was unusual. Additionally, indigo had been used in the inserts in the crown (Figure 21). We were days away from Digital Heritage 2018 and a production decision had to be made as to how far my artistic reconstruction could go. For the purpose of the completion of the narrative of this chapter, that production decision was to leave the cowl uncoloured. However, the discussion around this decision between ISAAC Lab and myself is significant in the understanding of the process of translating analytical findings into interpretive product and a valuable insight into how these two systems differ. This discussion will be unpacked in Chapter 8 in the context of other decisions around the relationship between analytical finding, hypothesis and speculation. The XRF instrument also triggered debate as to how one represents analytical process for a non-specialist museum audience; this too will be opened for discussion in Chapter 8.

[30] Some visual examples of the images of the virgin and child from national collections will be presented in Chapter 8 as part of the more detailed discussion.

Figure 21: Crown of the Flawford Virgin showing traces of indigo blue.

7.2.4 Sword Blow

My RTI investigation of the damage to the face of the Flawford Virgin was not verified analytically. To do so would have involved a forensic investigation outside the capability of the ISAAC Lab. This would have been time consuming and potentially expensive. Again, a production decision was made to maintain the description of the damage as the 'sword blow hypothesis'. Presenting the 'sword blow' as a hypothesis had certain advantages to the creation of an interpretive product as it could generate space for the visitor to arrive at their own interpretation. It also raised some interesting issues around how hypothetical issues are interpreted and understood by the visitor. As with the decision to leave the cowl uncoloured the issues surrounding the presentation of a hypothesis within the Flawford Virgin films will be discussed in greater detail in Chapter 8.

7.3 The Films

The film for Digital Heritage 2018 was designed in its initial manifestation to encompass a narrative that introduced both the presence of the ISAAC Lab team and the implications of their investigation and combine this with a historical context for the sculpture itself provided by the Museum. As well as explaining the science it allowed the more speculative and hypothetical aspect of the findings such as the sword blow hypothesis and the artist's reconstruction of the face. I felt it important that the science had a high profile, and that the discovery of the original polychrome was justified for the visitor in scientific terms. This would be achieved through an

understanding of the analytical processes that had informed them. The version that went forward to Digital Heritage 2018 conference contained a lengthy sequence of 3D animation explaining the operations of the analytical instruments and how they were responsible for identifying the pigments and the gold. Although the real instruments used on Site Visit 2 appear in the film this does not explain how they work. To achieve this 3D animated 'avatars' of the instruments were created to demonstrate their analytical capacity and text was presented to explain their workings (Figure 22). Admittedly the audience at this conference would be heritage professionals, however not particularly science specialists. I was aware that my audience at Digital Heritage 2018 may have some specialist knowledge, but a general museum audience would not. I was attempting to create an explanatory and accessible film that would reach a non-specialist audience. As the discussion programme suggested this is a key element of integrating analytical content into museum interpretation. However, the transition from the analytical starting point to non-specialist interpretive product in the form of a film brought with it a complex raft of issues around the appropriate use of language, maintaining the integrity of the science and how scientific principles are portrayed visually. This needed to be considered in the context that the audience for this material is at liberty to ignore it (Ham, 2013, p. 1). An example of this was the avatar of the XRF instrument. Considerable debate revolved around how much detail should be shown in the animation to explain the behaviour of the electrons. This complex set of issues and its bearing on the analytical and interpretive as separate systems will receive a thorough investigation in Chapter 8

The first iteration of the Flawford Virgin film was screened at Digital Heritage 2018 in San Francisco and for eighteen months this brought closure to the film production process. At the appropriate time, the Digital Heritage 2018 film was presented to the Museum management and their exhibition consultants for consideration as to how the film was to be deployed by the Museum. In April 2020, the Museum issued an initial brief for the final edits and formats for the films to be discussed and finalised (Appendix 1). This was significant, as it was at this point that agency passed into the hands of the Museum. As the 'end user' of the research they could clearly define what role it was to perform for them. One might consider that the film that I created for Digital Heritage 2018 was my research output, created from a brief that I had set myself to make a film appropriate to the Museum. What was set out in the Museum's initial brief was clearly designed to meet their interpretation requirements and their immediate marketing needs, related to their reopening. My analysis is that this brief is an essential part of crossing the rigour-relevance gap. It is interesting to note that Kieser and Leiner (2009, p. 525), observe that with two systems in collaboration separate outputs are required to meet the stakeholder interest. My research outcome is converted, through the needs analysis of requesting the brief, into an interpretive product relevant to application for the Museum at that time, through a process of

discussion. The Museum's brief formed part of my research, yet my ability to develop that brief with the Museum and deliver it to the Museum's requirements drew on my pre-existing skill set of creative contractor. The subsequent analysis, described below, of my delivery of this brief places me back in the role of researcher. I note this transition of role as an important aspect of crossing the rigour-relevance gap. In whatever form the research-led output may satisfy academic needs, it may require further development to ensure that the end-user has that output tailored to their requirement.

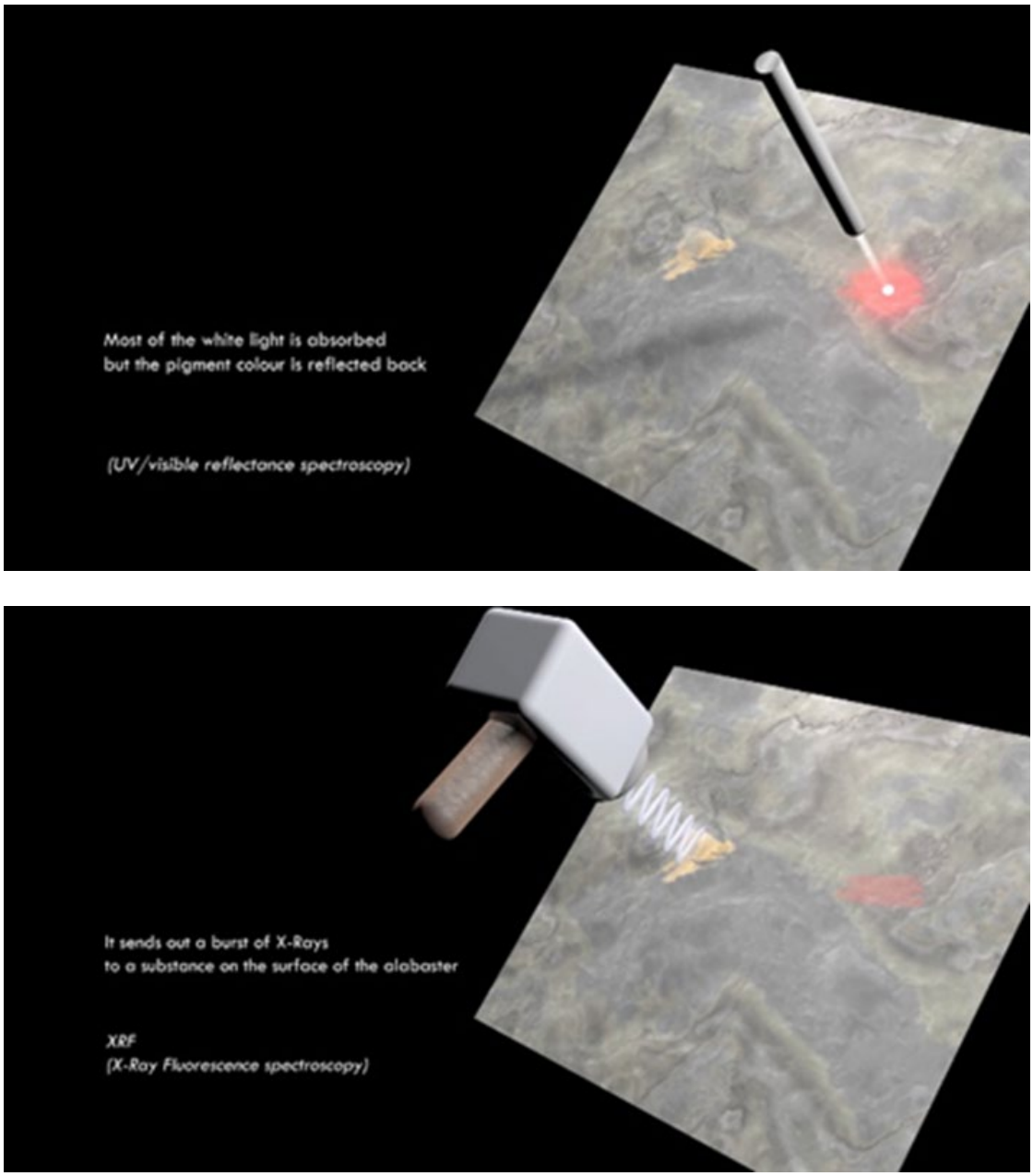

Figure 22: Two stills from the ten-minute film showing the 'avatars' of the UV/Visible Reflectance Spectroscopy and XRF instruments and explaining their function

The brief presented at this time was for four films (see Appendix 1 for the brief signed off by the Museum in May 2020). The first was an edited-down version of the original Digital Heritage 2018 film. This included the addition of a music soundtrack with minor editing of the scenes with the

scientists setting up their mobile lab. Other than that, the now ten-minute film contained the same content as its twelve-minute Digital Heritage 2018 original. Because of its length, the detailed description of the object biography and the focus on the analytical process, this film was considered 'special interest' by the Museum.

The second film the Museum requested through the brief was more challenging. It was to be three minutes long with a music soundtrack. However, it needed to encapsulate the entire narrative of the ten-minute film. The edits to the narrative required from the ten-minute version would be to: compress the narrative of the sculpture's discovery at Flawford; remove a description of the thickness of the alabaster from which the sculpture is carved; and most significantly, heavily abridge the description of the analytical process, focusing on the end result. This film was designated in this brief to be web based. The next two films defined by the brief were to be social media outputs: the first of twenty seconds duration targeted at Twitter, the other at ninety seconds targeted at Facebook and Instagram. Both relied on unanswered questions to encapsulate the narrative. The rationale behind this was that it would lead viewers of the social media content to seek answers via the website or a visit. The brief was designed for the four films to interact. The twenty- and ninety-second social media films were targeted at different demographics but both films were to achieve the same aim. This was to signpost social media users to the web content, the centrepiece of which would be the three-minute film. The intention would be for the three-minute film to be the core of the film interpretation for the Flawford Virgin. It would also be the departure point for those with sufficient interest to access the ten-minute film containing a more detailed description of both the object biography and the analytical investigation[31].

7.4 The Final Films: An Analysis

To access the films discussed in this section go to: Heritage Imaging.

The three- and ten-minute films are focused on narrative. They tell the story of the discovery of the sculpture, lay out the evidence for the polychromy, and then suggest uncertainty as to how she became damaged and why. The analytical investigation is presented as evidencing certain aspects of this story with other aspects remaining more speculative. This is an important juxtaposition within the films as it speaks to the interrelationship between the outcome of analytical investigation and the more speculative process of meaning making. Inherent within this

[31] The actual application of the films at the time of writing will be discussed in Chapter 9

is a resonance with the concept of the rigour-relevance gap. In the next chapter I will make a critical evaluation of this juxtaposition with reference to the literature. Here I would like to focus on how this juxtaposition is managed in filmic terms and how the narrative is presented.

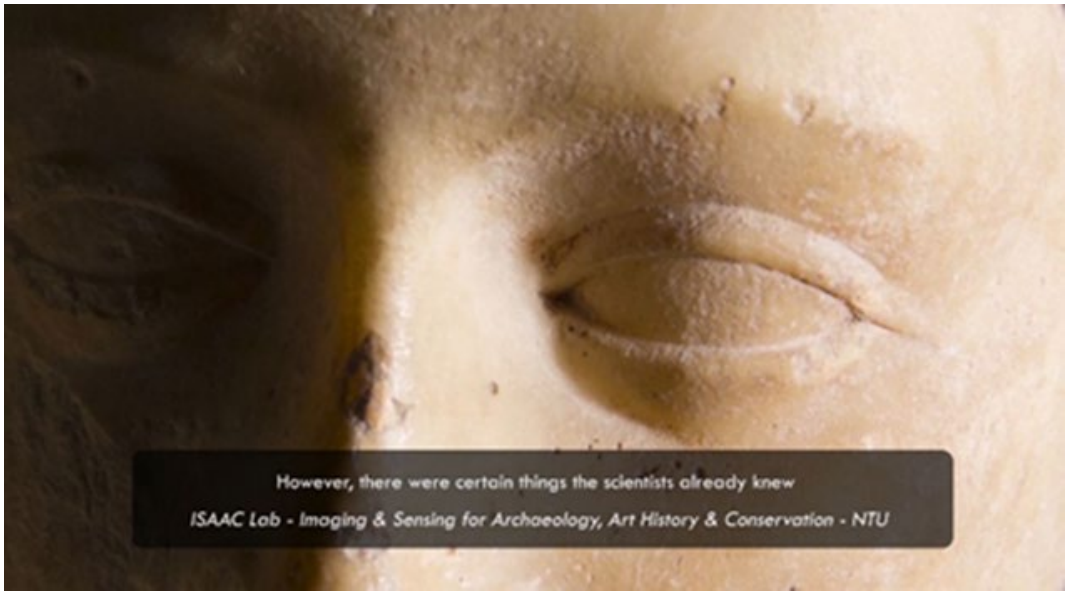

Figure 23: Two stills from the ten-minute film. These illustrate the sculpture in its 'black void' with the 'Ken Burns' effect used to animate still photography, drawing closer in for dramatic effect.

Both the three- and the ten-minute films make extensive use of the Ken Burns effect. This term is now in common usage in filmmaking and is a method by which still images can be employed in film by panning and zooming over the image to give the sense of the movement of the camera. It is named after the documentary filmmaker Ken Burns who made masterful use of it employing archival photography in his noted documentary *The Civil War (1990)* (Nichols, 2017, p. 12). The effect is now generated within modern filmmaking software and requires no actual camera work.

This technique allows the 'camera' to explore a photograph and highlight aspects of the subject for visual or narrative affect. Where the Flawford Virgin is not animated as a 3D model this technique is employed, as most of the images of the sculpture were still images with carefully constructed lighting. It is also worth noting that in the 3D animated sequences the model is used in a similar way. It is choreographed to advance, retreat and rotate to serve the need of the narrative. The deliberate management of this choreography is an important part of establishing the mood and pace of the films. The use of directional lighting and a *'black void'* space behind the sculpture are maintained in both the Ken Burns effect and 3D animation sequences (Fig 23). As well as providing an effective backdrop for the narrative text, the black void creates a timeless space where the sculpture can exist without context. Within this space it moves of its own free will to illustrate the narrative. In this way it acquires a certain anthropomorphic quality having agency or 'life' in telling its own story (Mandelli, 2019, p. 79). To stress this the narrative text actually refers to the sculpture as 'she'. She moves to show us the damage she has sustained, appears in a Victorian garden related to her provenance, and at the end of the film she draws back and the recolour evidenced by the ISAAC team is presented (figs 24 & 25). This is followed by a more speculative recolour of the face. As the finale for the films this is the point at which you actually *'meet her'* (Staiff, 2014, pp. 98–99). However, where the narrative is describing the work of the ISAAC team, we see the sculpture removed from the black void and presented very much in our real world. The 'she' status is revoked, and the sculpture is presented as an inanimate object under investigation (fig 26). This filmic device is used to demarcate where the analytical investigation is generating data and evidencing findings and a more fictive narrative of questions and possibilities. This interface where the film is presenting analytically evidenced information juxtaposed with the more suppositional element also resonates with the interplay between facts and the process of meaning making (Mason, 2005). This is an aspect that I will give critical analysis to in the next chapter.

Figure 24: The sculpture appears in a Victorian garden.

Figure 25: The results of the analytical analysis are displayed visually. This transitions to the more speculative artist's reconstruction of the face. The black void is employed to give a contextless space where these transitions occur.

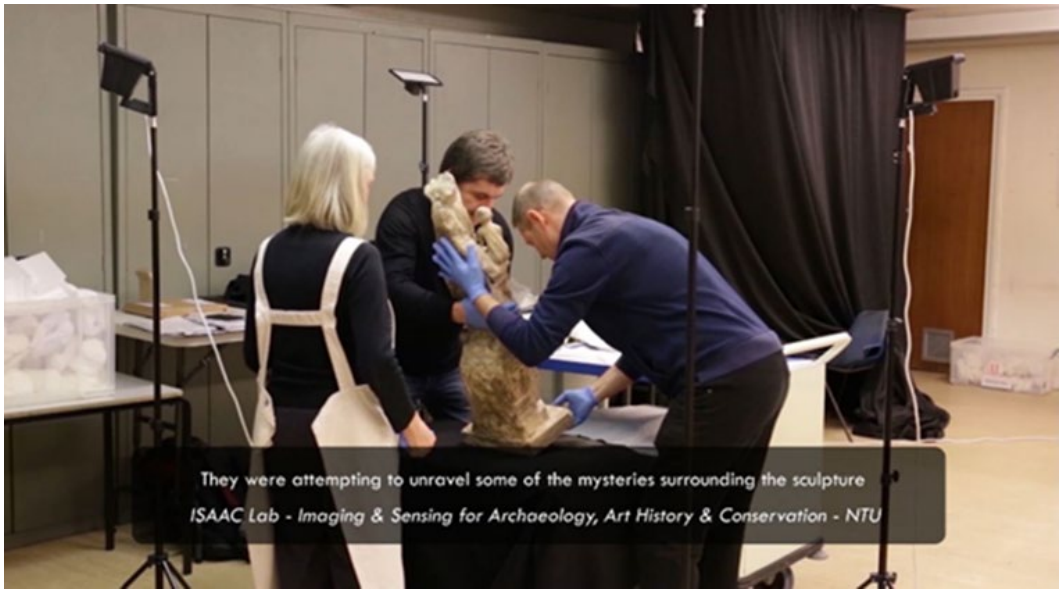

Figure 26: The sculpture is now out of its 'black void' and shown in the real world of the analysis. It has now become an inanimate object with its 'she' status removed.

The narrative structure of the films relies on the audience being posed certain questions and possibilities; there being *'mysteries'* requiring *'unravelling'.* This is not an uncommon trope in science documentary (Hornig, 1990). Not all of these questions were addressed by the analytical investigation. The sword blow hypothesis could only suggest the possibility of a blow being an explanation for the damage to the face of the sculpture. This illustrates how the interplay of the text and the visual presentations have been used to separate where hypothesis and supposition meet analytically evidenced findings. Digital evocations of the sword blow and the face of the Flawford Virgin are quite convincing (fig 25 & Fig 27).

Figure 27: Animation of the sword blow using light and sound effects. Can these powerful visual evocations create false facts?

The sword blow particularly, with its detailed animation of the fracture of the sculpture, the sword evoked in light, the unexpected nature of this animation and the use of a specific sound effect give it impact. This creates an issue around the power of digital evocations to create false facts which I will explore in greater detail in the next chapter. Within the film this demarcation had to be demonstrated with the use of text. In the ten-minute film, when the recolour appears the text reads "The science gives us this…However, historical research suggests there may have been other colours and areas of painting." When the Flawford Virgin's face appears, it is described as "…an artist's impression giving an indication of how she *may* have looked." The use of language in the three-minute film had to be briefer to meet the editing requirements. This was achieved through posing questions with simple answers. In the case of the sword blow the question "Could a sword blow from one of Henry's agents have broken her into three pieces?" the answer is simply "Possibly." (fig 28). This use of questions comes to its full application in the ninety- and twenty-second films.

Figure 28: In the films, text is used to demarcate the evidenced analytical facts from the speculative element

The ninety-second film is designed, with soundtrack, as a social media output, using scenes from the original ten-minute film. It starts with the introduction: "Flawford Virgin, Alabaster c1380" followed by five questions which essentially encapsulated the core narrative of the film: "Why was she hidden?"; "How did she get broken?"; "Where has she been since she was found?"; "How would she originally have looked?" and "Can science give us some answers?" (See Appendix 1). The film closes with the close-up face of the Flawford Virgin transitioning from plain alabaster to the artist's impression of the face, as indeed all the films do. The target audience was defined by

the original brief as millennial to middle-aged and the platform is Facebook/Instagram. The fourth and final film is also for social media output. It is twenty seconds long, which simply shows the colour transition from a close-up of the plain alabaster face changing to the painted artist's impression. The text presents as a statement and a question: "Nottingham's alabaster sculptures today" with the subtitle "Flawford Virgin, Alabaster c1380." A transition then takes place to the facial reconstruction and the question is posed "Were they originally painted?" Again, a soundtrack is employed. The target audience demographic was defined at the time as younger, or millennial and the film was targeted at Twitter. In both cases these are interpretive products yet their intended employment as marketing tools is notable. The use of questions performs an awareness raising and signposting role to the other two films with the potential to relate to the interpretive offer presented by the Museum in association with the real object. This use of social media within the museum context has received some commentary within the literature and I will discuss this further in Chapter 8 along with the Museum's final application of this proposed strategy.

7.5 Conclusion

Chapter 6 described the initiation of the case study, the development of the research questions and the technical and logistical issues around applying scientific research methodology, film and 3D imaging techniques to a speculative analytical investigation within an N-SREO museum. This investigation sought lines of research that enhanced object biography and had the potential to create interpretive products. During this process I observed a level of agency that the scientists required to work effectively and how the museum needed to facilitate the scientific requirements to ensure the quality of the science. This necessary shift in agency was reflected upon in the context of the literature exploring museum and university partnerships (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; National Co-ordinating Centre for Public Engagement, 2016). I also sought resonance with the experiences described in the discussion programme and the concepts of 'two systems' and the 'bilingual/bi-competent facilitator' (Kieser and Leiner, 2009). In this chapter, I describe the progression of the analytical investigation once the initial data had been gathered on site. I have noted how different research themes manifest in different ways, some suspended for pragmatic reasons, others reaching analytical conclusions that did not generate interpretive products. Other research themes produced interpretive product with little or no scientific investigative value. The overarching observation was that it was very difficult to predict how each theme would reach conclusion without pursuing it, this being the nature of research. This raises the idea mooted in Chapter 6 of seeking a point of synergy where one could review the early process of analysing the research questions, seeking those that offered the most

fruitful combination of significant science and interpretation potential. Would it be possible to focus and streamline the progression through investigation to output by identifying this point of synergy in the research questions early? This research poses this question but cannot answer it.

As this chapter's narrative of resolving the research themes to their analytical and interpretive outcomes progressed, I observed issues that arose for further consideration. These issues were: the nature of images and how they communicate scientific information and/or interpretive messages; the relationship between analytical findings, hypothesis and speculation as expressed through an interpretive product; and the interrelationship of interpretation and social media. This chapter has indicated significant issues around language, the portrayal of analytical process and its derived data, and the management of film content to meet the Museum's interpretation and marketing need. These issues lie at the watershed of the translation of content from the 'analytical system' to an 'interpretation system'. Unpacking this interface is the subject of Chapter 8.

Part 3

Reflection and Analysis

In Part Two the reader observes the translation of the outcomes of an analytical investigation into an interpretive product in the form of a suite of films on the Flawford Virgin. Key observations are that the lines of analytical enquiry came to a conclusion that favoured either analytical outcomes or interpretation outcomes, with others not reaching resolution in either. What was significant was that the analytical outcomes associated with the Flawford Virgin represented a synergy of scientific interest and interpretation potential. An important aspect of this translational process is the management of analytically specified findings and more hypothetical or speculative findings which are valuable to an interpretive product and the processes of meaning making. Part 3 takes a more reflective approach to analysing the case study narrative. With reference to literature, it makes a critical analysis of the translation process and explores the role of hypothesis, speculation and the artist's reconstruction in the creation of an interpretive product with potential to enact meaning making. Additionally, it reflects on the relationship between heritage science's accustomed methodology of communication through peer review publication and that of the interpretive product as defined by the Museum as end user. This relationship is considered within the context of the rigour-relevance gap. In conclusion it presents a '*theoretical proposition*' that when analytical investigation is brought into the N-SREO museum, meaningful science and effective interpretive product can be produced and the rigour-relevance gap bridged.

Chapter 8: Issues of Transition: From Analytical Outcome to Interpretive Product

Throughout the case study described in Chapters 6 and 7 a number of issues for further discussion were highlighted. This chapter aims to return to these issues and unpack them in light of reflections on the experience of practice and analysis of the relevant literature. The role that images, visual representations and artists' reconstructions have in both scientific and interpretive contexts was mooted on numerous occasions. Artistic representations of scientific findings have to represent the accuracy of those findings, without obscuring the clear interpretive message with specialist subject detail. This has a resonance with the concept of the rigour-relevance gap (Bell *et al.*, 2014; Dillon *et al.*, 2014) . As one moves into the creation of an interpretive product that employs visual material to communicate scientific concepts and findings, a raft of issues arise surrounding how the findings are understood by the audience in receipt of the interpretation. Here an understanding of the act of meaning-making manifest in the audience is of importance. In addition, the nature of the artist's reconstruction and its relationship with fact, hypothesis and supposition also becomes of significance. As was noted in Chapter 7, the interrelationship between the employment of interpretive product as interpretation and its use as a marketing tool is also of interest. This resonates with the idea of a required move away from the 'what' and 'how' questions required by analytical analysis to the 'why' and 'for whom' questions required to make the analytical content relevant to an end user of the analytical outcome (Martensson and Martensson, 2007, p. 1328). A body of literature exists discussing the use of social media within museums, which is pertinent to the brief presented by the Museum. Additionally, some attention has been given in the literature to the role of language in the intercommunication between museum, conservator and heritage scientist (Curran and Zimmermann, 2021). Within this chapter the use of language and its position between maintaining accuracy and scientific integrity, and effective communications, is noted. It is here that the relevance of Kieser and Leiner's (2009, p. 516) concept of two separate systems of analysis and interpretation is pertinent. Therefore, the role of this chapter is to open a discussion on these issues and relate them to the suite of Flawford Virgin films. The main body of the discussion is focused on the content of the three- and ten-minute films. I will however close with a literature-based context for the two films designed for social media content. It should be noted that this chapter discusses the theoretical potential that the films present to the Museum. In reality, at the time of writing, the Museum are still resolving their web presentation of the films discussed here. The final web presentation of the three-minute film has not taken place and no link back from the physical gallery exhibition to any of the web-based material is available. The Museum are aware of the potential that an interplay

of web-based film and physical exhibition has, and will be reviewing this in due course. They are also aware of the role that the social media content could play in this interconnectivity and are working towards its development.

8.1 Communicating Science Through Image and Language

I place this short excerpt of autoethnographical writing here to help illustrate the attitude of the analytical research team accustomed to the precision required for peer reviewed publication being asked to allow their material to be accessible to a non-specialist audience.

> I arrived home at 3.00pm having been in an involved meeting with the ISAAC Lab team over the animated sequences for the analytical processes used in the research. I had used on-screen titling, the wording of which had been the subject of some discussion. We had, after some debate, arrived at an agreed wording and changing this in the compositing software was not too difficult. However, concerns had been raised about an animation sequence involving electrons and atoms in the animation describing the use of the XRF gun. The reanimation of this sequence posed considerable challenges.
>
> I finished making the changes to the text and then turned my attention to the animation problem. The complex screen of the 3D animation software opened in front of me. I adjusted timelines, altered XY coordinate boxes, but getting anything satisfactory eluded me and I was now days away from the conference in San Francisco.
>
> I was searching YouTube for technical inspiration when I heard the front door open. My wife hung her coat and dropped her bag and, as was routine, came up the stairs to say good evening.
>
> "How you doing?" she chirped.
>
> "OK….look, do me a favour, watch this and tell me what you think".
>
> She duly watched the XRF gun beaming X-Rays to a sub-atomic level. As I pressed pause, I looked at her expectantly.
>
> "Well?"
>
> "Well what?"
>
> "Well, did you understand what it was showing you?"
>
> "Yes, I think so. The gun thing shoots X-Rays at the atom and how much energy comes back tells you what atom it is. That's how they knew it was gold".

I explained about the complexities of the electron shells, which to be frank, lay on the very outer limits of my own understanding. When I finished I looked to her for a reaction. She pushed up her bottom lip, raised her eyebrows and nodded.

"Do you want a cup of tea?"

I scraped my thumb and forefinger together across my closed eyelids to pinch the bridge of my nose.

"Err…yes, thank you…I think I am done for the evening."

As she turned to leave the room, she left me with her parting shot.

"I don't give a monkey's about electrons!"

***

This short autoethnographical piece might at first be seen as a flippant aside but it does revolve around quite an important issue. How much of a complex scientific concept does one transfer to the interpretive product to maintain scientific integrity and not obscure the interpretive message with extraneous detail? Being mindful of comments in the discussions in Chapter 5, concerning science being too 'highbrow', might this be an obstruction to a museum accepting this content as interpretation? In this case study, this was a matter of negotiation between myself and the ISAAC Lab team. It was a negotiation because the scientists and I held different positions: the scientific team were concerned with how their science was portrayed and I was concerned about how it would be perceived. This I would argue is a fundamental issue of knowledge exchange.

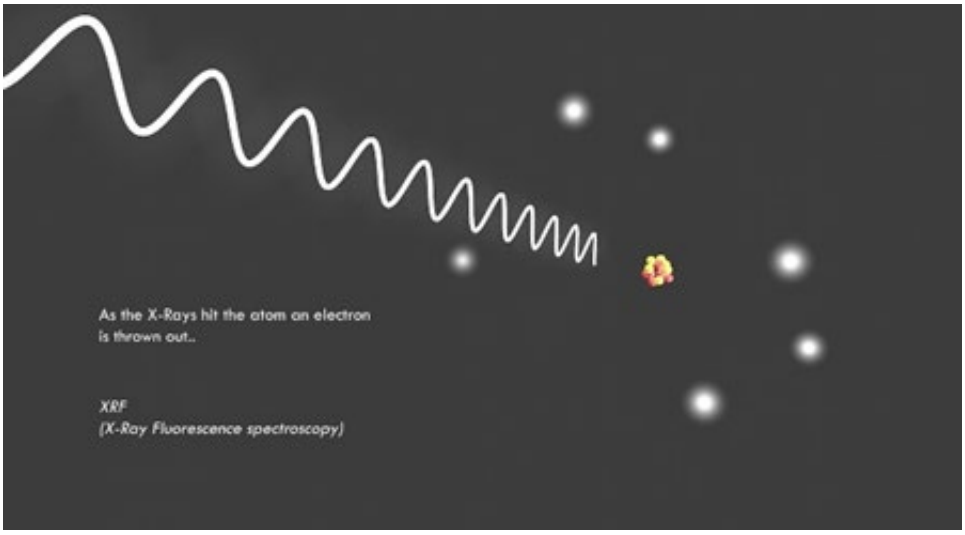

Figure 29: Still from the ten-minute Flawford Virgin film showing X-Rays reaching an atom of gold and affecting the electrons.

To illustrate this issue a little further I would like to dig deeper into the discussion concerning the animation of the XRF equipment employing X-Rays to excite atoms and hence identify them. One point of discussion was my portrayal of the X-Rays as a sine wave which was not felt to be entirely accurate, although it was accepted that this was a requirement to visualise what was invisible (Figure 29). The real point of debate was in my animated portrayal of the X-Rays hitting the atom, the electrons absorbing that energy, becoming excited, expelling an electron and releasing a pulse of energy in 'reply' as they settled down to their original state, this 'reply' being the identifier for an atom of a particular element. This description encapsulates what I judged to be the essential narrative that had to be communicated. However, the scientific position was that the movement of the electrons from one energy state to the other was described in terms of their electron 'shells' and a failure to describe this in the animation undermined the accuracy of the information. I opposed this view from two perspectives. The first was a practical one. My animation showed an increase in the speed and movement of the electrons represented as small dots of light spinning around a cluster of red and yellow protons and neutrons, portrayed somewhat like snooker balls. This in itself is a popularised graphic image trope from a school textbook and not actually representative of real atomic structure. The animation itself, with my skill level at the time, was difficult to achieve. As the pulse of X-Ray energy hits the atom it expels the electron. This event I managed to animate, but recording which electrons had moved to each shell was much more challenging. We are reminded of the two systems or logics that Kieser and Leiner (2009, pp. 516-517) suggest are in play in the understanding of a rigour-relevance gap. The very process of ensuring that the analytical findings are explained accurately and in full as one would do for a peer reviewed output is the barrier that would also exclude the non-specialist museum audience from the potential knowledge exchange. Hodgkinson and Rousseau (2009, p. 536) suggest that these systems can be 'dynamic' rather than 'closed'. I had to negotiate away from the peer reviewed output approach yet maintain accuracy through careful abridgement of the analytical content to achieve a translation from one to the other. From a film production perspective, I was designing the film for a general museum audience and took the view that tackling the considerable animation challenges in recording the movement of electrons within their electron shells was not justified when set against what this detail added to the understanding. This production decision also being made in the light of the tight deadline for Digital Heritage 2018. Secondly, I would suggest that the addition of such complex details clouds the clarity of the narrative, making it more difficult to follow. In the film the text states 'As the electrons rearrange themselves they create a pulse of energy which is sent back to the instrument'. The use of the word 'rearrange' is a generic to cover the activity that the electrons engage in without extraneous detail. My position was that the scientists had conflated detail with accuracy. I needed to 'top-slice' the scientific content, presenting to the museum audience only

that which was relevant to carry the narrative. The negotiation between the production of engaging narrative and describing the science with integrity is not an easy one. Judgements as to what actually matters to a general audience when including science in a narrative are just that, judgements. My judgements were based on my years of experience as a creative practitioner and educator.

It is worth considering this discussion in the light of the Museum brief (Appendix 1). It was clear from this brief that at the time, the centrepiece of the interpretive product that the Museum wanted was the three-minute film with almost all of the scientific explanatory content stripped out. One might consider that I had overestimated the relevance of the scientific explanation. However, the brief did require the ten-minute film for special interest. It would be reasonable to assume that this special interest audience would not be entirely comprised of heritage scientists but would include other heritage professionals. For this reason, my decision not to describe the electron shells in detail could be justified. What is interesting is that at the proofing stage for the production of the suite of Flawford Virgin films, the four films were presented to the ISAAC lab team for final comment and sign off. This triggered a return to the debate regarding the selection of certain language in the ten-minute film now that it was identified as 'special interest'. Words such as 'wavelength', 'energy' and 'frequency' were then requested to be reconsidered in the ten-minute film to move them closer to more scientific understandings. These requests were met. We see here a clear interplay between the desire expressed by the scientists to maintain the integrity of the scientific finding and process and the need to create a communicative interpretive product. I propose this to be a manifestation in practice of the negotiation of the rigour-relevance gap by translating from one system to another in a 'dynamic' way (Hodgkinson and Rousseau, 2009, p. 536). It could be argued that the significance of understanding language when science is working collaboratively within the heritage environment, as identified by Curran and Zimmerman (2021), is also significant in the production of interpretive product. From a rigour-relevance perspective, Bell et al (2015, p. 19) comment on how issues surrounding language and communication emerged in a holistic way across their data set suggesting that it underpinned many aspects of collaborative research. The fact that the language used in the films could be negotiated and adjusted to acknowledge both the scientists and the interpretation requirements would suggest that the systems are 'dynamic' rather than 'closed' (Hodgkinson and Rousseau, 2009, p. 536). Kieser and Leiner's (2009, p. 517) suggestion that science would become 'lost *in* and *before* translation' does not fully ring true. Instead, I found that the analytical content had to be edited and abridged relative to the application. Hodgkinson and Rousseau (2009, p. 543) assert that "…[t]ranslation will not be enough to bridge the gap between research findings and potential end users." However, being selective as to how much information is appropriate and selecting the language carefully can create such a bridge. This supports Fincham and Clark's (2009, p. 510)

critique that both the 'lost *in* and *before'* barriers can be overcome by considering the accessibility of the output publication and collaborative negotiation. Kieser and Leiner made an important point with regards output. That was that separate outputs and "…bilingual and bi-competent facilitators…" would be required in a fruitful collaborative exchange (Kieser and Leiner, 2009, p. 528). Curran and Zimmerman (2021, p. 12) suggest that this linguistic capacity should be provided by the heritage scientists. We have seen how separate outputs were created. The ISAAC Team received pedological advantage from PhD students using their instrumentation on site and potential publication from the salt glaze research theme by way of output. The films are a museum centric output. My own analysis is that I was required to provide the bilingual/bi-competent facilitation as this was not available within the ISAAC Team skill set.

It is also worth noting that the Museum's brief, splitting the film content into four, enabled the films to meet different audience needs, with the approach to language handled differently in the social media content to the longer films. This is testament to the flexibility of film as an interpretive medium. Within this chapter I would like to open up a discussion on the interrelationship between scientist and filmmaker and how science is presented to the general public. However, before I do so there is one other observation of the experience of practice that has resonance with this debate. This is an understanding of how analytical imaging serves the need of the scientific process and how this differs from images of science that are required to communicate that process. One might consider these images as a language, subject to the same translational process.

8.1.1 Scientific Imaging and Images of Science

In Chapter 6 I described how images of lace were produced at high magnification using the photographic technique of focal stacking (Helicon Soft, 2017). When an image of lace is at very high magnification only part of the image is in focus. I described how moving the focus incrementally downwards produced a series of images with the in-focus pixels in 'slices' starting at the top of the lace sample and progressing incrementally to the bottom. By recording how much the lens moves to bring the in-focus pixels down to the next slice, a measurement could be taken. This metric has potential scientific value. In Chapter 6 I described how these focal stacks were processed in both scientific (MATLAB, MathWorks 2021) and photographic (Helicon 6, Helicon Soft 2017) software and that the outcome from the photographic software was selected as most appropriate for an interpretation need. I would like to return to this film production decision and open it up a little further. I believe it reveals an interesting juxtaposition between

the purpose of images in science and those for interpretation and has a resonance with the concept of the rigour-relevance gap.

By processing to select in-focus pixels from each one of the images and then aligning and combining them together it is possible to combine all of the sliced images in the focal stack into one in-focus image. Additionally, because depth measurements have been taken, a 3D model can be created. How the scientific and photographic software achieve this demonstrates a difference in approach between the scientist and the artist. Figure 30 is a 3D model produced in the MATLAB software which was managed with the purpose of maximising the accuracy of the model. At the time it was created by a member of the ISAAC Lab team who was familiar with managing this software. The pixel information from the images and camera positioning is managed as data and the scientists can understand the image in these terms as they can precisely control what

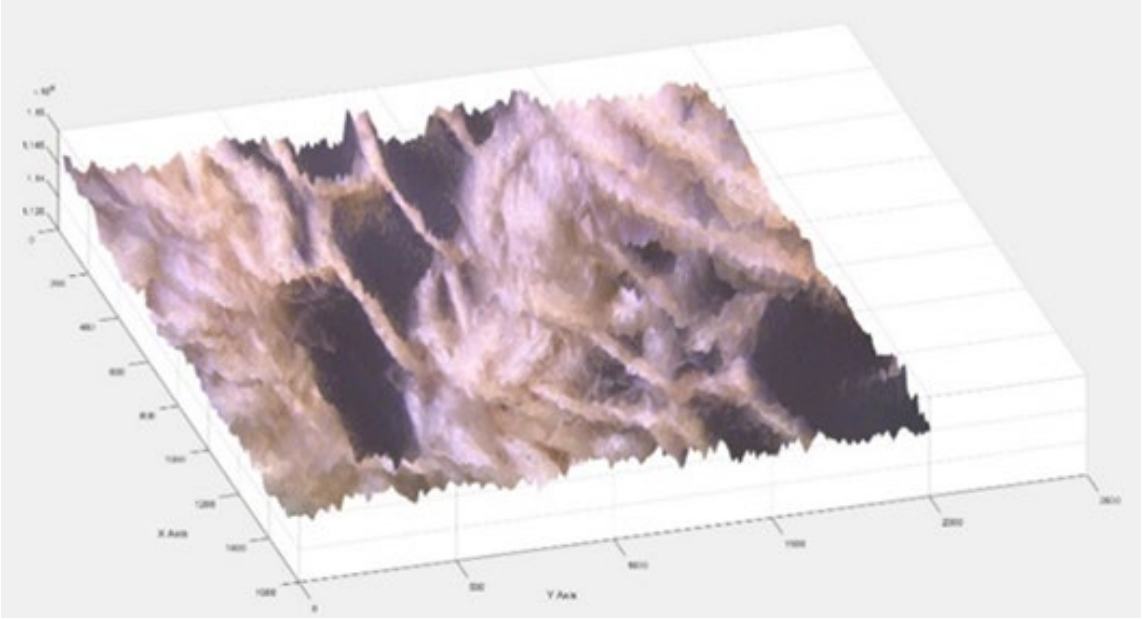

Figure 30: A focal stacked image produced in MATLAB software.

calculations have been made to create it. Within MATLAB they have access to and can write the programming software. In this way the model in Figure 30 is an analytical tool that can be tuned to the purpose the scientist has for it. The 3D model in Figure 31 is created from a similar focal stack but this time the processing software is photographic (Helicon 6). This software is easy to use, with many elements of the processing automated. The software is designed to create visually eloquent images and models. The image of lace it produces has this visual eloquence in that it mimics the real-world experience of seeing. Other than knowing that you are looking at lace at high magnification, it has the visual eloquence to describe the nature of lace non-verbally. This image's ability to communicate the structure and intricacy of lace in an entirely non-verbal way makes it more appropriate as an integral part of the interpretation of lace. However, for the

scientist the software is a 'black box' due to the hidden processing techniques, making unspecific and unknown alterations to the input data that are beyond the control of the researcher. From a scientific perspective, despite the visual eloquence of this image, the data it represents has been corrupted. This could limit this image's potential as an analytical tool. I will discuss further later in this chapter how visualisation and simulations can feed back into the scientific process. For now, what is significant is an understanding that there is a considerable distance between images produced by scientists for rigorous analytical reasons and the imaging of the same subject matter to enhance the visual eloquence relevant for interpretation. A negotiation between heritage science investigator and the designer of the interpretive product was required. This would need a clear vision of what the purpose of the image was, be it analytical or graphic presentation, and would need to define how the production of the image was approached and how one was supposed to engage with it. This speaks clearly to the two-systems model espoused by Kieser and Leiner where one imaging approach sits firmly in an analytical system where processing data is the priority. The other imaging approach is targeted at a specified audience. As Martensson and Martensson (2007, p. 1328) point out, the questions that are asked by these two approaches are different. The analytical imaging approach is focused on "what" and "how" questions requiring data analysis. The audience specific approach deals with "why" and "for whom".

Figure 31: An image of lace from a Levers Lace machine made from a focal stack using Helicon 6 photographic software.

8.2 Film Production and Communication of Scientific Concepts

Film is essentially a visual medium and therefore translating the 'what' and 'how' questions of analysis into the 'why' and for 'whom' questions of film production are pertinent here. Before exploring the actual issues raised within the case study, I would like to provide some discussion from the pre-existing literature around the relationship between the non-specialist filmmaker, the scientific investigator and the non-specialist audience.

Working with the ISAAC Lab team to create the Flawford Virgin films I was working with a highly specialist group of experts, accustomed to publishing their findings in a peer reviewed context. As previous chapters have made clear, my level of expertise as a conservator was not sufficient for me to operate as a heritage scientist. However, I did have a grounding in the instrumentation and principles they would employ; in a sense I was outside the scientific system but bilingual and bi-competent in it. Sheila Curran Bernard offers this advice for those making films outside their own area of expertise:

> "Note that when you are negotiating for the rights to a story, you will want to retain creative control over your film. The author may be an expert on the subject, but you are an expert on translating it on film to a general audience. You don't need a degree in science to make an extraordinary science documentary or a degree in social work to create a compelling portrait of runaway teens. What you need are intelligence, curiosity, and ability to learn fast, and a readiness to consult with people who *are* experts in those fields. Ideally, there is a positive collaboration between expert and filmmaker that serves to enrich the film."
>
> (Curran Bernard, 2016, p. 38, original emphasis)

To what extent I was an 'expert' in the context of filmmaking is debatable, but as a teacher I was an expert in the communication of complex concepts to individuals of varying levels of understanding. Curran Bernard (2016, p. 93) goes on to suggest that it is telling the story of the discovery and its implications that engages the audience, not the description of the science. The Flawford Virgin films are driven by a narrative that is interwoven with the analytical finding's ability to author that narrative. The analytics in these films is important and how it is portrayed was important to the ISAAC Lab team. Yet the relevance of these films to the Museum was centred in the interpretation possibilities of the narrative including its hypothesis, speculations and fictive elements. There is a resonance here with the concept of the two systems that generate the rigour-relevance gap. Science on its own terms does not produce interpretation output in a museum context, instead it produces rigorous analytical findings by application of scientific methods. Museums on the other hand do not publish undiluted scientific peer review

quality science as interpretation for their audience. The films are a bridge between these two stakeholder positions. They start their journey in the rigorous application of analytics and end it in the interpretation of the significance that those analytics have for the museum audience in a format relevant to museum application. This overall case study observes an interplay between how the system of analytics frames and constructs its investigations and the translation required to present this within a system of interpretation. A process of consultation with the scientific experts was vital to understand the content of the films. However, the pitfall of conflating accuracy with detail had to be avoided if an effective interpretation product was to be created. My response to this process produced the Digital Heritage 2018 version of the film. In this case study a second round of consultation took place in the form of the Museum issuing their brief. Here they exercised their role as experts in interpretation and as end users of the interpretive product. The final stages of proofing and sign off enabled the ISAAC Lab team to renegotiate some of the language for the ten-minute special interest film. This interplay of consultation was an important part of defining the iterations of the Flawford Virgin films. Yet one had to maintain creative control over the nature of the films. It is here that the bilingual/bi-competent facilitation takes place.

The separation of these two systems bears further investigation. Boon (2008, p. 1) makes the following comment: "…nothing absolute separates pure fiction from the constructed narratives of factual films - there is a continuum." If there is no clear line between science fact and science fiction, then the scientist contributing facts into the documentary format could find themselves on uncertain ground as to how their facts are being employed. Some literature even reflects on an ambivalence that scientists feel towards the popularisation of science (Hornig, 1990; The Royal Society, 2006; Boon, 2008). Susanna Hornig (1990, p. 12) discusses how 'scientific truth' is socially constructed for scientists through discussion, conference and peer review journals; it is arrived at by consensus and the evolution of this 'truth' is understood within this context. She suggests that the removal of these 'truths' from this context leads to a "dissatisfaction within the scientific community with media accounts of science". Boon (2008, p. 235) comments on how scientists have often considered that popularising one's work can diminish its seriousness. The Royal Society (2006, pp. 10-11) found that 20% of their survey of the scientific community thought that scientists who engaged in public engagement were less well regarded by their peers. They also found that attitudes around public engagement activity as 'bad for their careers' and done by those who were 'not good enough for an academic career' still persisted. However, in contrast to these observations, science is very effective at public engagement output. Fields such as astronomy and climate science have been very successful in captivating the public interest and science's representation within more political arenas. It is this capacity that heritage science has aspired to develop (Bell, 2015; Corbeil, 2015; Heritage and Golfomitsou, 2015; Lithgow, 2015) to

manage this broader socio-political role to operate “locally, regionally and globally” (Bell, 2015, pp. 20–21).

Managing issues of audience demographic are very pertinent for any museum and so how a public engagement output relates to those demographics is of high priority. Film that uses analytical investigation as interpretation must respond to an enthusiasm for science, yet communicate analytical content to an audience with limited scientific capital at their disposal. The creation of both a three-minute film and a ten-minute film cater for differing levels of scientific literacy. This resonates with the issue of cultural capital discussed in Chapter 1 where Mason (2005, p. 232) points out that this dissemination is a significant challenge in museum practice. The key point is that science documentary and science need to have a managed and negotiated relationship. To pursue this argument a little further I would like to take a look at science documentary as a form of interpretation.

Timothy Boon (2008, p. 4) actually makes a distinction between science documentary as a narrative form and research films. In a research film the cine camera is used as a ‘scientific instrument’. The former is a documentary, the latter a document. Documentaries are not documents they are interpretive products with what Bill Nichols (2017, pp. 104–105) refers to as a “strong sense of voice”. Paul Ward (2005, p. 7) supports this, describing how all documentaries are non-fictional but not all non-fictional films are documentaries. Searle Kochberg states:

> “We must steer a steady course through representation and remain alert to the bias and cultural shapings that affect our work, and that can change over time. At the same time we must remain positive to the force of non-fiction which is grounded in some version of actuality and experience.
>
> (Kochberg, 2002, p. 31)

This voice that expresses a constructed point of view has parallels with the act of interpretation within museum studies. In this context the content would be curated by the documentary maker from a defined positionality, from which they will express what they feel is the significance of the issue. As with all forms of media and interpretation, when the documentary reaches its audience, how it is received is contextual and dependant on the socio-political environment in which it is viewed. It might be considered as informative, highly critical or propaganda. I would argue that this interrelates with museum studies through Lidchi’s (2013, p. 121) ‘constructionist’ model, as discussed in Chapter 1, employing ‘poetics’ and ‘politics’, where the ‘poetics’ are formed from the significance of the object and the meanings associated with how its interpretation is designed, the ‘politics’ being created through the context in which it is presented. As Mason (2005, p. 226) points out, the intentional interpretations of the curator and the potentially unintended and

unpredictable interpretations of the visitor are where meaning is created. This in-between space where meaning-making occurs is important within this discussion as the Flawford Virgin films suggest hypothesis without resolution. The viewer is invited to fill that space with their own interpretation.

The three-minute and ten-minute Flawford Virgin films are presented as documentary and interpretation. Their foundation is in non-fictional information. As with all interpretation they are selective as to what information, be it factual or hypothetical, is used to construct the narrative. Patricia Aufderheide (2007, p. 23) describes how most documentary filmmakers consider themselves storytellers not journalists. Sheila Curran Bernard (2016, p. 1) talks in terms of grabbing and holding audiences through "creative, innovative storytelling". Many commentators on the genre of documentary refer to John Grierson, who many consider as one of the founding fathers of the genre, who defined documentary as the "creative interpretation of actuality" (Ward, 2005, p. 10; Aufderheide, 2007). Ward (2005, p. 57) discusses Stella Bruzzi's comments that describe documentary in general as "a negotiation between filmmaker and reality and, at heart, a performance" (Bruzzi, 2006, p. 186). Filmmakers make choices as to how facts are assembled and which facts best illustrate the issues being discussed and best serve the interpretive product being created. As the filmmaker makes choices they do so subjectively (Curran Bernard, 2016, p. 5). Aufderheide describes documentary as:

> "…a movie about real life. And that is precisely the problem; documentaries are about real life; they are not real life. They are not even windows onto real life. They are portraits of real life, using real life as their raw material, constructed by artists and technicians who make myriad decisions about what story to tell to whom and for what purpose."
>
> (Aufderheide, 2007, pp. 23–24)

If one considers the 'real life' of the Flawford Virgin being its assembled object biography with the addition of new scientific discovery, then the 'portrait' that is painted is incomplete. The debate as to how factual the portrait should be and how much speculation is permitted from an analytical starting point is an important part of the integrity of the films and an expression of the tension that lies between the two systems. From an interpretation perspective this incompleteness is a place where the visitor has agency to interpret, weigh options the film presents, and have free reign to construct meaning outside those presented within the framework of the film in an act of meaning-making (Mason, 2005). My key observation here is that an interpretive product that enables meaning-making and presents hypothesis and speculation as positive attributes of interpretation, is not automatically a comfortable place for

scientists to publish their findings. How their work is represented in this format is a matter of careful negotiation between the two systems.

8.3 Simulation, Reconstruction and the Creation of 'Facts'

In the last section I have offered a brief discussion of the relationship between analytical findings and how they are expressed in a film which is an interpretive product. The Flawford Virgin films as interpretive products make use of speculation and uncertainty as an interpretive device. In doing so they visualise these hypotheses and speculations in graphic forms. I would now like to take a closer look at the 'Sword Blow' hypothesis and the recolour of the Flawford Virgin's face to explore some issues around artistic reconstruction and how this relates to evidenced analytical findings.

Figure 32: Still from the Flawford Virgin three-minute film showing a digital reconstruction of the sword blow.

The sword blow digital reconstruction was based on my observations as a conservator and used RTI photography, which as an analytical technique would be seen as qualitative. As was explained in Chapter 7 although a viable research question, it did not receive analytical verification of the observations and this was presented as a hypothesis within the films (Figure 32). This hypothetical status allowed it to operate in a meaning-making capacity.

The sword blow has a particular role in the Flawford Virgin films. It generates a hypothesis inviting the viewer to consider a mystery, ponder on the possibility of a violent act perpetrated

purposefully, and then throw doubt on this dramatic possibility by offering other more mundane explanations. This creates interpretive possibilities. The film supports its hypothesis with the object biography. The sculpture was created as a devotional object in the medieval period. Its presence in a church during the Reformation could have plausibly exposed it to an act of violence and the fact that it was found in 1779 apparently hidden under the floor of the church would support this hypothesis. However, its time since discovery outside the protection of the church means that this hypothesis is by no means certain. The film suggests a workman's spade at the point of discovery as a possible explanation of the damage on her face. The sword blow hypothesis creates a narrative, which due to its uncertainty has a fictional element, and then populates that narrative with an unknown person from the past motivated to act in a certain way. Russell Staiff (2014, pp. 97–98) makes the point that narratives have to be peopled. It is characters that enhance the narrative power. The viewer can adopt the violent interpretation or the more prosaic one without either being right or wrong. This more playful and potentially fictitious narrative works well for interpretation (Parry, 2013). It enables a place for discussion and interaction between visitors allowing them to bring their own knowledge and experience to bear as to which side of this argument they stand and hence an act of meaning-making takes place. In Chapter 1 I drew attention to the work of Wehner and Sear (2010, p. 146) who found that object biographies that centred around human experience, historical change or cultural context worked most effectively in exhibition. However, it is worth noting that I generate a digital reconstruction of this event that appears plausible. Does the creation of convincing reconstruction influence the meaning-making process? I would like to look at this question in more detail and look at the other artist's reconstruction that is consistent in all four films, including the social media content: the recolour of the Flawford Virgin's face.

Within Chapter 7 I described how the analytical data allowed a vision of the Flawford Virgin with gilt undergarments, crown and hair, a vermillion robe and red lips. This vision was evidenced from the analytical data. However, the data set did not evidence the actual appearance of the face or the colour of the cowl. With the films re-edited in accordance to the Museum's brief, right through to the twenty-second social media clip, the part of the narrative that endures in all of the films is the recolour of the Virgin's face. This is the finale, the moment when we finally meet 'her'. The white alabaster face of the Flawford Virgin surrounded by gilt hair and red lips transitions to a recognisable coloured face. This is also a transition from the evidenced scientific position to one of speculation. In the narrative in Chapter 6 I describe reaching this definitive point of how far an artist's reconstruction can go, with the final film production decision being to recolour the eyes but to leave the cowl as plain alabaster. In this chapter I would like to make a closer investigation of this decision.

A significant part of the debate centring on the artist's reconstruction was the colour of the Flawford Virgin's cowl. My artistic instinct was based on what I as an artist would have done if colouring the sculpture. The knowledge that indigo blue was available on the artist's palette was evidenced in the data. The painting of these sculptures was regarded as the most expensive stage of the production process due to the cost of the pigments (Cheetham, 1984, p. 27). For this reason, one could suppose that the artist would limit the pallet as much as possible. An image search of 14th century Madonna and Child sculptures in collections worldwide and within the online collection of the V&A and British Museum indicated blue to be a likely colour (Figures 33 to 37)[32]. This would have resulted in me being willing to colour the cowl blue in the final scene. However, the analytical instrumentation detected no evidence. Additionally, the literature suggested that not all clothing was coloured but sometimes just edged with gilt (Cheetham, 1984, p. 26). Do I show the supposition of the blue cowl with its interpretive impact or reflect that the science is inconclusive? Do I risk the power of the graphic image to create pseudo-fact, where no factual evidence existed? The final choice was to respect the scientists' position and the cowl remained uncoloured. The obverse of this decision to not colour the cowl was to pull back from the full impact of the interpretive potential of that final image for the viewer. Here at the interface between the two systems we see an example of the negotiation required to bridge the rigour-relevance gap. Figure 37 shows a film still of the final shot employed in various degrees of zoom in all of the Flawford Virgin films alongside the 'coloured cowl' version that I presented to the ISAAC Lab team as part of the decision-making process. The blue portrayed here is probably far too light but the graphic impact of this image is apparent. The decision over the colouring of the eyes was slightly different.

The science showed evidence of red on the lips and a respectable scholarly source (Cheetham, 1984, p. 27) suggested faces were partially painted, with eyes and lips painted in and the flesh represented by the natural colour of the alabaster. However, my decision to make the Virgin's eyes blue was informed by the presence of blue on the limited artist palette. The eyebrows as light brown was purely intuitive as hair covered in gilt (evidenced by the science) gave the appearance of a blond woman. The key issue here is that the ISAAC Lab team and I knew the eyes would have been painted, we just didn't know what colour. In the production of the films this presents as a watershed where the analytical evidence interfaces with the artistic reconstruction. In the case of the cowl there was no analytical evidence and the historical evidence threw doubt on if there ever was a colour. However, the historical evidence suggested the eyes would have been coloured. As such the supposition in choice of colour that was required to create the impactful finale for the purposes of interpretation was acceptable to the ISAAC Lab team. It

[32] The images in Figures 34 to 36 are reproduced in accordance with the creative commons licensing published on the museum websites.

should be noted that these decisions were film production decisions not historical research decisions. This is in light of the fact that they were made days before the production deadline for Digital Heritage 2018.

Image redacted for copyright compliance

Figure 33

Figure 33: Above. Screen shot from the author's pc showing the results of an image search on 14th Century virgin and child.

Figure 34: Madonna & Child. Giotto, 1310-15. (National Gallery of Art Washington, 2021 © CC Zero in the public domain).

Figure 35: The Virgin & Child c1400. Dalmatian/Venetian. (The National Gallery, 2021 ©CC BY-NC-ND 4.0).

Figure 36: Virgin & Child, late 15th Century. (The British Museum, 2021 ©CC BY-NC-SA 4.0).

Figure 34

Figure 35

Figure 36

Figure 37: Two comparative reconstructions of the Flawford Virgin with plain alabaster and coloured cowl.

M. Norton Wise refers to the use of images in science in the following way:

> "[Images] have often appeared, on the one hand, as much too powerful, likely to lead to the deceptive excesses of imagination rather than the calm reflections of reason, and, on the other, as much too weak, capable of illuminating only the surface of things rather than their deep structure. These two problems of images, trust and depth, have long infected science and its history with a series of unfortunate dichotomies."
>
> (M. Norton Wise, 2006, p. 79)

The plausible portrayal of the sword blow and the recolour of the face generate convincing and evocative images. One might consider the proposal to colour the cowl lacked the 'calm reflections of reason' produced by the analytical evidence, yet the recolour of facial features was considered to be a reasonable supposition based on what evidence was available. The need to engage in this debate within the creation of an interpretive product from an analytically evidenced starting point is significant. As Hornig (1990, p. 11) has pointed out, even the presentations of scientific

conclusions outside the peer review context can make scientists uneasy. For them to be guarded over supposition is hardly surprising. The medium of film for public engagement with its agenda to 'grab and to hold' the audience's attention (Curran Bernard, 2016), and indulge the 'deceptive excesses of imagination' as portrayed by the artist, could understandably make scientists wary. Yet interpretation does need to engage its audience. As Ham reminds us they are at liberty to ignore it (Ham, 2013, p. 1). Hornig with reference to the portrayal of science on television comments that it "…somehow presents a more objective reality by conveying to the viewer a sense of 'really being there'", and that it "ignores – perhaps even conceals – the extent to which this technology inevitably packages or 'refracts' reality" (Hornig, 1990, p. 13). Certainly, in the making of the Flawford Virgin films the level of 'refraction' had to be continuously negotiated.

I would argue that the sword blow and the recolour sit within a negotiated territory between evidenced science and hypothesis and artistic supposition required to create an effective interpretive product. This is a rigour-relevance gap that opens up and, through discourse with the stakeholders of the two systems, one the films have to bridge. The sword blow represents a hypothesis founded on the conservation-based observation, analysis using RTI and the object biography that pre-existed the investigation. The ten-, three- and ninety-second films all ask the question 'did this actually happen?' and invite visitors to arrive at their own interpretation through an act of meaning-making. The recolour of garments, hair and crown were evidenced from analytical research. The recolour of the Flawford Virgin's face was much more an act of supposition. This is a comfortable thing to do within interpretation but generates issues for negotiation when one is negotiating across the boundary of the two systems. The next consideration is, are the presentations of supposition perceived as facts?

If a hypothetical observer of the Flawford Virgin films were asked 'what do you now know about the Flawford Virgin?' and the answer came back 'she had blue eyes and was hit by a sword' this creates something of a dilemma. Our understanding of the meaning-making process is that audiences create their own meanings relative to the content of the interpretation, the context in which the interpretation is presented, and the context provided by the audience's own personal experience. Moreover, as the creator of an interpretive product one should not expect to be able to pre-empt this process. The dilemma here is that the Flawford Virgin films are focused on an analytical investigation and its findings; 'she had blue eyes and was hit by a sword' are suggested as possibility and supposition and not given the support of an analytical investigation. One should bear in mind Hornig's points above in considering how the scientist involved in the production of this interpretive product would react to this. The text in the films goes to great lengths to ensure that this divide is clear and that the film does not dress supposition as analytically supported fact. There is a conscious effort through the use of language to show the watershed between the

analytical and interpretation systems. The production decisions in this case were negotiated with the ISAAC Lab team. However, to 'see' the sword blow and 'see' its aftermath as convincing and plausible, and to see a plausible human face in the facial reconstruction could influence the meaning-making process. This relates directly to the point Staiff (2014, p. 83) makes in the discussion in Chapter 1 where our visual construct of the past is generated by our consumption of film, media and gaming images. The digital representation of the sword blow and the face evokes a reality. It is not a drawn animation or illustration. This leads us to discuss the possibility that the hyper-reality of digital reconstruction or visualisation, if left unmitigated, can create 'facts' from hypotheses (Flynn, 2007, p. 349; Amakawa and Westin, 2018, p. 321). Bernadette Flynn (2007, p. 349) observes that our way of understanding our heritage has become intertwined with digital visualisations, commenting that an "algorithmically accurate large scale 3D model of a cathedral or castle is taken as the hallmark of authenticity." Jeffrey et al (2020) comment on how community digitisation projects can promote a site's significance. Seth Giddings (2015) explores this concept of the perception of fact in digital reproduction using the BBC series *Walking with Dinosaurs* (1999). Giddings (2015, p. 146) reflects on how critics see digital visualisation as a 'depthless image' and generating a 'loss of meaning'. In particular he critiques theories which put 'spectacle' and 'knowledge' in binary opposition to each other. He comments:

> "[F]ears of the merging of the museum with the theme park and retail outlet are only intensified in the vivid glare and eye-catching effects of digital media – but they do offer or promise new possibilities for engagement and interaction. Again these innovations have been viewed with distrust as well as excitement."
>
> (Giddings, 2015, p. 149)

Giddings describes the criticisms of *Walking with Dinosaurs* centred on its adoption of a wildlife documentary format, where speculative behaviours such as mating and feeding are given the status of facts. Giddings makes the point that science is itself a speculative practice and cites Michael J Benton, a palaeontologist who worked on the series as saying; "Science would be rather dull if we had to restrict ourselves to what we could see and touch, to 100% certainty." (M J Benton as cited in Giddings, 2015, p. 151). Science by its very nature progresses into the unknown. It hypothesises based on known fact or recent discovery and moves forward by testing hypotheses and reassessing them in the light of their findings. An important issue surrounding the creative nature of reconstruction is that it can be interactive with, and contributory to, scientific understanding. Both Benton (2001) and media and culture commentator Jose van Dijck (2006), observe that in the making of *Walking with Dinosaurs* the scientists worked with the animators, whose abilities to bring these skeletal structures to life began to inform the scientific understanding of how these creatures might have moved. As van Dijck (2006, p. 5) states:

"[S]cience documentaries do not illustrate but enable scientific claims; they visualize knowledge while substantiating hypotheses." Therefore, the animators were simulating dinosaur movements based on the scientific understanding. Giddings (2015, pp. 156–157) makes a clear distinction between the creation of the virtual space and simulation. The former is an audio-visual evocation. The latter is a working system where inputs can be varied, and outcomes observed.[33]

Consider the RTI analysis of the damage to the Flawford Virgin's face accompanied by the digital 'simulation' of the effect of the sword blow. This frames a plausible research question but how far down the road of simulation this goes is debatable. The judgements made as to how the sword and pieces of the sculpture act in the film were judgements made by 'feel' much akin to an artist's decision-making process. If one could calculate the power of the sword blow and estimate the weight and structural integrity of the alabaster, then putting these parameters into a simulation would enable the hypothesis to become more evidence-based. This question remains unanswered within the film but has potential to trigger further scientific interest which, in turn, could have the potential to create more interpretation content for the museum.

Reconstruction within heritage is based on fact, but to some degree supposition and/or hypothesis has to fill in where facts are absent to complete the picture. In some cases, it is an artistic intervention that generates the supposition. Wang *et al* (2019) noted this in their critical review of the *Dinosaurs of China* exhibition at Wollaton Hall and Lakeside in Nottingham. They observed that paleoart[34] could "…not only help visitors' understanding but could also be misleading." (ibid, p. 521). A cited example was the illustration of the *Sinosauropteryx* whose fossilised remains were in the '*Dinosaur Death Pose'* with the head thrown back (ibid, p. 531-2). This pose has theories as to what causes it, but it is believed to be a post-mortem feature. However, the artist employed it in the visualisation as a courtship display. The scientific content with regards to feather colour and anatomical detail was accurate, the employment of the pose was supposition if not pure artistic expression. Wang *et al.* comment that "…the dance-like pose made for a joyful and compelling narrative." Having seen the exhibit, I would suggest it also made the skeletal remains easier to interpret as the illustration mimicked them. Did *Sinosauropteryx* throw its head back in courtship as it did in death? No one knows. What is problematic for the visitor is that the dividing line where the science stops and the supposition starts is unclear. This echoes Hornig's point earlier about the context of scientific fact and presenting those facts to a non-specialist audience. It is notable from Wang *et al's* account that the drive to engage an audience was strong. This came to light with the description and illustration of *Sinornithosaurus*

[33] This is a highly theoretical area, an exploration of which is outside the remit of this PhD. For a greater in depth study see: (Fransca, 2013) (Lister *et al.*, 2003).

[34] Paleoart is the artistic reconstruction of prehistoric life according to scientific evidence. For a full explanation and history see: Lescaze (2017) Visions of the Prehistoric Past

(ibid, p. 532). The scientific community is undecided as to whether this dinosaur was venomous but the drama this uncertain hypothesis creates could not be resisted by the artist. Interestingly, this was done with the full support of the deputy director of the Paleozoological Museum of China who was "…very satisfied with this image and strongly suggested the *Dinosaurs of China* exhibition highlight this hypothesis as she believed that this feature would make this dinosaur more attractive to visitors." (ibid, p. 532). Here we see the challenge science faces as it crosses the rigour-relevance gap, where the relevance is not positioned in scientific terms but with the needs of interpretation. Should interpretation support a controversial theory for audience impact or retreat to a nonpartisan position? The curatorial team at Wollaton Hall redacted the theory from the text panel and allowed the image to be interpreted as the visitor felt fit. Evoking the act of meaning-making here is interesting as it is being employed to step back from a controversial debate. Wollaton Hall have a high level of paleontological expertise. Would the interpretation have been more didactic, presenting the venomous dinosaur as a 'fact', had the deputy director in China made this interpretation decision rather than the curatorial team at Wollaton Hall? The interrelationship between science fact, hypothesis and artistic supposition is to be negotiated in the creation of an interpretive product. As Giddings points out, it is in some cases welcomed, although as this case study suggests, each supposition would be negotiated on a case by case basis and positioned into either the analytical or interpretation system.

Modern digital reconstruction can create a hyper-reality to step beyond the artist's illustration. It becomes very difficult to see the join between fact, hypothesis and supposition. Bettina Habsburg-Lothringen (2015, pp. 332–333) describes the work of German ethnologist Gottfried Korff, who proposed that when museums evoke the past they should not strive to generate a 'reality' but signify the "… artificial character of any world created by the museum" to be "… made apparent through specific alienating effects and distortions", which would "… enable a critical and plural approach to history …". I would argue that the black void in the films performs a similar task. It distances the sculpture from any historical reconstruction and instead focuses the view on the visual experience of seeing. The International Council on Monuments and Sites (ICOMOS) advises that:

> "Visual reconstructions … should be based on detailed and systematic analysis … The information sources on which such visual renderings are based should be clearly documented and alternative reconstructions based on the same evidence, when available, should be provided."
>
> (ICOMOS, 2008, pp. 4–5)

However, how many times does one see multiple possibilities presented? They certainly were not in the case of the *Dinosaurs from China*. Digital reconstructions are normally singular and not offered in varying iterations for the audience to engage in a more critical sense of meaning-making. The tendency for the audience would be to assume 'that's how it was!' With the sword blow and the recolour of the Flawford Virgin, it is the narrative text that calls the viewer back to question and consider the different possibilities and triggers the act of meaning-making. In the case of the sword blow this was quite discursive. However, the face reconstruction presents as a visual statement due to its requirement to be the finale, the full stop that ends the film. In both the three- and ten-minute films this sequence uses the word 'may' to present the suppositional nature of this reconstruction. Both the ninety- and twenty-second films employ unanswered questions, inviting the visitor to the Museum or the website to find out more.

8.4 The Flawford Virgin Films as Interpretation

Figure 38: The Flawford Virgin in exhibition at the newly refurbished Nottingham Castle Museum and Art Gallery. Left, the 'object-information package' presented by the object and its associated information. Right, The Flawford Virgin in her display case. What 'sensory experience' do we get from this 'object-subject interaction'? Images by the author reproduced by kind permission of Nottingham Castle Trust.

In Chapter 1 the work of a number of significant commentators was assembled to arrive at an understanding of what constituted interpretation. The central concept of meaning-making was introduced by Mason (2005). Lidchi (2013) described her constructionist model comprising the 'poetics' of an object's significance and the 'politics' of the context of its display. Ham (2013) defined the ingredients of interpretation to be 'teaching', 'entertaining' and 'provoking', with

provocation being the most indispensable. Finally, Staiff (2014) and Dudley (2010, 2012) envisage a complex interrelationship with museum objects, our experience and pre-knowledge of them and the information provided with them. I would like to return now to these commentators to examine the suite of Flawford Virgin films.

Both the three- and ten-minute films tell the story of the Flawford Virgin as portrayed by myself as filmmaker. This experience will be different to encountering the real sculpture within the museum gallery. Let us take a theoretical view of this. In theory, on encountering the real sculpture one will have a 'sensory experience' (Dudley, 2010, p. 1) of standing in front of a hand carved nine-hundred-year-old object. However, this experience will be entirely visual and restrained by the mode of exhibition, which in reality it is (Figure 38). Theoretically, before engaging in any of the interpretation provided, one could see remnants of paint and damage to the face and speculate. Who was the individual who carved it? What was the nature of the world it was carved in? This would be Lidchi's politics in play. If 'we' were then to ask ourselves the question 'why was it carved?' then if 'we' are members of a Northern European Christian culture, we are likely to already know. This would be culturally embedded through childhood and adult experiences, church visits, school, weddings and funerals etc. The significance and symbolism of the Madonna and Child in Christian culture is clear, and the identification of this as a devotional object for Northern Europeans would be tacit. This may not be the case for those outside that culture (Staiff, 2014, p. 82) who might bring a different pre-knowledge and have a very different sensory experience. Here we see demonstrated a concept formulated by David MacDougal and described by Wehner and Sear (2010, p. 152) as 'knowledge of being', focused on the sculpture's physical presence and the sensory experience of encountering it, and a 'knowledge of meaning' which is culturally based and as such a form of situated knowledge. Russell Staiff argues that heritage cannot be viewed 'pre-epistemically' and that each visitor brings with them a pre-existing 'knowledge' generated by a broader social and media culture (Staiff, 2014, p. 82). Mason (2005, pp. 202–3) discusses the work of Ferdinand de Saussure, inventor of semiotics or 'the science of signs'. When applied to objects this implies that they have no inherent meaning but are 'signifiers' to sets of meanings and associations which are relative to the cultural context of the viewer of the object. For this reason, the meaning of objects is a matter of interpretation. Both Sandra Dudley (2010, 2012) in a museum studies context and David MacDougall (2006) in a media studies context, explore the interface between a knowledge created by visual encounter and that generated by the context and information provided. MacDougall (2006, p. 1) maintains that visual experience is a form of non-verbal or non-textual knowledge. Sandra Dudley (2010, p. 3) also sees a dichotomy between the sensory experience and what she regards as the 'object-information package' of the exhibition object and text panel. Dudley's view is that these two do not rest easily with each other, at the potential cost of the sensory experience. Dudley makes the case that the

object-information package dilutes the sensory experience. As such it denies a more immediate and intimate experience of an object which might involve the object's materiality, including touch and even smell. As such, she promotes the primacy of the 'object-subject interaction' (ibid, p. 5). In this interaction the object enters a relationship with the visitor (subject) in the initial stages of meaning-making centred on the visitor's pre-knowledge and immediate experience of the object's materiality. To 'know' the object as a 'thing' before one engages in a more Saussurian investigation of its significance. This aligns with MacDougal's knowledge of being at the first point of contact. From a conservation perspective the access to an object to touch and smell is highly problematic. As Caple (2000, p. 22) stated: "people are bad for objects" . However, Dudley (2012) describes her encounter with a Chinese horse in a museum, prior to reading the text panel, which is presented on a wall nearby. Despite her inability to touch the object her experience is emotive and centred in her own pre-existing knowledge and, for her, a vital part of the museum experience (Dudley, 2012, pp. 1–2). Dudley (2010, p. 9) does acknowledge that imagination can, and sometimes will have to, step in to supplement the object-subject interaction in the absence of physical contact.

My view is that these two experiences, one of object-information package and the other of object-subject interaction may interact, and not to the detriment of either. Consider the Flawford Virgin as both object in a museum, with its interpretation material forming an 'information package', and the potential 'information packages' of the three- and ten-minute films. These films have the potential to be displayed entirely independently on the website or hyperlinked from the interpretation panel in the Museum. However, surely the potential for one's experiences is a layering of these interpretations. In the potential museum visit the physicality of the medieval sculpture will be the first experience as one enters the exhibition hall to view it. A human face will be the first port of call for the eye. This is the object-subject interaction, the knowledge of being at the moment of meeting that Dudley and MacDougall describe. Next comes the desire to know more and to contextualize this object and it is now one might turn to the interpretation material provided, at which point one engages with the information package. However, if we consider the three- and ten- minute films, the visual encounter is quite long. The sculpture animates allowing an intimate view not enabled from standing in front of the sculpture in a museum context. Intimate details are drawn to the visitor's attention. The time the eye is given to linger on any aspect is extended. This is reminiscent of the idea of guiding the undisciplined eye as described by Wasson (2015, pp. 604–18) in Chapter 1. It combines additional information in narrative form but also suggests mysteries and reveals secrets. Ross Parry (2007, p. 80) describes the museum object as a "molecule of interconnecting pieces of information". In this scenario the materiality of the object, its associated information package and its reiteration in associated digital formats all coalesce to create the meaning-making experience. I argue there is an interplay of both a

knowledge of being and a knowledge of meaning, an interchange of object-subject interaction and the object-information package. However, in the case of the films it is not intuitive for the visitor but choreographed by me. These are 'poetics' in museum studies terms. The emphasis on the visual presence of the sculpture in its black void theatrical space, the slow metred pace of the film, the subtitles and the use of music and light, are used to hold the visitor's attention and choreograph their viewing experience as this interaction plays out. It also responds to Ham's (2013) assertion that to reach the interpretation 'end game' (ibid, p. 53) one has to entertain and inform. However, Ham also maintains that it is provocation that is the key element of the interpretation end game (ibid, pp. 53–59). It is the sword blow and its uncertainty that provokes the viewer's independent thought.

I see the elements of the experiences described above as mutually beneficial and creating a richer experience and understanding of the object. As MacDougal (2006, p. 4) points out "A good film reflects the interplay of meaning and being, and its meanings take into account the autonomy of being." However, he notes: "Meanings can easily overpower being." It is worth noting that the films are destined to be on the website and as such they have the potential to present as standalone interpretation pieces. For anyone viewing the website with no intended visit this would be the case. Digital or multimedia material can become an 'object' in its own right (Witcomb, 2007, p. 38) existing as 'born digital' (Parry, 2010, p. 4). In this sense an interpretation of the sculpture could be completed simply by seeing the films. In this scenario my choreography of the viewing experience has to enable both 'being' and 'meaning' to interplay. On the other hand these films may be the first experience of the sculpture prior to a visit. This would invest a degree of cultural capital in the form of pre-knowledge for the sensory experience of seeing the real sculpture. Again, this is an enrichment of that experience.

As the exhibition of the Flawford Virgin currently presents itself the information package is strong, with a large format text panel in close proximity to the sculptures displayed (Figure 38). Additionally, the lighting within the gallery is quite subdued and any hint of the remaining polychrome is difficult to see. It is however indicated that polychrome did exist in the interpretation panel associated with the Flawford Virgin sculpture itself. At the time of writing there was no means of experiencing the films in the gallery or connecting the research done with the physical display. For this reason, the interconnectivity to create the interplay I suggest of meaning and being, object-subject and object-information, is yet to be realised. When the film material is fully published on the website an ability to acquire a pre-knowledge prior to a visit is provided. However, if the physical visit is the only experience of the sculpture the visitor has, then they are very much held within the object-information package and a large part of the interpretation experience is lost.

8.5 The Twenty- and Ninety-Second Film's Role as Social Media Content

Between the issue of the original brief described in Chapter 7 (2020) and final application in 2021 a number of changes occurred at the Museum. There was a change of management structure and the marketing and communications agent influential in the creation of the original brief was replaced by an internal marketing department. The current iteration of the website will be discussed in Chapter 9. The strategy for the social media content remained more consistent. The current view for the film content is now that the three-minute film is seen to have potential for application with Facebook. The ninety-second film is seen as targeting Instagram and the twenty-second film remains targeted at Twitter. The Museum's initial motivation for requesting the social media content was one of marketing and this remains the case. However, indicators from the current strategy show that a degree of interpretation potential has been identified. I would like to deal first with the marketing aspect of social media, as in the first applications of the twenty- and ninety-second films they were focused around the Museum's reopening after refurbishment.

Recent research has given an indicator that a large proportion of social media from museums is driven from a marketing perspective[35] (Kidd, 2014, p. 48). In this role Kidd observes that levels of conversation were limited between visitors and museum staff and so social media as a medium of openness and debate was not demonstrated in her sample (ibid). The lack of complexity or richness in the conversation was also noted with a tendency to 'small talk' and this was seen as an undeveloped potential (ibid, p. 49).

Once social media content is released into a social network then the museum is not in control of how it is employed.

> "Social media starts by offering a way to 'widen the audience', 'reach new constituencies' but it ends by changing heritage and by asking everyone to participate in its construction, encouraging openness not closure of interpretation and valuation, making flux, uncertainty and doubt critical."
>
> (Fairclough, 2012, p. XVii)

The desire to widen audiences and reach new constituencies would be shared by all museums but how many of them would welcome having their interpretation offer subject to flux, uncertainty and doubt is debatable. Curators fully conversant with the nature of meaning-making may be

[35] Kidd states 42%

comfortable with this. In the context of communicating analytical investigations, as has been discussed, is there a danger of the science being misinterpreted? However, this uncertainty is manifest in all forms of museum interpretation (Lidchi, 2013, p. 121). This is a dilemma that the museum finds itself in (Kidd, 2014, pp. 43-45). The process of sharing social media content opens up what Kidd (2014, p. 51) referred to as :"…a rabbit warren of additional content: reviews, blogs, podcasts, archival materials and other media content…" . Russell Staiff (2014, pp. 115–119) considers this question. Over a period of years, he has been setting his students a self-directed task of responding to a specific heritage site in a social media context. He then has conflated these projects into the work of an 'imaginary student' named 'Gabriel'. Gabriel's first task was to assemble a body of pre-existing heritage information of the site that was available on the internet. What followed was a ramification of more personal material and responses interlinked with Gabriel's social media presence. This covered a diverse and personal set of experiences from multiple contributors, who in some way had a connection with the heritage site. These responses were as diverse as recipes, university architectural projects, the memories of grandparents, virtual tours of the site, photographic studies of architectural features, reflections on the masculinity of the local men and a link to the Assassins Creed video game. What is also interesting is that the website continued to evolve and change beyond the original and had to be limited to invitation only. What Staiff has described here is an organic growth of interconnections akin to Kidd's 'rabbit warren'. If the social media output from the museum is the catalyst then the reaction that follows is no longer mediated by the museum.

> "Museums must recognise the fact that in this digital environment it's likely visitors and students will use the museum collections in ways which may surprise, delight or even worry them a little bit"
>
> (Swift 2011 as cited in Kidd, 2014, p. 134)

Kidd (ibid) illustrates this tension that exists within the museum by explaining how simultaneously the museum will wish to practice 'internalism' to maintain "institutional purpose, policy and voice" and 'externalism' expressing a "concurrent wish to look outward, to throw off their authorial voice".

The employment of the Flawford Virgin films as a social media output by the Museum would appear to position itself closer to internalism and to focus around a marketing need, but recognising they have little control over how people engage with it and share/use it afterwards. Angelina Russo (2012, p. 147) feels maintaining the museum's "…traditional remit as an authoritative source…" can be combined with the enhancement of the relationship between "…institutions and audiences by means of new forms of cultural participation." To facilitate this

the museum needs to feel a confidence in its traditional base of interpretation and look to translate this across to a new media context (Henning, 2011, p. 642). As Henning puts it:

> "New Media and old are sometimes distinguished too sharply on the presumption of abrupt and absolute distinctions between the "virtual" and the "real" and the "digital" and the "analogue." In new media theory, a more interdependent relationship between old and new media is suggested by the concept of "remediation.""
>
> (Henning, 2007, p. 26)

Bolter and Grusin (2000, p. 55) use the term 'remediation' to describe the interplay between new and old media and how the existence of both simultaneously affect each other. The films have the potential to remediate the viewing experience of the real sculpture through animation as they are watched. By the same process the viewing experience of the real sculpture could be remediated by a pre-knowledge of the films. Both the twenty-second and ninety-second films were designed to use unanswered questions to draw a social media audience to the web content (three- and ten-minute films) once it is finalised. This web content would then directly refer to the actual sculpture on exhibition in the museum. Initial social media contact could theoretically result in a visit to see the actual sculpture. This remediation would fulfil the marketing aim and the films could provide a pre-knowledge of the sculpture which would influence the meaning-making experience (DeWitt, Effronsyni and Godec, 2019). However, as has been previously explained, to enable this remediation activity to be complete, the visitor would need to access web content from within the physical exhibition. This said, the questions posed by the social media content are to a great extent brought to closure by viewing the longer films. To what extent the audience for the social media content that the Museum requested will use this to catalyse a community response that Kidd and Staiff describe is still under development. However, at the time of writing the current social media strategy was to be themed at Christmas 2021[36] around storytelling and this would include 'stories hidden within objects'. The initial brief from the Museum does not explore how social media could be used to trigger a debate around the validity of the sword blow hypothesis for example. Would this follow in due course as the 'stories hidden within objects' theme is launched? Will the potential of social media in a museological context be fully realised? At the time of writing one can only speculate. However, Russo (2012, p. 154) acknowledges that museums have enormous cultural capital in their collections and have achieved public status through virtual presence. However, they still "…struggle to situate themselves in the contemporary, media-saturated environment."

[36] This was later postponed due to internal priorities.

8.6 Conclusion

This chapter has attempted to position the Flawford Virgin films in the context of their role as an interpretive product. As such they have potential to create a meaning-making experience and evoke an interplay between the object-subject experience and the object-information package. In many respects they facilitate an emulation of the viewing experience in a choreographed way. I would argue that certain distance is observed between the role of the films as an interpretive product and their starting point as analytical investigation. This has been considered in the context of the existence of a rigour-relevance gap separating the systems of analytics and of interpretation. Discussions took place to resolve the portrayal of scientific issues both visually and in language in the translation of one to the other. The films had to communicate the analytical outcomes to a non-specialist audience and manage the more fictive and playful nature of hypothesis and supposition. This generated the potential of the film content to hold the attention and evoke meaning-making. The role of artist's reconstruction and the decision-making processes the artist employs to enable an interpretive product to function as a site of meaning-making have been discussed. However, these processes have discernible distance from the evidence-based foundation of science. This means that the science had to be communicated through a medium less comfortable than the peer review publications that science would normally employ for discourse. Finally, when the films reached their final iteration as instructed by the Museum's brief, a further move took place as analytical investigation becomes a means by which interpretation is employed as a marketing tool. I highlight the gap to be bridged from analytical investigation to interpretive product and its employment as a marketing tool, as manifestations in practice of the concept of the rigour-relevance gap currently being discussed in heritage science literature (Bell *et al.*, 2014; Dillon *et al.*, 2014; Katratazis *et al.*, 2018; Curran and Zimmermann, 2021). With reference to the literature I have also taken on board some of the more overarching concepts of rigour-relevance. Throughout the case study Kieser and Leiner's concept of analytical investigation being in a separate system to that of museum interpretation has been observed. Although the analytical content did not get 'lost' in translation it did have to be edited and abridged to enable it to operate in the museum interpretation system. In this sense this research would appear to support the assertion that the separate systems are dynamic and transcendable (Fincham and Clark, 2009, p. 510; Hodgkinson and Rousseau, 2009, p. 536), with my role being one of bi-lingual and bi-competent facilitator (Kieser and Leiner, 2009, p. 528).

Chapter 9: Reflections and Conclusions

At the beginning of this thesis, I mapped out how the fields of heritage science and conservation have expressed a desire for a heightened level of socio-political profile. I proposed that heritage science specialists in HEI's could work collaboratively with N-SREO museums, extending their practice outside their familiar relationship within the SREO environment. I then laid out a case through literature review that the political and research funding environment would be conducive to such collaborations and hence the research presented here is timely. However, I then go on to illustrate through the literature that collaborations of this type are nuanced. The literature observes phenomena such as 'power imbalance', 'cultural difference' and a 'rigour-relevance gap' that can manifest in collaborations of this type. Through a case study observing the interaction of heritage scientists running an analytical investigation on objects in a real museum, a granular understanding of how the above phenomena manifest in practice is observed. These observations are juxtaposed with the discussion programme which indicates resonance with the findings in the literature. The key issue that emerges is that analytical investigation into N-SREO museum collections will need to meet museum ethos in generating interpretive product to answer to a core mission statement of public engagement. This defines the museum's 'end user' need. Simultaneously, the analytical practice generated by the HEI-based heritage scientists has to have meaningful output. This could take the form of publishable peer review quality research outcomes, pedagogical advantage and opportunities to deliver knowledge exchange in response to the modern research funding environment. This difference in outcome and approach defines the rigour-relevance gap that exists between these two 'systems'. The concept of rigour-relevance is only just entering the critical debate on how heritage science interfaces with potential end users such as museums. Its observance in practice forms the new knowledge presented by this research.

Before discussing the above relative to the research questions, it is worth bringing closure to the final outcomes of the research. In many respects this illustrates the disconnect between a research-driven intent and real-world application. At the time of writing the salt glaze research is at an advanced stage and preparations for peer review publication are under consideration. With respect to the films, throughout the progress of this research the Museum has been through a period of enormous transition. Not only in respect of its planned refurbishment but through two changes in management structure and an international pandemic delaying their reopening. In certain respects, the Museum that started this research process is not the one that is now completing it. This transition should be considered in terms of where the Museum finds itself at the end of this process. The brief presented by the Museum in 2020 made facility for the three-

minute film to be web based and the centrepiece of the interpretation experience created by the films. The social media content would point to it, and it would be a departure point for the ten-minute film for those with special interest. At the time of writing this is still under development. The web presence is currently the twenty-second film which is hyperlinked to the ten-minute film on the Museum YouTube channel. This is a temporary situation due to the web site currently being unable to host a three-minute film. The intentions of the original brief in this respect will be established as soon as is practicable. As stated in Chapter 8 the Museum is aware of the potential that a connection from the physical exhibition to the developing web content offers them. Their current approach is to review this potential and act accordingly in line with their ongoing developmental policy. A similar situation is in play with the lace images and films. The original brief still stands, to employ Artcodes as a link to content presented on the Museum website, but this aspect of the Museum's interpretation awaits development.

9.1 Considering the Research Questions

Within this section I would like to return to the research questions as posed in the introduction:

- How might a critical examination of literature and practice enhance an understanding of the current relationship between heritage science, its embedded specialism of conservation science and the wider museum sector?
- How might the creation of an interpretive product tailored for a museum setting make effective use of an analytical investigation?
- How might the creation of this interpretive product act as a bridge between the outcome of a heritage science analytical investigation and museum interpretation?

The issues arising here are: why would heritage science want to develop a broader relationship in the heritage sector to promote its public and socio-political profile? What evidence is there in the literature that this is being pursued? What environment exists externally for this issue to be successfully managed? Additionally, this research considers whether a heritage science investigation translates effectively into interpretive product, and if it forms a bridge between the analytical and interpretation systems that has potential to transcend the rigour-relevance gap. The next few sections consider the research questions and these issues in a holistic manner.

9.1.1 The Current Relationship Between Heritage Science, Conservation, and the Wider Museum Sector

Conservation had to be considered within the critical examination of the current relationship between heritage science and the wider museums sector. Conservation has an intimate relationship with heritage science and an even more intimate one with heritage science's embedded discipline of conservation science. Heritage science facilitates knowledge of museum objects, informs conservation decision making and develops new conservation treatments. Heritage science shares the same ethical framework as conservation and can inform a museum object's position on the RIP triangle (Caple, 2000, p. 34). This PhD has focused on the interrelationship between heritage science as presented by an HEI, and an N-SREO museum. It has sought to demonstrate heritage science's potential to be a proactive generator of interpretation. It could be argued that conservation has the same potential. This PhD has not had the facility or capacity to explore this potential in the same way as it has for heritage science, the sword blow hypothesis being the exception. Yet I would maintain that the principle is transferable. Conservators could proactively explore aspects of object biography which would generate interpretive product. In this role they might promote their position as proactive generators of interpretation rather than custodians of the object's condition and its physical representation (Brooks, 2013; Crofts, 2021).

In Chapter 1 I highlighted a desire, as expressed in the literature, for heritage science, conservation science and conservation to enhance their socio-political standing on local, national and global levels (Bell, 2015; Corbeil, 2015; Heritage and Golfomitsou, 2015; Lithgow, 2015). In Chapter 2 I set this desire in the context of the DCMS seeing heritage as a 'calling card to the world' (HM Government, 2019, p. 2) and expressing how the agenda of heritage had risen in the government's eyes as an economic driver within the tourist industry. The DCMS sought this through promoting new digital media within the sector that was capable of bringing new audiences and encouraging wellbeing (DCMS, 2018a). Within the HEI sector I stressed the rising significance of societal impact for universities through the current REF and forthcoming KEF (UK Research & Innovation, 2019; UKRI: Research England, 2020). Along with this the research funding bodies (UKRI/AHRC) were reflecting the government's agenda in seeking public facing outputs which are research driven (UKRI and AHRC, 2020). What I identified here was a commonality of purpose. However, within the examination of the relationship between heritage science and the wider museum sector I highlighted literature that suggested that a potential climate of interconnectivity was caveated (Bonacchi and Willcocks, 2016; Dent and Willcocks, 2016; National Co-ordinating Centre for Public Engagement, 2016; Markham *et al.*, 2019). Firstly, that a

phenomenon of cultural difference existed between Museums and HEIs, which manifested in working practices, time scales and use of language amongst other factors. Secondly, a potential for power imbalance was observed within museum and university partnerships, with the HEI taking the upper hand (Bonacchi and Willcocks, 2016, p. 30; Dent and Willcocks, 2016, p. 20). In addition to this the NCCPE research noted that the 'hard sciences' were heavily underrepresented in museum and university partnerships, with a predominance of arts and humanities subjects (National Co-ordinating Centre for Public Engagement, 2016, p. 4; Markham *et al.*, 2019, p. 42). It would seem that heritage science investigation conducted by an HEI in a museum is quite a rare and potentially complex event. The theoretical proposition presented in the research is that, by combining heritage science investigation with the production of an interpretive product, the potential is generated for a vehicle to bring heritage science to a wider audience. In addition, it has potential to respond to current trends in the funding landscape and those within the metrics for the assessment of HEI effectiveness in employing this funding.

In Chapter 2 it is proposed that a partnership between an N-SREO and an HEI is the most conducive way for heritage science to reach the N-SREO environment. The chapter highlights the desire within the UK research funding bodies to explore bridges between the humanities and sciences (UK Research & Innovation, 2020, p. 65) and create "… major research-driven public facing outputs…" (UKRI and AHRC, 2020, p. 3). Chapter 2 then goes on to explore the literature behind the phenomenon of the rigour-relevance gap, which manifests between an analytical investigation and the relevance that investigation has to the N-SREO museum. Outside the field of heritage science considerable debate exists as to how bridgeable the rigour-relevance gap is (Martensson and Martensson, 2007; Fincham and Clark, 2009; Hodgkinson and Rousseau, 2009; Kieser and Leiner, 2009). A small body of research is developing exploring the wider relationship between heritage science and its collaborators (Katratazis *et al.*, 2018; Curran and Zimmermann, 2021). The literature specific to the rigour-relevance gap that is relevant to heritage science is relatively minimal and entirely statistically based (Bell *et al.*, 2014; Dillon *et al.*, 2014). Not only that but a critical review of it would reveal that the rigour-relevance phenomenon is observed as 'statistically significant' (Dillon *et al.*, 2014) rather than clear and prominent. In this research I have taken the principle of rigour-relevance and sought its manifestation in practice.

In Chapter 6 I observe a transition in the nature of the research questions that the Museum first presented to the ISAAC Lab team and how those questions had to be reframed and negotiated to be presented in scientific terms for the ISAAC Lab team to tackle them. In Chapter 7 I describe a number of debates and discussions with the ISAAC Lab team about the use of language to describe the analytics and the level of detail in which the analytical processes are presented. On the one hand there was a desire by the scientists to have their processes described with precision

and accuracy, and on the other was the selection of the depth of analytical content, language and detail appropriate to communication with a non-specialist museum audience. As the films reach their final iteration informed by the brief issued by the Museum, I demonstrate how the final outcomes move further from the starting point of describing an analytical investigation into a marketing and promotional role relevant to the Museum at the time; this being focused predominately on the object biography. In Chapter 8 I discuss the interplay between fact and hypothesis and how that relates to the communication of scientific ideas as opposed to the more personally responsive nature of meaning-making and interpretation. Within the professional discussions in Chapter 5 I highlight an indication that a heritage science investigation would have to be in alignment with the museum's programmes ethos and mission statements within the N-SREO environment to have relevance to it. I present this distance between the HEI and N-SREO museum in the context of Kieser and Leiner's (2009, p. 516) assertion that they are different systems and share different logics which challenges their collaboration.

Each of these issues and observations can be viewed through the lens of the concept of the rigour-relevance gap. I propose that bridging the rigour-relevance gap, through an understanding of how a heritage science investigation transitions into an interpretive product that can induce an act of meaning-making, is a useful tool for the heritage scientist and museum professional. For N-SREO museums it signposts a potential relevance that heritage science investigation has for their sector. The intention being that, if this relevance was more widely understood, heritage science investigation has the potential to become a more frequent contributor to the understanding of the objects held within this sector. For heritage science it could enable an understanding of the relevance that research has to the N-SREO environment. It has the potential to assist in pursuing the goal of raising the profile of heritage science and conservation in a socio-political context. However, to do this, heritage science's investigative outcomes must make a transition from analytical outcome (rigour) to end user application (relevance). It is a detailed understanding of the issues revolving around this transition that form the content of this PhD. Kieser and Leiner's position is that the rigour-relevance gap between two differing systems is unbridgeable. This thesis and many of Kieser and Leiner's critics (Martensson and Martensson, 2007; Fincham and Clark, 2009; Hodgkinson and Rousseau, 2009) challenge this view. However, much of what Kieser and Leiner describe as characteristics of two system collaboration have been observed within this case study. They suggested that separate outputs are required for the research and practice systems (Kieser and Leiner, 2009, p. 525) and that a bilingual and bi-competent facilitator is required as a catalyst (ibid 2009, p. 528) both of which have been described within this case study. Having said this, the analytical content was not 'lost in' or 'lost before' the process of transition (Kieser and Leiner, 2009, p. 517) but effectively filtered and edited to be presentable to the end user (Fincham and Clark, 2009, p. 510). The key is an empathy with the aims, objectives

and modes of dissemination for the two systems; once the 'what?' and 'how?' of research has been achieved, it is asking the 'why?' and 'for whom?' questions that build the bridge across the rigour-relevance gap (Martensson and Martensson, 2007, p. 1328).

9.1.2 How Might Heritage Science Generate Analytical Findings that can be Translated into Effective Interpretation?

This translation from the analytical to interpretive system comes with challenges. As discussed in Chapter 8, in the development for imaging for lace, imaging that is diagnostic for scientific purposes does not automatically communicate visual information in a sufficiently visually eloquent way to serve the purpose of interpretation. This reflects the rigour-relevance argument. The more metric images generated in the early attempts to create lace images from the focal stack and those created from the OCT equipment did not communicate the twists and knots of the microscopic nature of lace structure. Whereas the purely photographic images enabled the viewer to see the lace as it was[37]. The experience of the case study was that scientific imaging was focused on the purpose of analysis and that images describing and communicating the analytical investigation had to be manufactured to fulfil an interpretation need. This is presented as an image-based bridging activity across the two systems. As well as the lace imagery this essential principle was reflected in the scientists being asked to mock-up their investigations on site (Chapter 6) and the creation of 3D modelled 'avatar' instruments animated in the 10-minute film to explain the analytical processes (Chapter 7, Figure 22). In the end the case study produced imaging for the films that was manufactured for the purpose of interpretation rather than images that were generated for scientific analytical methodologies.

Within the case study the ISAAC Lab team was asked to work in a speculative way, using their instrumentation to seek lines of investigation that would develop the object biographies of the selected objects. This approach exposed the distance between the research questions that the Museum generated for their interpretation need and those which presented tangible problems to be solved with scientific methodology. Within the case study it is worth noting that the research question where this distance was smallest, the investigation of the Flawford Virgin's polychrome, was the most capable in meeting the dual need of successful analytical investigation and relevant application for the Museum. This observation is perfectly logical, but it does assist in focusing the nature of a potential research question negotiation. The case study would suggest that both HEI

[37] See Figure 31 in Chapter 8.

based heritage scientists and N-SREO museums are seeking to identify, within the research questions, a synergy where both stakeholder needs are met.

Although the existence of this synergy was not premeditated into the research methodology, the ISAAC Lab team did succeed in finding it. As such their findings created the foundation of an interpretive product in the form of a suite of films with embedded 3D animation. These films had to be based on analytical findings and yet they also had to present as interpretation which could enable a degree of meaning-making. As explored in Chapter 8, 'facts' that are generated by the progress of scientific research within their specialist peer review community have been considered less didactic than 'facts' as understood by the general populous. (Hornig, 1990, p. 12) The Flawford Virgin films present scientific 'facts' as findings and then step beyond into more hypothetical questions: was the damage to the face from a bladed weapon or a spade? Could the Flawford Virgin's face really have looked as it was presented in the film? These are left as issues of interpretation and step beyond the boundary of the scientific findings. This is an important understanding in managing the transition from analytical outcome to interpretive product.

The films present a view of the sculpture which has the potential to act in conjunction with the experience of seeing the real sculpture within the Museum. The rotating 3D model gives an intimate portrayal of the Flawford Virgin and reveals aspects of its physicality that are not immediately apparent if staring into a vitrine. However, the film format has an element of didactic presentation. The view of the sculpture is dictated by the editing rather than the exploring eye of the viewer standing in front of the artefact on display. Should the Museum be able to facilitate a higher level of interactivity between physical exhibition and web content, a true act of meaning-making would occur at the interface between these two presentations. The Museum expressed a vision through the brief and is making progress towards realising it. I believe that this can be presented as a theoretical proposition that, in principle, if one brings a speculative heritage science investigation into an N-SREO museum it can simultaneously create worthwhile heritage science, HEI and museum interpretation outputs.

9.1.3 The Potential of Interpretive Products to Act as a Bridge between Heritage Science and Museum Interpretation.

A central theme of the research presented in this thesis is that N-SREO museums are not generally pursuing self-perpetuating analytical investigations into their collections and so are not generating scientifically framed research questions that heritage scientists are being asked to answer. In this case what purpose does heritage science perform in the N-SREO environment? As proposed, if heritage science could be perceived as a proactive generator of interpretation

content, then it could be part of a wider programme of generating interpretation for that environment. If we accept the presence of a rigour-relevance gap between the output of a purely analytical investigation and the audience engagement, interpretation and marketing needs of the N-SREO museum, then a bridge that transcends this gap is required. This research proposes such a bridge in the form of an interpretive product generated from a heritage science starting point. In the case study for this PhD, this bridge is in the form of film with embedded 3D animation. What was noteworthy was that under the direction of the Museum the original research outcome of the ten-minute film was repurposed into two social media outputs (twenty- and ninety-seconds) and a three-minute film focused on the object biography and slightly adapted ten minute 'special interest' film. This special interest film extended the object biography and gave a fuller explanation of the analytical investigation and its scientific methodology. These are all interpretive products, but within the context in which the Museum received them it was their marketing potential for the reopening of the Museum that was employed first. I would observe from this that the rigour-relevance gap that required bridging between the analytical outcome and the relevant application by the Museum was wider than first anticipated. However, all the research proposes is that a bridging device is employed. This would need to be driven by a brief from the N-SREO museum to ensure the need that the museum has identified is met. It could take a more journalistic format; blog, podcast and social media content could all have the potential to bridge the rigour-relevance gap and still deliver MacGregor and Serota's (2010) vision of the museum as publisher and broadcaster.

A bridge needs to connect both banks with its span and allow two-way traffic. Within this case study the interaction between HEI based heritage scientists and an N-SREO museum produced a potential exchange of interest. HEI based heritage science could identify some pedagogical and research interest in PhD development, including potential peer review publication within the salt glaze research theme. Opportunity for some of the ISAAC Lab team to develop their skills for working on site was also offered. There was also a clearly defined analytical outcome in the successful identification of the Flawford Virgin's original polychrome. There is also an argument that this research has been a catalyst to pursue research themes in medieval alabaster and lace. An interest has been expressed by both ISAAC Lab and the Museum to develop further the investigation of the alabaster collection. ISAAC Lab have also just commenced a programme of research focused on the small lace collection held by NTU. Additionally, a final iteration of the films by the Museum would have relevance to the REF for NTU as well as potential relevance to the forthcoming KEF assessments.

The Museum in turn received an interpretive product. However, I stress the significance of the fact that it was tailored directly to their need by requesting and delivering to their brief. To bridge

the rigour-relevance gap in the Museum's direction the outcome of my research activity had to be transitioned further into an interpretive product that could deliver social media and marketing output. I offer the provocation that the bridge has to be pushed to its bank rather than stop at the stanchion to which pure research may have taken it. A pragmatic response to this provocation could enable the HEI based heritage scientist in realising the AHRC's vision of " …ensuring that research agendas are informed by organisational and user need…" (AHRC, 2018a, pp. 4–5). I am also proposing that the commitment to meet the identified end user need has the potential to manage the cultural differences that have been identified and has potential to address the subsequent potential power imbalances that have been observed in the literature. I also propose that by ensuring that both stakeholder needs are met the bad practice highlighted in Chapters 2 and 5 (Bridgeman, 2019; Markham *et al.*, 2019), where the HEI simply employs the museum as a research resource, could be avoided.

9.2 Contribution to Knowledge

9.2.1 Observing the Rigour-Relevance Gap in Practice

The relationship between HEIs and museums, the phenomenon of the rigour-relevance gap and the desire within heritage science and conservation to promote their socio-political agenda are all represented in the existing literature. What is not apparent in the literature is the interrelationship between them. This research proposes that these issues are interrelated. As suggested, if heritage science can become increasingly public facing and more commonplace within our routine heritage experience, then this could be a step towards developing a higher socio-political agenda. However, the current situation would suggest that heritage science intervention within the N-SREO environment is rare. By observing the phenomenon of the rigour-relevance gap in practice, a more granular understanding of the issues surrounding transitioning an analytical investigation into an interpretive product to bridge that gap is established. The implications of this theoretical proposition are discussed later as further research. The key contribution to knowledge is that the rigour-relevance gap is observed in practice beyond its identified statistical significance. An understanding of the nature of this rigour-relevance gap, manifest as the distance between the analytical research outcome and its relevant application to the museum, could form the foundation of methodologies of how this gap is to be bridged. It also forms an understanding of the value of literature outside the fields of heritage science in interpreting the rigour-relevance gap and informing how it manifests in practical terms. The

interplay between establishing analytical findings, interpretation in a museum context, and meaning-making, is at the core of an understanding of this transition.

9.2.2 The Application of Autoethnography and My Positionality in a Museum Studies Context

As explained in the methodology in Chapter 3, there was a research element to the application of autoethnography. Autoethnographic content is used extensively in Chapter 4 to establish my own positionality within the research, and my positionality is a factor in how this research should be perceived. Autoethnography is returned to in Chapter 5 to allow a more visceral sense of how those within the museum sector feel with regards to their interaction with both the HEI and science. Again, in Chapter 8 I use it to illustrate my personal experience and stress a particular issue to be discussed. In each of these cases I could remain within the ethical boundaries of autoethnography in expressing my own personal experience and preserving the anonymity of those who were experiencing it with me (Adams, Holman-Jones and Ellis, 2015, pp. 57–62). As explained in the methodology in Chapter 3, the decision to present the case study experience in a more distanced, metered voice was an ethical one. I could not maintain the anonymity of the participants. More than this, the organisations involved could not be anonymised. Through the memorandum of understanding that exists between NTU and the Museum, a political interrelationship had been negotiated and would continue beyond my research. The sensitivities of institutional and professional identities were in play. This is a reflection of worth with regards to the application of autoethnography as a research methodology. A prominent exponent of exploring autoethnography within the field of museum studies is Duncan Grewcock (Grewcock, 2014b, 2014c). Yet if we look at Grewcock's work we see him channelling his own personal experience of museums and heritage events. He employs his facility to engage in an act of meaning-making and be justified in the meanings he makes. As an exploration of how one makes meaning and how one might manage that process curatorially, this has value in the field of museum studies. From the case study experience one can see how, as the research develops from an analysis of imaging, analytical and interpretive techniques, at its very early outset, to one coloured by more institutional and professional interrelationships, autoethnography becomes increasingly inappropriate as a research methodology. This move to explore these interrelationships was driven by my positionality. Most of my working life has been from outside academia. I could not see how a research activity could be considered in isolation from its potential practical application. I felt that one had to understand the environment in which the research output would operate to truly understand its efficacy and relevance: by identifying a potentially conducive funding environment; by finding gaps in the literature in the understanding

of the rigour-relevance gap in practice; by seeing interconnectivity between the concepts of power imbalance and cultural difference with a desire to enhance heritage science's agenda to raise its socio-political profile. This is achieved through the potential for HEI based heritage science investigation to create interpretive product. Through seeing these interconnectivities an understanding of the potential efficacy of this research is reached. From here one has to consider how a potential efficacy might be developed.

9.3 Further Research: Limitations, Established Foundations, and a Future Direction.

As Yin (2014, p. 21) points out, a single case study is methodologically acceptable, but it is a theoretical proposition that it can produce; further research would be required to evidence that proposition. The discussions programme was designed to juxtapose the case study experience with the wider field. However, the development of the programme alongside the analytical research themes and the film production meant that the case study could not be presented in its entirety to the whole cohort. As a result of this the response from them is not consistent and comparable. They raise some interesting issues and observations, but further research would be required to appraise the final outcome of this research in the varied scenarios and organisational environments in which it might be applied; not least of which would be the potential application by other HEI based heritage science investigators.

It should be stressed that the Museum and the ISAAC Lab team were brought together through the desire to facilitate this PhD and the research was conducted within the context of the conducive research relationship between NTU and the Museum. The important point is that I was not observing an organic interrelationship that would have taken place without me, but one that had been constructed for my investigation. Although the observations that create my theoretical proposition were made 'in the field' with a real heritage science group and a real museum which produced real analytical outcomes and real films, the constructed nature of the interaction should be considered to be closer to a 'lab experiment' rather than 'an observation from nature'. A small concession was made to this in the description of working practice given in Chapter 5 from Conservator 6 working within SREO 3, where SREO 3 had used conservation-based investigation as a starting point for interpretation. Nevertheless, the outcome of the experiment is that heritage science investigation can be translated into interpretive product within the context of a small research project conducted by an HEI in the N-SREO environment.

The final iterations of film, social media content and interconnectivity with the object on exhibition are still being resolved by the Museum. It is worth reflecting that as a PhD researcher I

was not party to the design process that created the exhibitions for the Museum's reopening, as I might have been as filmmaker contracted to work directly from the design brief. The interaction of heritage scientist and museum designer is one that might bear greater investigation. However, from the experience of this research I caveat that the ongoing nature of analytical investigation and the uncertainty of where it might lead does not predispose it to firm exhibition deadlines and prejudged outcomes. Instead, a parallel output of social media and web content referenced to the exhibitions, enabling the museum to be 'porous' and subtly represent how its exhibition content is being interpreted.

The evidence that heritage science investigation can generate effective interpretive product, and opportunity for meaning-making in this context, does provide a foundation on which to develop further research. I would identify certain findings from within the case study experience and the discussions that would inform the next stage. I propose that the key is for the stakeholders to understand each other's stakeholder interest and accept that a cultural difference and rigour-relevance gap exists between them. An open and candid discussion of any perceived power imbalance should be conducted, in the context of the necessity for the heritage scientists to have control and agency as to how they conduct their science to achieve the best data. This would be balanced against the understanding of how the analytical findings need to be employed to create meaning-making opportunities for effective interpretive products to be produced. The nature of the production lies within the remit and expertise of the museum and its production is a defined stakeholder output with parity to the research outcomes. With this comes an acceptance that the boundary of where analytical findings leaves us, and hypothesis and speculation take over, has to be fluid and negotiated. Both stakeholders will need to understand the interconnectivity of web, social media and exhibition content. How the analytical findings can contribute, and continue to contribute to it, will have to form part of that understanding. I propose the above will need to be designed 'upstream' (Markham *et al.*, 2019, p. 40) at the very outset of the collaboration. I would like to return to the NCCPE definitions of degrees of quality for museum/university partnership described in ascending order in Chapter 2 as 'Sharing', 'Applying', 'Creating' and 'Consulting/Informing' (National Co-ordinating Centre for Public Engagement, 2016). 'Sharing' was evident with a suite of films that entice engagement through social media and explain the science and its implications at varying levels of public interest. As the suite of films was briefed and designed to meet the Museum need and employed, then 'Applying' is also evidenced. With the combination of the Museum's pre-existing collections knowledge and the creation of new knowledge created by the analytical investigation, it is proposed that the new object biography of the Flawford Virgin fulfils the 'Creating' criteria. With a potential for heritage scientists to have a greater understanding of the methodologies of dissemination of their work within the context of museum-university partnership, then 'Consulting/Informing' might also be claimed. This would

indicate a good alignment with the NCCPE parameters of a successful museum and university partnership. My research suggests that if the correct combination of science that pursues new knowledge, public engagement and interpretation are brought together then the current funding climate, including those available to museums (Arts Council England, 2020; Wilson and Furlong, 2020) could be conducive to pursuing this research line further.

This body of research generates a series of research issues that could not have been resolved within the confines of this PhD. What was notable from the case study was that analytical conclusions were not finite, and hypotheses were unproven. Could more evidence be found to inform the nature of the Flawford Virgin's face? How does the colouring of the clothing relate to other alabaster works of that period? Could a forensic investigation of the damage to the face create a definitive answer as to whether a violent blow was responsible? Obviously, these represent issues for further research but that is not really my point. In the context of this PhD what would be of interest would be the potential for these unanswered questions to continue to generate interpretation. Ongoing analytical investigations could continue to reveal updates and new findings, and in turn these could generate interpretation in the form of film updates to the museum You Tube channel, podcasts, blog entries, social media updates and press releases. This is the concept of a programme of ongoing broadcast and publication (Wilson, MacGregor and Serota, 2010) which would not necessarily be associated with major new exhibitions or openings but as part of an ongoing re-presentation of the museum's offer. The potential to engage with citizen science, volunteer programmes, research newsletters and local history initiatives is enabled. The first planned iteration of employment of the films and social media content by the Museum was intended for the run up to Christmas 2021 with their engagement theme of 'stories hidden within objects'. This creates the potential to increase the porosity of the museum, making it less of a visited institution and more an interactive hub (Cameron, 2015, p. 350). There is also a potential to develop contributions from museum collections from all over the country to contribute to the National Collection (UKRI and AHRC, 2020). At the beginning of this chapter, I suggested that conservators within museums could be proactive generators of interpretation, using their routine investigations and condition assessment as trigger points for creating material for the broadcast and publication channels above. Investigation of the potential, issues and sustainability of heritage science and conservation as broadcast content for the porous museum would be a potential research theme that could stem from this research.

The concept of meaning-making has been an important theme within this thesis, yet the structured, more didactic nature of the film format could be conceived as limiting this process. Research into how a meaning-making experience could be enhanced or assisted through more interactive digital means would be a potential extension of this research. Could narratives be

constructed through personalising viewing experience in a digital format so the viewer can pursue a personal line of investigation? Needless to say to push this research theme forward would require a level of understanding of the design of digital media beyond that represented in this thesis.

The precursor of any of the above would be an evaluation of the interpretive product produced by this research. There are two reasons that this did not take place: firstly, because publication of the film material was delayed and the nature of the publication amended by both the Covid-19 pandemic and the changes in management structure at the Museum; secondly because my positionality was one of external researcher not filmmaker working to a design brief dictated by the Museum's designers. As was suggested in the methodology chapter a degree of front-end and formative evaluation (Grewcock, 2014a, pp. 34–35; Ambrose and Paine, 2018, pp. 184–187) took place. Front-end evaluation as part of the initial target setting with regards to goals and audience for the films, and formative evaluations through consultation with both the ISAAC team and the Museum as expressed through their brief. From a further research perspective this leaves a summative evaluation (ibid). At some point in the future, should the Museum successfully publish the films and enact the social media content as originally intended then a summative evaluation should be possible. David Dean (1996, pp. 98–99) suggests a goal-referenced approach by "…clearly defining goals and objectives and quantifiable, testable components." From the content presented in this thesis one can see certain issues arise. How does the analytical content translate into interpretive product? Do the three- and ten-minute films create 'false facts' by presenting hypothesis too convincingly? Does the overall interpretive product work in a transmedia and remediated way and as such enhance the viewing experience? Evaluation of this nature would require both a quantitative and qualitative approach (Soren and Armstrong, 2014, pp. 40–41). This can be demonstrated through how one might examine the 'false facts' issue. The quantitative approach would be to elicit true/false/unsure responses to statements such as: the sculpture was found under the floor of Flawford Church; it was a blow from an axe or a sword that broke the sculpture into three pieces; the sculpture lost most of its colour after it was found; the sculpture's eyes were blue and eyebrows light brown. A data analysis of these responses would indicate if audiences could differentiate between presented fact and hypothesis. This could be cross referenced with a qualitative approach where opinions are sought as to whether it might have been a workman's spade or a sword that damaged the face or speculations as to eye colour. This approach would also give some indication of the level of meaning making the audience members had engaged in. An investigation of the remediation and transmedia efficacy could be conducted through a similar quantitative and qualitative approach. Quantitative measurements of social media metrics and web traffic would indicate the level of media response and interaction. Qualitative assessment such as questioning audience members with: "what did you know about

the Flawford Virgin before your visit? Where did this information come from?" would indicate any prior knowledge created via web or social media content. If this was combined with: "did you use the QR code to access more information? Which film did you choose and why? Have you told anyone about your visit and the Flawford Virgin on social media?" this would give some indication as to how social media interactions are generated by visiting.

The most pertinent research question that arises from this thesis is the step beyond the theoretical proposition presented here to 'would it actually work in practice? Could one establish a proof of concept? Is the relationship between HEI heritage scientist and N-SREO museum a sustainable one?' Museums could produce films about objects within their collections without the recourse to lengthy and invasive analytical investigations. Such films could meet the interpretation and marketing needs of those museums. On the other hand, a large SREO museum is potentially a much more comfortable environment for the HEI heritage scientist to operate in. They are more likely to have conservation and heritage science facilities within the museum and employ heritage scientists themselves. The likelihood of research questions being easier to frame in scientific terms and the analytical research outcome being the one that meets the museum's need is much greater. Would the ends justify the means? Would greater access into a broader landscape of heritage collections and its advantages of a higher socio-political profile and new and interesting lines of research be incentive enough? Is what a heritage science investigation brings to the understanding of the object biography enough to justify managing and facilitating the heritage science intervention in the museum? This research presents the theoretical proposition that it *could* work, it does not evidence that it *would*. Further research would need to be designed and trialled to address questions raised by this research. Is the socio-political profile of heritage science raised through analytical investigations that create interpretive products? Does the creation of interpretive product in analytical investigations develop and enhance the relationship between museum and HEI based heritage science researcher, in the context of cultural difference and potential power imbalance? Are N-SREO museums able to engage wider audiences and become more porous publishers and broadcasters through heritage science investigations? One might hope that in the current funding climate the support to trial and investigate this relationship further might be forthcoming and the potential, that I believe is inherent within this research, might be developed.

Data Access Statement

Film content produced through this research is available in the public domain via the following link: Heritage Imaging. Anonymised and aggregated data obtained during interviews are available in Appendix 2. Full transcripts cannot be shared due to their containing information that could compromise the privacy of research participants.

Bibliography

Adams, T., Holman-Jones, S. and Ellis, C. (2015) *Autoethnography*. E-Book. Oxford: Oxford University Press. Available at: https://ebookcentral.proquest.com/lib/ntuuk/reader.action?docID=1784095.

Adobe (2017) *Adobe Creative Cloud*. Available at: www.adobe.com/uk/creativecloud.html (Accessed: 5 September 2017).

AHRC (2018a) *AHRC's Heritage Strategic Priority Area: Future Directions, Update 2018*. London. Available at: https://ahrc.ukri.org/documents/strategy/heritage-strategy/.

AHRC (2018b) *AHRC Science in Culture Theme - Home page*, *Science in Culture Website*. Available at: https://www.sciculture.ac.uk/about/ (Accessed: 8 September 2020).

AHRC (2018c) *Science in Culture*, *AHRC Website*. Available at: https://ahrc.ukri.org/research/fundedthemesandprogrammes/themes/scienceinculture/ (Accessed: 7 September 2020).

AHRC and EPSRC (2009) *Science & Heritage Programme*. London. Available at: https://ahrc.ukri.org/documents/projects-programmes-and-initiatives/science-and-heritage-programme-research-programme-specification-march-2009/.

Aitchison, K. (2013) *Conservation Labour Market Intelligence 2012-13*. London.

Amakawa, J. and Westin, J. (2018) 'New Philadelphia: Using Augmented Reality to Interpret Slavery and Reconstruction Era Historical Sites', *International Journal of Heritage Studies*, 24(3), pp. 315–331.

Ambrose, T. and Paine, C. (2006) *Museum Basics*. 2nd edn. Abingdon: Routledge.

Ambrose, T. and Paine, C. (2018) *Museum Basics. The International Handbook*. 4th-E Book edn. Abingdon: Routledge.

Arts Council England (2020) *The Strategy 2020-30*, *ACE Website*. Available at: https://www.artscouncil.org.uk/strategy (Accessed: 26 February 2020).

Aufderheide, P. (2007) *Documentary Film: A Very Short Introduction*. E-Book. New York: Oxford University Press.

Barker, G. (1999) 'The Nature & Scope of Archaeology', in Barker, G. (ed.) *Companion Encyclopedia of Archaeology*. London: Routledge, pp. xxxiii–xlv.

BBC (1999) *Walking with Dinosaurs*. Available at: https://www.bbcearth.com/walking-with-dinosaurs/ (Accessed: 2 April 2020).

Bell, N. *et al.* (2014) *Mind the Gap: Rigour and Relevance in Heritage Science Research*. London. Available at: http://www.nationalarchives.gov.uk/documents/mind-the-gap-report-jan-2014.pdf.

Bell, N. (2015) 'How can we build an impactful future for science in conservation? Essential next steps', *Studies in Conservation*, 60(2), pp. 20–22. doi: 10.1080/00393630.2015.1117861.

Bennett, T. (1995) *The Birth of the Museum*. Abingdon: Routledge.

Benton, M. J. (2001) 'The Science of "Walking with Dinosaurs"', *Teaching Earth Sciences*, 24, pp. 371–400.

Black, G. (2018) 'Meeting the Audience Challenge in the "Age of Participation"', *Museum Management and Curatorship*, 33(4), pp. 302–319. doi: https://doi.org/10.1080/09647775.2018.1469097.

Boddington, A., Boys, J. and Speight, C. (2013) *Museums and Higher Education Working Together*. E-Book. Abingdon: Routledge.

Bolter, J. D. and Grusin, R. (2000) *Remediation*. Paperback. Cambridge MA: MIT Press.

Bonacchi, C. and Willcocks, J. (2016) *Realities & Impacts of Museum-University Partnerships in England*, *National Co-ordinating Centre for Public Engagement*. Available at: https://www.publicengagement.ac.uk/nccpe-projects-and-services/completed-projects/museum-university-partnership-initiative (Accessed: 2 March 2018).

Boon, T. (2008) *Films of Fact; A History of Science in Documentary Films and Televison*. London: Wallflower.

Bridgeman, R. (2019) 'Reflections on Research Outcomes from Birmingham Museums Trust'. [interview] Interviewed by Chris Pickup, 21 August.

Brokerhof, A. W. (2015) 'How Can Science Connect with and Contribute to Conservation? Recomendations and Reflections', *Studies in Conservation*, 60(Sup2), pp. 7–13. doi: https://doi.org/10.1080/00393630.2015.1117859.

Brooks, M. M. (2013) 'Culture and Anarchy: Considering Conservation', in Williams, E. (ed.) *The Public Face of Conservation*. London: Archetype Publications, pp. 1–71.

Brooks, M. M. (2014) 'Decay, Conservation, and the Making of Meaning through Museum Objects', in Cook, H. J. et al. (eds) *Ways of Making and Knowing: the emprical culture of empircal knowledge*. Michigan: University of Michigan Press, pp. 377–404.

Brown, M. (1992) *Project Management in a Week*. London: Hodder & Stoughton.

Bruzzi, S. (2006) *New Documentary*. 2nd-E Book edn. Abingdon: Routledge.

Bulow, A. E., Stitt, J. and Brokerhof, A. W. (2018) 'I Can See Further Now: Preventive Conservation in a Changing World', *Studies in Conservation*, 63(Sup1), pp. 35–42.

Cameron, F. (2015) 'The Liquid Museum; New Institutional Ontologies for a Complex Uncertain World', in Witcomb, A. and Message, K. (eds) *International Handbook of Museum Studies; Museum Theory*. Oxford: Whiley & Sons, pp. 345–361.

Cannan, F. (2010) 'If Marble Will Not Serve', in Williamson, P. (ed.) *Object of Devotion; Medieval Alabaster Sculptures form the Victoria & Albert Museum*. Illustrate. Alexandria: Art Services International.

Caple, C. (2000) *Conservation Skills*. Abingdon: Routledge.

Casetti, F. (2015) *The Lumiere Galaxy, Seven Key Words for the Cinema to Come*. New York: Columbia University Press.

Cheetham, F. (1962) *Medieval Alabaster Carvings in the Castle Museum, Nottingham*. Nottingham: City of Nottingham Art Galleries and Museums Committee.

Cheetham, F. (1984) *English Medieval Alabasters*. Oxford: Phaidon.

Cheung, C. S., Spring, M. and Liang, H. (2015) 'Ultra High Resolution Optical Coherence Tomography for Old Master Paintings', *Optics Express*, 23(8).

Christie, I. (2012) 'A disturbing presence? Scenes from the history of film in the museum', in Dalle Vacche, A. (ed.) *Film, Art, New Media: Museum Without Walls?* New York: Palgrave Macmillian, pp. 241–255. doi: 10.1057/9781137026132.

Cook et al, I. (2005) 'Positionality/Situated Knowledge', in Atkinson, D. (ed.) *Cultural Geography: A Critical Dictionary of Key Concepts*. London: Tauris, pp. 16–26.

Cooper, C. L. (2013) 'A Case Study in Collaboration: Displaying Greece and Rome at the Fitzwilliam, Cambridge, UK', *Museum Management and Curatorship*, 28(5), pp. 467–490. doi: 10.1080/09647775.2013.850827.

Corbeil, M. C. (2015) 'Conservation institutions as agents of change', *Studies in Conservation*, 60(2), pp. 32–38. doi: 10.1080/00393630.2015.1117863.

Crofts, S. (2021) *Conservators in the Spotlight*, *ICON Website*. Available at: https://www.icon.org.uk/resource/conservators-in-the-spotlight.html (Accessed: 17 May 2021).

Crowley, S. *et al.* (2014) 'Introduction', in Crowley, S. et al. (eds) *Enhancing Communication & Collaboration in Interdisciplinary Research*. E-Book. Los Angeles: Sage, pp. 1–10.

Cultural Heritage Imaging (2017) *Overview of CHI Technologies*. Available at: http://culturalheritageimaging.org/Technologies/Overview/ (Accessed: 15 May 2017).

Curran Bernard, S. (2016) *Documentary Storytelling: Creative Nonfiction on Screen*. 4th, E-Book edn. New York: Focal Press.

Curran, K. and Zimmermann, N. (2021) 'The Dynamics of Collaboration in Heritage Science', *Studies in Conservation*, [pre-print. doi: 10.1080/00393630.2021.1875175.

Davidson, A. (2011) 'Translational Research: What Does it Mean?', *Anesthesiology*, 115(5), pp. 909–911.

Davidson, H. *et al.* (2019) *Careers in Heritage Science: Opportunities and Constraints*.

Dawson, J. and Gilmore, A. (2009) *Shared Interest: developing collaboration partnerships and research relationships between higher education, museums, galleries and visual arts organisations in the North West*, *A Joint Consultancy Research Project commissioned by: Renaissance North West, Arts Council England and the North West Universities Association*. Available at: https://webarchive.nationalarchives.gov.uk/20090705002932/http://research.mla.gov.uk/evidence/documents/shared-interest-report-NW-2009.pdf (Accessed: 14 January 2019).

DCMS (2018a) *Culture is Digital*. London. Available at: https://www.gov.uk/government/publications/culture-is-digital.

DCMS (2018b) *Culture is Digital - executive summary*. London. Available at: https://www.gov.uk/government/publications/culture-is-digital.

Dean, D. (1996) *Museum Exhibition: Theory and Practice*. London: Routledge.

Delamont, S. (2004) 'Ethnography and Participant Observation', in Seale, C. et al. (eds) *Qualitative Research Practice*. London: Sage, pp. 205–217.

Dent, K. and Willcocks, J. (2016) *The Impact of Strategic Agencies on University Partnerships with Cultural Heritage Organisations in England*, *National Co-ordinating Centre for Public Engagement*.

Available at: https://www.publicengagement.ac.uk/nccpe-projects-and-services/nccpe-projects/museum-university-partnership-initiative (Accessed: 2 March 2018).

Department for Culture Media & Sport (2016) *DCMS: The Culture White Paper*. London. Available at: www.gov.uk/government/publications.

DeWitt, J., Effronsyni, N. and Godec, S. (2019) 'Recognising and Valuing Student Engagement in Science Museums', *Museum Management and Curatorship*, 34(2), pp. 183–200.

Van Dijck, J. (2006) 'Picturizing Science: The Science Documentary as Multimedia Spectacle', *International Journal of Cultural Studies*, 9(1), pp. 5–24. doi: 10.1177/1367877906061162.

Dillon, C. *et al.* (2014) 'Mind the gap: rigour and relevance in collaborative heritage science research', *Heritage Science*, 2(1), p. 11. doi: 10.1186/2050-7445-2-11.

Dudley, S. H. (2010) 'Museum Materialities; Object, Sense and Feeling', in Dudley, S. H. (ed.) *Museum Materialities*. 1st edn. Abingdon: Routledge, pp. 1–17.

Dudley, S. H. (2012) *Museum Objects: Experiencing the Properties of Things*. E-Book. Abingdon: Routledge.

Duffy, S. M. (2013) *Multi Light Imaging for Heritage Applications*. Swindon.

Eastop, D. (2011) 'Conservation Practice as Enacted Ethics', in Janet Marstine (ed.) *The Routledge Companion to Museum Ethics*. 1st edn. Abingdon: Routledge, pp. 426–444.

Ellis, C., Adams, T. and Bochner, A. (2011) 'Auto Ethnography: An Overview', *Forum: Qualitative Social Research*, 12(Article 10).

Elsaesser, T. (2004) 'The New Film History as Media Archaeology', *Cinemas*, 14(2–3), pp. 75–117.

Emerald Publishing (2020) *How to...Carry Out Action Research*, *Emerald Publishing Website*. Available at: https://www.emeraldgrouppublishing.com/archived/research/guides/methods/action_research.htm (Accessed: 18 May 2020).

European Commission (2017) *Guidelines to the Rules on Open Access to Scientific Publications and Open Access to Research Data in Horizon 2020*. Available at: https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf.

European Research Infrastructure for Heritage Science (2018) *Mission & Vision*. Available at: http://www.e-rihs.eu/about/about/ (Accessed: 15 March 2019).

Facer, K. and Enright, B. (2016) *Creating Living Knowledge: The Connected Communities Programme, community-university relationships and the participatory turn in the production of knowledge*. Bristol.

Fairclough, G. (2012) 'Others', in Giaccardi, E. (ed.) *Heritage and Social Media: Understanding Heritage in a Participatory Culture*. E-Book. Abingdon: Taylor & Francis, pp. xiv–xvii.

Fincham, R. and Clark, T. (2009) 'Introduction: Can We Bridge the Rigour-Relevance Gap?', *Journal of Management Studies*, 46(3), pp. 510–515.

Flynn, B. (2007) 'The Morphology of Space in Virtual Heritage', in Cameron, F. and Kenderdine, S. (eds) *Theorizing Digital Cultural Heritage: A Critical Discourse*. 1st edn. Cambridge MA: MIT Press, pp. 348–368.

Fransca, G. (2013) 'Simulation Verses Narrative', in Wolf, M. J. P. and Perron, B. (eds) *The Video Game Theory Reader*. eBook. Abingdon: Routledge, pp. 270–286.

Gibson, A. S. (2012) *Reverse Lens Macro: Close up*, *Digital Photography School*. Available at:

https://digital-photography-school.com/reverse-lens-macro-close-up-photography-lesson-3/ (Accessed: 15 October 2017).

Giddings, S. (2015) 'Simknowledge: What Museums Can Learn from Video Games', in Henning, M. (ed.) *International Handbook of Museum Studies: Museum Media*. Chichester: Whiley & Sons, pp. 145–164.

Gosden, C. and Marshall, Y. (1999) 'The Cultural Biography of Objects', *World Archaeology*, 31(2), pp. 169–178.

Gray, C. and McCall, V. (2018) 'Analysing the Adjectival Museum: Exploring the bureaucratic nature of museums and the implications for researchers and the research process', *Museum & Society,* 16(2), pp. 124–137.

Grewcock, D. (2014a) 'Before, During, and After: Front-End, Formative, and Summative Evaluation', in Lord, B. and Piacennte, M. (eds) *Manual of Museum Exhibitions*. 2nd edn. Maryland: Roman & Littlefield, pp. 33–40.

Grewcock, D. (2014b) *Doing Museology Differently*. Abingdon: Routledge.

Grewcock, D. (2014c) 'Performing Heritage (studies) at the Lord Mayor's Show', *International Journal of Heritage Studies*, 20(7–8), pp. 760–781. doi: http://dx.doi.org/10.1080/13527258.2013.807434.

Habsburg-Lothringen, B. (2015) 'From Object to Environment: The Recent History of Exhibitions in Germany and Austria', in Henning, M. (ed.) *International Handbook of Museum Studies: Museum Media*. Chichester: Whiley & Sons, pp. 327–347.

Ham, S. (2013) *Interpretation: Making a Difference on Purpose*. E-Book. Golden: Fulcrum.

Hein, H. (2000) *The Museum in Transition: a philosphical perspective*. Washington: Smithsonian Institution.

Hein, H. (2006) 'Assuming Responsibility: Lessons from Aesthetics', in Genoways, H. H. (ed.) *Museum Philosophy for the Twenty First Century*. Landam: AltaMira Press, pp. 1–9.

Helicon Soft (2017) *Helicon Focus 6*. Available at: http://www.heliconsoft.com/heliconsoft-products/helicon-focus/ (Accessed: 12 January 2018).

Henning, M. (2006) *Museums, Media and Cultural Theory*. E-Book. Maidenhead: Open University Press.

Henning, M. (2007) 'Legibility and Affect: Museums as New Media', in Macdonald, S. and Basu, P. (eds) *Exhibition Experiments*. E-Book. Oxford, pp. 25–46.

Henning, M. (2011) 'New Media', in Macdonald, S. (ed.) *A Companion to Museum Studies*. 2nd-E-Book edn. Chichester: Whiley & Sons, pp. 642–676.

Henstock, A., Hildyard, R. and Wood, P. J. (2010) *Nottingham Salt-Glazed Stoneware 1690 -1800*. Nottingham: Nottingham City Museums and Galleries.

Heritage, A. and Golfomitsou, S. (2015) 'Conservation Science: Reflections and future perspectives', *Studies in Conservation*, 60(sup2), pp. 2–6.

Hermens, E. (2012) 'Technical Art History: The Synergy of Art, Conservation and Science', in Rampley, M. et al. (eds) *Art History and Visual Studies in Europe*. Leiden: Brill, pp. 151–166.

Higgins, C. (2009) *The Museum of the 21st Century*, *The Guardian Online*. Available at: https://www.theguardian.com/artanddesign/2009/jul/08/museums-future-lies-online (Accessed: 27 October 2020).

HM Government (2018) *Industrial Strategy - Creative Industries Sector Deal*. London. Available at:

www.gov.uk/beis.

HM Government (2019) *Industrial Strategy - Tourism Sector Deal*. London. Available at: www.gov.uk/beis.

Hodgkinson, G. P. and Rousseau, D. M. (2009) 'Bridging the Rigour-Relevance Gap in Management Research: It's Already Happening!', *Journal of Management Studies*, 46(3), pp. 535–546.

Hooper-Greenhill, E. (1995) *Museum, Media, Message*. E-Book. Abingdon: Routledge.

Hooper-Greenhill, E. (2000) *Museum and the Interpretation of Visual Culture*. Abingdon: Routledge.

Horiba (no date) *What is Raman Spectroscopy*, *Horiba Website*. Available at: https://www.horiba.com/en_en/raman-imaging-and-spectroscopy/ (Accessed: 21 January 2021).

Hornig, S. (1990) 'Television's NOVA and the Construction of Scientific Truth', *Critical Studies in Media Communication*, 7(1), pp. 11–23.

Humphreys, L. (2015) *Research on Display: A Guide to Collaborative Exhibitions for Academics*. Edited by L. Humphreys. London: Queen Mary University of London. Available at: https://www.qmul.ac.uk/geog/media/geography/docs/staff/Research-on-Display-Final.pdf.

ICOMOS (2008) *16th General Assembly of ICOMOS - Quebec 2008*. Available at: https://www.icomos.org/quebec2008/charters/interpretation/pdf/GA16_Charter_Interpretation_20081004_FR+EN.pdf (Accessed: 1 April 2020).

InFocus Film School (2020) *Filming with Green Screen: Everything You Need to Know*, *InFocus Film School Website*. Available at: https://infocusfilmschool.com/filming-green-screen-guide/ (Accessed: 21 January 2021).

IPERION HS (2021) *How to Access*, *IPERION Web Site*. Available at: http://www.iperionhs.eu/iperion-hsaccess/ (Accessed: 9 August 2021).

Jeffery, S. *et al.* (2020) '3D Visualisations, Communities and the Production of Significance', *International Journal of Heritage Studies*. doi: https://www.tandfonline.com/action/showCitFormats?doi=10.1080/13527258.2020.1731703.

Katratazis, K. *et al.* (2018) 'Enhancing Research Impact in Heritage Conservation', *Studies in Conservation*. doi: 10.1080/00393630.2018.1491719.

Keene, S. (2002) *Managing Conservation in Museums*. 2nd edn. Oxford: Butterworth-Heineman.

Kidd, J. (2014) *Museums in the New Mediascape: Transmedia, Participation, Ethics.* Abingdon: Routledge.

Kieser, A. and Leiner, L. (2009) 'Why the Rigour-Relevance Gap in Management Research Is Unbridgeble', *Journal of Management Studies*, 46(3), pp. 516–533.

Kloppmann, W. *et al.* (2014) 'Tracing Medieval and Renaissance Alabaster Works of Art Back to Quarries: A Multi-Isotope (Sr, S, O) Approach', *Archaeometry*, 56(2), pp. 203–219.

Kochberg, S. (2002) 'Narrativity and Intent in Documentary Production', in Kochberg, S. (ed.) *Introduction to Documentary Production: A Guide to Media Students*. London: Wallflower, pp. 29–57.

Kvale, S. (2007) *Doing Interviews*. London: Sage.

Langford, M., Fox, A. and Sawdon Smith, R. (2007) *Langford's Basic Photography*. 8th edn. Oxford: Focal Press.

Leona, M. (2009) 'The Materiality of Art: Scientific Research in Art History and Art Conservation at

the Metropolitan Museum', *Metropolitam Museum of Art Bullietin*, 67(1), pp. 4–11. Available at: https://www.jstor.org/stable/40588561.

Lescaze, Z. (2017) *Paleoart*. Cologne: Taschen.

Liang, H. (2012) 'Advances in Multispectral and Hyperspectral Imaging for Archaeology and Art Conservation', *Applied Physics A*, 106(2), pp. 309–323. doi: 10.1007/s00339-011-6689-1.

Lidchi, H. (2013) 'The Poetics & Politics of Exhibiting other Cultures', in Hall, S., Evans, J., and Nixon, S. (eds) *Representation*. 2nd edn. London: Sage, pp. 120–187.

Lister, M. *et al.* (2003) *New Media a Critical Introduction*. eBook. Abingdon: Routledge.

Lithgow, K. (2015) 'Communicating conservation science', *Studies in Conservation*, 60(2), pp. 57–63. doi: 10.1080/00393630.2015.1117856.

Luhmann, T. *et al.* (2014) *Close-Range Photogrammetry and 3D Imaging*. 2nd edn. Berlin: De Gruyter.

M. Norton Wise (2006) 'Making Visible', *Isis*, 97(1), pp. 75–82. Available at: https://www.jstor.org/stable/10.1086/501101.

Macdonald, S. (2002) *Behind the Scenes at the Science Museum*. Oxford: Berg.

MacDougall, D. (2006) *The Corporeal Image: Film Ethnography and the Senses*. Princeton NJ and Oxford: Princeton University Press.

Mandelli, E. (2019) *The Museum as Cinematic Space: the Display of Moving Images in Exhibitions*. Edinburgh: Edinburgh University Press.

Markham, K. *et al.* (2019) *Mapping Collaborative Interactions Between Higher Education Institutions in the UK and the Heritage Sector*. Newcastle. Available at: http://www.heritage2020.net/.

Martensson, A. and Martensson, P. (2007) 'Extending Rigour and Relevance: Towards Credible, Contributory and Communicable Research', in *ECIS Proceedings*, pp. 1325–1333. Available at: http://aisel.aisnet.org/ecis2007/124.

Mason, R. (2005) 'Museums, Galleries & Heritage: Sites of meaning-making and communication', in Corsane, G. (ed.) *Heritage, Museums and Galleries. An Introductory Reader*. 1st edn. Abingdon: Routledge, pp. 221–237.

MathWorks (2021) *MATLAB*, *Mathworks Website*. Available at: https://www.mathworks.com/products/matlab.html (Accessed: 2 June 2021).

McGovern, P. E. (1995) 'Science in Archaeology: A Review', *American Journal of Archaeology*, 99(1), pp. 79–142. Available at: http://www.jstor.org/stable/506880?origin=JSTOR-pdf.

McHugh, M. C. (2014) 'Feminist Qualitative Research: Towards Transformation of Science and Society', in Leavy, P. (ed.) *The Oxford Handbook of Qualitative Research*. Oxford: Oxford University Press, pp. 137–164.

Michalski, S. (2015) 'Tools for Assessing Needs and Impacts', *Conservation Science*, 60(Sup 2), pp. 23–31.

Munoz Vinas, S. (2005) *Contemporary Theory Of Conservation*. 2nd edn. Abingdon: Routledge.

National Co-ordinating Centre for Public Engagement (2016) *Museum-University Partnerships in REF Impact Studies: a review*, *NCCPE*. Available at: https://www.publicengagement.ac.uk/nccpe-projects-and-services/completed-projects/museum-university-partnership-initiative (Accessed: 2 March 2018).

National Co-ordinating Centre for Public Engagement (2018) *Museum-University Partnership Initiative*. Available at: https://www.publicengagement.ac.uk/nccpe-projects-and-services/completed-projects/museum-university-partnership-initiative (Accessed: 20 May 2019).

National Gallery of Art Washington (2021) *Giotto. Madonna and Child, c.1310/1315*, *NGA Online Editions*. Available at: https://www.nga.gov/collection/art-object-page.397.html (Accessed: 29 June 2021).

National Heritage Science Forum (2018) *Strategic Framework for Heritage Science in the UK 2018-2023*. Available at: http://www.heritagescienceforum.org.uk/documents/NHSF_StrategicFramework-FINAL_Web.pdf.

National Heritage Science Forum (2019) *About*, *NHSF Website*. Available at: http://www.heritagescienceforum.org.uk/about (Accessed: 24 April 2019).

Nichols, B. (2017) *Introduction to Documentary*. 3rd-E-Book edn. Bloomington: Indiana University Press.

Nottingham Trent University (2020) *Voices of Museums*. Nottingham. Available at: https://museumsofthefuture.com/publications.

OCT for Art (no date) *OCT4Art*. Available at: http://www.oct4art.eu/ (Accessed: 21 January 2021).

Ottens Consultancy (2013) *Conservation Science in Context*. Available at: http://ottensconsultancy.nl/pdf/conservation_science_in_context.pdf.

Pachter, M. (2010) 'Why Museums Matter', in Parry, R. (ed.) *Museums in the Digital Age*. 1st edn. Abingdon: Taylor & Francis, pp. 332–335.

Paddon, H. (2016) *Redisplaying Museum Collections: Contemporary Display and Interpretation in British Museums*. Abingdon: Routledge.

Panton, A. and Plumbe, R. (2019) 'Shining a Light on the Emerging Conservator: Challanges Facing the Future Generation'. [conference presentation] Belfast: The Institute of Conservation, 14 June.

Parry, R. (2007) *Recoding the Museum: Digital Heritage and the Technologies of Change.* Abingdon: Routledge.

Parry, R. (2010) 'The Practice of Digital Heritage and the Heritage of Digital Practice', in Parry, R. (ed.) *Museums in the Digital Age*. 1st edn. Abingdon: Taylor & Francis, pp. 1–7.

Parry, R. (2013) 'The Trusted Artifice: Reconnecting with the Museum's Frictive Tradition Online', in Drotner, K. and Schroder, K. C. (eds) *Museum Communication and Social Media: The Connected Museum*. eBook. Abingdon: Routledge, pp. 34–55.

Penz, F. (2012) 'Museums as Laboratories of Change', in Dalle Vacche, A. (ed.) *Film, Art, New Media: Museum Without Walls?* Basingstoke: Palgrave Macmillian, pp. 278–300.

Phillips, B. D. (2014) 'Qualitative Disaster Research', in Leavy, P. (ed.) *The Oxford Handbook of Qualitative Research*. Oxford: Oxford University Press, pp. 533–556.

Pickup, C. (2020) *Lace Sample. Leavers Lace Machine*, *Heritage Imaging You Tube Channel*. Available at: https://www.youtube.com/@heritageimaging (Accessed: 14 May 2021).

Pickup, C. and Harris, S. J. (2017) 'Reflectance Transformation Imaging: A Possible Alternative to Ammonium Chloride Coating for Specimen Photography', *The Geological Curator*, 10(8), pp. 481–486.

Pye, E. (2001) *Caring for the Past*. London: James & James.

Pye, E. and Sully, D. (2007) 'Evolving challenges, developing skills', *The Conservator*, 30(1), pp. 19–

37. doi: 10.1080/01410096.2007.9995221.

Rambo, C. (2005) 'Impressions of my Grandmother: An autoethnographic portrait', *Journal of Contemporary Ethnography*, 34(5), pp. 560–585.

Ramsay, N. (1991) 'Alabaster', in Blair, J. and Ramsay, N. (eds) *English Medieval Industries, Craftsmen, Techniques, Products*. London: The Hambledon Press, pp. 29–40.

Reed, M. S. (2016) *The Research Impact Handbook*. Huntly: Fast Track Impact.

Russo, A. (2012) 'The Rise of the "Media Museum"', in Giaccardi, E. (ed.) *Heritage and Social Media: Understanding Heritage in a Participatory Culture*. E-Book. Abingdon: Taylor & Francis, pp. 145–157.

Saldana, J. (2011) *Fundamentals of Qualitative Research*. E-Book. New York: Oxford University Press.

Science & Technology Committee (2006) *Science & Heritage*. London. Available at: https://publications.parliament.uk/pa/ld200506/ldselect/ldsctech/256/256.pdf.

Silverman, D. (2006) *Interpreting Qualitative Data*. 3rd edn. London: Sage.

Soren, B. and Armstrong, J. (2014) 'Qualitative and Quantitative Audience Research', in Lord, B. and Piacennte, M. (eds) *Manual of Museum Exhibitions*. 2nd edn. Maryland: Rowman & Little, pp. 40–53.

Southwell and Nottingham Church History Project (no date) *Flawford St Peter*, *Church History*. Available at: https://southwellchurches.nottingham.ac.uk/flawford/hfitting.php#alabasters (Accessed: 16 October 2017).

Speight, C., Boddington, A. and Boys, J. (2013) 'Introduction', in Boddington, A., Boys, J., and Speight, C. (eds) *Museums and Higher Education Working Together: Challenges and Opportunities*. Abingdon: Routledge, pp. 2–23.

Spring, M. (2001) *Conservation Scientist in the National Gallery: A Day in My Life*, *Science Magazine*. Available at: https://www.sciencemag.org/careers/2001/06/conservation-scientist-national-gallery-day-my-life (Accessed: 26 February 2020).

Staiff, R. (2014) *Re-imagining Heritage Interpretation: Enchanting the Past-Future*. E-Book. Abingdon: Routledge,.

Stead, N. (2011) 'Performing objecthood; museums, architecture and the play of artefactuality', *Performance Research*, 12(4), pp. 37–46. doi: 10.1080/13528160701822619.

Strlič, M. (2015) *A Brief Theory of Heritage Science*, *Heritage Science Research Network*. Available at: https://heritagescienceresearch.com/2015/11/17/theory_heritagescience/ (Accessed: 13 March 2019).

Tate Gallery (2018) *Conservation Science and Preventative Conservation*, *tate.org.uk*. Available at: https://www.tate.org.uk/about-us/conservation/science-preventive-conservation (Accessed: 26 February 2020).

Teach (2019) *Learning Styles*. Available at: https://teach.com/what/teachers-know/learning-styles/ (Accessed: 17 April 2019).

The British Museum (2021) *Virgin & Child 15thC (late)*, *British Museum Online Collection*. Available at: https://www.britishmuseum.org/collection/object/H_1956-0701-1 (Accessed: 29 June 2021).

The Heritage Alliance (2016) *Heritage 2020 - Home Page*, *Heritage 2020 website*. Available at: https://www.heritage2020.net/ (Accessed: 8 September 2020).

The Institute of Conservation (2017) *Icon's Strategy 2017-2021*. London.

The National Gallery (2021) *The Virgin & Child*, *National Gallery Online Collection*. Available at: https://www.nationalgallery.org.uk/paintings/dalmatianvenetian-the-virgin-and-child (Accessed: 29 June 2021).

The National Gallery (no date) *The Meaning of Making*, *The National Gallery Website*. Available at: https://www.nationalgallery.org.uk/research/about-research/the-meaning-of-making (Accessed: 3 March 2020).

The Royal Society (2006) *Science Communication*. London. Available at: https://royalsociety.org/-/media/Royal_Society_Content/policy/publications/2006/1111111395.pdf.

Thermo Fisher Scientific (2020) *What is XRF and How Does it Work*, *Thermo Fisher*. Available at: https://www.thermofisher.com/blog/ask-a-scientist/what-is-xrf-x-ray-fluorescence-and-how-does-it-work/#:~:text=composition of materials.-,XRF (X-ray fluorescence) is a non-destructive,a primary X-ray source. (Accessed: 21 January 2021).

Thoroton, R. (1790) *Parishes: Rodintone*, *Thoroton's History of Nottingham Volume 1. Republished with Large Additions by John Throsby*. Edited by J. Throsby. Nottingham: British History Online. Available at: https://www.british-history.ac.uk/thoroton-notts/vol1/pp123-132.

Tillmann, L. M. (2009) 'Body and Bulimia Revisited: Reflections on "A Secret Life"', *Journal of Applied Communication Research*, 37(1), pp. 98–112.

Trent, A. and Cho, J. (2014) 'Interpretation Strategies: Appropriate Concepts', in Leavy, P. (ed.) *The Oxford Handbook of Qualitative Research*. Oxford: Oxford University Press, pp. 639–657.

UK Research & Innovation (2019) *REF 2021*. Available at: https://www.ref.ac.uk/about/what-is-the-ref/ (Accessed: 21 January 2019).

UK Research & Innovation (2020) *The UK's Research and Innovation Infrastructure: Opportunities to Grow our Capability*, *UKRI*. Available at: https://www.ukri.org/files/infrastructure/the-uks-research-and-innovation-infrastructure-opportunities-to-grow-our-capacity-final-low-res/ (Accessed: 16 April 2020).

UK Research & Innovation (2021) *Open Research*, *UKRI Website*. Available at: https://www.ukri.org/our-work/supporting-healthy-research-and-innovation-culture/open-research/ (Accessed: 7 September 2021).

UKRI: Research England (2020) *Knowledge Exchange Framework: Decisions for the First Iteration*. London. Available at: https://re.ukri.org/sector-guidance/publications/?startRow=21&nextNID=EAAB599F-2C8C-45A4-B2DFE1420CF4BD15.

UKRI and AHRC (2020) *Towards a National Collection: Open UK Heritage to the World*. London. Available at: https://ahrc.ukri.org/documents/calls/discovery-projects-call-guidance/.

University College London (2019) *Share Academy*, *UCL Culture*. Available at: https://www.ucl.ac.uk/culture/projects/share-academy (Accessed: 6 August 2019).

University of Nottingham (2016) *Artcodes.co.uk*. Available at: https://www.nottingham.ac.uk/research/groups/mixedrealitylab/projects/artcodes.aspx (Accessed: 10 July 2020).

Virtualspeech (2021) *Average Speaking Rate and Words per Minute*, *Virtualspeech Website*. Available at: https://virtualspeech.com/blog/average-speaking-rate-words-per-minute (Accessed: 16 September 2021).

Visual Computing Lab (2017) *MeshLab*, *MeshLab Website*. Available at: https://www.meshlab.net/# (Accessed: 3 November 2017).

Wang, Q. *et al.* (2019) 'A Critical Review of the Application of Paleo-art in Paleontological

Exhibition - A Case Study of the Dinosaurs of China Exhibition in Wollaton Hall and Lakeside Arts, Nottingham', *Museum Management and Curatorship*, 34(5), pp. 521–536. doi: 10.1080/09647775.2019.1573700.

Ward, P. (2005) *Documentary: The Margins of Reality*. E-Book. New York: Columbia University Press.

Wasson, H. (2015) 'The Elastic Museum: Cinema Within and Beyond', in Henning, M., Macdonald, S., and Rees Leahy, H. (eds) *The International Handbooks of Museum Studies*. Chichester, pp. 603–627. doi: 10.1002/9781118829059.wbihms326.

Watson, S. (2010) 'Myth Memory and the Senses in the Churchill Museum', in Dudley, S. H. (ed.) *Museum Materialities*. 1st edn. Abingdon: Routledge, pp. 204–223.

Wehner, K. and Sear, M. (2010) 'Engaging the Material World.', in Dudley, S. H. (ed.) *Museum Materialities*. 1st edn. Abingdon: Routledge, pp. 143–161.

Williams, E. M. (ed.) (2013) *The Public Face of Conservation*. London: Archetype Publications.

Williams, J. (2009a) *The Role of Science in the Management of the UK's Heritage*. London. Available at: http://www.heritagescienceforum.org.uk/documents/nhss_report_1_web.pdf.

Williams, J. (2009b) *The Use of Science to Enhance our Understanding of the Past*. London. Available at: http://www.heritagescienceforum.org.uk/documents/nhss_report_2_web.pdf.

Williams, J. (2009c) *Understanding Capacity in the Heritage Science Sector*. London. Available at: http://www.heritagescienceforum.org.uk/documents/nhss_report_3_web.pdf.

Wilson, I. and Furlong, S. (2020) 'Reflections on Research Outcomes from Arts Council England'. [interview] Interviewed by Chris Pickup, 28th Feb.

Wilson, J., MacGregor, N. and Serota, N. (2010) *The Museum of the 21st Century*, *YouTube*. Available at: https://www.youtube.com/watch?v=tVhXp9wU5sw (Accessed: 27 October 2020).

Witcomb, A. (2007) 'The Materiality of Virtual Technologies: A New Approach to Thinking about the Impact of Multimedia in Museums', in Cameron, F. and Kenderdine, S. (eds) *Theorizing Digital Cultural Heritage: A Critical Discourse*. 1st edn. Cambridge MA: MIT Press, pp. 35–48.

Yin, R. K. (2014) *Case Study Research: Design and Methods*. 5th edn. Los Angeles: Sage.

Young, J. (2002) 'Structure & Script', in Kochberg, S. (ed.) *Introduction to Documentary Production: A Guide for Media Students*. London: Wallflower, pp. 5–27.

Appendices

Appendix 1 Nottingham Castle Film Final Brief

Flawford Virgin Clip 1

Max 30 sec

Target audience: Younger/millennial

Channel: Twitter

Visual: Full sculpture transitions to gold and red clothing.

Text: Flawford Virgin, Alabaster c1380. Did she look like this? (11 sec)

Visual: Transition to face

Text: Was this her face? (6 sec)

Sound: Short music sequence or sound effect

Notes and comments:

- External connections to exhibition details and additional films will be embedded in the text element of the tweet.

Flawford Virgin Clip 2

Max 90 sec

Target Audience: Millennial/middle-aged

Channel: Facebook/Instagram

Visual: To be confirmed by story board prior to editing but to include full sculpture colour change and face colour change.

Text: Total time 42 sec

- Flawford Virgin, Alabaster c1380 (10 sec)
- Why was she hidden? (5 sec)

- How did she get broken? (5 sec)
- Where has she been since she was found? (8 sec)
- How would she originally have looked? (7 sec)
- Can science give us some answers? (7 sec)

Sound: Music soundtrack

Notes and comments:

- External connections to exhibition details and additional films will be embedded in the text element of the post.

Flawford Virgin Clip 3

Max 3 Min

Target Audience: Unspecified

Channel: Website

Visual: To be confirmed by story board prior to editing but to include: abbreviated narrative of the backstory, research project and full sculpture colour change and face colour change.

Text: To be confirmed by story board prior to editing.

Sound: Music soundtrack

Notes and comments: It is anticipated that the reduction in the narrative from the original 12 min film will include the following compromises.

- Reduced description of the scientists set up and excluding salt glaze and lace.
- Compressed narrative of the discovery at Flawford.
- Removal of the description of the plaster thickness.
- Heavily abridged description of the scientific process focusing on the end result.
- Removal of a full credits sequence (please see note on branding).

Questions:

- Is a progress bar required on this film? (Marcomms agent to advise)
- All links to more information/documentary be included on the web page or platform interpretation text and not in the film.

Flawford Virgin Documentary

Anticipated time 10-12 mins

Target Audience: High interest individuals & specialist heritage/museum professionals

Visual: Original film

Text: Original film

Sound: Music soundtrack

Notes and comments:

- Some editing will be required: Reduction in the initial introduction to remove salt glaze and lace references.
- Further reading/research links to: instrumentation; information on NTU's ISAAC Lab team website; links to further research in this field to be made available on the web page supporting this film. NTU to advise.

Flawford Virgin Images

300 dpi image. Virgin uncoloured

300 dpi image. Virgin coloured full sculpture

300 dpi image. Virgin face

Lace Images

X2 300 dpi images of two lace types. (Client to specify).

Lace Film

Make available the pre-existing 10 second film sequences for the lace samples specified above, for continuous loop on the website. (Client to provide additional interpretation material).

Branding

Stakeholders including NTU, Midlands 4 Cities, AHRC and yourselves will need to be represented. This will need to be discussed; placing appropriate branding on a web page or in gallery interpretation material may suffice. If it has to be embedded in the film content, then this will need to be considered early in the process as it will impact on the proposed timings. (Decision to be made at forthcoming meeting).

Chris Pickup

19/5/20

Appendix 2: Outcomes from the Discussions Programme Analysis to Inform Chapter 5

A2.1 Methodology

Within the anonymised programme there were thirteen organisations and thirty-five individuals. Each discussion was of approximately an hour. The transcription of every word spoken at approximately eight thousand words an hour, would have resulted in the combined transcripts being over a hundred thousand words (Virtualspeech, 2021). In order to draw my conclusions, I needed to formulate some methodology to access common themes for a more holistic resume to be written into Chapter 5, Perspectives from the Field. It is not claimed that this has any analytical or statistical value beyond that of enabling an effective snapshot of opinions from the discussions to inform the chapter. However, a breakdown of my process is presented here to inform the discussion presented in Chapter 8.

The discussions were conducted in an open-ended format (Silverman, 2006, pp. 109-113), where the interviewer facilitates the discussion allowing ideas and views to be formulated and expressed. The audio recordings were transcribed in an abridged form and a short resume of the key issues was written for each transcript. Each member or convener of the discussion group was then sent their transcript and allowed time to respond if they felt the transcript was not an accurate portrayal of the views of those present. These 'member validated' transcripts (Kvale, 2007, p. 125) were then used to enable more detailed understanding of the issues raised and views expressed. These individuals were speaking from personal experience and expressing views that would not necessarily represent those of their host organisations. Therefore, the methodology required that the analysis anonymised the participants and the organisations.

A basic coding technique (Kvale, 2007, p. 105) was adopted where issues were identified and counted across the data set. It was felt a threshold had to be set to identify issues which had commonality across the data set. Hence, an issue raised once would be simply a personal opinion, twice perhaps a coincidence, however issues that appeared three times within the data set prompted the start of the coding process. From that point onwards, these issues were identified in the resumes and counted to measure frequency with which they occurred across the data set. Table 6 shows the entire discussion group, with each organisation given an anonymous letter prefix. This indicates the scientific research enablement status of the organisation and an identifying number suffix. The next column gives information for the professional background of each of the participants within each organisation, again with an identifying number suffix. The coloured bars at the top of the table represent each of the issues. The numbered squares below

show which issues were responded to within each organisation. A response from the organisation to an issue was recorded by using a number “1”. Table 7 details each identified issue and expresses the total number of responses to each issue across the cohort as a bar chart. Table 8 shows the breakdown of the entire cohort with regard to their research enablement status and organisation type. A national heritage organisation is one which would own or manage numerous sites under one administrative umbrella. Most SREO museums would receive funding as Independent Research Organisations (IRO) or Public Sector Research Establishments (PSRE) to conduct scientific research programmes. However, a museum may be considered a SREO due to its association with a research establishment such as an HEI. N-SREO museums could receive funding from numerous sources including Arts Council England (ACE) and local authorities. This funding would not define scientific research as part of the museum’s remit

A2.2 Results

Interview Response Analysis		Impact as a driver	Good Public Engagement	3D for Bridge Building	Brokerage	Untold Stories	Public Engagement	HEI Empathy	Service Provision	Dissociated from Research	Time Budget Infrastructure
Org Code	Staff Code										
N-SREO-1	Curator-1		1	1	1	1		1		1	
	Curator-2										
N-SREO-2	Conservator-2		1	1		1	1	1	1		1
	Conservator-3										
	Curator-3										
	Curator-4										
N-SREO-3	Curator-5						1	1		1	1
	Curator-6										
	Curator-7										
N-SREO-4	Conservator-7		1	1			1			1	1
	Curator-8										
	Curator-9										
N-SREO-5	Conservator-17		1	1		1	1	1	1	1	1
	Conservator-18										
	Curator-11										
SREO-1	Conservator-1	1	1		1			1	1	1	1
SREO-2	Conservator-4	1	1	1							1
	Conservator-5										
	Heritage Scientist-1										
SREO-3	Conservator-6		1	1	1				1	1	1
SREO-4	Heritage Scientist-2	1	1	1		1	1		1	1	1
SREO-5	Conservator-10		1	1		1		1	1	1	1
	Conservator-11										
	Conservator-12										
	Conservator-8										
	Conservator-9										
	Curator-10										
	Heritage Scientist-3										
SREO-6	Heritage Scientist-4	1	1	1		1		1	1	1	1
	Heritage Scientist-5										
SREO-7	Conservator-13		1	1	1				1	1	
SREO-8	Conservator-14	1		1	1	1	1			1	
	Conservator-15										
	Conservator-16										
	Heritage Scientist-6										
Total Responses		**5**	**11**	**11**	**5**	**7**	**6**	**7**	**8**	**11**	**10**

Table 6: shows the entire discussion group with each organisation given an anonymous letter prefix which indicates the scientific research enablement status of the organisation and an identifying number suffix. The next column gives information for the professional background of each of the participants within each organisation. The coloured bars at the top of the table represent each of the issues. The numbered squares below show which issues were responded to within each organisation.

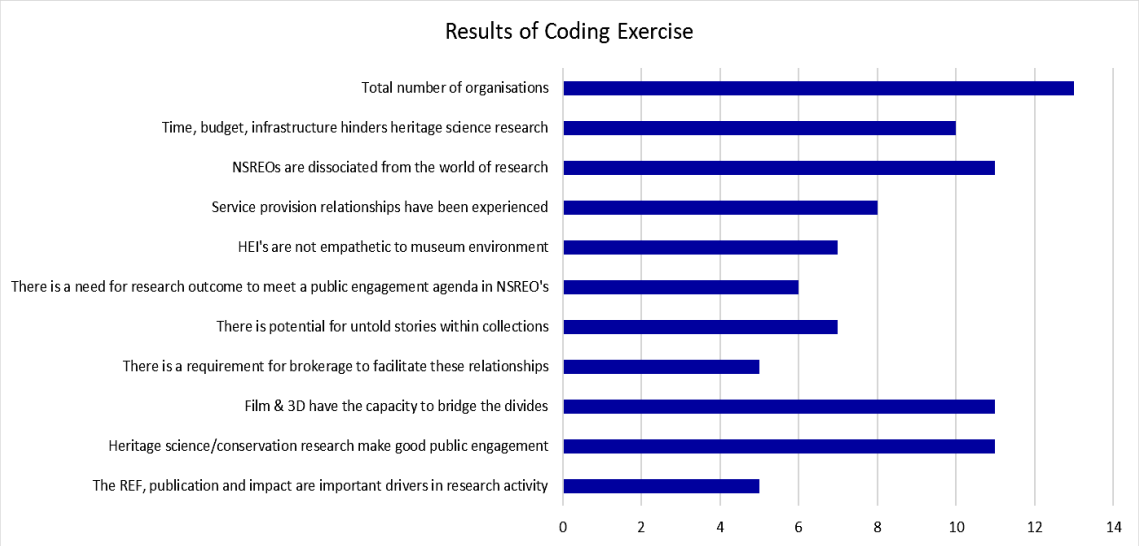

Table 7: details each identified issue and expresses the total number of responses to each issue across the cohorts.

Breakdown of Research Enablement Status and Organisation Type

Research Enablement	Organisation Type		
	Museum	National Heritage Organisations	Other- with description
Scientifically-research-enabled organisations (SREO)	SREO-2 SREO-5 SREO-6	SREO-1 SREO-4 SREO-7	SREO-3: Advisory & Conservation Service SREO-8: Higher Education Institution
Non-scientifically-research-enabled organisations (N-SREO)	N-SREO-2 N-SREO-3 N-SREO-4 N-SREO-5		N-SREO-1: Archive linked to a large commercial concern

Table 8: shows the breakdown of the entire discussion group with regard to their research enablement status and organisation type.

A2.3 Analysis of the Issues Arising from the Coding

Below is a resume of each issue identified by the coding exercise with a brief analysis of the frequency with which these issues occur. This is to assist in the interpretation of the data presented above.

A2.3.1 The REF, Publication and Impact are Important Drivers in Research Activity

Within recent years there has been a growing awareness within HEIs to consider the public engagement aspect of their research output. To a certain extent this has grown with the initiation, in 2014, of the Research Excellence Framework (REF) (UK Research & Innovation, 2019) which has an element within it that monitors this output. This issue was opened up to the discussion group to investigate a level of understanding of it and observe how it might be considered or enacted by them.

Five out of the eight SREOs commented that they were aware of the issues of public engagement outcomes and the need for publication. Three out of that five SREOs' commentary came from heritage/conservation scientists, with none of the five N-SREOs passing comment. This is not a particularly surprising result. It is organisations that are remitted to engage in research that would understand how their research would be required to meet organisational and research council requirements. What is more interesting is that this may not be an issue that an N-SREO would consider when collaborating with a research establishment such as an HEI.

A2.3.2 Heritage Science/Conservation Research Makes Good Public Engagement

For a research activity to enable public engagement it would have to engage its target audience. This issue was explored with the discussion group to open up any experiences they had of such research reaching their audiences and to explore what potential they felt it had for public engagement.

From the coding exercise, eleven out of the thirteen organisations supported this statement, with the coverage being even between N-SREOs and SREOs. Within the context of these discussions, it would imply the view that heritage science and conservation research do engage the public. The view that if such activity could be communicated as public engagement it would be accepted as a positive attribute was widely held.

A2.3.3 Film & 3D Have the Capacity to Bridge the Divides

As the above would suggest the discussion group were open-minded to methodologies to present scientific or conservation-based research as public engagement. The SREO sector were more agile in how they might do this, as scientific analytical investigation is an output of what they do. The divide that exists manifests itself within the N-SREO sector, where an analytical investigation would have to be justified as a public engagement. Participants were asked to comment on how 3D documentation, animation and film presentation might enable research activities to become effective public engagement. The view that this suggestion was valid was held by the majority of respondents (eleven out of the thirteen) with only one N-SREO and one SREO not passing comment.

A2.3.4 There is a Requirement for Brokerage to Facilitate these Relationships

This issue revolves around whose job it would be to enable a discourse between an analytical research facilitator such as an HEI and an N-SREO. In an HEI with heritage science specialism this relationship may be easier to broker than with scientists who lack heritage experience.

An awareness of this issue appears to predominate within the SREO cohort, with four out of the eight SREOs supporting the view and only N-SREO 1 responding from the N-SREO cohort. N-SREO 1 is an archive and not a public-facing museum and has had research relationships that have been both receptive and proactive and it may have had a heightened experience with regards to this issue. It is possible that with the other N-SREOs not having analytical research firmly on their agenda, they would not see access to it requiring brokerage as an issue. They would need to understand what was available in order to be aware of the difficulties they would have in gaining access. Other than acknowledgement that this was an issue there was not a wealth of discussion exploring it. The need for brokerage has been noted by research literature exploring museum and university partnerships (Bonacchi and Willcocks, 2016, p. 21; Markham *et al.*, 2019, p. 40). Outside the heritage fields the bilingual and bi-competent facilitator has been identified to broker between scientific/analytical and practice-based systems (Kieser and Leiner, 2009, p. 528).

A2.3.5 There is Potential for Untold Stories within Collections

This issue revolves around the potential that objects within museum collections have to reveal their object biographies through investigation and the potential that these biographies have for public engagement. The object biography is significant to the conservator as it can inform the

appropriacy of treatment and as a result the conservator could be at the forefront of uncovering such biographies through their work. However, the current convention would be for much of this material to be encapsulated within a conservation report rather than exploited for its public engagement potential. This issue asks the discussion group whether any realisation of this potential lies within their organisations.

Of the seven respondents the split across the organisation types was fairly even, with three N-SREOs and four SREOs commenting. Again, an acknowledgement of the issue rather than discussion was the most common response. The essential sentiment, that collections were an untapped resource and that much material capable of engaging the public lay buried in conservation reports, was generally accepted by those who expressed an opinion.

A2.3.6 There is a Need for Research Outcome to Meet a Public Engagement Agenda in N-SREOs

Here we explore the idea that N-SREOs are predominantly funded and staffed to deliver public engagement via interpretation as their mission statement. The justification to provide curatorial resource to engage in analytical investigations on their collections would be that the output from that investigation would enable a public engagement event.

This issue only solicited six responses, which could be interpreted as it being a weakly supported issue. However, with only five N-SREOs in the sample, four of them responded confirming this statement quite adamantly. The one that didn't (N-SREO 1) is an archive and not a public-facing museum. From this small sample the view supported is that, for those organisations focused solely on public engagement, any analytical research within an N-SREO would need to contribute to a public engagement agenda.

A2.3.7 HEIs are not Empathetic to the Museum Environment

This issue explores the cultural difference between a museum and an HEI (Speight, Boddington and Boys, 2013; Dent and Willcocks, 2016; National Co-ordinating Centre for Public Engagement, 2016; Markham *et al.*, 2019). It investigated within the discussion group what experiences they had in such collaborations and how they reflected upon the means by which these relationships could be improved.

With seven respondents out of the thirteen this might be considered a weak response but again the bulk of the respondents lay within the N-SREO cohort, as they would experience this

phenomenon most acutely. The one N-SREO that did not support this statement (N-SREO 4) was exceptional in that it described the roles of its curators as co-producers and it had a very successful relationship with a local HEI, providing conservation students with placements. This enabled them to satisfy a large degree of their conservation need at minimal cost.

A2.3.8 Service Provision Relationships Have Been Experienced

A service provision relationship is essentially a favour-for-favour exchange. This exchange takes place over a period of time. In a successful relationship the exchange is two-way traffic with both stakeholders ultimately benefiting. An example of this might be the museum using the university's equipment and expertise to provide data to inform museum interpretation or a conservation issue. At a later date, the museum might facilitate access to its collection to progress a research theme in the university's interest. Although this may not be the ideal relationship, it was observed within the discussion group. They were asked to reflect on their existing relationships with HEIs and analytical research and how that manifested in their working practice.

This issue was quite interesting in that six of the eight SREOs responded, many identifying levels of service provision in the role they performed within their organisations. This was somewhat at odds with the experience of the case study where the HEI did not regard themselves as service providers but proactive researchers. The two N-SREOs who commented both have established relationships with their regional university and had experienced the service provider relationship first-hand.

A2.3.9 N-SREOs are Dissociated from the World of Scientific Research

When an SREO and HEI collaborate, it could be argued that there is a 'like to like' relationship where scientific researcher talks to scientific researcher and research organisation works with research organisation. From the commentary offered by SREO 6 it should not be assumed that this is automatically empathetic, but there is a potential for these organisations to interact with each other as informed participants. Our cohort were asked to reflect on the issues faced by N-SREOs to access and engage in the world of analytical research.

With eleven of the thirteen organisations in the sample supporting this statement, this would suggest that an N-SREO's dissociation from the world of analytical research was generally accepted by the discussion group, as the state of play. One of the two organisations that did not respond here was N-SREO 2, which has a successful memorandum of understanding with its

regional HEI and is enjoying a high degree of scientific support from that. SREO 2 also did not respond to this but as a large research enabled organisation may simply not have experienced it.

A2.3.10 Time, Budget, Infrastructure Hinders Heritage Science Research

Ten of the thirteen in the sample supported this statement with four of the five N-SREOs and six of the eight SREOs. So, it would be reasonable to assume that it was a widely and homogenously held view amongst the discussion cohort and not a particularly controversial one within the current funding climate.

Appendix 3: Descriptions of the Analytical Instruments Employed in Site Visit 2

Four instruments from ISAAC Lab's mobile resource were identified as being those most appropriate to the analysis. This section presents the reader with an introduction to each of these instruments so that their application can be better understood. It should be noted that OCT, XRF and UV/Visible Reflectance Spectroscopy all had a role to play in the investigation of the objects, the Raman data collected during the site visit was not employed by the ISAAC team. The description of Raman is included here for completeness as it was an instrument station in the initial investigation.

A3.1 Optical Coherence Tomography (OCT): Analysing sub surface structures

The OCT equipment shines a laser on to the surface of the material under investigation that penetrates vertically downwards. The laser will pass through any layer of the material that is transparent or translucent. If, in its passage, it strikes any interface, inclusion or substrate that scatters the laser, the instrument records the intensity of this scattering and the time the laser takes to return to the instrument. The outcome is that the laser can image the changes in the subsurface structure or 'tomography' creating a picture of structures that lie just below the surface. [38]

A3.2 X-ray Fluorescence Spectroscopy (XRF): Detecting Elements

XRF sends a burst of high-energy X-rays into the material under analysis. This is absorbed by individual atoms of elements that are present. In absorbing this energy, the atom's electrons at lower energy states or inner 'shells' are ejected. As the outer-shell electrons drop back and fill the vacancies left by the ejected electrons, a pulse of energy is released which is detected by the XRF instrument and is diagnostic of a particular atom's identity. This gives identification for some of the elements present. [39]

A3.3 The UV/Visible Reflectance Spectroscopy: Identifying Pigments

The UV/visible reflectance spectroscopy instrument emits ultraviolet and visible light across all the visible and UV wavelengths in the spectrum. When this light hits a surface, such as a layer of

[38] OCT: To access a publication list go to OCT4Art (no date). Recommended is: Cheung, Spring and Liang (2015)
[39] XRF: An overview of this technique is available from: Thermo Fisher Scientific (2020)

paint, some of the wavelengths are absorbed and some reflected back. The precise pattern of absorption and reflection gives a diagnostic for particular pigments in the paint mixture. [40]

A3.4 Raman Spectroscopy: Identifying Molecular Compounds

Raman Spectroscopy is named after the Indian physicist Sir C.V. Raman. It uses a laser to excite the bonds between atoms in a molecule. The instrument senses subtle changes in the laser frequency or wavelength scattered by the molecular bond and again is diagnostic of that compound. The advantage of this technique is that it can identify molecules in a very precise way.[41]

For Site Visit 2 each object would receive analysis from each of the instruments. This would enable cross-referencing of the data for diagnostic purposes. This was particularly significant for the findings surrounding the Flawford Virgin as explained in more detail in Chapter 7.

[40] UV/Visible Reflectance Spectroscopy: The definitive paper and some indication of cross referencing with other techniques is Liang (2012)

[41] Raman Spectroscopy: An overview of its operation and history is available from Horiba (no date)

Appendix 4: An Expanded Description of Techniques Employed in the Research Described in Chapter 6 and Issues Arising

A4.1 Photogrammetry

A predominant recording technique employed in this research was photogrammetry (Luhmann *et al.*, 2014; Cultural Heritage Imaging, 2017). This is because it can be achieved by taking multiple photographs with a regular DLSR camera and affordable software and does not require any specialist equipment. The photographs are taken in a 360^0 rotation around the object and this process is repeated with the object in different orientations until the entire visible surface is photographed. These photographs need to overlap, and the software matches the overlaps and can use these images and metadata from the lens to build a 3D model much like a 3D jigsaw. This works well with 3D objects such as pottery as the software can track the photographs around the object until it gets back to where it started. This was used with some success in the creation of the 3D model for the Flawford Virgin but posed a number of problems with application for lace. For the purposes of photogrammetry, we could understand a piece of lace as an essentially flat, two-dimensional object. One can create a successful 3D model of a flat surface and this I had done in the past (Pickup and Harris, 2017). The difficulty is that it is single sided, so that when rotated 180^0 you see a hollow back, much like looking at the inside of a mask. The software was not capable of tracking the shape of the object past the edge of the flat plane. The obvious solution was to create two 3D models, one of one side and one of the other, and join them. Here again there was a problem. The technique of photogrammetry requires the removal of the background behind the object so that it does not become part of the model. In the case of a pot this is easy to do manually using Photoshop. However, lace is a highly complex lattice structure. Bearing in mind a 3D model could comprise seventy to one hundred images, manually cleaning each one was not practicable due to the time budget and the fact that the cleaned edge could be quite ragged. A technique of cleaning the model digitally using 'green screen' [42] to remove the background was trialled but this did not create a clean edge to the models and when joined the models looked ragged and incomplete and still showed traces of the green screen background (Figure 39).

[42] Green screen is a film technique for removing part of an image. The processing software can be controlled to remove all bright green content in the image. As long as the subject is not green this isolates the subject and removes the green background leaving no digital content in the spaces. For a detailed explanation go to InFocus Film School (2020)

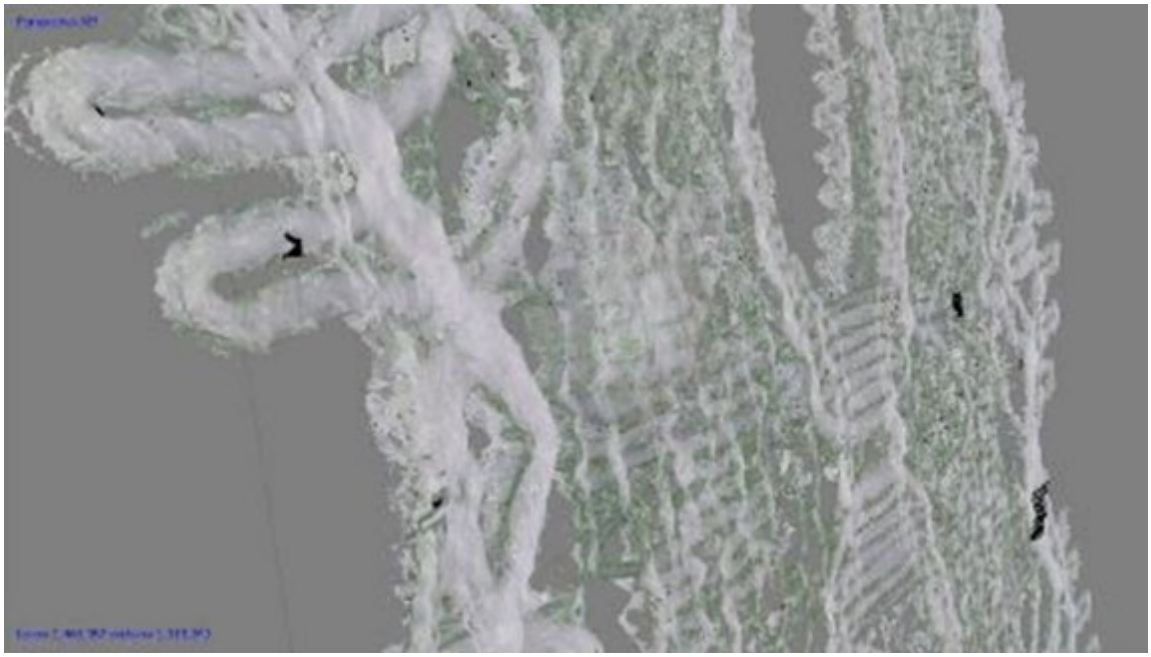

Figure 39: The ragged effect of trying to join two single side lace models together. Note the green 'residue' from using a green screen to remove the background from in and around the lace structure.

Figure 40: The best quality lace model produced using photogrammetry. This is the model at its maximum magnification before the problems in figure 39 become apparent.

The best result from the photogrammetric process is shown in Figure 40. However, I could not achieve the level of magnification required. This was not the only barrier. Photogrammetry requires the entire object in the photography to be in focus. As the camera lens gets closer to a subject the amount of the subject in focus reduces. This is referred to as 'depth of field' (Langford, Fox and Sawdon Smith, 2007, pp. 45–46). The best lens for photogrammetry has to have deep depth of field and so could not come close up to record the detail of the lace's characteristics of manufacture. Photogrammetry would not produce the required 3D image and another technique

was required. Interestingly, the apparent shortcoming of a camera lens in a photogrammetric technique was its advantage using the technique of focal stacking.

A4.2 Focal Stacking

Figure 41: Left, an image of lace from the top of the focal stack. Right, an image of lace from the bottom of the focal stack.

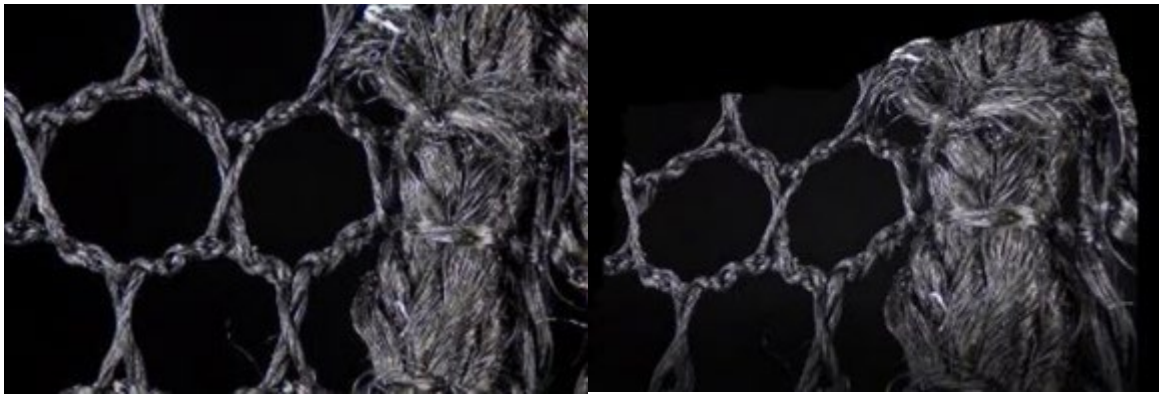

Figure 42: Left, focal stack image of machine-made lace from a Levers Lace machine. Right, 3D model of same from which the software can produce a short animation sequence.

At high magnification a camera lens will only have part of the subject in focus. This is a very shallow ‘depth of field’. In the case of a lace sample this would have been just the uppermost threads closest to the lens. As the lens is moved towards the lace sample the uppermost threads slip out of focus and a thin slice of threads just below them come in to focus (Figure 41). By repeating this slicing process and accurately recording the incremental movement of the lens it is possible to measure the distance between the threads that are in focus at the top of the lace sample and the threads that are in focus at the bottom. The focal stack technique was explored by the ISAAC Lab team using the data analysis software MATLAB (MathWorks, 2021). It produced an accurately measured image but was visually very difficult to interpret. I then turned to more photographic based software. By processing using Helicon 6 software to select in-focus pixels from each one of the images and then aligning and combining them together it was possible to

combine all of the sliced images in the focal stack into one in-focus image (Helicon Soft, 2017). Additionally, because depth measurements have been taken, a 3D model can be created (Figure 42). This image, although lacking the measured accuracy, had a much greater visual eloquence.

The next challenge was to get the camera lens to a high enough magnification. This was achieved by a photographer's 'hack' of reversing a standard 18-55mm lens. By using a special fitting ring the standard lens can be put on the camera the wrong way round, which has a magnifying effect (Gibson, 2012). This magnifying effect can then be greatly enhanced by moving the reversed lens away from the camera through the use of extension tubes (Langford, Fox and Sawdon Smith, 2007, pp. 95–96; Gibson, 2012) (Figure 43). This focal stacking technique and its subsequent high magnification, deep focus image had enormous potential to record the imagery of lace.

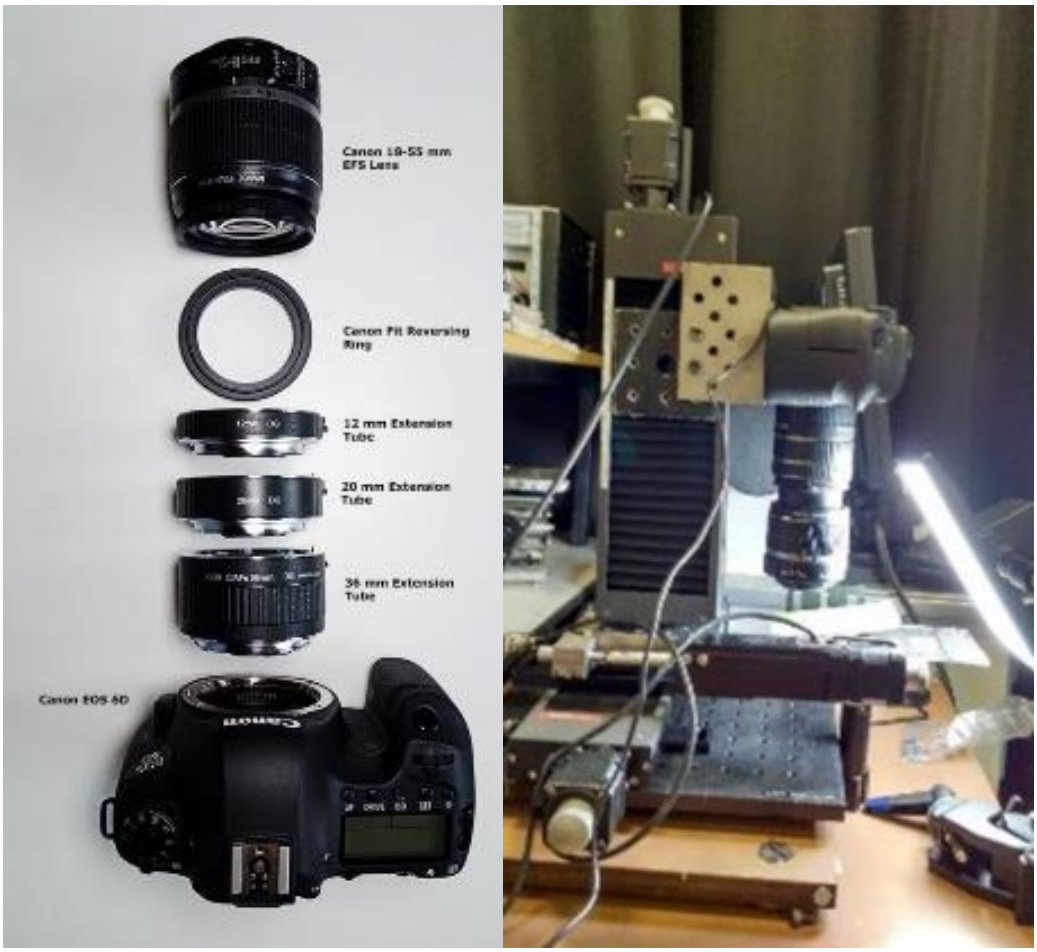

Figure 43: Left, set up for the 'photographer's hack' using three extension tubes and a normal 18-55mm lens mounted in reverse on the camera using a reversing ring. Right, the camera and lens setup on an XYZ stage supplied by ISAAC Lab. This enabled the camera to be manoeuvred up, down, left and right with nanometre precision. Also note the powerful directional lighting required to get the image.

The Helicon software (2017) allowed the focal stack images to be processed into short sequences of film where the 3D model could be animated to illustrate its structure (Figure 42) (Pickup, 2020).

The scientific instrumentation also presented an imaging option for lace with Optical Coherence Tomography (OCT) (Cheung, Spring and Liang, 2015). When applied to lace, the threads of the lace scattered the laser but it was unimpeded by the gaps in the lattice structure. The laser penetrates vertically downwards and works across a line approximately a centimetre in length. This again represents a slice down through the lace structure. If the laser is moved fractionally to one side and the process is repeated, then a second slice is created. If then repeated over a square centimetre a series of slices like a loaf of bread is created. Processing these slices in a similar way to the focal stack technique creates a 3D model which can also be animated in a film format (Figure 44). A detailed discussion of the implications this had for the research is discussed in Chapter 8.

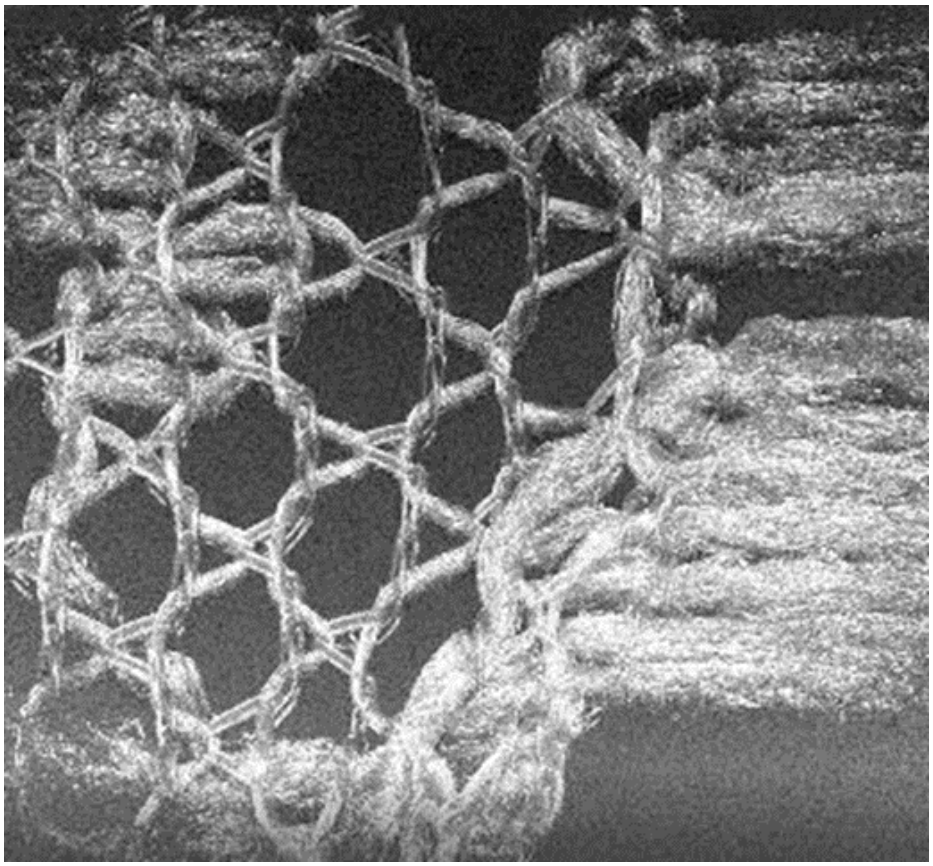

Figure 44: Image of lace created using the OCT equipment supplied by ISAAC Lab

A4.3 Reflectance Transformation Imaging (RTI)

Unlike photogrammetry, in RTI the camera and subject remain fixed. Multiple photographs are taken of the same subject, each lit from a different light direction, rotating through 360 degrees[43]. Some of the light directions are raking just above the surface, others are more direct illuminations. The software processes these multiple images into one digital presentation which can be manually animated enabling a 'digital torch light' to be manoeuvred over the surface of the object remotely. In addition, the software offers processing tools to enhance the image when a light direction is chosen. The result of this is that surface or 'topographical' detail can be revealed that would be difficult or occasionally impossible to see with the naked eye. This technique was used analytically to create the sword blow hypothesis and images from it were animated as film sequences.

[43] For more information on RTI see Cultural Heritage Imaging (2017) My paper in Geological Curator (Pickup and Harris, 2017). Sarah Duffy's definitive paper is highly informative (Duffy, 2013).

Appendix 5: Useful Links.

Below is a collection of a few useful links to access aspects of the research and save the reader from having to trawl though the Bibliography.

All of the film material for this programme of research plus some additional material is available on My Heritage Imaging You Tube channel available at: https://youtube.com/@heritageimaging

The current iteration (2022) of the Nottingham Castle Museum and Art Gallery website, with its Flawford Virgin Content is available here:

Re-imagining the Flawford Virgin: new research shows what historic alabaster figure would have looked like hundreds of years ago | Nottingham Castle

More information on the work of, and current research projects for ISAAC Lab are available here:

https://www.isaac-lab.com

The Flawford Virgin page of the ISAAC Lab website is here:

https://www.isaac-lab.com/creating-a-continuum-from-scientifi