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| <b>Institution:</b> University College London  |   |  |
| <b>Unit of Assessment:</b> 32 Art and Design: History, Practice and Theory   |   |  |
| <b>Title of case study:</b> Contributing to Cultural Heritage through Conservation Science: sustainable conservation and non-invasive analytical solutions for use in treatments, display and preservation   |   |  |
| <b>Period when the underpinning research was undertaken:</b> 2013-2018   |   |  |
| <b>Details of staff conducting the underpinning research from the submitting unit:</b>   |   |  |
| <b>Name(s):</b><br>Emma Richardson<br><br>Lora Angelova<br>Elizabeth Wooley  | <b>Role(s) (e.g. job title):</b><br>Honorary Senior Research Fellow<br>Associate Professor in Materials<br>Lecturer in Materials<br>Postdoctoral Fellow<br>Research Assistant | <b>Period(s) employed by submitting HEI:</b><br>2019-present<br>2018-2019<br><br>2012-2018<br>2014-2016<br>2015-2017 |
| <b>Period when the claimed impact occurred:</b> 2014-2019  |   |  |
| <b>Is this case study continued from a case study submitted in 2014?</b> No  |   |  |
| <p><b>1. Summary of the impact</b> (indicative maximum 100 words)</p> <p>Richardson's multifaceted scientific research has impacted three main areas of cultural heritage: the treatment of paintings in historic buildings, the use of LED lighting in museum and heritage display, and the conservation and preservation of semi-synthetic archive film. Her research has: improved condition assessments of works of art and established conservation treatments in the heritage industry; developed understanding of the scientific framework on which to base new approaches to conservation among, and affecting policy for, specialists and professionals; enhanced the environmental conditions under which a broad cross-section of the public can enjoy historic cultural heritage, from wall paintings to archival celluloid film.</p>  |   |  |
| <p><b>2. Underpinning research</b> (indicative maximum 500 words)</p> <p>As a trained analytical chemist who directed the Material Studies Laboratory located within the History of Art Department at UCL from 2012 until August 2019, Richardson is a leading researcher in conservation science in the UK, who has developed non-invasive analytical techniques and sustainable conservation solutions in a number of applications vital to cultural heritage. Richardson's expertise spans the preservation of a range of historic material classes, from medieval wall paintings to modern cellulose film. Her research relies on the collaborative nature of scientific research and falls into three main areas: Treatment, Display and Preservation.</p> <p><b>Treatment:</b> Based on Richardson's extensive research into the application of portable, non-destructive technologies for the analysis of works of art, Richardson and Angelova conducted in-depth scientific analysis to assess the performance of various commercial gel cleaning systems developed for use on paint surfaces. The research demonstrated that only one of the gel systems (agarose polysaccharide) was able to provide an increased level of solvent control when compared with the established swab cleaning methods generally used for cleaning painted surfaces; and supplied the scientific evidence as to why this should be the case [R1]. As part of this research, Richardson and Woolley undertook non-destructive analysis of the historic ceiling painting of the Queen's Staircase at Hampton Court Palace. In order to monitor the effects of polysaccharide adhesives on the existing paint layers, the latest methods (using single-sided nuclear magnetic resonance or NMR) were used to visualise the deposition and drying times of the adhesives under analysis [R2].</p> <p><b>Display:</b> Solid-state lighting systems (commonly known as LEDs) are increasingly finding application in museums and heritage institutions, providing energy efficient solutions for collection display. Richardson's research investigated the effects of LEDs on works of art, in particular, Old Master oil paintings and 18th-century British watercolours, for English Heritage. Richardson and Woolley identified vulnerable paints and pigments in order to ensure that future preservation policies are put in place to avoid the exacerbation of damage and reduce the need for conservation. Colour shift and molecular alterations in 36 pigment and paint systems were investigated following exposure to an accelerated ageing regime. An association between LED</p> |   |  |

and the oxidation of certain pigments (lead chromate sulfate, arsenic sulfide and carmine lake oil paints) were found. In other cases, LED was shown to perform better, in paint stability terms, than the tungsten halogen lamps currently installed at English Heritage [R3].

**Preservation:** Establishing preservation strategies for historic objects necessitates an in-depth understanding of production and processing methods. Building on her longstanding work on the relationship between the composition of synthetic and semi-synthetic plastics and their chemical and physical stability [R4, R5, R6], Richardson's research assesses degradation and investigates the absorption of humidity in historic archival film, especially in relation to their storage environments. Her findings have shown that the amount of moisture absorbed by archival polymer films increases rapidly at humidities above 40% leading to differential flaking of gelatine photographic or animation paint layers [R4]. She has interrogated the processing, physical instability and degradation of semi-synthetic archival film using spectroscopic analytical techniques. Heavily degraded objects often prevent ready identification of cellulose-derivative artefacts, but Richardson has shown this to be resolved through coupling non-invasive total-reflectance infrared spectroscopy with historic and technological evidence of production. This research provided insights into the challenges of establishing markers of identification following extensive material change and degradation in historic plastic artefacts [R6].

### 3. References to the research (indicative maximum of six references)

- R1. Angelova, L., Ormsby, B., Richardson, E.** (2016). Diffusion of water from a range of conservation treatment gels into paint films studied by unilateral NMR: Part I: Acrylic emulsion paint. *Microchemical Journal*, 124 (January), 311-320. doi: [doi.org/10.1016/j.microc.2015.09.012](https://doi.org/10.1016/j.microc.2015.09.012). Emerged from grant (iv)
- R2. Richardson, E., Woolley, E., Corda, K., Julien-Lees, S., Pinchin, S., Roberts, Z.** (2017). In situ characterisation of readhesion treatments for ceiling paintings using unilateral NMR. *Insight: Non-Destructive Testing and Condition Monitoring*, 59(5), 249-255. doi: [10.1784/insi.2017.59.5.249](https://doi.org/10.1784/insi.2017.59.5.249)
- R3. Richardson, E., Woolley, E., Yurchenko, A., Thickett, D.** (2019). Assessing the Impact of LED Lighting on the Stability of Selected Yellow Paint Formulations, *The Journal of the Illuminating Engineering Society*. 16(1), 67-85. doi: [10.1080/15502724.2019.1574139](https://doi.org/10.1080/15502724.2019.1574139) Emerged from grants (i) and (ii)
- R4. Richardson, E., Truffa Giachet, M., Schilling, M., Learner, T.** (2014). Assessing the physical stability of archival cellulose acetate films by monitoring plasticizer loss. *Polymer Degradation and Stability*, 107, 231-236. doi: [10.1016/j.polymdegradstab.2013.12.001](https://doi.org/10.1016/j.polymdegradstab.2013.12.001)
- R5. Giachet, M.T., Schilling, M., McCormick, K., Mazurek, J., Richardson, E., Khanjian, H., Learner, T.** (2014). Assessment of the composition and condition of animation cels made from cellulose acetate. *Polymer Degradation and Stability*, 107, 223-230. doi: [10.1016/j.polymdegradstab.2014.03.009](https://doi.org/10.1016/j.polymdegradstab.2014.03.009)
- R6. Cucci, C., Bartolozzi, G., Marchiafava, V., Picollo, M., Richardson, E.** (2016). Study of semisynthetic plastic objects of historic interest using non-invasive total reflectance FT-IR. *Microchemical Journal*, 124 889-897. doi: [10.1016/j.microc.2015.06.010](https://doi.org/10.1016/j.microc.2015.06.010). Emerged from grant (iii). All outputs were peer reviewed.

#### Grants Associated with this Research:

- i. Heritage Protection Commission – Dr Emma Richardson, (2015-2017) GBP34,255
- ii. Analytical Chemistry Trust Fund – Dr Emma Richardson, Tom West Analytical Fellowship (2015-2017), GBP15,000
- iii. The Leverhulme Trust – Dr Emma Richardson, Leverhulme Research Fellow (2016-2018) GBP38,995
- iv. The Royal Society – Dr Lora Angelova, Newton International Fellow (2014-16) GBP48,000

### 4. Details of the impact (indicative maximum 750 words)

The adoption of new conservation treatments and preservation strategies depends on robust, scientific research. Richardson collaborated extensively with heritage institutions in the UK and North America (Historic Royal Palaces, English Heritage and Disney) to provide world-class, evidence-based research to improve the condition, care and conservation of cultural heritage. Her research in treatment, display and preservation has: enabled the successful completion of

work by professional conservators and heritage organizations; improved environments for experiencing art in galleries and museums and; transformed understanding of the conservation science of plastics. Beneficiaries of her research span industry professionals and a large general public better able to appreciate our cultural heritage.

#### **Treatment: Hampton Court Palace, Historic Royal Palaces**

The ceiling painting of the Queen's Staircase painted by William Kent in 1734 is an at-risk heritage asset within Hampton Court Palace, the world-renowned historic royal building that drew 919,000 visitors in 2019. Previous attempts to fix the significant deterioration over the entire surface of the historically significant ceiling had been unsuccessful. This had left it at risk of deteriorating beyond repair though major losses of the original paint. Hampton Court Palace has been exploring solutions to this issue for 15 years. Richardson's research resulted in Hampton Court Palace's adoption of a new conservation method to their treatment protocols. As a Conservator at Historic Royal Palaces (HRP), the charity that maintains the palace, explains: 'In previous phases of work there was a reluctance to use aqueous adhesives for fear of activating salt cycles or affecting the original technique in a way that would cause the painting to fail further. Aqueous adhesives would be preferable for this application as they are more re-treatable and have less of a potential to leave shiny residue on the surface' (A). Richardson's and Angelova's investigation into the effects of various polysaccharide gel cleaning systems using portable, non-destructive analysis demonstrated the appropriate technological methodology for in situ analysis of the Kent ceiling [R1]. Their conservation trials with the polysaccharide adhesive Jun Funori, coupled with onsite analysis, demonstrated that this novel adhesive was safe to use as a consolidation treatment, performing better than historic treatments on the ceiling paintings and providing a method for future treatment. HRP stated: 'The results showed that aqueous adhesives are safe to use. This allows for a whole new group of adhesives to be considered in the next testing phase' (A). The extensive flaking of Kent's ceiling is a common problem in wall painting conservation, exhibited globally across historic built sites. This research provided the evidence and protocols to move forwards with this valuable non-destructive technology and treatment. Both the methodology and conservation have significantly contributed to a robust understanding of preservation practices for wall paintings of considerable historical importance and supports broader collections care strategies for England's national heritage. As HRP said, 'The research demonstrated that it was possible to use this analytical technique in situ from scaffolding. It allowed the team to consider how it could be used on other wall paintings which may prove to be useful for future projects' (A). Richardson's research contributed to the fulfilling of HRP's objective, as set out in its Royal Charter: for the benefit of the nation, to manage, conserve, renovate, repair, maintain and improve the Palaces to a high standard consistent with their status as buildings of Royal association and historic and/or architectural importance.

As a result of this research [R2], Richardson was invited in 2019 by Opus Conservation to conduct similar treatment trials and analysis of the 19th-century Baptistry wall paintings of the Crypt Chapel of St Mary Undercroft at the Palace of Westminster to help direct best treatment practice in the face of extensive flaking. Opus Conservation was commissioned by the Palace to undertake their conservation programme and the Director explains: 'Previous attempts to consolidate flaking paint layers with acrylics as adhesives have proved unsatisfactory [...] The use of Jun Funori on wall paintings is a recent development, so a scientific understanding of its properties and suitability for readhesion interventions on wall paintings was essential in Opus Conservation choosing it for assessment' (B). Opus Conservation confirmed the validity of Jun-Funori polysaccharide in their treatment regime as a direct consequence of Richardson's research: 'Opus Conservation is guided by UCL's research as it provides a scientific framework on which to design practical conservation solutions in the field and negotiate and explain its use with stakeholders' (B). The Palace of Westminster has now introduced polysaccharide and protein-based adhesives into their treatment practice. The Collections Care Manager notes the research assisted 'in developing our strategy for care of the Baptistry wall paintings' (C).

#### **Display: English Heritage**

While LED lighting is proven to be energy saving and cost efficient, its safety for use in museum and heritage display has required careful examination. Richardson's findings, from her analysis

of Old Master oil paintings and 18th-century watercolours of the kind found in many historic houses, have demonstrated that LED lighting is safe to use in display, except in the case of a few vulnerable pigments, which she isolated [R3]. Richardson and Wooley's 50,000-word report, *Assessing the Impact of LED Lighting on Pigments and Paper in Collections*, was submitted to the Heritage Protection Commission to contribute to developing best practice and future policy (D). It led English Heritage to initiate installation of LED lighting in their painting collections. English Heritage, responsible for the care and conservation of 1300 paintings, is able to effectively light paintings with LEDs knowing paint pigments will not be affected. As a Senior Scientist from English Heritage, stated in February 2020, 'the results of this research mean that heritage institutions can confidently progress with lamp replacement programs and English Heritage is now currently in the process of installing LED lighting across its various paintings collections based in these findings' (D). English Heritage avoided the demands upon resources that uncertainties surrounding the safety of LED lighting had placed upon major institutions. English Heritage also reported: 'At present, the collections are displayed with tungsten halogen lamps, which are an increasingly obsolete technology, whilst also having the negative characteristic of generating heat energy. The move to LED lighting will therefore benefit the collection through a reduction in replacement costs and a reduction in energy consumption' (D). As a result of this research-led change, English Heritage visitors (6,037,000 in 2018 across 400 sites) are provided with the opportunity to enjoy the paintings they encounter in the best possible lighting conditions. The report has been frequently quoted in English Heritage policy documents and 87 major heritage institutions downloaded it to inform their LED lighting policies (D).

Considerable interest has been shown in Richardson's reported findings [R3 and D]. Richardson subsequently provided guidance to Peter Martindale Conservation on lighting the medieval Doom painting of the Church of St Thomas in Salisbury. As the Director explains: 'Based on her research into the stability of paint pallets, I was able to provide conservation guidance on the Doom painting that incorporated Emma's research. Directly based on the results of Richardson and Woolley's research [four] observations and lighting recommendations were made to the Parish of St Thomas [...] These recommendations will be incorporated into the future lighting installation following conservation of the painting.' (E).

### **Process and Preservation: Communicating Conservation Science**

Richardson has worked extensively on understanding the stability of plastics, in particular the production, processing and preservation of early semi-synthetic and synthetic polymers. Her assessment of the physical instability and degradation of semi-synthetic archival film has informed the longevity and preservation of early animation and film by Disney [R4 and R5]. Since 2010, Disney and the Getty Conservation Institute have been undertaking research into the degradation of Disney animation film and the optimal storage environment for archival film. On the basis of her expertise, Richardson was commissioned to produce a report reflecting on and making recommendations on Phase 1 of the project (F), and to serve on the Disney Animation Research Library (ARL) Advisory Board from 2014-2017, whose mission is to provide independent oversight of its conservation research and preservation strategy. The advisory board reviews and makes recommendations on the progress of this project, shaping conservation and preservation practice for Disney's 50 million animation related artworks. Richardson's expertise shaped the methodology of this research project to determine the ARL's new storage guidelines, published in January 2021, that safeguard the artwork of many thousands of animated films, which might otherwise be lost due to the plastic's susceptibility to degradation. As the Art Exhibitions and Conservation Manager explains: 'Richardson's ongoing quarterly review of our progress has been invaluable, ensuring that all members of the research project are exploring and considering additional external data to make our study more robust and thorough' (F).

Richardson's work on modern synthetic materials, especially plastics, has attracted considerable interest from a wide range of partners, including individual artists and media channels. Her research on cellulose-derived film [R4, R5] formed an integral part of the concept and narrative of a film installation by artist Frances Scott, in which a number of natural and semi-synthetic plastic objects were presented using collage, laser scanning and photogrammetry techniques. Conversations between Richardson and the artist 'informed the development of the film script' (G). Scott's work *PHX [X is for Xylonite]* commissioned by Bow Arts in 2018 as part of



their project *Raw Materials: Plastics*, was displayed at the Nunnery Gallery (London) 16 May – 25 August 2019 (visitor numbers 1405) and shown at the New York Film Festival and London International Animation Festival, both in 2019. For Scott, Richardson's 'thinking around plastics as strata played an integral part in my approach to layering the constituent parts of the film' (G).

Richardson has increased public awareness of innovative conservation science through her curatorial and public engagement activities. In 2016, Richardson's research led to the co-curation of the exhibition *Dangerous Diaries: Exploring Risks and Rewards in Fabrication* held at the Octagon Gallery, UCL. Delving into the daily lives of a group of materials and fabrication enthusiasts, including contemporary artists, chemists, conservators and anthropologists, the exhibition interrogated the perils of production and how perceptions of risk have changed over time. In conversation with artefacts drawn from across UCL Collections, the diaries reflected how people have historically and cross-culturally evaluated the risks and benefits of hands-on engagement with materials. A review in the Royal Society of Chemistry's *Chemistry World* said 'chemists have as much in common with craftsmen and artists as scientists. Wandering among the exhibits, *Dangerous Diaries* could equally be considered a history of chemistry in objects. This gives chemistry's empirical, experimental essence a sobering perspective' (H). An exhibition attendee tweeted that it was 'the first time [I've] ever seen an exhibition on safety in a gallery', demonstrating that evidence-based research can raise awareness of the perception of risk and an understanding of how the context of materials determine their danger (H). Richardson has communicated to a wide public the urgent challenge plastics pose to conservation, including to public health, exemplified by her talk on the use of synthetic plastics by West Coast American artists for the *Space Shifters* exhibition, Hayward Gallery, 2018. The Senior Curator at the Hayward Gallery stated that 'the audience greatly appreciated her knowledge and ability to communicate her insight into material studies so clearly. Dr Richardson's expertise contributed to the overall rigor and increased the audience engagement of our public programme' (I). Her research raises awareness of the threat plastics pose to the environment and encourages understanding of the complexities of conservation of these now historic objects and materials.

Richardson interrogated the dichotomy between persistence in the environment and the need for preservation of plastics within collections in a BBC Four Documentary broadcast in November 2020. As a leading UK researcher on the conservation science of historic plastics, Richardson was interviewed in 2019 for *21<sup>st</sup> Century Mythologies*, based on Roland Barthes' chapter *Plastics* in his seminal book *Mythologies*. The discussions of the documentary centred around the material properties and degradation of plastics, and assumptions and ideologies that underpin their ubiquity and public perception. This is particularly timely given the current focus on plastics in the environment and the public's awareness of plastics as persistent materials. The producer and presenter stated, 'Her co-curation of the wonderful 2016 exhibition *Dangerous Diaries* led us to believe that she might also be a fine communicator to audiences beyond academia... Emma's segments in the film helped us to make a documentary that *The Guardian* described as 'the kind of intellectually stimulating TV that gives BBC Four its identity' and *The Times* said was 'fascinating', reaching 193,000 viewers on the night it was first aired' (J).

##### 5. Sources to corroborate the impact (indicative maximum of 10 references)

- A. Statement: Conservator, Hampton Court Palace, Historic Royal Palaces
- B. Statement: Director, Opus Conservation
- C. Statement: Collections Care Manager, Palace of Westminster,
- D. Statement: Senior Scientist, English Heritage, and: Richardson, E. and Woolley (2017) Assessing the Impact of LED Lighting on Pigments and Paper in Collections, Unpublished Report, Heritage Protection Commissions.
- E. Statement: Director, Peter Martindale Conservation
- F. Statement: Disney Animation Research Library, and: Richardson, E., Truffa-Giachetti, M.T., Schilling, M., Pesme, C., Shahoua, Y., and T. Learner (2013) *Disney Animation Research Library Interim Report*, Unpublished Report, Getty Conservation Institute.
- G. Statement: Frances Scott, Artist
- H. Review of *Dangerous Diaries* and tweet from visitor
- I. Statement: Senior Curator, Hayward Gallery
- J. Statement: presenter and producer *21<sup>st</sup> Century Mythologies*