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BOP Consulting

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Evaluation of AHRC World Class Labs

Final Report

Version 2

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Executive Summary

This report presents the final impact evaluation of the AHRC World Class Labs (WCL) investments. It assesses the extent to which the programme, including the activities funded, is making, or has made an impact against its aims. This evaluation applied an outcome harvesting approach to explore and identify the main results of the WCL investments. This approach drew from monitoring data, desk research, a survey of grant holders and a set of wider stakeholder interviews to identify the breadth of outputs, outcomes and impacts emerging from the WCL.

The WCL Fund

The UKRI World Class Laboratories (WCL) Fund helps universities and cultural organisations / Independent Research Organisations (IROs) maintain and improve facilities and ensure researchers have access to world class laboratories, equipment, and digital resources.

In 2020, the Arts and Humanities Research Council (AHRC) successfully won a tranche of funding from UKRI's World Class Laboratories (WCL) Fund expansion programme, with the specific objective to help universities and cultural organisations / Independent Research Organisations (IROs) maintain and improve their facilities. AHRC's WCL Fund comprises three programmes:

- **Capability for Collections** (CapCo), which awarded £37m through 62 grants, is a capital only fund and focused on heritage collections and heritage science research infrastructure. CapCo awards have been granted in phases, with the first launched in September 2020 and subsequent phases in September 2021, and in February and March 2022.
- **CapCo Impact Awards**, which awarded £0.4m through 14 grants to provide follow-up support to CapCo grant holders to support revenue costs for a small cohort of specific, collections-led research projects. The CapCo Impact Awards ran between February 2022 and June 2023, with projects ranging from seven to 18 months in length.
- **Creative Research Capability** (CResCa), which awarded £25.5m through 23 grants to provide capital investment to support smaller specialist Higher Education Institutions (HEIs) that focus on creative and practice-based research. The call for funding was open between July and September 2022, with funded projects running between September 2022 and June 2024.

Evaluation findings

This evaluation of AHRC's WCL demonstrates that the WCL grants have made a valuable contribution to enhancing the capabilities of conservation and heritage science facilities and practice-based research in the creative industries and creative arts in the UK, enhancing their research capabilities and their digital capacity. The programme has enabled grant holders to maintain and improve their facilities and improve researchers' access to laboratories, equipment, and digital resources. Despite the relatively short time frame since many of the grants were awarded, grant holders reported a breadth of benefits. In particular, the grants have been valuable for improving preservation and dissemination of historic and cultural materials, enabling new avenues for understanding human culture and history, engaging with the wider public and creative and heritage sectors, all of which are in clear alignment with all AHRC's overarching priorities.[1]

[1] https://www.ukri.org/who-we-are/ahrc/what-we-do/ [Accessed 25/4/2024]

Research-related benefits were most prevalent amongst grant holders, with 83% reporting (via survey) at least some research-related benefit. This reflects the high proportion of grant holders from research organisations (58% of CapCo awards and 78% of CResCa awards) and is in line with the driving rationale for these investments (to support research related activities). Most commonly cited research outputs included publications, and improved access to data and data collection tools. The new instruments and facilities supported by WCL have also supported grant recipients to expand the scope of their research, either by supporting the researchers to break into areas of work that were new to them, or because they can now use existing resources more efficiently and effectively. For example, the National Museums of Scotland have been able to build on non-destructive analytical techniques to arrive at new findings and found that new portable equipment allowed them to analyse artefacts previously thought to be too fragile to be transported to labs.

A third of grant holders noted that the WCL had enhanced their reputation internally within their organisations and with external partners. In the short term, this enhanced reputation has enabled organisations to leverage further funding, both in the form of public grants and industry co-funding. In the survey of grant holders, 54% reported that their AHRC WCL grant funding had led to additional funding or further investment in their work, while 43% reported that they anticipated further funding in the future (number of responses to the survey (n)= 58). Monitoring data collected by AHRC in December 2023 noted grant holder organisations had leveraged a total of £19 million in funding. For example, the University of Oxford's Gardens, Libraries and Museums' WCL grant enabled them to secure a grant from the Leverhulme Trust for a four-year project Ruskin's Painting Materials: What He Used, What He Chose, What He Taught which will rely on the museum's new suite of cutting-edge non-invasive analytical techniques.

Two thirds of grant holders reported **skills and capability benefits**. These benefits mainly related to the training and upskilling of grant holder staff, particularly for their technical skills and development of new expertise. Monitoring data collected by AHRC in December 2023 noted that 959 staff members were trained or upskilled on new equipment, with responses to the survey detailing that this included new or improved skills in all aspects of the research process, including data collection, data analysis (facilitated through investments in software), data literacy and in the upkeep of equipment. For example, Amgueddfa Cymru - National Museum Wales has established a formal Technical Services Group to promote the use of their WCL supported equipment which has led to the development of an internal peer support network, facilitating the exchange of knowledge and skills among staff and the training of PhD and Professional Training Year students. WCL grants also provided organisations with the internal leverage to secure further or retain staff roles. Grant recipients reported 58 FTE staff were employed as a result of the WCL funding (as of December 2023), 43 of which were from CapCo awards. Around a third of grant holders also indicated this equipment supported student training and skills development. A smaller proportion of grant holders reported that equipment supported the training of collaborators and users, including wider beneficiaries. For example, through their CResCa grant, Historic Environment Scotland acquired two immersive experience systems to better engage visitors and enhance learning opportunities. This acquisition not only broadened institutional knowledge and staff skills, upskilling of external organisations and enhanced collaborative training initiatives and is also supporting training for Innovate UK-funded Museums in the Metaverse research staff.

Two-thirds of grant holders reported their WCL grants had supported the development of **new collaborations and partnerships**, and the enhancement of existing partnerships. Through the AHRC quarterly reporting collected in December 2023, grant holders from all three strands reported 649 new partnerships or collaborations, with cultural and heritage organisations, and with academic organisations. A small proportion of grant holders provided examples of instances where their new infrastructure had facilitated projects in collaboration with local community organisations or to engage with the wider public at the local level. One notable example is the Museum of London Archaeology's new partnership with the Creating Tomorrow Trust in the context of engaging local communities with their Roman past through the use of ceramic radiography. Such examples of local community engagement demonstrate the ways in which grant funding can provide opportunities for place-based benefits as well. A small number grant holders (~5) specified that they had developed new partnerships with international organisations due to their WCL grants. For example, the Courtauld Institute of Art developed new relationships with the Kode Museum in Norway, the Van Gogh Museum in the Netherlands and the Kunsthaus in Switzerland. Additionally, some grant holders also reported that instrumentation in new facilities had increased the alignment of staff working within an organisation, indicating where the WCL grants had contributed to wider organisational strategy and increased coherence of research activities. The British Antarctic Survey reported a more joined-up approach to working between their Communications and Archives teams, and the University of Nottingham developed a new collaborative network of researchers within the institution.

Around half of grant holders indicated **innovation and economic** related outcomes. Most often this pertained to increased efficiency and decreased costs of research activities realised by the grant-holding organisation. The University of Exeter estimates that in-house analytical capabilities, that were previously outsourced, has saved them £15,000 in research expenditure, whilst the University of Oxford purchased equipment that was significantly quicker and easier to use than their previous equipment. As part of their WCL grant, Historic Buildings and Monuments Commission for England has enabled the implementation of a cost-recovery model that charges bench fees and project rates for the use of their equipment to enhance accessibility to the equipment, whilst increasing the commercial sustainability of the organisation in line with their non-profit objectives. Given the relatively limited amount of time for benefits and impacts to emerge, there were no clear indications of innovation or economic benefits to end-users at this stage. Some CResCa grant holders also noted new commercial contracts and access to new industry users with some notable examples, such as the Manchester Fashion Institute who signed a deal with Burberry for £3 million in industry co-funding. However, this information was often not clearly detailed enough for the evaluation to validate at this stage. This does however demonstrate that, particularly for CResCa awards, there is potential to support innovation and economic impacts to materialise for industrial users in future.

The wider **societal benefits** of the WCL investments will take more time to emerge as the use of infrastructures and supported research is applied to wider societal challenges. Despite this, two thirds of respondents indicated they had realised some outputs or outcomes in this area. Most often, the WCL grants supported increased or improved public engagement activities, including facilitating access to new audiences, generating new avenues for story telling or new ways of engaging audiences. Less commonly cited, but nonetheless valuable, benefits referred to WCL enabled research that had improved understanding of historic materials and could support more environmentally sustainable research and conservation processes in future. For example, the University of Bradford's School of Archaeological and Forensic Sciences WCL grant is contributing to national digitisation efforts, establishing one of the UK's first dedicated facilities for cross-sectional imaging in archaeology and heritage science, whilst the National Museums

Scotland reported that the investments in new computed radiography systems led to a significant reduction of chemical waste produced by the laboratory. Grant holders also provided examples where WCL infrastructure facilitated research that captured more inclusive cultural narratives by enabling research and data collection relating to previously underexplored communities and data sources.

Lessons learnt

Overall, the grant holders were satisfied with the level of support from AHRC. Although this evaluation did not formally include a process evaluation of the programme's design and implementation, some potential areas for improvement or consideration in the future did come through strongly in the evidence collected for this evaluation. We recommend AHRC:

- Consider options for providing funding to cover operational expenditure in future grants, to ensure grant holders have sufficient capacity to implement, maintain and operate funded infrastructure for a period of time, and to support further training and user support to ensure this is not a limiting factor to realising the full potential of outcomes and impacts.
- Explore opportunities and options for coordinating or facilitating networking and awareness raising amongst WCL grant holders and with the wider sectors to strengthen the communities in the creative arts and in the heritage science and conservation respectively.
- Take forward the lessons learnt from WCL with respect to the timing and communication of grant funding processes to improve awareness amongst potential applicants and minimise the impact of tight timeliness on project delivery.

Next steps

The timing of this evaluation has meant there has been a relatively limited time for outcomes and benefits to materialise. As an infrastructure grant fund, the outcomes of these investments materialise in their use and application, as well as programmes of wider engagement activities, which all require time to accrue.

Given the relative novelty of this type of grant funding for AHRC and these target communities, the breadth of potential benefits and how they would emerge was largely undefined. With this evaluation, we have been able to map the outcomes emerging from the WCL grants and with this, develop a Theory of Change and logic model to describe how the investments have and are expected to produce results. The outputs of this evaluation will then serve as a foundation for future evaluative activities.

1 Introduction

1.1 AHRC's World Class Labs

The UKRI World Class Laboratories (WCL) Fund helps universities and cultural organisations / Independent Research Organisations (IROs) to maintain and improve facilities and ensure researchers have use of world class laboratories, equipment, and digital resources. In 2020, the Arts and Humanities Research Council (AHRC) successfully won a tranche of funding from UKRI's world class labs expansion programme. The investment, part of a wider £300 million investment, enabled the launch of a new portfolio, which comprises three sub-programmes with a diversity of funding purposes and sectoral contexts.

Two of the programmes focus on collections-led research in cultural heritage science, with 62 grants (£37m) via the Capability for Collections fund (CapCo) and 14 grants (£0.4m) via follow-up CapCo Impact awards. The main CapCo strand was a capital only fund and focused on heritage collections and heritage science research infrastructure. CapCo projects aimed to support the replacement and upgrade of existing equipment (e.g., Historic England's replacement of old microscopes and cameras). The follow-up CapCo Impact awards additionally supported revenue costs for a small cohort of specific, collections-led research and engagement projects that utilised equipment and instruments through the main CapCo fund.

In contrast to CapCo, awards made via the Creative Research Capability fund (CResCa) were focused on the creative industries and creative arts. The 23 grants (£25.5m) were capital investment only and aimed to support smaller specialist Higher Education Institutions (HEIs) with a focus on practice-based research. CResCa's programme objectives are:

- Support the development of world-class research and development capabilities, particularly in the UK's smaller specialist institutions (SSIs)
- Improve the visibility and resilience of specialist, practice-led research in arts and humanities
- Support the UK's creative and cultural economy via funding advanced production and practice facilities.

These objectives, allied with some of the technologies that CResCa has invested in, show a clear read across to other recent innovation / research council funding streams (e.g. the AHRC Creative Industries Clusters Programme).

1.2 The evaluation

The objective of the evaluation is to assess the impacts of the World Class Labs (WCL) investment across a research portfolio comprising the three sub-programmes (CapCo, CapCo Impact and CResCa). The evaluation explores and demonstrate the breadth of impacts being supported by the funds, including: academic research impacts; jobs created and supported; new and existing collaborations; impacts on innovation; community access to facilities and equipment; sectoral resilience; and increased resources.

The tender for the evaluation also noted the intention to capture direct and indirect impacts on Net Zero, EDI and place, as well as capture any unexpected outcomes. Additionally, the evaluation will assess their economic impact and the extent to which they represent value for money.

The evaluation of the WCL investment across the AHRC portfolio was delivered across two phases. An interim findings presentation, which closed out the first phase, was delivered in February 2024 and presented the emerging outputs. This report is the Final Evaluation report.

1.3 Methodology

The evaluation findings are based on the outcome of the following data collection and analysis activities:

- **Review of programme data and documentation**, including a portfolio analysis of grant data, as well as existing documentation from the AHRC monitoring exercise and ResearchFish.
- **Survey of AHRC WCL Grant Holders**, addressed to all grant recipients. With an overall response rate of 62% (56, N=94), the survey was used to gauge the relative significance of different outcome types, a description of outcomes and reflections on how these outcomes were enabled by AHRC WCL investments. Two survey respondents held two WCL grants each and were asked to complete the survey for each project. Throughout the analysis, these have been treated as two separate responses, so the total sample for the survey (n) is 58.
- **7 Interviews with System level Stakeholders** to capture system level perspectives on the added value of the WCL grants and wider contextual factors. These interviewees are listed in Appendix C.
- **Case studies**, to further substantiate and capture the outcome claims made by grant recipients and provide detail on the pathway to realising these benefits. These case studies were developed using the outputs from the survey of grant holders, desk research and further interviews with grant holders and where possible, collaborators or users. These case study interviewees are listed in Appendix B. All case studies were approved by the relevant contributors prior to submission of this Final report.
- **Interim Findings Workshop** with representatives from AHRC's infrastructure team, to discuss key emerging findings and case study subjects. Feedback from this workshop has been incorporated into this report.
- **AHRC Quarterly Monitoring Data** from December 2023, which collected data from grant recipients on the number of jobs created since the start of funding, the number of events and their attendance and that amount of additional funding that had been leveraged.

To explore and identify the main results of the programme, the evaluation applied an impact/outcome harvesting approach. This was an iterative process, whereby we identified the breadth of outputs, outcomes and impacts emerging from the AHRC WCL investments. A summary of these outcomes relating to research, skills, collaboration, innovation and economic benefits and broader societal benefits are presented below.

1.4 This report

The remainder of this report is organised as follows:

- Section 2 provides a description of the AHRC World Class Labs investments, and a portfolio analysis of the projects funded so far.
- Section 3 sets out the emerging evidence of the impact and outcomes of the ARHC WCL programme for organisations and wider beneficiaries
- Section 4 presents a limited reflection on the AHRC WCL process, including the challenges and barriers to realising programme benefits and further support that AHRC can provide
- Section 5 reflects on this evidence to reach the overall conclusions of the evaluation, including the assessment of the programme's value for money
- Section 6 presents the Theory of Change that has emerged from the evaluation and an overview of the programme activities and outcomes

- Section 7 sets out sets out recommendations for AHRC to take forward to support the ongoing monitoring and evaluation of the benefits of the investments.

Appended to the report are:

- Appendix A - **Portfolio analysis** of the three programme strands that comprise the AHRC WCL investments
- Appendix B - Ten **case studies** of grant holders across the three programme strands, that detail emerging outcomes and impacts for the organisation and for wider beneficiaries. Vignettes of the case studies are presented throughout the report, distilling particular examples of outcomes realised
- Appendix C - List of **System Level Stakeholders interviewed** and list of grant holders interviewed for case studies
- Appendix D - Summary of **beneficiary survey** response rates and outcomes

2 AHRC World Class Lab Investments

The UKRI World Class Laboratories Fund helps universities and cultural organisations / Independent Research Organisations to maintain and improve facilities and ensure researchers have use of world class laboratories, equipment, and digital resources.

In 2020, the Arts and Humanities Research Council successfully won a tranche of funding from UKRI's world class labs expansion programme. The investment, part of a wider £300 million investment, enabled the launch of a new portfolio, which comprises three sub-programmes with a diversity of funding purposes and sectoral contexts: the Capability for Collection fund, the Impact Awards, and the Creative Research Capability fund. The following three sections detail each of these three sub-programmes.

The investment was in line with the strategic vision set out in UKRI's 'Opportunities to grow our capability' report[2]. The report estimated the national gross value added (GVA) of the heritage economy at £29bn and identified the need for investment in conservation and heritage science facilities, and for physical spaces that bring together practitioners, curators, and scientists.

Such facilities, housed in collections-based organisations, including universities and museums, act as hubs for knowledge creation and inter- and multidisciplinary research, innovation, and teaching. Ensuring that equipment therein is maintained, refreshed, and replaced as needed and contributes to enabling the examination, preparation, study, and digital capture of objects selected for public display.

2.1 Capability for Collections fund (CapCo)

The Capability for Collections (CapCo) strand of WCL provided capital funding of £37m in total through 62 grants, to support the upgrade, replacement and maintenance of conservation heritage science and collection storage facilities, to foster innovation driven by heritage science and support increased access to heritage collections. This included supporting existing conservation studios, heritage science labs, digital capture and imaging facilities, and study spaces in collections-based organisations. The fund supported a series of targeted, capital investments to renew and upgrade research facilities within UK galleries, libraries, archives, and museums (GLAMs), as well as universities with specialisms in heritage science and / or with associated university museum collections. The programme is a starting point in addressing the underfunding of UK heritage science facilities and equipment that has been ongoing for several decades. The scale of this issue is such that CapCo represents only the start of AHRC's funding in this area, which continues through to 2025 through the 10-year £80m Research Infrastructure in Conservation and Heritage Science (RICHeS) programme to further support heritage science. Two types of activities were funded for collections-led research in cultural heritage:

- **Refresh/upgrade of major facilities**, at up to £3 million per bid.
- **Urgent replacement or upgrade of core equipment and instruments**, including instrumentation for heritage science (for example, spectrometry, spectroscopy, digitisation and imaging), and for conservation and storage of collections equipment (including for example, (shelving, book scanners and digitisation, study spaces), costed at £10,000 - £1 million per bid.

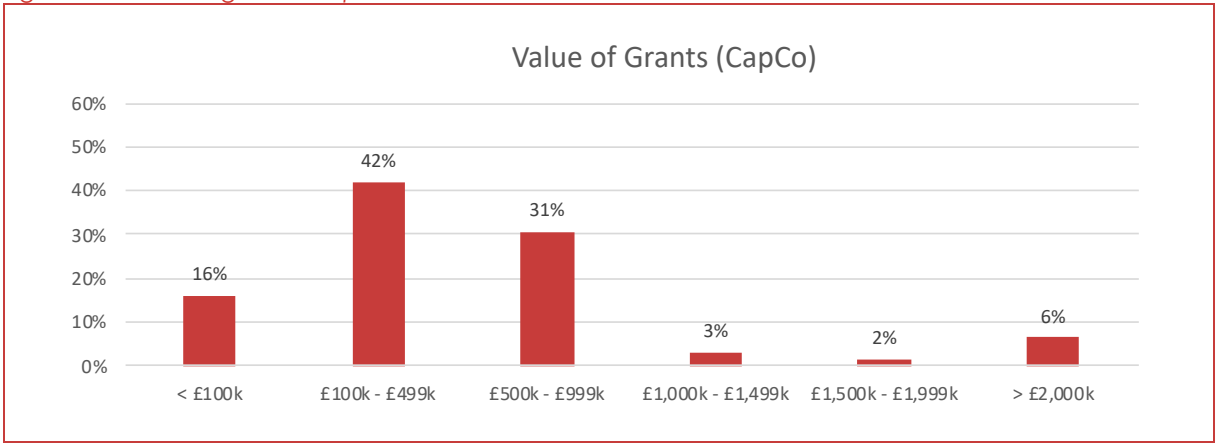
[2] UKRI (2020) UKRI Infrastructure Opportunities. Available online: http://ukri.org/wp-content/uploads/2020/10/UKRI-201020-UKinfrastructure-opportunities-to-grow-our-capacity-FINAL.pdf

These activities were expected to ensure baseline capability for collections-led research at a larger scale and make this accessible to broader community of researchers (than is usually the case). They also intended to support a variety of imaging outputs and data that can have uses in new types of creative content which would add value to and enhance the UK's cultural offering.

The competition ran in several rounds, disbursing funds as they were made available to AHRC. The first opportunities opened in September 2020 and February 2021, both with a spending deadline at end of March 2021. Three further opportunities were announced in September 2021, and in February and March 2022, allowing for awards to be spent by end of March 2022. The assessment of the applications included a focus on urgency, plans for accessibility and use, and a clear demonstration of the feasibility of spend within the set timeframe. Consideration was also given to sustainability and management arrangements, value for money, and to ensuring a balanced geographic spread and an accessible distribution of upgraded equipment and facilities.

Eventually, all fundable proposals were awarded investment through the CapCo programme, a total of 62 grants. Though these grants range in value from £150,000 to £3.9m, the average grant is around £890k (median). As shown in the figure below, half the grants (58%) made were below £500k and a further third between £500k and £1m (N=62).

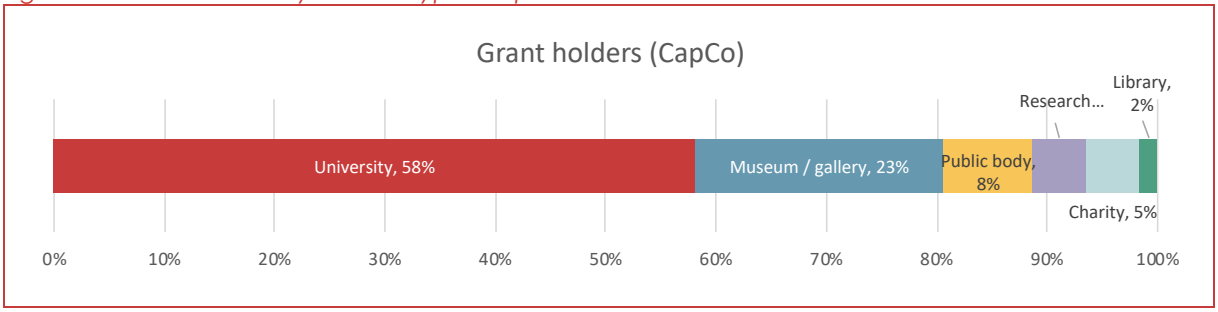
Figure 1 Value of grants: CapCo



Source: CapCo grant data, N=62

Most grant recipients were universities (58%, 36), museums or galleries (23%, 14) as well as public bodies, charities or libraries (N=62). Of the 50 unique grants holders for CapCo, 12 hold two CapCo grants.

Figure 2 Grant holders by institute type: CapCo



Source: CapCo grant data, N=62

2.2 CapCo Impact Awards

The CapCo Impact Awards were a **public engagement funding opportunity to support the operational costs of collections-led research projects in cultural heritage that use facilities or equipment previously supported through the CapCo fund**. The call focused on highlighting understudied parts of collections at recipient organisations, to enable the research, display, and use of these objects for public engagement purposes.

Applicants could bid for up to £35,000 (with potential for larger grants to be considered upon contacting the commissioner) towards the full economic cost of a research and public engagement programme. Eligible costs included payroll costs for staff working on the funded project, travel and subsistence for staff and members of the public (if their participation posed a significant commitment), estates and indirect costs, and additional research, technical, administrative and support staff costs.

The objective for commissioning the Impact awards was to enable additional capability in CapCo funded projects to create collections and catalogues, develop new methods and tools, generate new knowledge, and research, and build capability and processes for the future. The competition aimed to cultivate public engagement by encouraging organisations to engage with audiences not only upon the presentation of findings, but also during the research process. The methods and activities chosen to deliver public engagement had to directly respond to the interests and needs of the selected audience group, for whom the project would deliver demonstrable positive impact.

A total of 14 grants with a total value of £410,000 were awarded to support the research outputs of funded projects. On average, these grants were valued at around £28,000 each, ranging from £16,000-£36,000.

The Impact awards included several projects that were led by universities (57%, 8 projects), museums / galleries (29%, 4 projects) and public bodies (14%, 2 projects). Projects varied in length, ranging from 7 to 18 months (average of 10 months), between February 2022 and June 2023.

2.3 Creative Research Capability fund (CResCa)

The Creative Research Capability fund (CResCa) awarded 23 grants of £25.5m in total to institutions conducting **practice-based research in the creative industries and creative arts**. It focused on facilities in creative industries sub-sectors and institutions that were predominantly not covered by the Creative Industries Clusters programme, such as fine arts studios, design studios, recording facilities, theatre performance facilities, and music conservatoires.

CResCa was commissioned with three high level objectives in mind:

1. To ensure that AHRC can respond to major funding opportunities arising from in-year fiscal events, e.g. in-year BEIS (now DSIT) underspends, end-of-year underspends, non-association with Horizon Europe.
2. To support the development of world-class R&D capability, particularly in the UK's smaller specialist institutions (SSIs).
3. To improve the visibility and resilience of specialist, practice-led research organisations within the arts and humanities.

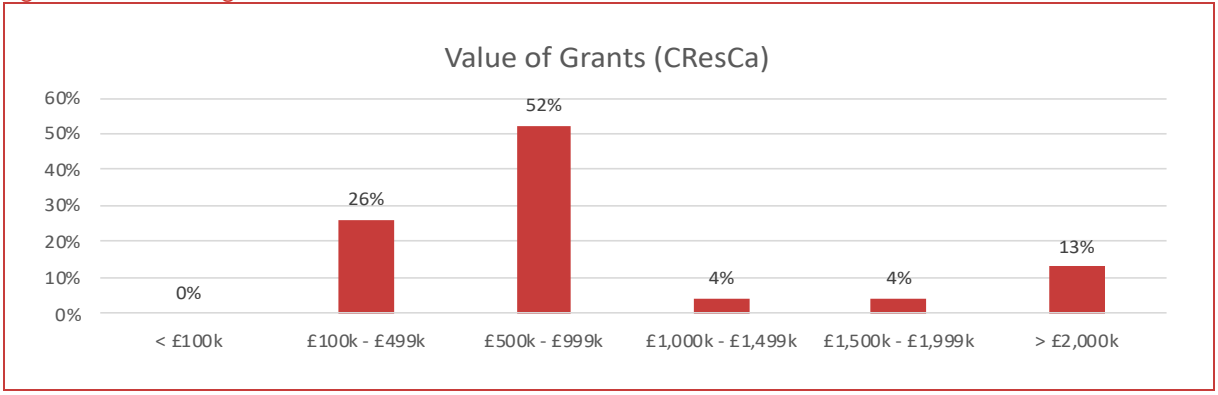
Grantees were funded to support 100% of the full economic cost of capital investments in three types of activity:

- Equipment upgrade / replacement of up to £1m, completable by 31 March 2023.
- Refurbishment / upgrade of small to medium-sized facilities, up to £3m, completable by 30 September 2022.
- New / repurposing of major facilities, up to £10m, completable within 18 months.

Eligible costs included equipment, maintenance contracts (up to five years), software and associated licences, and costs associated with construction or other contracted works.

Across all 23 grants funded through CResCa, the awarded projects ranged in size from £150k to £3.8m per grant, with an average of £892k per grant (median) (see figure below) (N=23).

Figure 3 Value of grants: CResCa



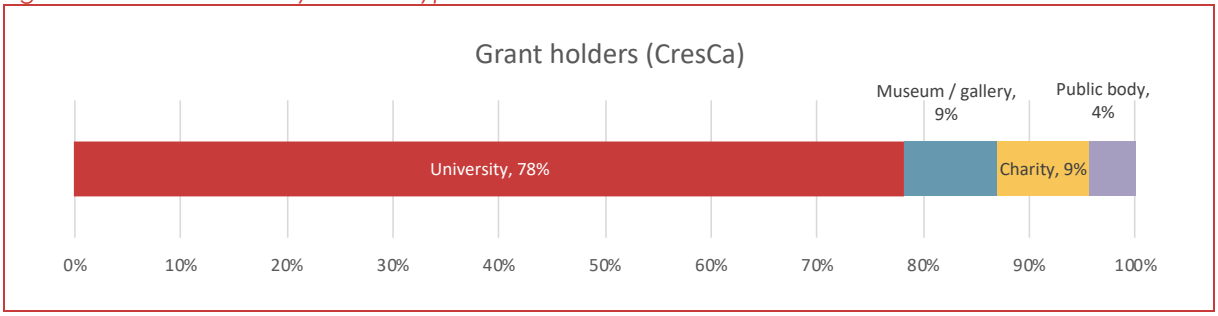
Source: CResCa grant data, N=23

The call for funding was open between July-September 2022, with funded projects running between September 2022 and June 2024. Applications to the competition were assessed based on strategic fit (organisation's need for the proposed intervention), feasibility (evidence that the proposed activity will be delivered within the stated timeframe and budget), and value for money.

The majority of awards were allocated to universities (78%, 18), with museums, charitable organisations and other public bodies making up the small remainder (see figure below).

Although application to more than one strand was possible, each institute in the CResCa portfolio received only one award.

Figure 4 Grant holders by institute type: CResCa



Source: CResCa grant data, N=23

3 Emerging Outcomes of WCL Investments

The following sections present the outputs of the outcomes mapping for the WCL investments.

To explore and identify the main results of the programme, we used an outcome harvesting approach to retrospectively identify emergent benefits (outcomes and impacts). The analysis and presentation of the outputs of this study have been grouped into the following high-level outcome areas: research, skills, collaboration and partnerships, innovation and the economy and society.

These high-level outcomes areas provided the preliminary analytical framework to qualitatively code survey responses. The open responses have been manually coded and analysed using qualitative content analysis to identify themes and topics and to assess the extent to which they are emphasised or not across the different respondents. The outcomes have also been clustered or presented according to their prevalence in the information provided by the respondents.

The results presented below relate to the proportion of respondents that had clearly indicated they had realised benefits in particular areas. It is therefore possible that grant holders have realised a wider range of benefits but chosen not to name or identify these benefits in response to this survey, or that certain types of sub-benefits may have emerged more often, but the responses provided were not sufficiently detailed to assign specific sub-categories.

3.1 Research and research outputs

While grant funding under AHRC's WCL investments was for capital expenditure only (i.e. facilities and equipment purchases), the driving rationale for many of these investments is to enable research activities. It is therefore not surprising that the benefits relating to research and research outputs were the most commonly cited benefits reported by grant holders; 83% of survey respondents indicated they had realised some type of benefit that related to their research activities (n=58).

Most prevalent research related outcomes

Publications, either in the form of academic articles or conference presentations, were the most frequently cited outcomes resulting from WCL funded infrastructure. Over a third of respondents who reported benefits relating to their research activities indicated they had produced publications (38%, n=48). ResearchFish data from 2023 revealed that CapCo grant recipients had published a total of 10 publications, including articles, conference papers and a book chapter. The information provided by grant holders in the survey indicate this number has grown in the past year as instruments come online, are being used and data acquired is analysed and publications produced. Based on the information provided by grant holders in the survey, these publications span a breadth of subject areas and disciplines, from creative and heritage sciences, through to materials science and robotics, as well as technical papers detailing new research techniques and methods. For example, the Manchester Fashion Institute published papers on opportunities for robotics in sustainable fashion and the Tate published a journal article exploring the materials and condition of 20th century dolls.

Just under a fifth of respondents who reported research-related benefits noted that their WCL grants had **improved access to data and data collection tools** (21%, n=48). This included enabling improved tools and techniques, providing better data sources, and enabling new analytical processes. This was often facilitated through the purchase of new, specific equipment but also included references to bringing facilities and instruments 'in house', improving the organisation of, and user interface for, data sharing. For example, a new dedicated server for data storage, installed at Historic Royal Palaces, has facilitated the safe access and archiving of scientific data. Additionally, grant holders noted that providing

organisations with portable equipment ensured that results obtained from data analysis were reproducible. New data collection tools were noted to be easier to use, more reliable and more user friendly. For example, investment in a new digital 3-D microscope at the Historic Buildings and Monuments Commission for England helped a student with visual impairment to engage with archaeobotanical research. Grant holders noted that the main improvements to data collection tools were in the quality of data that could be collected in-house, and in the number and type of users with access.

Project end information from CapCo grants captured through ResearchFish indicates that funding has led to improved access to data sharing. Four grant holders reported they had developed four new databases which have been made available to researchers to access for future work. Grant holders also reported that equipment was used to digitalise collections and artifacts, making them available for students to use. These new data sources were then used to re-visit old research findings for an improved understanding of historic materials and artifacts.

A third of respondents who had realised research benefits (32%, n= 48), indicated the WCL grants had supported them to **expand the scope of their research** , largely due to the availability and access to new instruments and facilities supported by WCL. This was achieved either because the instruments provided new capabilities that they did not have access to before, or because they now had the capacity to take on a greater volume and an increased complexity of work. This, in turn, freed up resources to support wider sets of activities. For example, the National Museums of Scotland have been able to build on non-destructive analytical techniques to arrive at new findings and found that new portable equipment allowed them to analyse artefacts previously thought to be too fragile to be transported to labs.

A small number of respondents indicated that by undertaking work in new research areas, they were able to develop new technical capabilities that positioned them as experts in their respective research fields, as well as demonstrating the potential of their work for future collaborations or funding.

A third of grant holders who noted research benefits found that WCL had **enhanced their reputation** (30%, n=48). Respondents noted that these investments in facilities and equipment led to enhanced visibility and reputation of the team both internally (within the grant holder organisation) and externally within the wider sectors. Grant recipients reported that an enhanced reputation provided teams with the ability to advocate for increased resources internally and improved the confidence of research teams working within the organisation. Some grant holders also noted that this, in turn, was valuable for either recruiting or retaining staff. Externally, state-of-the-art equipment and for some, the first and only equipment of its kind in the country, increased the profile of the organisation and made the research more visible. For example, research groups were selected to be featured on the UKRI website demonstrating the societal impact of heritage science research and in one notable example, underpinned a REF 2021 case study on the safe storage of archaeological metals at Cardiff University. In the long-term, organisations are increasingly recognised for the importance of the creative and cultural research activities that they undertake.

A fifth of the respondents (36%, n=48), who described the benefits relating to research activities described how the WCL grants had enabled them to **leverage further grant funding**, including making applications for additional funding . When asked directly about whether WCL had led to additional funding or further investment in their work, 54% (n= 58) of grant holders reported that their AHRC WCL grant funding had realised further funding, while 43%, reported that they anticipated further funding in the future . Monitoring data collected by AHRC also noted that grant-holder organisations had leveraged a total of £10.06 million in funding The funding is

predominantly from UKRI sources, although there are some notable examples of international funding sources including the German Research Foundation and the Swiss National Science Foundation. There are also examples of funding that has yet to be awarded, including many applications from CapCo grant recipients to RICHeS. Notably, three respondents made clear reference to the ways in which their WCL funded grant has supported or underpinned a wider set of research projects, some of which were new.

Box 1 Examples of research benefits

GLAMTech: Technologies for Gardens, Libraries and Museums Collections | CapCo | The University of Oxford's Gardens, Libraries and Museums | 2021
Grant funding has markedly enhanced research capabilities within the University of Oxford's Gardens, Libraries and Museums (GLAM), catalysing significant advancements in collections research, enhancing training and teaching potential, and allowing the exploration of new research areas. This includes publications in prestigious journals, including *Studies in Conservation* and *Egyptian Archaeology*, and contributions to major exhibitions, for example *Colour Revolution* at the Ashmolean Museum or the *Life, as we know it* redisplay programme at Oxford University Museum of Natural History. The updated equipment has allowed the organisation to revisit previous research, utilising the more sophisticated technology facilitated by CapCo to achieve superior results. For instance, enhanced infrared photography techniques now reveal previously unseen details in underdrawings in a possible Rembrandt panel painting.

GLAM's enhanced research capabilities have led to leveraged funding from the Leverhulme Trust for the four-year project *Ruskin's Painting Materials: What He Used, What He Chose, What He Taught*. Utilising the museum's new suite of cutting-edge non-invasive analytical techniques has been instrumental in this project.

Capability for Human Bioarchaeology and Digital Collections | CapCo | The University of Bradford | 2021
The University of Bradford's School of Archaeological and Forensic Sciences possesses a significant digital heritage collection and is renowned for pioneering work in human bioarchaeology and archaeological technology. Outdated technical infrastructure limited accessibility to this digital collection, prompting a desire for an update and integration with new data capture facilities.

The grant holder acquired the UK's first cone beam CT and one of two micro-CT units in UK universities, while modernising data storage and computing units. These advancements boosted institutional visibility, enhanced research capabilities, and attracted further funding. The grant enabled the use of high-resolution imaging for more detailed future study, reducing material handling and damage.

Beyond advancing institutional capabilities, the development contributed to national digitisation efforts, establishing one of the UK's first dedicated facilities for cross-sectional imaging in archaeology and heritage science.

Less prevalent research benefits

In addition to those benefits cited most often amongst grant holders, there are a set of other benefits that were cited more than once by survey respondents. These include:

- Three grant holders made specific reference to prizes or awards received by researchers within their organisations which were at least in part to attributed their WCL grant. For example, English Heritage's WCL project contributed to their winning a Marsh award for conservation science excellence, whilst the University of Bristol's WCL grant underpinned research that was subsequently shortlisted for the 'M+H Awards Best Use of Digital UK'.
- Two respondents noted that the WCL grant made contributions to or informed their wider organisational research strategy.
- Two respondents directly stated that the WCL grants increased the quality of their research.

3.2 Skills and Capabilities

Over two thirds of survey respondents reported benefits in terms of the skills and capabilities of their research teams (67%, n=58). From the perspective of grant holders and wider stakeholders, historic underinvestment in the creative, cultural and heritage science sectors, (prior to AHRC

WCL investments), organisations and research teams did not always have direct access to facilities and equipment, or at least the most cutting-edge equipment. As a result of the WCL investments, grant holders and users have been learning how to best operate and apply these new tools and techniques to their work.

Most prevalent skills and capabilities outcomes

Staff training and the upskilling of staff were the most frequently cited benefits relating to increased skills and capabilities (85%, n=39). Grant holders reported that prior to investments, few staff were fully trained on state-of-the-art equipment and those that were trained, were trained on equipment that was technologically obsolete in the research field. Investments in new equipment enabled staff to be trained in all aspects of the research process, including data collection, data analysis (facilitated through investments in software), data literacy and in the upkeep of equipment. Monitoring data collected by AHRC in December 2023 noted that grant holder organisations have trained or upskilled 959 staff members on new equipment since the start of their grants. Grant holders also reported that they were better able to design future research studies through an increased understanding of data collection tools and techniques, and therefore were able to take on work that was more ambitious and complex.

In addition to upskilling existing staff members, investments provided organisations with the internal leverage to **secure further staff roles** and **increase their capacity for research**. While the AHRC funding did not support operational expenditure to fund research or technical staff, organisations used new equipment to make the case for new permanent staff members to support ongoing research. Grant recipients reported that their organisation employed 58 staff as a result of the WCL funding (as of December 2023). It is important to note that although this indicates that some jobs were secured through the WCL investment, one of the major challenges to realising benefits that grant holders cited was the lack of support for staff funding. This challenge is further detailed in Section 4.1.

Additionally, grant holders specifically noted the **training of students** as a benefit of the grants (31%, n=39). Beneficiaries noted that investment in equipment reduced or removed the cost of specialised analysis for unfunded students and undergraduate students. This is because researchers could then spend their limited resources on providing students with advanced skills in the field. These grant holders indicated that equipment was being used as part of university degree programmes and to support PhD level research. One grant holder noted that investments in new equipment and facilities supported the development of formal training and educational programmes. A notable example from one grant holder, Bishop Grosseteste University, specified that it was in the process of validating England's first Level 7 Archaeological Specialist Apprenticeship which would partly depend on the WCL supported infrastructure.

Box 2 Examples of skills benefits

Enhancement of equipment-based research and conservation capability for Amgueddfa Cymru-National Museum Wales |Amgueddfa Cymru - National Museum Wales | CapCo | 2021

The museum has established a formal Technical Services Group. This has played a crucial role in enhancing the institution's research and conservation efforts by promoting the use of the equipment and ensuring it is managed sustainably. This initiative has led to the development of an internal peer support network, facilitating the exchange of knowledge and skills among staff. So far, approximately 35 staff members, placement students, and collaborators have received training, becoming competent in the use of the equipment. Moreover, PhD and Professional Training Year (PTY) students have benefitted from enriched skills development opportunities. These experiences prepare them for future careers in the heritage sector, instilling a deep understanding of both the practical and theoretical aspects of conservation and research.

Creating Immersive Experiences / Eternal Connections | Historic Environment Scotland | CResCa & Impact Award | 2021/22

Through the CResCa grant, HES acquired two immersive experience systems (IESs) to better engage visitors and enhance learning opportunities. This acquisition not only broadened institutional knowledge and staff skills but also facilitated the upskilling of external organisations and enhanced collaborative training initiatives. Notably, the funding supported training for Innovate UK-funded Museums in the Metaverse research staff.

HES is currently exploring methods to build traditional skills through immersive virtual environments, leveraging a 360-degree video camera acquired through the CResCa grant. Additionally, the procurement of a large-scale video wall has enhanced HES's events offer, allowing the organisation to host knowledge exchange events such as workshops and conferences. These efforts not only benefit HES staff but also contribute to the broader development of skills and knowledge within the heritage sector.

Less prevalent skills and capabilities benefits

Although less commonly cited, some grant holders reported that benefits relating to increasing skills and capabilities extended beyond their organisation. Equipment was used to **support and train collaborators and users** that lacked specialist facilities or for collaborators that were working towards shared research goals (18%, n=39). For example, the University of Nottingham offered training to centre staff, network partners and creative and cultural sector partners. In total, the University reported offering over 30 hours of training to over 100 participants and noted that they anticipated more to be trained in the next year.

Some respondents also noted that training and use of the equipment was made available to wider beneficiaries, including local museum professionals, community groups and freelance researchers. Opportunities such as these (see Box 2 above) provided beneficiaries with new skills and capabilities that, without WCL investments, they would otherwise not have had access to.

3.3 Collaboration and Partnerships

Overall, 67% (n=58) of respondents reported some form of benefit relating to new or improved collaborations and partnerships. Through the AHRC quarterly reporting collected in December 2023, grant holders across all three strands reported 649 new partnerships or collaborations. This included 236 collaborations for CapCo, 412 for CResCa and one for Impact Award grant holders.

Based on the information provided by grant recipients, these partnerships span the range of the creative, cultural and heritage science sector and include galleries, libraries, archives, and museums (GLAM) as well as new partnerships with charities and academia. The nature of these partnerships is not always clear from the Researchfish and survey data, as respondents provided varying levels of detail on who the new collaborations were with, the extent to which they were new and exactly how the WCL investment enabled this collaboration. However,

given that the WCL grants are held by single organisations, the extent to which they have contributed to enabling new collaborations and partnerships is a clear outcome of these grants.

Most prevalent collaboration and partnership benefits

Around 29% of respondents specified they developed **new or strengthened partnerships with creative or heritage organisations**, including galleries, museums, libraries and trusts (19 grant holders, n=39). One notable example is the Museum of London Archaeology's new partnership with the Creating Tomorrow Trust in the context of engaging local communities with their Roman past through the use of ceramic radiography. Many grant recipients noted that they anticipated that these new collaborations would extend beyond the lifetime of existing research projects and included commitments to share resources for efforts such as digitising of collections.

A third of respondents detailed **new or strengthened partnerships with academic organisations** (28%, n=39), while also making reference to new applications for grant funding (as detailed above).

A quarter of those respondents (26%, n=39) who indicated some sort of new / improved collaboration or partnership reported **new or strengthened partnerships with industry** . While limited, there were more industrial partnerships reported by CResCa grant recipients than CapCo. Historic England estimates that the heritage industry contributed £15.4 billion to the UK economy in 2021[3], while the Department for Culture, Media and Sport (DCMS) estimates that the creative industries contribute £126 billion in the same year[4], more than eight times that of the heritage industrial base. As such, perhaps it is unsurprising that more industrial partnerships emerged from CResCa grant funding, considering the relatively limited industrial base as compared to the creative sector.

Less prevalent collaboration and partnership benefits

Additionally, four grant holders reported that instrumentation in new facilities **increased internal networks within their organisation** (8%, n=39). The British Antarctic Survey reported a more joined-up approach to working between their Communications and Archives teams, and the University of Nottingham developed a new collaborative network of researchers within the institution (detailed in Box 3). Where departments had previously been working in a siloed fashion, grant holders reported that they were increasingly working cooperatively and with a more strategic focus. Grant holders noted that lab equipment functioned as a consolidation of resources and facilitated a focused strategy for the organisation to develop joined-up plans for the delivery of research. This demonstrates the ways in which the WCL investments have acted as a focal point for coordinating research within an organisation and reflects an earlier outcome where WCL investments had contributed to enhancing grant holders' internal reputation and to their wider research strategy.

A handful of grant holders noted that new equipment **enabled wider engagement with the local community.** Based on the information provided by grant holders, equipment funded through AHRCL WCL investments supported digitisation efforts that increased the ability of the local community to interact with heritage artifacts. The University of Stirling, for example, digitised collections of the Scots Independent newspaper archive and of the Alloa Burns Club (a local club that celebrates Burns night) minutes and papers archive for the first time. Digitised

[3] https://url.uk.m.mimecastprotect.com/s/2T3rCK699Tw79phnPuWb?domain=historicengland.org.uk

[4] https://www.gov.uk/government/statistics/dcms-and-digital-economic-estimates-monthly-gva-to-sept-2023/using-annual-estimates-from-summed-monthly-data-dcms

collections, grant holders noted, enable wider engagement with the local community by supporting voluntary groups to better understand and protect their local heritage. This indicates the potential for the WCL grants to underpin outcomes at the local level, supporting the realisation of place-based benefits.

New international partnerships, although less commonly cited, were also noted by two grant recipients. For example, the Courtauld Institute of Art developed new relationships with the Kode Museum in Norway, the Van Gogh Museum in the Netherlands and the Kunsthaus in Switzerland. Another grant holder noted that investments in portable equipment enabled them to travel to international collections for analysis, which facilitated new partnerships. Looking forwards, a wider set of grant holders noted that these investments enhanced their research capabilities and reputation, which they expected may also contribute to their increased ability to attract new international collaborators in future. This indicates the potential for WCL investments to have a longer-term impact on the reputation of the UK's research capacity in these particular research fields.

Box 3 Examples of new or enhanced collaborations or partnerships

Building networks for creative and cultural responses to historic pollution and climate change research | The University of Nottingham | CResCa | 2022

The grant supported the development of a new network for heritage science researchers across the University. The Nottingham Materials and Environment Science and Heritage Laboratories Network (N-MESH) draws together heritage science researchers from different disciplines, including Medical Sciences as Biosciences.

Previously heritage science capabilities at the University were being delivered in silos, with minimal collaboration and awareness of activities. N-MESH has facilitated a more collaborative and creative approach, forming new partnerships and facilitating greater interest in the heritage science offer at Nottingham.

Longer term, the team at Nottingham plan to grow the network beyond the university, to include industry, creative, and cultural sector groups. This will provide increased opportunities for research partnerships and build on the new partnerships developed thanks to the network.

Performance Lab: Innovating Practice-led Research and Development in Immersive and Digital Technologies in Theatre and Performance | The Royal Central School of Speech and Drama | CResCa | 2022

The grant enabled the establishment of Performance Lab, a centre for technology, art, and well-being, which enhanced Central's visibility and partnership portfolio. Collaboration took place with the National Theatre London, Digital Theatre Plus, Association of British Theatre Technicians, Association of Sounds Designers and Practitioners (ASDP), c&t, d&b audiotechnik, Donmar Warehouse, and Queen's Theatre Hornchurch, among others.

The grant holder reported that they were able to draw on these new and enhanced partnerships in their successful Expanding Excellence in England (E3) bid, to expand Performance Lab into the Centre for Performance, Technology, and Equity (PTEQ). This development will strengthen Central's R&D offer for industry and enable the continuation of enhanced collaboration and partnership efforts.

3.4 Innovation and the Economy

Given the relatively limited time for benefits and impacts to emerge, 48% (n=58) of survey respondents made reference to benefits relating to innovation or economic impact. Of these benefits, the majority related to outcomes for their own organisation, rather than those realised by wider users. In future, as the use and application of these facilities increases, we would expect a greater range of innovation activities and economic impacts to be reported, particularly for end users.

Most prevalent outcomes relating to innovation and economic benefits

An **increase in the efficiency of research** was the most cited outcome because of the AHRC WCL investments, realised by 36% (n=58) of all survey respondents. Grant holders noted that prior to investments, research was conducted either on obsolete equipment or on equipment that was slower and more expensive to keep updated. For example, the University of Oxford purchased equipment that was significantly quicker and easier to use than their previous equipment. The WCL grants supported equipment that allowed researchers to conduct their research more efficiently and at lower cost. As a result, a couple of respondents noted that this increase in efficiency had enabled them to train more staff and students on the equipment. Two grant holders also noted that this increased efficiency in their work meant they were more productive, increasing the overall *quantity* of research they were able to undertake.

Two grant holders specified that the WCL grants had **decreased the cost of their research activities.** Based on information from these grant holders, prior to AHRC WCL investments, organisations were outsourcing the analysis of samples to larger organisations with existing capabilities. By moving equipment 'in-house', organisations are less reliant on external capacity and do not have to pay other organisations to carry out research on their behalf. The University of Exeter estimates that in-house analytical capabilities, that were previously outsourced, has saved them £15,000 in research expenditure.

Similarly, grant holders also noted an **increase in the efficiency of digitisation** capabilities. ResearchFish data provided by grant recipients indicates that four new digitised collections have emerged as a result of grant funding. Grant holders commented that investments that supported digitisation efforts helped to manage collections more efficiently, as well as preserving and curating heritage materials with greater precision and accessibility.

Less prevalent outcomes relating to innovation and economic benefits

Five grant holders indicated their WCL grants enabled new **commercial contracts and access to new industry users**. While there are some industrial applications of techniques that emerge from CapCo funding, for example in the analysis of paint layers, grant recipients observed that a small heritage science community makes industrial collaborations challenging. In comparison, there were some notable examples of CResCa grant holders engaging with industry. For example, the Manchester Fashion Institute signed a deal with Burberry for £3 million in industry co-funding. Additionally, ResearchFish data provided by grant holders indicates that there a number of industrial partnerships emerging from CResCa grant funding, including with Pixel Artworks, a company focused on immersive experience design and production and WildWorks, an American video game company. This demonstrates that, particularly for CResCa awards, there is potential to support innovation and economic impacts to materialise for industrial users in future.

Box 4 Examples of new or enhanced innovation or economic benefits

Refresh and upgrade of analytical optical microscopy and associated imaging capabilities for heritage science research | Historic Buildings and Monuments Commission for England | CapCo | 2021

The grant has enabled the implementation of a cost-recovery model that charges bench fees and project rates for the use of their equipment. This model supports a tiered charging system that makes advanced scientific equipment accessible to a wider range of researchers, both from commercial archaeology units and academic institutions, expanding the Commission's support for the archaeological science sector. This allows for a successful blend between the Commission's non-profit objectives with sustainable commercial practices.

To aid this process, the team has sought to meet increasing demand by streamlining the process of booking and minimising time spent on administrative tasks. However, there remains limited capacity for staff members to meet the high demand from visiting researchers, commercial units and students, creating a barrier to the realisation of further commercial benefits in the short term.

On-Demand Design & Manufacturing of Customised 3D Fashion & Textile Products | Leeds Institute of Textiles and Colour (LITAC) at the University of Leeds | CResCa | 2022

LITAC works closely with industry partners, ranging from emerging start-ups to established multinationals. Whilst the commercial nature of many of LITAC's ventures make it complex to provide direct examples, innovations in textile verification, auto-sorting textiles, and the recycling of novel blended textiles are having direct impacts on the move towards a circular economy. These research projects have been facilitated by the CResCa funded equipment, allowing LITAC to identify practicable, implementable solutions that can be used by its partners.

A key innovation has been work developing traceable particles that can be spun into recycled fibres. This makes textiles that are fully traceable, allowing for authenticity checking and verification of source materials. Linked with this, and thanks to the additional equipment, the team at LITAC have been able to explore the recycling potentials of polymer and elastane blends, creating new traceable textiles from fibres which were previously considered to have a finite life with no recycling possibilities. This all contributes towards a strengthened offer for industry users, leading to increased use of and interest in the facilities at LITAC by industry partners.

3.5 Societal benefits

Societal benefits are those that largely relate to the wider engagement and application of the research findings enabled by the WCL investments. Though the WCL grants have had a relatively short time period to realise such wider benefits, 60% (n=58) of all survey respondents indicated they realised or expected to realise some form of societal benefit .

Most prevalent societal outcomes

Increased or improved public engagement was the most frequently cited societal outcome facilitated by AHRC WCL funding. Over half of grant holders (54%, n=35) who reported some form of societal benefit indicated increased public engagement activities, either facilitating access to new audiences, generating new avenues for story telling or new ways of engaging audiences. Grant recipients reported that they organised a total of 937 events attended by 442,635 people via AHRC's December 2023 monitoring exercise. In addition, ResearchFish data revealed that 43% (n=33) of all research dissemination events were to members of the public, policymakers, or to the public through broadcast media. For example, the National Museum of Scotland held a Science Saturday event, intended to open-up the collections to the public, that was attended by 6,000 people, and the University of Bristol developed a virtual museum co-curated with young people.

In a related and sometimes overlapping point, almost half of respondents (43%, n=35) who realised some form of societal benefit referred to the **increased accessibility of data and lower barriers to entry**. In this sense, respondents noted how through the WCL grants, organisations were able to improve their routes for sharing data and information with wider audiences and improve the mechanisms through which members of the public engaged with their work.

Less prevalent societal outcomes

Four respondents who were CapCo grant holders noted that investments in equipment led to an **improved understanding of historic materials.** For example, National Museum Wales used equipment to focus on cultural historical materials from the Indian sub-continent and worked with local people with Indian heritage. Based on the information provided by grant holders, investments in equipment allowed organisations to re-visit earlier investigations that used older versions of the same equipment to reveal new results.

In addition, 17% of grant holders noted that **more inclusive cultural narratives** had been facilitated by investments in new equipment (six grant holders, n=35) . These projects detailed where WCL equipment was facilitating the collection and collation of data from communities that had previously been underexplored or under engaged. For example, The Royal Central School of Speech and Drama delivered a project focused on Black dance and motion capture, which supported collaborative cultural co-production.

Three grant holders noted the **improved sustainability of their research and conservation practices.** This included the use of less destructive analytical techniques to preserve artefacts, the use of more sustainable collection management practices and less international travel. For example, National Museums Scotland reported that the investments in new computed radiography systems led to a significant reduction of chemical waste produced by the laboratory.

Box 5 Examples of benefits to society

Equipping the Vision of Kelvin Hall | University of Glasgow | CapCo | 2021

New equipment funded by the CapCo grant has allowed the research group and the Hunterian to be more closely aligned in the analysis and conservation of the collection. In collaboration with the Hunterian at the University of Glasgow, the research group has put together programming and events to present the results of research collaborations. For example, a collaborator at the Hunterian shared that a research talk was held to present the technical elements of conservation and paint analysis of a John Hoyland painting. New research insights afforded by new equipment enabled knowledge sharing activities and the engagement of the wider heritage science community. Feedback from attendees suggested that the event will be used as a model for other Scottish research organisations to continue to engage the public on issues relating to heritage science research.

Creating Immersive Experiences / Eternal Connections | Historic Environment Scotland | CapCo Impact | 2021

Through the Impact Award funding, HES were able to build a collaborative community project, using CapCo-funded equipment to uncover the story of fragments of a medieval Islamic glass drinking beaker that was discovered near Dumfries in the 1990s. Following scientific analysis and 3D modelling of the glass, the grant holder worked with creative practitioners and community groups to use both the scientific and the digital data to explore new ways of understanding the contemporary links between Scotland and Islam through the experiences and insight of two Scottish community groups. HES were able to run a series of workshops around scientific analysis and digital capture, as well as collaborate with creative wellbeing practitioner Vicky Mohiedden to deliver community engagement sessions at the Amina Women's Resource Centre.

4 Reflections on process

Although a full process evaluation is beyond the scope of this evaluation, the evaluation asked both grant holders and wider stakeholders about the barriers and challenges of realising the benefits of these grants, as well as ongoing research support that AHRC could provide beyond the lifetime of the WCL investments. We asked these questions to better understand the contextual factors and assumptions in the causal pathways to impact, as well as the factors which might limit the extent to which the programme has achieved its intended objectives. Given the limited opportunities for both capital and operational expenditure research grants in the creative and cultural and heritage science sectors, such questions can provide key insights as to the importance of these AHRC WCL investments and the extent to which lasting impact in the field can be achieved.

4.1 Barriers and Challenges

Both grant recipients and wider stakeholders identified the short timeframe for realising programme benefits as a key challenge of this grant funding. Some grant recipients received award letters as late as the 18th of February 2023, with terms and conditions requiring all equipment to be purchased and delivered by the 31st of March 2023.[5] Despite these short timescales, most grant recipients were able to work through this, although some survey responses indicated that there were still continued development of facilities. For example, a handful of survey respondents noted that new research facilities were still under construction and that some had experienced delays due to supply chain constraints.

While equipment alone can have an impact on the research capabilities of an organisation, longer-term outcomes are facilitated by the *use* of that equipment. As such, staffing capacity was frequently cited as a key challenge to realising programme objectives. These outcomes are therefore contingent on sustained resources, such as staff time and continued funding, to support training, upgrades, and the maintenance of facilities.

AHRC WCL investments were viewed by system-level stakeholders and grant recipients as a first step in historically underfunded fields. However, continuing to realise the benefits from these investments will depend in part on the capacity of grant holders to leverage further funding, either through grants or industry co-funding. In the grant-holder survey, CapCo grant holders cited RICHeS as an important next step for heritage science research, with funding available for both capital and operational expenditure. For the creative and cultural sectors, it is less clear what dedicated funding sources are available beyond the ARHC WCL investments. The outlook for industry investment or co-funding is also less clear at this stage of the evaluation, particularly for heritage science, where the size of the market (and therefore availability of industry funding) is significantly smaller than that of the creative industries.

As noted above, the remit of this evaluation did not formally include a process evaluation. We have not therefore explored the implementation of the WCL grants in detail. However, it is worth acknowledging at this stage the extent to which the implementation of CResCa followed a funding design that is novel for AHRC, and for the applicants. AHRC had not, prior to WCL, run funding calls to cover research infrastructure in these sectors. In addition, the distribution of WCL grants took place over in tranches as and when funds were made available to AHRC as a result of UKRI underspend. As a result, there will be a certain degree of learning within AHRC and amongst the applicants.

[5] The CapCo Experience, the University of Oxford, accessed at: https://www.heritagescienceforum.org.uk/documents/OxfordUni_CapCo_2022_01_28.pdf

In addition to the 23 grants already awarded, as of March 2024 there are 25 fundable projects that have not yet received support but will be awarded whenever budgets become available. A summary of the number of grants and funding disaggregated by strand is summarised in Table 1.

Table 1 Summary of number and value of unfunded CResCa grants

	Number of grants	Funding
Strand 2	12	£19.9m
Strand 3	13	£93.8m
Total	25	£113.7m

Source: AHRC programme data

The number of unfunded applications that are eligible for funding, and the breadth of topics, suggests that there is continued appetite for large-scale infrastructure funding from the creative and cultural sector. It is perhaps indicative of the limited other funding opportunities for the creative sector beyond the AHRC WCL investments.

What is not apparent at this stage however, and seems not to be apparent to the applicants, is how long the list of eligible but unfunded projects will be in use for. Through interviews with wider stakeholders and with the AHRC research infrastructure team, it seems that the funding model has not been consistently understood by applicants to CResCa.

Though 56% (n=14) of these projects were applications from institutions that had already received funding under either CapCo or CResCa, the remaining institutions had not received other WCL funding.

4.2 AHRC support for ongoing impact of WCL projects

Overall, grant holders reported that they were satisfied with the level of AHRC support for their projects. To realise the full benefits of the investments in equipment and infrastructure, survey analysis suggests that **funding for staff and the ongoing maintenance, upgrades and running operations are key** areas of support that AHRC can provide. Staff funding is required for maintenance, upgrades and the operation of equipment and ensures that the achieved outcomes are sustainable for organisations. For CapCo grant holders, in particular, RICHeS was highlighted as a good example of future funding that provided support for both capital and operational expenditure. Operating infrastructure on larger scales and complexity increasingly relies on a range of skills, especially as the scope of disciplinary research is widened. As staff are encouraged to become increasingly research active, this can only be achieved if the underlying workflows for care of, and access to equipment are resilient. Grant holders reported that there is little evidence of continued public funding of operational expenditure in both the creative, cultural and heritage science sectors.

As benefits begin to emerge for individual organisations, both grant holders and wider stakeholders suggested that sustainable, sector-wide impacts will require **strategic support for opportunities for networking and collaboration**. Some activities have already been undertaken by AHRC to increase visibility across grant holders. Both the heritage science and creative and cultural sectors expressed an interest in more networking opportunities. To date, there is some evidence of networks being built across departments and within organisations. For example, the N-MESH project (Nottingham Materials and Environmental Science and Heritage Laboratories) at the University of Nottingham brings together facilities across the University, including laboratories and capabilities in the Life Sciences, in Medicine, and in Health to boost Heritage Science research. Increased support of national networks, however, would raise awareness among grant holders about the facilities available at other institutions, as well as

helping organisations build new relationships for future projects. This is particularly valuable for organisations proposing larger, more complex infrastructure projects (e.g. applying for funding at European level).

5 Conclusions

Overall, AHRC's World Class Lab Funds and grants have been well received and have already enabled a range of benefits for the grant holders. The grant holder and wider stakeholder community recognise that WCL funds have provided valuable and necessary support to address a previously underserved need. The scope and breadth of the WCL grants in terms of the range of project size and focus have enabled AHRC to meet a breadth of needs of their hugely diverse research community.

Outcomes of World Class Labs

This evaluation of AHRC's WCL demonstrates that the WCL grants have made a valuable contribution to enhancing the capabilities of conservation and heritage science facilities and practice-based research in the creative industries and creative arts in the UK, enhancing their research capabilities and digital capacity. This is turn has been valuable for improving preservation and dissemination of historic and cultural materials, enabling new avenues for understanding human culture and history, engaging with the wider public and creative and heritage sectors. This evaluation demonstrates that the WCL is enabling outcomes and benefits that are in clear alignment with all of AHRC's overarching priorities:[6]

- Contemporary challenges: analysing the present, and learning lessons from the past to shape a better future
- Creative economy: research supporting the recovery and growth of the cultural and creative economy
- Cultural assets: conserving, curating, and maximising the impact of our museums, galleries, libraries and archives so our national collections are accessible to all
- Discovering ourselves: supporting cutting-edge rigorous enquiry-led research with international impact that leads to new discoveries and helps us understand ourselves and the world.

Despite the relatively short time frame since AHRC awarded many of the grants, many grant holders reported a breadth of benefits. The WCL grants have thus far had the most substantial impact on grant holders' research capacities and activities, and on the skills and capabilities of the staff involved in operating and using this equipment. As a result of these benefits and the WCL grants, grant holders have also seen new and strengthened collaborations and partnerships spanning cultural and heritage organisations and academic organisations. A smaller proportion of grant holders reported some societal and innovation-related outcomes. This is unsurprisingly limited as increased societal benefits are expected to emerge in future with more time and greater uptake of facilities and the application of WCL enabled research and development activities.

Research-related benefits were the most prevalent amongst grant holders, with 83% (n=58) of survey respondents reporting at least some research related benefit. This reflects the high proportion of grant holders from research organisations (58%, n=62) of CapCo awards and 78% (n=23) of CResCa awards) and the driving rationale for these investments to support research related activities. Research outputs in the form of publications were the most commonly cited amongst grant holders, as was improved access to data and data collection tools. The new instruments and facilities supported by WCL have also supported grant recipients to expand the scope of their research, either by supporting the researchers to break into new areas of research for them, or because they can use existing resources more efficiently and effectively.

[6] https://www.ukri.org/who-we-are/ahrc/what-we-do/ [Accessed 25/4/2024]

In all these instances, grant holders highlighted the ways in which their WCL funded facilities and equipment were enabling new avenues of research activities and leading to and increased understanding of historical objects

A third of grant holders (27%, n=48) noted that WCL funding had enhanced their reputation, both internally within their organisations and with external partners.

In the short term an enhanced reputation enabled organisations to leverage further funding, in public grants and industry co-funding. In the survey of grant holders, 54% (n=30) reported that their AHRC WCL grant funding had led to additional funding or further investment in their work. In addition, 43% (n= 24) reported that they anticipated further funding in the future. Monitoring data collected by AHRC noted that grant holder organisations had leveraged a total of £19 million in funding. In this sense, the WCL grants sustain further research in the creative and cultural sectors and catalyse further research and innovation activities.

Staff training and upskilling were the most frequently cited benefits relating to increased skills and capabilities. Monitoring data collected by AHRC noted that 959 staff members were trained or upskilled on new equipment, with the responses to the survey detailing that this included new or improved skills in all aspects of the research process, including data collection, data analysis (facilitated through investments in software), data literacy and in the upkeep of equipment. WCL grants also provided organisations with the internal leverage to **secure further or retain staff roles.** Grant recipients reported that they had employed 58 FTE staff were because of WCL funding (as reported by grantees to AHRC in the December 2023 quarterly reporting), 43 of which were from CapCo awards. A smaller proportion of grant holders also reported that equipment **supported and train collaborators and users**, including wider beneficiaries and students through increased access to equipment for graduate and undergraduate students. In this way, the WCL aligns with AHRC's objective to develop the capabilities, people and skills to "sustain a culture of enquiry" (Discovering Ourselves).

There is evidence that these grants support the development of **new collaborations and partnerships**, and the enhancement of existing partnerships. The AHRC quarterly monitoring exercise, grant holders reported a total of 649 new partnerships or collaborations. Based on the analysis of the grant-holder survey, these partnerships spanned academic, cultural and heritage organisations. At this stage however, the attribution and nature of these new partnerships and collaborations are not always clear, but instead something that AHRC could explore in future evaluative activities. A small proportion of these new collaborations and partnerships detailed by grant holders are related to partnerships with international organisations, reflecting the ways in which the enhanced capabilities and reputation of these organisations can contribute to grant holders' international footprint. Similarly, a small proportion of grant holders provided examples where their new infrastructure enabled projects in collaboration with local community organisations or to engagement with the wider public at the local level, demonstrating the extent to which these grants can provide a platform for place-based outcomes.

Additionally, some grant holders reported that instrumentation in new facilities had **increased the alignment of staff working within an organisation**. In these examples, the WCL grants helped bring greater attention and focus to collaborative working across different teams and departments, which has or was expected to lead to less siloed work and increased consolidation and coordination of research strategy and resources across the organisation.

Though less prevalent than outcomes relating to research, skills and collaborations, the most common outcomes relating to 'innovation and economic benefits' pertained to **increased efficiency and decreased costs of research activities** realised by the grant-holding organisation. Given the relatively limited time for benefits and impacts to emerge, there were no clear indications of innovation or economic benefits to end users at this stage. Some

CResCa grant holders noted new **commercial contracts and access to new industry** users. However, this information was often not specific enough for the evaluation to validate at this stage. This does, however demonstrate that, particularly for CResCa awards, there is potential to support innovation and economic impacts to materialise for industrial users in the future. Although these benefits are still emerging, there is already some evidence that the WCL investments and capability developed could enable economic benefits for the wider creative industry sector economy, in alignment with AHRC's priority area 'Creative economy'.

The wider societal benefits of the WCL investments will take more time to emerge as the use of infrastructures and supported research is applied to wider societal challenges. However, even at this stage, grant holders provided some examples and preliminary indicators of early benefits being realised. Most commonly, grant holders reported that the WCL had supported **increased accessibility to collections** to wider audiences, including technical and public audiences. Less commonly cited, but nonetheless valuable, benefits referred to WCL enabled research that had improved understanding of historic materials and could support more environmentally sustainable research and conservation processes in the future. Grant holders provided examples of where WCL infrastructures had facilitated research that captured inclusive cultural narratives and supported engagement with new audiences. In these various respects, the WCL grants are realising benefits in clear alignment with AHRC's priority to support activities to address contemporary challenges.

Lessons learnt

Grant holders and the wider community view AHRC WCL investments as a starting point for long-term research continuity. Although this evaluation did not formally include a process evaluation of the programme's design and implementation, some potential areas for improvement or consideration in future did come through strongly in the evidence collected for this evaluation.

The range of benefits realised is positive and grant holders reported that they were satisfied with the level of AHRC support for their projects. Some lessons have also been learnt through the implementation of WCL, which largely reflect grant holders' views on the barriers and challenges of realising the benefits of their grants. As the WCL Funds represent the first tranche of AHRC investments to support research infrastructure, these preliminary findings could also inform the scoping or design of future investments in these spaces.

Should AHRC seek to implement similar grants in the future, we recommend some provision be made to cover the operational costs of grants, to ensure this is not a limiting factor to realising the full potential outcomes and impacts. This will ensure the ongoing operation, maintenance, and use of instruments and data, as well as the availability of resources to support training and engagement with a wider set of potential users.

The **availability and accessibility of further funding to support continued maintenance and benefits realisation from WCL investments are not clear**. Several stakeholders and grant holders acknowledged that AHRC's subsequent programme RICHeS would serve to address some of these remaining gaps, as the scope of the programme is limited to the Conservation and Heritage Sciences. It is less immediately clear to grant holders or to the evaluation what dedicated funding sources are available for the creative and cultural sectors. The proportion of unfunded CResCa grants for organisations that were not recipients of other WCL grant funding indicates there are a cohort of projects and organisations that could also benefit from such grants but may not have access to suitable routes to funding. As noted abov, however, the availability of wider funding from public and private sources is not clear at this stage and merits further investigation to identify the extent of gaps and challenges in this space.

As benefits begin to emerge for individual organisations, both grant holders and wider stakeholders suggested that sustainable, sector-wide impacts will require **strategic support for opportunities for networking and collaboration**. Grant holders expressed interest in opportunities to build their knowledge of and connections with other WCL grant holders, to raise awareness of potential complementarities in capabilities, and to build relationships for future projects and applications.

The final set of lessons learnt concern the timing and communication of the application and awarding process, specifically to the time in which grant holders can spend the grant and the ways in which the funding is allocated, particularly for CResCa. In future, the AHRC Infrastructure team might helpfully consult with other UKRI councils running comparable funding programmes to learn lessons from their funding and implementation models, and incorporate feedback from the community into the design and implementation of future funds where appropriate.

The timing of this evaluation has meant there has been a relatively limited time for outcomes and benefits to materialise. As an infrastructure grant fund, the outcomes of these investments materialise in their use and application, as well as programmes of wider engagement activities, which all require time to accrue. As is typical with most types of investments into research and innovation (infrastructure or otherwise), realising the full spectrum of benefits, including spillover benefits and longer-term impacts to the wider society and economy, often take far longer to evidently materialise. With this in mind, the following sections present a Theory of Change and Logic Model for the WCL funds, and proposals for future monitoring and evaluative activities to capture these benefits in future.

6 Theory of Change

Using the outputs of these consultations and of the outcomes and impacts identified above, we have prepared a Theory of Change (ToC) and logic model for the investments.

A ToC is a "programme theory" that explains how an intervention is expected to produce its results.[7] In short, the ToC for the investments draws the connections between the investments made (inputs), the activities undertaken and the immediate outputs that they generate. It also describes how these outputs could then materialise into short and long-term outcomes. The box below provides further guidance on how to navigate the ToC.

Box 6 Navigating the ToC

By design, the ToC reflects the intervention logic (or logic model) of the programme. Logic models essentially map the expected chain of events through project activities to outputs, outcomes, and eventually economic and social impacts. It is presented, in its graphic representation, as a linear succession of events. However, we will be clear in the narrative that there are various feedback loops and reinforcement mechanisms through the entire pathway to impact.

The ToC is organised into three main blocks or areas: intention, attribution, and contribution and influence. The **intention** block denotes the objectives and rationale of the investments as well as the main inputs and activities (including the two types of investment).

The **attribution** block contains activities and outputs. These should be within the control of the programmes and projects. Outputs may be considered "deliverables".

The **contribution and influence** block contains short- and long-term outcomes and impacts. Achievement of these higher-level results is dependent on a number of external factors and other initiatives, investments, and drivers. There is no clear demarcation between short- and long-term outcomes, but instead are presented with the understanding and expectation that benefits emerge along a continuum and may emerge at different timescales. The distinction between short- and long-term outcomes is instead grounded in the understanding that short-term outcomes are more likely to emerge sooner and more commonly across the breadth of different grants. Longer-term outcomes are those expected to emerge with more time, and subsequently to the realisation of certain outputs and short-term outcomes. A programme of this relatively modest scale cannot be expected to be held to account for achieving a measurable improvement in a country's economic growth, but it can contribute to it. In evaluation terms, is a 'contributory cause' and part of the 'causal package'.

In addition, the ToC articulates the implicit and explicit rationale and **assumptions** that have informed the design and implementation of the programme and addresses the fact that the success of the programme is contingent on the influence of a range of external factors and additional activities (e.g., additional investment, change in behaviour) that - to a greater or lesser extent - are outside the programme's remit. This ability of the programme to influence external factors diminishes as we move to the right of the ToC: outcomes and impact.

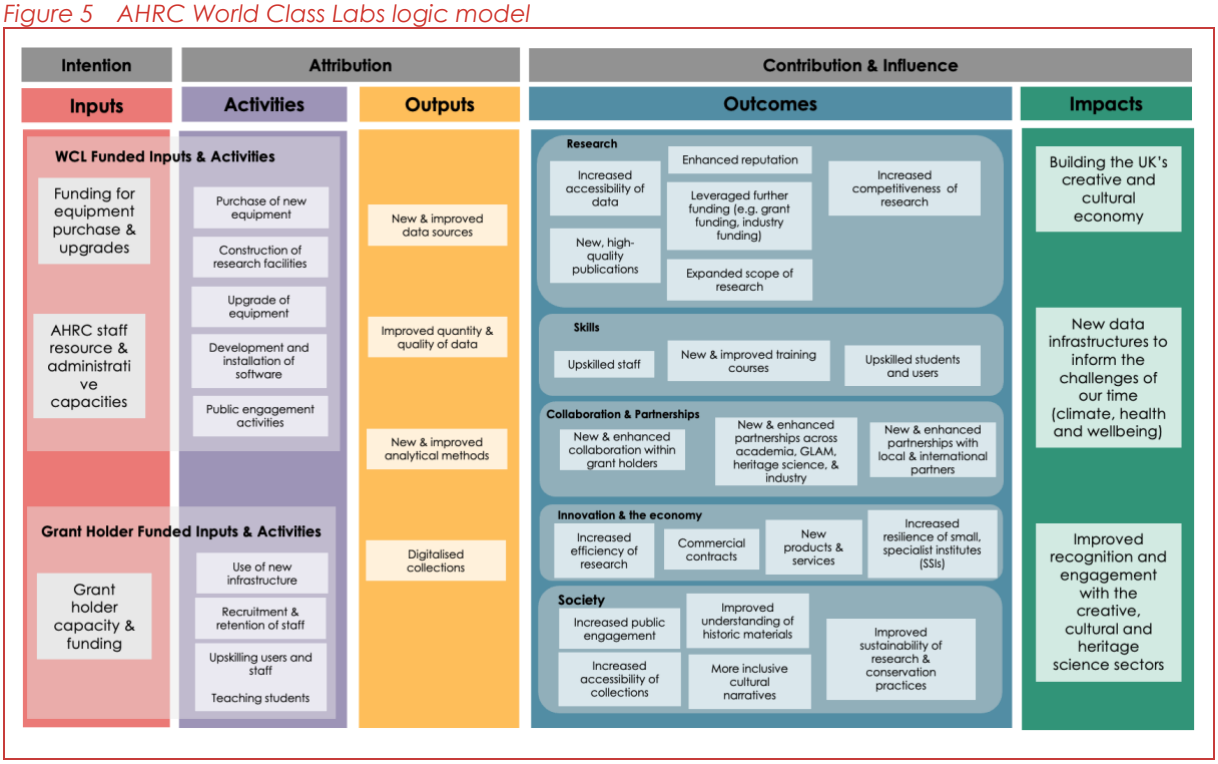
The Theory of Change for the World Class Labs investments has been conceptualised ex-post following the outcome harvesting approach presented above. The organisation and presentation of the outputs and short- and long-term outcomes aligns with the framework set out in Box 6 above, with consideration for the prevalence of benefits emerging through the outcome harvesting. This means that those outcomes which emerge from the analysis as being more prevalent have been presented here as short-term outcomes. Those outcomes that have emerged less often or were identified by grant holders as outcomes they expect in future or that would logically be expected to emerge for more grant holders in future are presented as longer-term outcomes.

[7] Funnell, S.C. and Rogers, P. J. (2011) Purposeful program theory: effective use of theories of change and logic models. San Francisco: Jossey-Bass/Wiley

This ToC focuses on the impact of the programme on beneficiaries and the wider community. Benefits to AHRC (such as increased understanding of the sector and ability to design better interventions) are not captured here, though we do acknowledge these as potential spill-over benefits from these investments.

Figure 5 presents the overall logic model, while the subsections below discuss each sphere of influence in turn.

Figure 5 AHRC World Class Labs logic model



Objectives and rationale

The main objective of the AHRC WCL programme is to provide a **refresh and upgrade of major facilities and core equipment and instruments, particularly in the creative, cultural and heritage science sectors.** Overall, the programme is intended as a starting point to address the decades-long underfunding of UK heritage science and creative facilities. Funding for such activities was expected to ensure baseline capability for collections-led research at a larger scale and to improve the visibility and resilience of specialist, practice-led research organisations within the arts and humanities. The programme focuses on three strands, CapCo, CResCa and CapCo Impact Awards which are detailed in Section 2.

Some of the key challenges for the creative, cultural and heritage science sector were highlighted in the 'The UK's research and innovation infrastructure: opportunities to grow our capability' report published by UKRI in 2020.[8] Priority areas to invest in that were identified in the report include:

[8] UKRI (2020) UKRI Infrastructure Opportunities. Available online: http://ukri.org/wp-content/uploads/2020/10/UKRI-201020-UKinfrastructure-opportunities-to-grow-our-capacity-FINAL.pdf

- **Centres for play, creativity, and skills**, particularly for the creative and cultural economies. This would be used to build "creative confidence" and to promote the interaction with materials, objects, and crafts.
- **Infrastructure and advanced facilities for the storage, conservation, and analysis of physical artefacts**, as the combination of overflowing storage and limited resourcing and staffing puts the conservation of artefacts at risk. Ensuring that equipment is maintained, refreshed, and replaced as needed contributes to the examination, preparation, study, and digital capture of objects selected for public display.

The AHRC WCL investments sit in alignment with the overall challenges of the sector, with grants supporting activities such as the purchase of new equipment and the construction of new research infrastructure.

Activities and outputs

There are five main activities that are directly supported by grant funding. These include:

- The **purchase of new equipment** to renew the research infrastructure of galleries, libraries, archives, and museums (GLAMs), as well as creative organisations such as art studios and design labs.
- The **construction of new research facilities** to house new centres for the creative and cultural sectors. These are used to bring together different groups of researchers, as well as to create purpose-built spaces for collections-led research and analysis.
- **Upgrades to existing equipment**, including **the development and installation of new software** to ensure that instrumentation is up to date and compatible with state-of-the-art methods and techniques, building baseline capability for practice-based research.
- **Public engagement activities,** which was the rationale for the CapCo Impact awards and covered operational costs associated with collections-led research projects in cultural heritage.

The WCL grants have enabled and stimulated a range of activities on behalf of the grant holding organisations. Though not directly funded by the WCL grants, these activities are important to realise subsequent outputs and outcomes. These could be understood as assumptions or pre-requisite for the WCL grants to realise their intended outputs and outcomes. Examples of such activities include:

- **Use of new research infrastructure**, including academic and applied research. Infrastructure was used primarily by the grant holder organisation but was also occasionally reported as used by partner organisations and members of the public as well, particularly in the case of the CapCo Impact Awards.
- Grant holders reported they had **recruited and retained staff** to support the use, operation and maintenance of the new equipment and infrastructure. Though not directly supported by the WCL grants, this activity is important for grant holders and users to measure the outputs and outcomes realised and expected.
- To support the use of this new infrastructure, grant holders have supported the **training and upskilling of users and staff** in new research techniques, new software use and in day-to-day operation and maintenance of the equipment. Users included internal staff and partner organisations, though some grant holders also reported training students how to use the new infrastructure.

The primary outputs of the grants are those that emerge directly from the implementation and use of the WCL supported investments. The outputs presented below have either emerged based on our evaluation and are documented in our findings or are expected to continue to

emerge in the months following the end of the grants. There are four main (headline) outputs from the three funding strands:

- **New, and improved data sources** as well as an **improved quality and quantity of data** have emerged. This includes new analytical techniques, new databases and data collected through imaging and surveying of artifacts
- **New and improved research and analytical methods** have emerged, as organisations make use of new infrastructure. This includes improvements to techniques and the uptake of new technologies to support research activities.
- **Digitised collections** have emerged, as organisations make use of the equipment provided under funding.

Main assumptions and risks: Most of the listed outputs have already been documented throughout the course of the evaluation, either in the survey of grant beneficiaries, case studies, ResearchFish data or in monitoring data collected by AHRC. Where projects are ongoing, these listed outputs should be expected upon completion of the projects. As such, this does not rely on strong assumptions. A minor risk for some applicants has been supply chain delays or delays in construction work on large research infrastructure and facilities that have limited the number of outputs from projects.

Outcomes

There are 21 main (headline) **short-term and long-term outcomes** from the programme strand. This evaluation has collected emerging evidence of some of the short-term outcomes that have been realised to date as a result of AHRC WCL funding. Where this evidence is not yet available, assumptions have been made to anticipate what outcomes might be achieved going forward. To aid in the presentation and discussion of these outcomes as they relate to the Theory of Change, they have been grouped into outcome areas as presented in previous sections.

Research Outcomes

- An **increased accessibility of data** for researchers has been documented, including the establishment of open access data bases, data sharing platforms and standardised data formats. As these databases continue to be populated, they are anticipated to facilitate the storage, retrieval, and dissemination of data from various sources. In the long-term, standardisation may also enable data integration, comparison and analysis and make it easier for researchers to combine data from multiple sources to derive new, meaningful insights into historic materials.
- **New, high-quality publications**, including peer reviewed journal articles and presentations at academic conferences.
- There is emerging evidence for an **enhanced reputation for research organisations,** leveraging both the announcement of the WCL investments themselves and the publication of new journal articles and conference papers. An enhanced reputation and increased visibility are anticipated to support organisations with 'in-house' capabilities as experts within the field. For smaller organisations, this may also help them to attract new researchers and staff.
- WCL supported equipment and facilities have enabled grant holders to **expand the scope of their research**, both through providing new or easier access to data sources, or enabling grant holders to work more efficiently with their existing resources.
- An **increased competitiveness of research** is observed, as new infrastructure, equipment and technical skills enables organisations to undertake increasingly complex research

projects. Advanced capabilities afforded by equipment have enabled researchers to conduct their research with higher precision and accuracy.

- There is also some evidence of an increased competitiveness of research leading to the **leveraging of further grant funding**. To date, evidence points to public funding as the source of future support, particularly for the heritage science sector. There is some evidence of industrial co-funding from the creative sector, although this is quite limited. This is expected to increase as projects mature and build new research proposals and will likely continue to emerge beyond the duration of the programmes.

Skills Outcomes

The training of staff within the grant holder organisations has led to upskilled staff. In the short-term this will be more focused on those teams who are directly responsible for the operation and use of the equipment, but in the longer-term may also spill over to wider staff in the organisation.

- Investments in new equipment have supported **new and improved training** for the upskilling of staff, students and users. New equipment has provided staff and students with hands-on experience to learn how to operate and troubleshoot complex instrumentation, develop experimental protocols, and interpret results effectively. WCL grant holders have also provided examples of training courses being made available to wider users. Considering the advanced nature of the funded equipment, specialised training modules dedicated to new equipment may be expected to emerge in the long-term.

Collaboration and Partnership Outcomes

- **New and enhanced partnerships** have formed across academia, GLAM and heritage science, as well as between businesses and academia as a result of these WCL grants. These new collaborations and partnerships could also be with **international** or **local** partners.
- There is some evidence to demonstrate that the WCL grants have also supported increased coordination and **collaboration within grant holder organisations**, helping to bring previously disparate teams together to work on new projects. Where work was previously carried out in a siloed fashion, new infrastructure and dedicated workspaces have allowed staff to collaborate on shared research goals to leverage collective skills and resources towards shared research challenges.
- As improvements in the internal alignment of staff work continue to emerge, it is expected that organisations will develop **an improved capacity to collaborate and address common challenges**. By collaborating within the organisation and with new partners, organisations are anticipated to better match the skills and abilities of research organisations with sectoral needs in the long-term. Cross-collaboration between organisations could also facilitate the exchange of ideas, methods and technologies that emerge from research activities.

Innovation and Economic Outcomes

- An **increased efficiency of research** has been documented, as the cost of conducting research has decreased (both in time and monies) and the volume of research has increased.
- **New products and services** have emerged to a limited degree throughout the evaluation. This includes those products and services developed and provided by grant holding organisations. For example, some grant holder organisations have developed a cost-recovery model that charges bench fees and project rates for the use of their equipment. In the longer term, collaboration with industry and industrial use of WCL equipment may also support the development of new products and services.

- New industrial partnerships and new products and services have in some cases resulted in **commercial contracts** and may lead to more in future. These are anticipated to emerge beyond the lifetime of the programme as WCL supported projects continue to mature and industrial use of facilities increases.
- New economic offerings and services may provide important sources of revenue for creative and cultural institutions, including museums, galleries, and studios. In addition to increased capacity and reputation, and leveraged funding, this may **increase the resilience of small, specialist institution (SSIs)** and enable organisations to achieve greater financial sustainability in the longer-term.

Societal Outcomes

- **Increased public engagement** has been documented. Organisations have shared their research findings in exhibitions, new cultural resources, and educational seminars. It is anticipated that such engagement activities will foster a deeper understanding of historical materials. In addition, it is anticipated that engagement with the public will increase support for the sectors and for students. New knowledge about the variety of research and artifacts may increase the attractiveness of a career in the creative arts or cultural heritage.
- An **increased accessibility of collections** has emerged from some projects funded under AHRC WCL investments. Digitising collections by creating high-quality digital images, documents and records has allowed broader access to cultural heritage materials for both researchers, particularly through the provision of open access databases and models.
- WCL enabled research has already supported research and analysis activities leading to **improved understanding of historic materials**, to the benefit of wider society.
- WCL funded facilities and equipment have enabled projects and research focussed on working with communities and issues that had previously been underexplored or under engaged. As a result, the WCL grants are supporting the development of **more inclusive cultural narratives**. As the number and scale of projects that use WCL funded facilities and equipment increases, this is expected to continue to grow in the coming years.
- New advanced equipment could lead to improved **sustainability of research practices,** enabled by improved understanding of conservation practices, supporting 'greener' analytical techniques and the generation of less waste during research.

Main assumptions and risks: Outcomes are already observed through evidence collected throughout this evaluation. However, some long-term outcomes are also expected to materialise beyond the life of the programme. As such, they rely on stronger assumptions and are affected by other external factors. The main assumptions and associated risks are:

- Organisations have the capacity (i.e. monies and resources) to support the staffing required to use equipment and realise continued outcomes. As such, a major risk, at this point in time, is the limited number of public funding opportunities within the creative, cultural and heritage science sectors. This would likely limit further research activities, as well as a number of longer-term outcomes.
- The increased engagement with the public on themes of the creative, cultural and heritage science sector will also depend on the appetite of the public to engage on these topics. A related assumption within this is that a better explanation of what heritage science is, for example, will lead to greater uptake from the public. Both of these are grounded in the assumption that this demand exists.

Impacts

The complete impacts of the AHRC WCL investments have not fully materialised to date. However, the evidence collected on emerging outcomes can be used to anticipate what

long-term impacts might be realised over time. Achievement of these higher-level results is dependent on a number of external factors and other funding initiatives, investments and drivers. A programme of this relatively modest scale cannot be expected to be held to account for achieving a measure of improvement in the UK's economic growth. It can, however, contribute to it. These main impacts include:

- Increased innovation and economic offerings may result in new sources of revenue for the creative and cultural sectors. Additionally, increased economic activity could stimulate job creation and economic growth in areas such as cultural tourism and the creative industries. In combination with other public funding programmes, such as RICHeS, Towards a National Collection and CoSTAR, as well as external drivers, the programme is expected to contribute to **building the UK's creative economy.**
- **New data infrastructures to inform the challenges of our time,** including climate, health, and wellbeing are expected to be informed by project activities and outputs. New open access database and models, digitised collections and creative new online engagement models will contribute to building new data infrastructures. Culture can be used as a conduit for public engagement, with artists, cultural and creative practitioners playing a crucial role in addressing complexity and confronting challenges with the public in new and engaging ways.
- An enhanced reputation for organisations, combined with a newly upskilled workforce with improved public engagement activities are expected to contribute to an **improved recognition of and engagement with the creative, cultural and heritage science sectors.**

Appendix A AHRC WCL Portfolio Analysis

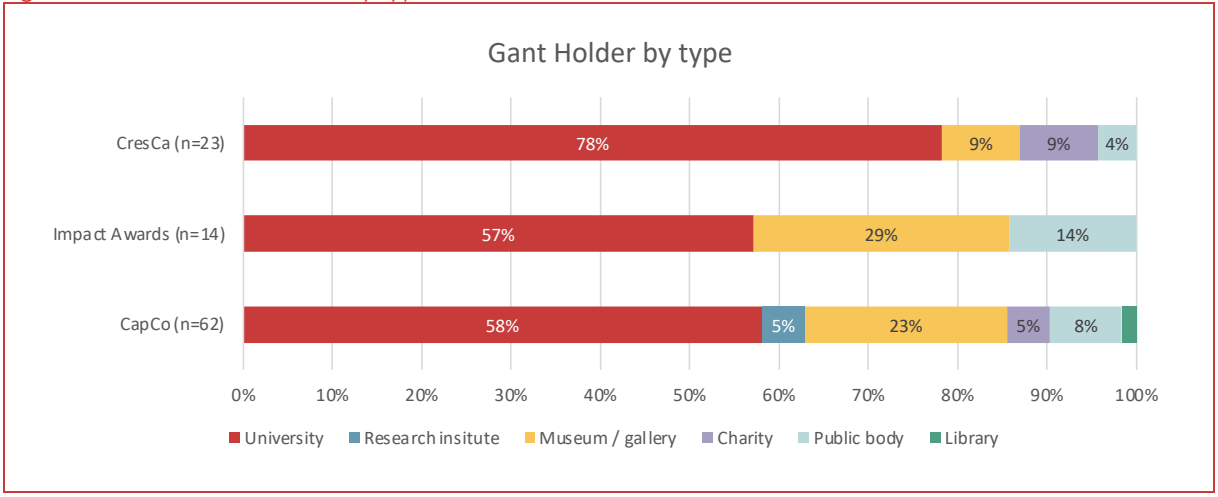
A.1 WCL Awarded Projects

The AHRC World Class Labs investment comprises three strands:

- Capability for Collections (CapCo)
- CapCo Impact Awards
- Creative Research Capability fund (CResCa)

To date, these three sub-programmes have awarded a total of 99 grants to a range of organisations delivering and supporting cultural and creative heritage research activities. Figure 6 and Table 2and below provides an overview of the distribution of grants according to the grant holder organisation type.

Figure 6 WCL - Grant holder by type



Source: AHRC WCL grant data

Table 2 WCL – Breakdown by institute type

Institute type	**CapCo**		**Impact Awards**		**CResCa**	
	Grants per type	Grants per type %	Grants per type	Grants per type %	Grants per type	Grants per type %
University / training	36	58%	8	57%	18	78%
Research institute	3	5%	0	0%	0	0%
Museum / gallery	14	23%	4	29%	2	9%
Charity	3	5%	0	0%	2	9%
Public body	5	8%	2	14%	1	4%
Library	1	2%	0	0%	0	0%
Total	62	*100%*	*14*	*100%*	*23*	*100%*

Source: AHRC WCL grant data

Table 3 WCL - Institutes receiving one or multiple grants

Number of grants per institute	CapCo		Impact Awards		CResCa	
	Number of institutes	Number of institutes %	Number of institutes	Number of institutes %	Number of institutes	Number of institutes %
One grant	38	76%	14	100%	23	100%
Two grants	12	24%	0	0%	0	0%
Total	*50*	*100%*	*14*	*100%*	*23*	*100%*

Source: AHRC WCL grant data

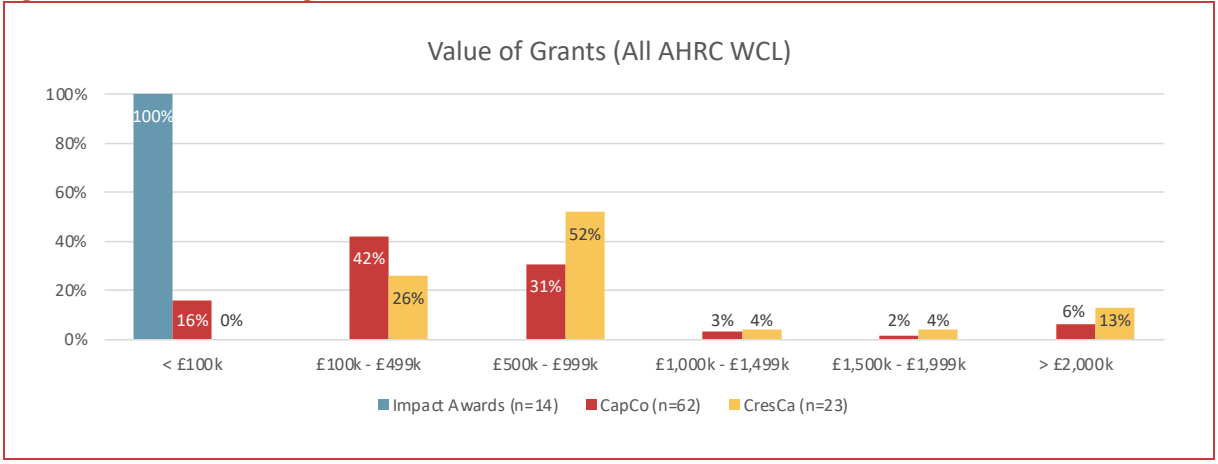
Each of the sub-programmes awarded grants according to different strands of activity, with different amounts of funding available to support different activity types. These are detailed in Section 2 of the main report. The table and figures below provide an overview of the value of AHRC WCL grant value. CapCo Impact Awards were a public engagement funding opportunity to support operations costs of collections-led research that had previously been supported through the CapCo fund. Applicants could bid for up to £35,000 and as such, constituted the majority of awards under £100,000.

Table 4 WCL – Grant value summary

	CapCo (n=62)	Impact Awards (n=14)	CResCa (n=23)
Mean	£136,712	£29,188	£1,100,604
Median	£121,022	£28,292	£892,776
Min	£23,968	£16,580	£150,789
Max	£291,136	£36,813	£3,887,065
Total	*£37,482,664*	*£408,638*	*£25,313,898*

Source: AHRC WCL grant data

Figure 7 WCL – Value of grants



Source: AHRC WCL grant data

Table 5 WCL - Breakdown by grant value

Range	CapCo		Impact Awards		CResCa	
	Grants in value range	Grants in value range %	Grants in value range	Grants in value range %	Grants in value range	Grants in value range %
< £100k	10	16%	14	100%	0	0%
£100k - £499k	26	42%	0	0%	5	22%
£500k - £999k	19	31%	0	0%	12	52%
£1,000k - £1,499k	2	3%	0	0%	1	4%
£1,500k - £1,999k	1	2%	0	0%	1	4%
> £2,000k	4	6%	0	0%	3	13%
Unspecified / not found	0	0%	0	0%	1	4%
Total	*62*	*100%*	*14*	*100%*	*23*	*100%*

Source: AHRC WCL grant data

Grants across each of the sub-programmes were funded across the UK, with the majority for both CapCo and CResCa located in London and the greater southeast.

Table 6 WCL – regional distribution of grants

Region	CapCo		Impact Awards		CResCa	
	Grants per region	Grants per region %	Grants per region	Grants per region %	Grants per region	Grants per region %
East Anglia	2	3%	0	0%	2	9%
East Midlands	4	6%	0	0%	0	0%
London	23	37%	5	36%	0	0%
North East	5	8%	2	14%	0	0%
North West	3	5%	1	7%	2	9%
Northern Ireland	1	2%	0	0%	0	0%
Scotland	8	13%	2	14%	1	4%
South	3	5%	0	0%	0	0%
South East	4	6%	1	7%	0	0%
South West	2	3%	1	7%	4	17%
Wales	3	5%	1	7%	1	4%
Yorkshire	4	6%	0	0%	1	4%

London & Greater South East	0	0%	0	0%	9	39%
West Midlands	0	0%	0	0%	3	13%
Total	*62*	*100%*	*14*	*100%*	*23*	*100%*

Note: Regions listed as they appear in the AHRC WCL grant data

A.2 Profile of Unfunded CResCa Applications

In addition to the 23 grants already awarded, as of March 2024 there are 25 fundable projects that have not yet received support but will be awarded whenever budgets become available. A summary of the number of grants and funding disaggregated by strand is summarised in the table below.

Table 7 Summary of number and value of unfunded CResCa grants

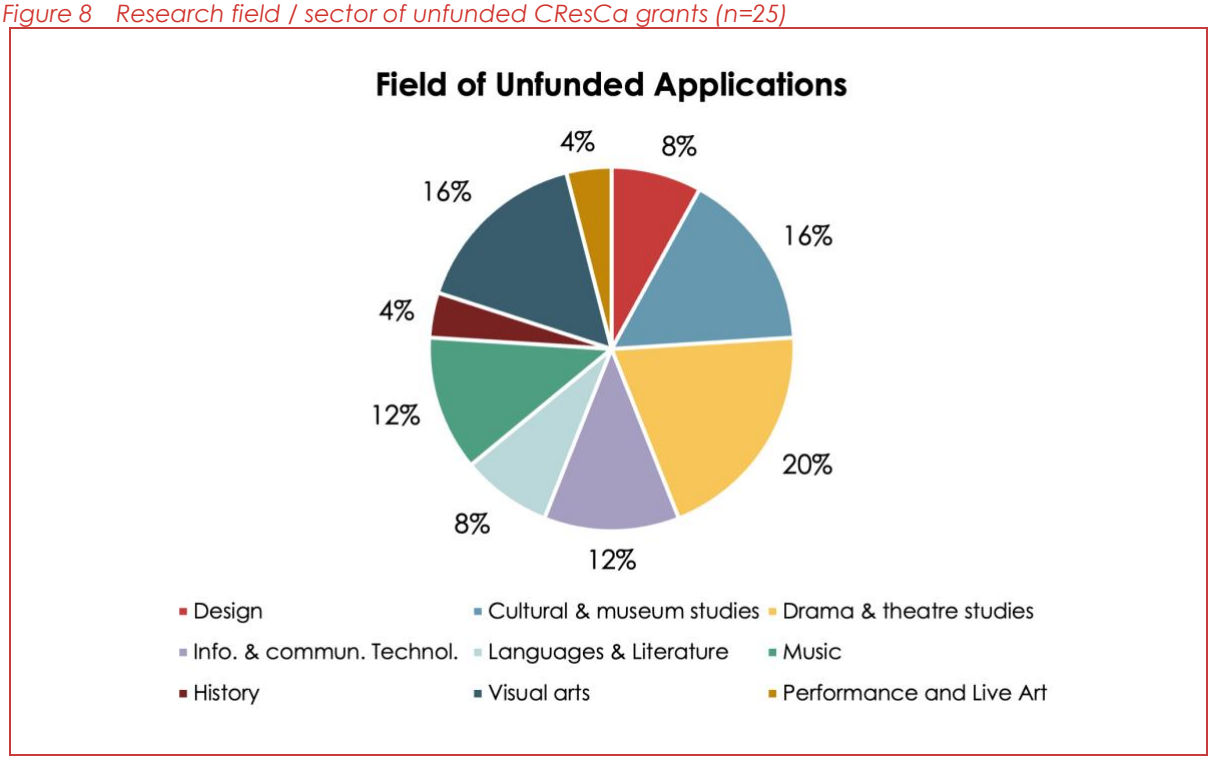
	Number of grants	**Funding**
Strand 2	12	£19.9m
Strand 3	13	£93.8m
Total	25	£113.7m

–

The majority of unfunded grants are to universities (88%), with theatres, charities and other Higher Education Institutions (HEIs) constituting the rest. Though 56% of these projects (n=14) were applications from institutions that had already received funding under either CapCo or CResCa, the remaining institutions had not received other WCL funding.

As shown in the figure below, the research fields of these unfunded CResCa grants is fairly equally distributed amongst a range of different areas.

Figure 8 Research field / sector of unfunded CResCa grants (n=25)



Source: Application data collected by AHRC

Appendix B Case Studies

To further substantiate the outcome claims made by the grant recipients and provide detail on the pathway to realising these benefits, we have developed a set of 10 case studies.

A longlist of ~13 potential case studies were identified through purposive sampling, drawing from the survey and from analysis of the programme data, and selecting those projects with identified outputs and outcomes in key areas of interest. The selection of the portfolio of case studies seek to cover a range of benefit types and coverage of:

- Each of the three sub-programmes
- Examples of projects that have realised spillover benefits to other sectors
- UK geography

The list of potential case studies was discussed and approved by AHRC at the Interim Workshop on the 20th of February 2024.

Case studies were drafted based on the programme data provided (e.g., grant data, AHRC success quarterly reporting inputs, or ResearchFish data if available), survey responses from grant holders, interviews with the project participants and wider desk research. Where appropriate, the project coordinators of WCL grants were also asked to identify and recommend any partners, wider stakeholders, or users of the infrastructure to also be interviewed and contribute to the case study.

The case studies follow a standard format, reflecting the outcome areas set out in the body of the report above. Short extracts have been included in the body of the report above to illustrate outcomes and benefits in particular areas, though many case studies have realised and expect benefits across a wider range of outcome areas.

Though presented as evidence against one of the impact areas, many of the case studies also demonstrate impact in another area as well. The table below provides an indication of the strongest and most interesting impact areas each case study illustrates.

Table 8 Case study outcome areas

Case	Project Code	Strand	Title	Organisation	Impact Area				
					Research	Skills	Collaboration & Partnerships	Innovation & Economy	Societal
1	AH/V012398/1	CapCo	Equipping the Vision of Kelvin Hall	University of Glasgow			x		x
2	AH/V01255X/1	CapCo	Capability for Human Bioarchaeology and Digital Collections	University of Bradford	x		x		x
3	AH/V012487/1	CapCo	Historic Royal Palaces' Heritage Science Laboratory Equipment Upgrade	Historic Royal Palaces	X		X		
4	AH/V011936/1	CapCo	GLAMTech: Technologies for Gardens, Libraries and Museums Collections Research	University of Oxford	X		X		
5	AH/V011758/1	CapCo	Refresh and upgrade of analytical optical microscopy and associated imaging capabilities for heritage science research.	Historic Buildings and Monuments Commission for England		X		X	
6	AH/V012673/1	CapCo	Enhancement of equipment-based research and conservation capability for Amgueddfa Cymru-National Museum Wales.	National Museum Wales	X	X			
7	AH/X009890/1	CResCa	Building networks for creative and cultural responses to historic pollution and climate change research	University of Nottingham			x		
8	AH/X01021X/1	CResCa	On-Demand Design & Manufacturing of Customised 3D Fashion & Textile Products	University of Leeds				X	X
9	AH/X009912/1	CResCa	Performance Lab: Innovating Practice-led Research and Development in Immersive and Digital Technologies in Theatre and Performance	Royal Central School of Speech & Drama	x		x		
10	AH/X010104/1 /AH/X000370/1	CResCa/ Impact Award	Creating Immersive Experiences / Eternal Connections	Historic Environment Scotland		x			x

B.1 Equipping the Vision of Kelvin Hall

Summary

The University of Glasgow was awarded a CapCo grant to upgrade and purchase necessary equipment to support collections-led and Cultural Heritage and Conservation Science research activities. This included high-resolution microscopes and spectroscopic mapping which was co-located alongside collections at Kelvin Hall. The investment catalysed a significant enhancement in research capabilities for Professor Cristina Young and her research team, allowing for technical assessments of artefacts and artwork that were previously unattainable. The investments also represented an enhancement in the reputation of the organisation, leading to increased internal appreciation of the research and an alignment of staff working within the organisation. Externally, an enhanced reputation attracted new partnerships with museums and charities.

As a result of an expanded scope of research, the grant holder and collaborators held events to both technical specialists and the public. As a result, collaborators and attendees reported closer ties between the community and heritage science research and anticipated future events of a similar nature.

While economic benefits are currently limited, new partnerships with the Royal Opera House are expected to yield cost-saving benefits. In a strengthened position, the University can now offer analytical services to other organisations and provide them with research evidence to inform their strategic decision-making.

Currently, the largest barrier to the realisation of further benefits to this grant are the limited number of follow-on funding opportunities for the creative and cultural heritage sector for staff.

The grant

The University of Glasgow holds one of the most significant research collections in Scotland, encompassing the Hunterian, the Archives and the Special Collections holdings of the university library.[9] At the core of their research collections is Dr William Hunter's bequest that created the museum. The original collection has since grown substantially, and the collections today include Roman artefacts from the Antonine Wall and ethnographic objects from Captain Cook's Pacific voyages. [10,11]

Kelvin Hall, located in the centre of Glasgow, is a landmark building that has been transformed into a shared space for research, teaching, and training. Importantly, Kelvin Hall made one of the National collections (National Libraries of Scotland Moving Image Archive) publicly accessible outside of Edinburgh for the first time. Around 1.5 million items, including artwork and artefacts, have been relocated from stores around Glasgow to a purpose designed study and storage facility for the University of Glasgow at Kelvin Hall.

Though Kelvin Hall was refurbished in 2016, the provision of research equipment was not included. AHRC's CapCo grant, awarded in February 2021, was utilised to purchase and upgrade state-of the art instrumentation that was used to integrate and enhance provision in the research and teaching of Cultural Heritage Science and Conservation at the University of Glasgow, within the College of Arts. Led by Professor Christina Young, the Principal Investigator, and Dr John Faithfull of the Hunterian (who has since retired), the funding supported the purchase of a suite of new specialised instrumentation.[12] Equipment was purchased in June of 2021 and subsequently installed in the lab. This included a range of high-resolution

[9] https://www.gla.ac.uk/hunterian/

[10] https://www.gla.ac.uk/hunterian/collections/permanentdisplays/theantoninewall/

[11] https://www.gla.ac.uk/hunterian/collections/collectionssummaries/archaeologyandworldcultures/worldcultures/

[12] https://www.gla.ac.uk/news/archiveofnews/2021/june/headline_795718_en.html

microscopes, an imaging Fourier Transform Infrared Spectroscopy (FTIR) for mapping multi-layered painted or coated surfaces, and instruments for non-invasive analysis, including pigment identification, surface relief and texture characterisation, quantifying the degree of light fading of object surfaces.

Prior to the AHRC WCL lab grant, the research team sourced equipment required for complex analysis from across various departments at the University, was loaned out from other institutes, or small samples were sent to collaborators to be analysed. With the CapCo grant, the research team now had access to these capabilities 'in-house', enabling them to conduct a wider scope of research more efficiently. From the perspective of the Professor Young, this new equipment was vital to ensuring that the University of Glasgow and the Hunterian remained competitive and up to date in terms of their technical capabilities for heritage and conservation science.

Research

The equipment funded under the grant, particularly the mapping FTIR capabilities, constituted a step-change in the quality and quantity of research that could be undertaken at the University of Glasgow.

Professor Young noted that prior to AHRC funding, the number of research projects the team could undertake were limited and mapping FTIR and Raman capabilities were outsourced.

The new equipment and the associated analytical software have facilitated new technical assessments of artefacts and artwork. Professor Young reported that a total of 20 research projects have been carried out since the installation of new equipment, including for example, the analysis and restoration of a painting by John Hoyland in the Hunterian Gallery.[13]

Grant funding also enabled an expanded scope of research for the University of Glasgow and the research team, where the advanced analytical techniques afforded by new equipment has enabled the team to take on projects that they were previously unable to do. For example, the team worked with the Hunterian's numismatic (coin) curator and University College London to determine the provenance of Roman coins. Using reflectance transmission imaging systems (RTI) purchased through grant funding, the team examined the coins for marks of tooling to determine whether they were genuine.

Despite these benefits, the research team at The University of Glasgow have found the lack of funding for research staff, including post-doctoral positions to be a barrier to realising additional and continued research benefits. As AHRC WCL investments were for capital expenditure only, the research activities of the group were also supported by other grants. The research teams were also supported by an EPSRC post-doctoral award and additional monies provided by the University of Glasgow. This makes attribution of realised research outcomes challenging, although new research equipment funded by AHRC WCL investments, including the FTIR instrumentation, played an important role in securing University funding.

Skills

From the perspective of the University of Glasgow, the upskilling of team members has been one of the most important outcomes emerging from the grant funding. The new equipment has provided staff at the Hunterian and within the College of Arts with the opportunity to train on state-of-the-art equipment. Professor Young noted that funding for both hardware and software enabled staff to learn new data collection methods as well as new data interpretation and analytical skills. The research team were then able to apply these new capabilities to arrive

[13] https://www.youtube.com/watch?v=LFNv00lfxSI

at more detailed and nuanced technical analyses of artefacts and paintings, as well as develop new research methodologies.

Post-doctoral researchers who were upskilled and trained on the funded equipment increased their competitiveness for future jobs. By funding the purchase of advanced equipment, post-docs were trained and were able to demonstrate their ability to both collect and analyse complex datasets. Professor Young reported that recent post-docs had secured research positions at UCL, the Victoria and Albert Museum, and the University of Rochester, and partly attributed their success to their new capabilities. From the perspective of the grant holder, these new positions from former post-docs and staff also supported networking with national and international research organisations. Despite the upskilling of the workforce within the lab, Professor Young also noted that staff turnover (due to awards coming to an end) acted as a barrier to continuing to realise benefits. Significant time and resources are invested in training new users, and key institutional knowledge is lost when staff move on to new jobs. As such, Professor Young reiterated her preference for additional funding for operational costs, including staff support.

Collaboration & Partnerships

University of Glasgow's CapCo grant has supported the enhancement of existing partnerships and the development of new partnerships. In having access to these 'in-house' capabilities, the research team have been able to better position themselves as experts within the field for future work and collaborations.

Within the University of Glasgow, Professor Young noted that new equipment has allowed the research group and the Hunterian to be more closely aligned in the analysis and conservation of the collection. Importantly, this grant funded equipment to be co-located alongside collections and teaching facilities. In doing so, both the collections staff and the research group were better able to match the needs of the collections, for example in curation needs, with the capabilities of the group. Partners at the Hunterian and the grant holder indicated that they anticipated collaborations to continue beyond the lifetime of the grant funding.

New collaborations facilitated by grant funding have extended benefits beyond the grant holder organisation. Professor Young has been conducting research on a series of paintings owned by Argyll and Bute Council, working in partnership with the regional culture support charity, the Culture, Heritage & Arts Assembly, Argyll & Isles (CHARTS). The charity is currently leading a review of the cultural significance of the Argyll Collection, including this collection of painting s hich was created as an education resource located throughout Argylls schools from the 1960s. The paintings offer an opportunity for Professor Young and her team to test new research methodology through the use of AHRC funded equipment.

The results of this research enable CHARTS to identify misattribution of artwork and provides them with a better understanding of conservation requirements. From CHARTS's perspective, the research support provided by Professor Young was vital for supporting their educational mission. Building on this initial collaboration, there are ongoing plans to develop a series of educational resources using the results of the research. These resources would then be distributed to teaching staff and others, for example professional artists worrying in schools and communities with the collection, to increase the engagement of students and the public with the artwork. CHARTS indicated that this was particularly valuable for students in the Argyll and Bute area, who have few accessible museums and galleries outside of these educational collections to interact with.

Innovation and Economic Benefits

The grant holder reported that at this point in time, outcomes related to innovation and economic benefits were limited. This was attributed in part to the short timeframe since grant

funding and to the limited industrial collaborations and applications of research in the heritage science sector.

University of Glasgow have however, realised efficiency and productivity benefits in terms of their research. Professor Young noted that prior to investments, analysis was sometimes outsourced to collaborators, costing the group the equivalent of £500 a day. Bringing capabilities 'in-house' enabled the organisation to direct their limited resources towards other research activities. Notably Professor Young indicated that without the equipment, other research would not have happened as they would not have been able to afford the day rates for shared equipment.

Both collaborators and the grant holder pointed to potential economic benefits that are arising for other organisations as a result of new collaborations. Professor Young's research group is supporting the Royal Opera House (ROH) with the analysis of large, painted canvases that are used as backdrops in theatrical productions.

The ROH noted that the storage process of these painted canvases is believed to be contributing, in part, to the decreased lifetime of the canvas and are speeding up the degradation process. The ROH shared that in recent years, the restoration of a tranche of such canvases could cost up to £250,000 and represented a significant financial burden for the organisation. As such, if the University of Glasgow's new capabilities are able to support the better understanding of how to care for these canvases, and inform the storage, preventative care and restoration of their painted canvases, there is potential to support significant cost-savings in the future.

Societal Benefits

This CapCo grant at the University of Glasgow has provided a platform for closer ties between the research community and the public, both in Glasgow and across schools in Scotland.

In collaboration with the Hunterian at the University of Glasgow, the research group has put together programming and events to present the results of research collaborations. For example, a collaborator at the Hunterian shared that a research talk was held to present the technical elements of conservation and paint analysis of a John Hoyland painting. New research insights afforded by new equipment enabled knowledge sharing activities and the engagement of the wider heritage science community. Feedback from attendees suggested that the event will be used as a model for other Scottish research organisations to continue to engage the public on issues relating to heritage science research.

Another event, geared towards the public, demonstrated the new microscope that was funded under AHRC WCL grants. A collaborator at the Hunterian reported that the event shared the value of the new instrumentation to the University of Glasgow and Kelvin Hall more broadly and encouraged public engagement with the creative and cultural sectors. From the perspective of the Hunterian, the research carried out on the Hoyland painting and the subsequent presentations functioned as a pilot for new ways of engaging audiences and anticipated that new work would continue as a result.

Reflecting on these experience and others, both the grant holder and collaborators indicated that they had seen an increase in the number of participants engaging with their cultural heritage and arts activities.

Conclusions

The CapCo grant awarded to the University of Glasgow has served as a catalyst for the enhanced research capability and capacity of Professor Cristina Young and her research team. State-of-the-art instrumentation, supported by grant funding, has brought the tools

required for complex research and analysis 'in-house'. Having these capabilities has enabled the research group to better position themselves in the field for future work and collaborations.

Grant funding has supported the development of new partnerships and collaborations, which in turn has expanded the scope of research conducted by the group. Locating the equipment alongside collections and archives has also matched the capabilities of the University with the needs of the collections and enabled an internal alignment of research priorities.

The grant holder noted that the development of and the upskilling of staff and post-docs was one of the most important outcomes emerging from grant funding. Providing early career researchers with the opportunity to train on advanced equipment allowed them to simultaneously upskill and provide them with valuable experience that made them more competitive for future jobs.

Benefits have also emerged beyond The University of Glasgow. AHRC WCL funding has increased the visibility of the research group and has led to the development of new partnerships and collaborations who also reported benefits to their own organisation. CHARTS, for example, reported that with the research support from the University of Glasgow, they were able to identify cases of misattribution within their collection and build educational resources for students with limited access to museums and galleries. The Royal Opera House, on the other hand, intends to use research to make strategic decisions around the storage of important artefacts and anticipates significant cost-savings for the organisation.

Looking ahead, the grant holder shared that for continued outcomes to be realised beyond the life of the grant programme, sustained investments and support for cultural and heritage science research, including operational expenditure costs, are important to build upon the foundations laid by the grant.

Sources:

- Interviews with:
  - Christina Young, Principal Investigator, Professor of Conservation and Technical Art History
  - Emma Troubridge, Head of Scenic Arts, Royal Opera House
  - Rosalyn McKenna, Project Manager, CHARTS Argyll and the Isles
  - Lola Sanchez-Jauregui, Curator of Art The Hunterian
- AHRC Monitoring Survey, collected in December 2023
- Evaluation of AHRC WCL – grant holder survey (Technopolis and BOP), January 2024

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- Introduction to the Wonderful Cultures Collection, the Hunterian, Available at : https://www.gla.ac.uk/hunterian/collections/collectionssummaries/archaeologyandworldcultures/worldcultures/ [Date accessed: 15/3/2024]
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- Restoring a John Hoyland Painting - The Hunterian Gallery, Glasgow, Available at: https://www.youtube.com/watch?v=LFNv00lfxSI [Date accessed: 15/3/2024]

B.2 Capability for Human Bioarchaeology and Digital Collections

Summary

The University of Bradford was awarded a CapCo grant to upgrade their facilities and equipment to advance capabilities in archaeological technology and research. The grant funding allowed the institution to purchase the first-ever FujiFilm NewTom 7G cone beam CT unit in the country, along with a Zeiss MetroTom 1500 micro-CT facility that is only the second such instrument in UK universities. Further investment allowed the upgrade of their mobile mapping capabilities and immersive technology infrastructure.

The upgrades funded through CapCo allowed the University to develop its data sharing and data capture capabilities, feeding into their educational offer and providing upskilling opportunities for both staff and students. It supported Bradford in securing further funding, increased their visibility, and enabled the strengthening of partnerships. The University of Bradford is now working closely with the local authority on a variety of legacy projects towards Bradford City of Culture 2025 and beyond.

The awardee is looking to further develop their capabilities and integrate these into arts and humanities research through initiatives like the RICHeS programme.

The grant

The University of Bradford has a significant digital heritage collection, generated from their collection of human skeletal remains, 3D replicas of heritage sites and museum collections, and large-scale marine and terrestrial landscape surveys.[14] The School of Archaeological and Forensic Sciences has been conducting pioneering work in human bioarchaeology and archaeological technology, for which it was recently awarded a coveted Queen's Anniversary Prize for Higher and Further Education. [15]

The university's digital heritage capabilities were catalysed by the *Digitised Diseases* project, which allowed researchers to access digital 3D models of human skeletal bone modifications, minimising the potential damage to the remains that could otherwise result from handling and analysis. However, over time, the accessibility of this digital collection has become limited by outdated technical infrastructure.

To expand access to the collection by researchers, educators, and the public, as well as improve quality and increase quantity of their data, the university used their CapCo grant to upgrade their data sharing and data capture technologies underpinned by a Dell Powerscale research storage infrastructure. They purchased the first cone beam CT scanner of its type in the UK, along with one of only two micro-CT facilities in universities in the country.[16] A range of devices complement this equipment to enable better sharing and interpretation of the generated data. The new capability not only advances the research capabilities of the University of Bradford, but also increases access to data by users outside the institution and supports strategic digitisation efforts at both a national and international scale.

This investment strengthened the work of Visualising Heritage, a research cluster at the University[17], and the University's position as a leading hub for imaging in human bioarchaeology research, supporting the advancement of its research activities and enhancing collaboration with a range of partners.

Research

[14] https://www.bradford.ac.uk/news/archive/2022/3m-archaeology-grant-to-boost-bradfords-digital-research-capability.php

[15] https://www.bradford.ac.uk/research/queens-anniversary-prize/

[16] https://www.bradford.ac.uk/news/archive/2022/first-ultra-high-definition-ct-scanner-of-its-kind-in-the-uk-will-be-used-on-mummies.php

[17] https://www.bradford.ac.uk/research/impact/ref-2021/visualising-heritage/

CapCo funded infrastructure has been utilised across a range of AHRC funded projects and other research activities of the university. The funding facilitated the installation of the UK's first FujiFilm NewTom 7G cone beam CT unit, in both clinical and non-clinical settings. This technology facilitates the rapid capture of cross-sectional data, particularly beneficial for examining large assemblages unearthed during major infrastructure projects. The grant holder viewed this development not only as one that expands their collection of data but also as a significant contribution to national digitisation efforts. It underscores the commitment of researchers to thorough examination of material using non-destructive testing and minimally invasive sampling methods, prior to measures (such as reburial) that may eventually place excavated remains beyond reach.

The cone beam CT is complemented by the Zeiss MetroTom 1500 micro-CT, one of only two such devices in universities in the UK, thus offering both speed of capture for large assemblages and resolution where needed. This combined capability supports the efforts of the grant holder to examine human remains and capture fine histological detail non-destructively. Further contextual data for human remains assemblages was provided by investment in updated geophysical prospection and mobile mapping capabilities that unite both above-ground and below-ground heritage assets. This includes the UK's first TRK 700 EVO mobile mapping system and the world's highest resolution mobile mapping camera – the first Mosaic Viking system in any university. Such an approach optimises the utilisation of these finite resources by ensuring the preservation of a permanent contextualised record for future study.

The volume of high-resolution data that are captured with the new instrumentation necessitated further investment in digital storage infrastructure. With the acquisition of a Dell PowerScale System, the grant holder was able to develop their digital documentation capabilities that help to document heritage sites (buildings, monuments, sites and landscapes), as well as invest in an immersive 7-metre iGloo cylinder and Soluis Reality portal for shared immersive experience for use with training and outreach. This allowed the utilisation of digital twin technologies to move beyond the object scale. *Virtual Bradford*, a digital twin of the city, has united different capture methods employed by Visualising Heritage researchers within the School. *Virtual Bradford* is central to data-driven decision making within the Digital Strategy for Bradford Metropolitan District Council.

Collectively, the CapCo investment marks the establishment of one of the first dedicated facilities in the UK for archaeologists and heritage scientists to routinely use mobile mapping and conduct cross-sectional imaging of a variety of materials. Allowing merged and stitched capture, the new facility enables the integration of biological collections into both real-world and digitally reconstructed environments.

Leveraging funding successes from CapCo, and building on an expanding knowledge exchange portfolio, efforts are underway to integrate this national capability into arts and humanities research through initiatives like the RICHeS programme. Further leveraged funding includes support for further work on *Virtual Bradford*, with funds from West Yorkshire Combined Authority and via the PropTech Engagement Fund, a successful bid to the Department for Levelling Up, Housing, and Communities co-developed with Bradford Council. Trans-disciplinary work is exemplified through links with the Bradford Institute for Health Research and the landmark Born-in-Bradford project team behind a community-focused project recently funded by the Medical Research Council (MRC). The MRC-funded *HUP North* project focuses on the importance of *Healthy Urban Places* as part of place-based research to develop and support neighbourhoods and communities in both Bradford and Liverpool. Crossing over into the area of population health, it involves the intensive study of four locations within Bradford, exploring the lived experiences of residents in efforts to improve their life chances. According to the grant holder, the major infrastructure funding from CapCo enables such projects to shape the life of individuals and communities in Bradford.

While conducting research with cutting-edge instrumentation necessitates a comprehensive understanding of the potential and limitations of the equipment, the grant holder reported that allocating the necessary staff time and resources towards the procurement and testing of the kit was a challenge under CapCo. To explore and leverage the full scope of possibilities offered by digital technologies in their area of research, it is necessary to allocate resources for project work and exploratory research. According to Professor Wilson, the university was supported in these efforts through its partnership with the council, and this challenge could be met through additional funding through the RICHeS programme, enabling the university to support training and personnel requirements for working with such advanced equipment.

Skills

The grant holder reported that CapCo has enabled the training and upskilling of staff members, inclusive of an uplift in technician skills in non-destructive testing methods both within their school, as well as across other faculties at the university. Training has been conducted for students and researchers alike for the routine use of the cone beam CT and the micro-CT, which has also been incorporated into dissertation projects the institution offers at undergraduate, postgraduate, and doctoral level.

According to Professor Wilson, CapCo has been cited as a major draw for some of their students. A recent Irish graduate from one of the university's Master's programmes explained that she chose Bradford over other institutions because of the WCL investment through CapCo – and she has now joined the Visualising Heritage Team to work on both the PropTech and UK-Ireland project work. The success of CapCo infrastructure for student engagement is seen both through hands-on practical work with the geophysical prospection kit and with students who explore the applications of 3D capture techniques in their areas of study. For example, a three-hour practical session with forensic archaeology and crime scene investigation Master's students explored the relevance of capture technologies used within archaeology and heritage that may equally be deployed for recording crime scenes and presenting information to a jury. Similarly, discussions with second-year architecture students highlighted how such techniques and the development of digital twins have a bearing on their practice for designing new buildings.

In conjunction with AHRC funding, the university has allocated resources towards refurbishing two spaces to house the cone beam CT and micro-CT and invested in a high-performance computing cluster and new shared immersive visualisation spaces. This has allowed students not only to gain hands-on experience using cutting-edge equipment but also to work with the generated data to create visualisations, incorporating the new capabilities into their studies. According to Professor Wilson, this is often a two-way flow, and a recent PhD graduate has been instrumental in putting some of the new kit into service whilst embedded with the local authority as part of his internship, whilst funded by the AHRC Heritage Consortium.

Beyond university staff and students, the grant facilitated the training of local council officers who are regularly engaged in training sessions to familiarise themselves with the technology and its applications. The grant holder reported that the council actively participate in learning about capture methods and data manipulation techniques, working with data captured with the CapCo-funded kit. The strategic partnership between the University and the local authority represents a shared vision for the city, seeking directly to benefit the city's residents by enabling the council to utilise advanced technologies and digital twin technologies for urban planning.

Collaborations & Partnerships

Infrastructure development resulting from CapCo contributed to higher levels of knowledge exchange with sector bodies, as well as non-HEI organisations and local government. The grant holder is collaborating with Bradford Metropolitan District Council and the City of Culture team, seeking to ensure the success of Bradford 2025 and its legacy beyond. This entails both strategic-level cooperation and support towards major infrastructure projects within Bradford.

The university is planning to offer its facilities as fringe venues for immersive experience and other cultural engagement activities. To deliver on these aims, a member of staff from the School of Archaeological and Forensic Sciences has been seconded two days a week to be embedded with the City of Culture team and facilitate the strategic partnership with the university.

The close collaboration between the university and the local authority led to a successful funding bid to the Department for Levelling Up, Housing and Communities with two rounds of funding under the PropTech Engagement Fund. Professor Wilson regards these successes as opportunities for the trialling of immersive spaces and related datasets to inform master planning in the city. According to the grant holder, such initiatives would not have been feasible without the funding and enhanced capabilities at the university. Close partnership working has directly led to upskilling and investment by the local authority in the use of drones. These sit alongside advanced drone capture methods with scanning capability and steps towards automated capture, which includes a Boston Dynamics dog which can carry 3D scanners and mobile mapping technology as payloads. Collectively, these will be used in collaborative projects aimed at regeneration and enhancing the digital infrastructure of the city. Using their 3D printing and projection mapping methods, the university created a new immersive model of Saltaire, a UNESCO World Heritage Site, which is intended for display in a forthcoming Saltaire visitor centre, recently granted planning permission.

The University has partnered with higher education institutions, including University College Cork, the University of St Andrews, and the University of Dar es Salaam in Tanzania, sharing capabilities and skillsets with international partners on strategic AHRC initiatives that respond to place-based research, the UN Year for the Creative Economy and UK-Ireland Collaboration in the Digital Humanities. Professor Wilson reported that these funding opportunities had broadened the collaborations that CapCo enabled. These opportunities cross into MRC and EPSRC (Engineering & Physical Sciences Research Council) disciplines, expanding the reach of the University for establishing partnerships and collaborations. Partnerships are also developing with non-HEI partners, including the National Trust, Canal and River Trust, Royal Armouries and Science Museum Group.

Innovation & Economic Benefits

The CapCo grant facilitated the employment of a Business and Partnerships Manager, to maximise the potential of the WCL investment and of the subsequently secured RICHeS funding. The university was also able to engage a CapCo Champion to promote the opportunities afforded through the new infrastructure. These opportunities have then allowed the recruitment of additional Research Associates.

The formal launch event of the Capability for Human Bioarchaeology & Digital Collections in September 2023 attracted over 200 attendees to an open exposition event aimed at showcasing new state-of-the-art capabilities to inform the heritage community of opportunities to deliver world-class science and develop opportunities for collaboration and innovation in the UK. The event was predominantly attended by non-HEI organisations, allowing new conversations and opportunities for engagement. [18,19]

Societal Benefits

The University of Bradford and its School of Archaeological and Forensic Sciences have long focused their research activities on how technological innovation can serve policy and society.

[18] https://www.youtube.com/watch?v=LGPL0b_9Hqo

[19] https://www.youtube.com/watch?v=k8PfNZPEjHg

However, the grant holder reported that access to improved facilities and equipment enabled the expansion of this aspect of their work.

Partnering with the local authority to capture local heritage buildings at risk of being lost has led to the university developing a digital twin for the city that allows residents to experience the city in novel ways through immersive technology. Through the use of this digital technology, people are able to virtually experience hidden heritage locations and consider other heritage assets, including industrial heritage buildings, that are too damaged to be visited or have limited accessibility. The grant holder hopes that this promotes reflection on the use of heritage for wellbeing and signposts narratives that connect people, heritage and place, whilst also advocating active travel among residents of Bradford and visitors from outside the city.

The grant holder has facilitated a number of public engagement activities, including a presentation for recent migrants to Bradford enrolled at Bradford College, a board-to-board meeting between West Yorkshire Police and senior management of the university, and various showcase events for communities, including World Heritage Day and Saltaire Arts Trail. The university also contributed to the 'Arts, Humanities & Place Showcase' at the University of Sheffield which examined the impact of different research initiatives on place-based issues and highlighted avenues for synergy between research, place, and policy.

Conclusions

The University of Bradford has used its CapCo grant to improve the quality of and access to its collections, investing in cutting-edge data capture and data sharing technologies. The acquisition of the UK's first cone beam CT scanner and one of only two micro-CT facilities in universities nationwide bolster the institution's research capabilities and support national digitisation efforts. An immersive 7-metre iGloo cylinder and Soluis Reality portal further enhanced data sharing capabilities at the University, enabling the use of immersive experiences for training and outreach. Similar firsts are seen through the use of their digital contextualisation work, especially through the use of digital twin technologies with the UK's first TRK 700 EVO mobile mapping system and the first Mosaic Viking system in any university.

The University was able to strengthen its position as a leading hub for imaging in human bioarchaeology research, a capability it is looking to further develop and integrate into arts and humanities research through initiatives like the RICHeS programme. Additional funding from RICHeS is expected to address some of the challenges faced under CapCo, as it allocates funding against staff time.

Funding supported skills development among university staff and students, and staff of the local council. The ongoing collaboration for Bradford 2025 is expected to maintain the close relationship between the University, the city and the local authority, that will bring further development opportunities to the grant holder. Meanwhile the University's development of the digital twin of Bradford allows people to experience locations and buildings that they would not be able to see otherwise. Through this work, the grant holder intends to promote wellbeing and active travel among residents of Bradford and visitors from outside the city.

As a result of the CapCo grant, the University has been able to secure the employment of a Business and Partnerships Manager and a CapCo Champion. These roles have helped to maximise the impact of the infrastructure investments, paving the way towards the longer-term benefits that are expected over the coming years.

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B.3 Historic Royal Palaces' Heritage Science Laboratory Equipment Upgrade

Summary

Historic Royal Palaces (HRP) has been engaged with heritage science for over thirty years through its dedicated heritage science laboratory. However, a range of factors had led to the equipment becoming dated, requiring the team to outsource some capabilities to other institutions.

Through the CapCo grant, the laboratory was transformed, with ten new pieces of equipment ranging from small portable instruments to large scale analytical instruments purchased, creating a versatile facility that means that previously outsourced projects can now be undertaken in-house. This has already realised research benefits, including the development of a new application for non- invasive analysis of dyes on historic tapestries through hyperspectral imaging, cementing the role of HRP as a world leader in this field.

The new equipment is also providing opportunities to upskill staff across HRP, increasing the breadth of conservators who can engage with the activities in the heritage science laboratory. HRP is also looking at mechanisms for sharing its learning with students, and aims to have PhD and Master's students engaging with heritage science and the HRP collections in the mid-term.

HRP takes an open-door approach to its facilities, sharing and collaborating with organisations across the heritage science sector. Amongst other collaborations, CapCo has enabled the development of new methods for working with historic parchment through work HRP has carried out with The National Archives. More broadly, HRP has been able to significantly increase its public engagement activities as a result of the transformed laboratory, most notably through a feature on the television programme Hampton Court: Behind Closed Doors.

In the longer term, the impact of this investment will continue to grow, rippling out across the sector as the team continues to use and learn from the new equipment. This will provide value and benefit to HRP, its partners and collaborators, and the wider heritage science community as they become better able to support, develop, and promote their scientific research.

The grant

Historic Royal Palaces (HRP) is an independent charity that cares for six palaces across England and Northern Ireland. The research lab at Hampton Court Palace was established over thirty

years ago, with heritage science embedded through the organisation and the way that it cares for its collections. Initially focused on historic textiles, a lot of the equipment in the lab was dated, in some cases having been purchased over twenty years ago, and limited, with a range of capabilities needing to be outsourced to other institutions and external contractors.

The CapCo grant provided HRP with an opportunity to transform its laboratories, providing new and upgraded state-of-the-art equipment to better their research capabilities. The delivery of the project took place within five months and included the purchase and installation of non-invasive portable instruments for in-situ technical analysis and digital recording of collections, sample preparation, and bench top or larger scale analytical instruments including microscopy, material analysis and accelerating ageing. HRP was also able to install a dedicated server for data storage to facilitate safe access and archiving of scientific data.

The capital investment has enabled Historic Royal Palaces to take an international lead in heritage textile research and has created new opportunities to develop techniques to protect and conserve the buildings, estates and collections in its care.

Research

The research capabilities at HRP have been significantly enhanced as a result of the CapCo grant. The research at HRP is applied research based on real life questions with a particular focus on the impact of the environment on the collections. Developing the lab through the CapCo investment has provided the team with a facility that is much more versatile, fits the requirements that they have, and can access answers much more quickly. It has allowed the focus on the full breadth of materials in HRP's collection (compared with the majority focus on historic textiles previously) and has allowed them to undertake previously outsourced projects in house.

The hyperspectral imaging scanner purchased through the grant has allowed HRP to develop a new application for non-invasive analysis of dyes on historic tapestries. This is at the forefront of hyperspectral imaging and has been presented at three international conferences and published a peer reviewed paper. HRP has also attracted an additional £200,000 from the Department for Science, Innovation and Technology to extend their hyperspectral imaging, with support from DCMS, English Heritage, and the UCL Institute for Sustainable Heritage. HRP are world leaders in this field, with only one other institution in France conducting similar work.

More broadly, the enhanced capabilities at HRP allow the team to take more of a leading role in terms of the delivery of its research and identifying new opportunities and areas for research. For example, there is a Rubens ceiling at the Banqueting House, the largest surviving work by the master still in situ. HRP has been involved in a long term research project to understand and record the paintings, which are 17 metres above the floor. Previously, analysis was carried out with scientists from across the EU who were able to share their facilities. Now, as a result of CapCo, HRP have some of these instruments in-house and can continue to develop their research internally.

As well as enabling worldwide recognition of the research conducted by the HRP Heritage Science Team, receiving significant investment and setting up a brand new lab with state of the art equipment has had a huge impact for the lab within the wider HRP structure. There is greater recognition of the role that the lab plays within the HRP infrastructure, the role that it plays in supporting the delivery of HRP's charitable purpose, and the benefits that are realised from the heritage science research for the wider understanding, conservation, and preservation of the collections held by HRP.

The intention for the lab at HRP is to continue to grow opportunities for sharing facilities, samples, and data with the wider heritage science community. HRP have made two applications under the RICHeS programme to further this, with the intention of setting up a facility that can organise

the samples and data already held by HRP and making them available online to create a teaching resource for universities, academics, and practitioners.

Skills

The heritage science team at HRP is small; currently there are only two full time members of staff (the Heritage Science Manager and the Heritage Scientist) and only one of them was in post at the time that the grant was approved. Both have received extensive training across all ten pieces of equipment delivered through the grant. Three further members of the team at HRP have received training, one on the HPLC, and the others on the use of portable analytical instruments. Over the coming financial year, there is an expectation that this training will be rolled out further in-house to conservators across the palaces, helping them to harness the scientific methods that can be delivered by the labs and identifying opportunities for internal collaborations in relation to particular applications of the new equipment.

In addition to internal training sessions, the team at HRP have delivered training on the impact of the upgraded scientific facility in delivering impactful Heritage Science research to 45 Master's students as part of the MA in Heritage Management which is being delivered by Queen Mary University of London in collaboration with HRP.

The next step is for the team to apply for funding for doctorate programmes and collaborative research programmes, with the hope in the longer term of having a number of PhD and Masters students engaged with the research at the collections. Similarly, from September the lab will be reinstating its Heritage Science Scholarship delivered in collaboration with the UCL Institute of Sustainable Heritage, providing further opportunities for skills development for students.

Collaborations & Partnerships

No direct collaborators or partnerships were planned as a result of the CapCo funding, with the focus instead on developing internal capabilities. However, HRP takes an open-door approach to its facilities and has already enabled access to the new equipment at The National Archives, English Heritage, and Birkbeck University. For example, The National Archives have used the Scanning Electron Microscope in the lab to examine samples of parchment in their collection, leading to the development of a new method for sampling liquids from historic parchment for isotope analysis. Meanwhile a PhD student from Birkbeck has been working with the portable XRF instrument to analyse archaeological bone samples.

HRP has also collaborated with the developer of the hyperspectral imaging system to develop the method that they use for analysing their tapestries. This was the first time that a hyperspectral imaging scanner had been made so large, and they are already discussing how they can develop the instrumentation further. In collaboration with the manufacturer of the ClydeHSI Art Scanner, a ground breaking non-invasive method was developed for the analysis of materials and dyes on historic tapestries. The processing of the data acquired from this method uses powerful algorithms enabling, for the first time, the individual mapping of each dye. This provides access to important information about the material culture of these large-scale tapestries by deconstructing their weaving method.

HRP recognises the benefits of collaborating and the team feel that the investment will generate many more new opportunities for collaboration and research as the equipment becomes more embedded. The infrastructure grant, the new methods being developed, and the developed in-house digital capabilities will help to progress these collaborations.

Innovation & Economic Benefits

The main economic benefits realised as a result of the CapCo grant have been through the ability to do significantly more of the analysis and research required to understand HRP's collections in-house. Whereas previously there were dependencies on external partners and collaborators to provide support with analysis, the new equipment allows for efficiencies and

savings both in terms of time and money. This will also enable HRP to innovate and have more access to digital technologies, supporting colleagues across the palaces with programmes of research in a much more effective way.

There are no current plans for using the new equipment with industry users, with HRP's focus concentrated on enabling access for partners and institutions that do not have their own access to similar scientific facilities.

The capital investment has supported the recruitment of a Heritage Scientist in a full-time post (this has been vacant for two years due to the impact of Covid-19). In the longer term, the increased capabilities at the lab will also support the next generation of heritage scientists by reinstating the HRP Heritage Science Scholarship.

Societal Benefits

The investment at HRP has allowed for a breadth of public engagement activities, increasing opportunities for the wider public to learn about the research taking place in the lab. Most prominently, the lab was featured in the TV series *Hampton Court: Behind Closed Doors*, with a particular focus on the work that the lab has been doing around the last surviving badge of Anne Boleyn, currently on long term loan to the palace. This provided an exceptional opportunity to showcase the research at the laboratory to a much wider audience, and the team felt it was unlikely that they would have had this opportunity without the upgrade to the facilities. Similarly, the lab has been profiled across the HRP social media channels, with one piece of content on TikTok reaching almost half a million viewers, furthering the showcasing opportunities.

Additional outreach has included public visits to the lab as part of British Science Week, delivered in collaboration with HRP's community groups, and an increasing number of public talks, including talks to HRP's volunteer body, and visits from key stakeholders and policy makers.

Conclusion

Financially, the Covid-19 pandemic had a devastating impact on HRP, which receives no funding from the government or the Crown. Losses from closures during the 2020-21 period totalled more than £100m and significant cost reduction measures were put in place, including taking on a loan through the Government's Cultural Recovery Fund. During this prolonged period of financial instability, despite the recognition of heritage science as a critical function at HRP, the ability to invest in research facilities was significantly depleted and additional heritage science work was put on hold. The CapCo investment has been significant, developing new analyses that would not have been possible without access to the instruments funded by the grant. The longer-term impact of this investment will continue to grow, rippling out as the team are able to use and learn from the new equipment. The team anticipate that this will provide value and benefit to HRP, its partners and collaborators, and the wider heritage science community as they become better able to support, develop, and promote their scientific research.

Alongside this, the leveraged funding that results from the CapCo investment, as well as the increased reputational gains inside and outside of HRP, will provide a further catalyst for realising benefits. Whilst announcements have not yet been made, the applications made for funding from AHRC's RICHeS programme demonstrate HRP's ambitions in this area and the potential opportunities that will be realised over the longer term thanks to the CapCo investment programme.

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B.4 GLAMTech: Technologies for Gardens, Libraries and Museums Collections Research

Summary

The CapCo grant awarded to the University of Oxford's Gardens, Libraries and Museums (GLAM) has enabled the acquisition of advanced equipment, catalysing notable advancements in collections research and the exploration of new areas.

As well as improving the efficiency and quality of research, grant funding has also fostered closer ties within the university and with external partners. Additionally, the new equipment has facilitated a breadth of training, with a significant number of staff, students, and external researchers benefiting from hands-on experience.

The grant has achieved economic benefits, generating revenue through commercial requests, and contributing to enhancing GLAM's online presence and public engagement. Efforts were also made to promote the rich heritage housed within GLAM and make it accessible to a broader audience, fostering a deeper connection and understanding of cultural and scientific heritage.

Currently, the largest barrier to the realisation of further benefits is the limited number of staff available to accommodate the high demand for the equipment from internal and external stakeholders.

The grant

The Gardens, Libraries and Museums (GLAM) of the University of Oxford contain some of the world's most significant collections, providing both an important resource for scholarly enquiry and a mechanism for opening up the knowledge and research generated by the university to the public.

GLAM's CapCo grant represents part of a determined effort to enable the four world-class museums at the University of Oxford (the Ashmolean, the Pitt Rivers Museum, the History of Science Museum, and Oxford University Museum of Natural History [OUMNH]), together with the Bodleian Library, to work together more effectively in terms of collections conservation and research. In line with the University's Strategic Plan[20], the grant also represents an opportunity for the museums and libraries to work more closely with academic departments. Currently, this involves the Research Laboratory for Archaeology and the History of Art (RLAHA), and the School of Archaeology.

Before the CapCo grant, acquiring new equipment was challenging; in the best-case scenario only one piece of equipment could be acquired at a time. However, GLAM recognised the significant capability benefits that could be realised if they were able to take a multi-purchase approach. The CapCo grant enabled this approach, funding the replacement equipment in two main areas – imaging and digitisation of the collection, including a scanning electron microscopy (SEM), and chemical analysis using X-ray fluorescence (XRF).

The University of Oxford is currently working to establish a Collections Teaching and Research Centre (CTRC)[21] in Oxford. This represents a joint initiative between the four museums and the Bodleian Library, and the University has already committed £11M towards this centre. The CTRC will provide two floors of dedicated specialist facilities for teaching, digitisation, research and conservation space. As well as hosting equipment the CTRC will act as the hub and outward facing centre for the use of CapCo funded equipment across Oxford when it

[20] https://www.ox.ac.uk/about/organisation/strategic-plan-2018-24

[21] https://www.glam.ox.ac.uk/collections-teaching-and-research-centre-ctrc

opens in 2025, presenting a unique opportunity to co-ordinate facilities and equipment for the study and care of more than 8.5 million objects in the University collections.

Research

Grant funding has enhanced research capabilities within GLAM, catalysing significant advancements in collections research and in the exploration of new research areas. This has led to notable research outputs, including publications in prestigious journals, such as *Studies in Conservation* and *Egyptian Archaeology*, and contributions to exhibitions including *Colour Revolution*[22] at the Ashmolean Museum or to the *Life, as we know it*[23] redisplay programme of the permanent displays at OUMNH. The speed and quality of the new equipment has greatly increased the number of works recorded as part of both a Getty-funded research project on Italian drawings and a further research project characterising and cataloguing Raphael's drawings[24]. Similarly, equipment has been used to create a teaching reference for the Historic Metallurgy Society archive[25]. This has created a set of metallographic images that will be used as a self-driving teaching resource for historic metallurgy.

The updated equipment has allowed GLAM to revisit previous research by utilising more sophisticated technology to achieve superior results. For instance, enhanced infrared photography techniques now reveal previously unseen details in underdrawings in a possible Rembrandt panel painting. The equipment's capability for non-destructive analysis and its mobility have broadened the scope of possible research across the university's collections, allowing for the in-situ analysis of items that are either too large or too fragile to move. A good example of this is the detailed analysis of William Burgess's *Great Bookcase,* a three-metre-high Victorian painted bookcase which has contributed to a European Research Council-funded project[26].

The grant holder noted improved research and analysis capabilities in addressing questions surrounding the adoption of new synthetic materials, application techniques, dating the provenance of materials, deterioration and conservation. GLAM's enhanced research capabilities have led to leveraged funding from the Leverhulme Trust for the four-year project *Ruskin's Painting Materials: What He Used, What He Chose, What He Taught*[27]. Utilising the museum's new suite of cutting-edge non-invasive analytical techniques has been instrumental in this project.

Skills

CapCo funding and the introduction of new state-of-the-art equipment has significantly supported the work of conservation departments in the long-term preservation and investigation of collections. Key to this transformation has been the equipment's user-friendliness and efficiency which has streamlined the training process for both new staff and students.

The breadth of training facilitated by the new equipment is noteworthy, with a significant number of staff, students, and external researchers benefiting from hands-on experience. Specifically, eight MSc students in metallography and analyses of archaeological materials

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[22] https://www.ashmolean.org/exhibition/colour-revolution-victorian-art-fashion-design

[23] https://oumnh.ox.ac.uk/life-as-we-know-it

[24] https://www.ashmolean.org/italian-drawings-project

[25] https://historicalmetallurgy.org/our-collections/

[26] https://chromotope.eu/news/just-published-william-burgess-great-bookcase-and-the-victorian-colour-revolution/

[27] https://www.ashmolean.org/ruskins-painting-materials

and two conservation students from West Dean have been directly upskilled, enhancing their research capabilities. With their increased knowledge in the use of the equipment, one member of the GLAM research team supervised a master's thesis in 2023. Moreover, the equipment is now commonly used for teaching undergraduates and postgraduates who require such skills in their own research, such as in the Digital Morphology skills course for the University Biology degree run by OUMNH staff.

Team members within GLAM have been trained to use individual pieces of new equipment, with each piece of equipment having a named responsible team member. This has been particularly useful as external demand for the equipment is growing. However, the increase in demand for these new resources has outpaced the current staffing capacity, leading to some requests not being accommodated. This lack of capacity and inability to fully absorb the extra demand poses challenges in maximising the impact on skills.

Collaborations & Partnerships

Grant funding has impacted the collaborative landscape for the University of Oxford, fostering more synergy across GLAM. The acquisition of equipment that purposefully accommodates the analysis of heritage collections has also strengthened cross-divisional collaboration internally with RLAHA, and the School of Archaeology.

The grant has revitalised existing partnerships and catalysed new collaborations, broadening the university's academic and research network. For instance, partnerships have been created with academic and educational institutions including Pompeu Fabra University in Spain, University of Reading, Mauritshuis in The Hague, Queen's University Canada, and Greyfriars Catholic School, Oxford. These collaborations foster an interdisciplinary approach, addressing multiple disciplines, such as papyrology, Egyptology, anthropology, heritage science, archaeology, and conservation science. The partnerships are centred around the unique resources and expertise the institutions can bring, as well as the availability of training and supervision. GLAM has also fostered partnerships with museums and archives such as the Victoria and Albert Museum, Newham Archives, and the Natural History Museum London. These collaborations are focused on the joint study of cultural artifacts and historical records.

Overall, grant funding has broadened and deepened GLAM's partnerships and collaborations, from enhancing internal synergies within the university, to forging new partnerships with academic institutions and museums.

Innovation & Economic Benefits

The CapCo grant's impact on innovation and economic benefits illustrates a successful integration of the equipment into GLAM's operational, commercial, and academic fabric.

In 2022 alone, CapCo funded equipment facilitated the generation of £28.5K in new business revenue. This revenue stream emerged from a combination of commercial requests, catalogues, publications, and research endeavours that leveraged the imaging capabilities provided by the equipment.

Equally valuable, although less easy to quantify, are the opportunities provided by the funded photography equipment to better advertise GLAM's offer online. The photography department, in particular, has utilised these resources for enhancing online collections, developing commercial products, and fulfilling photography requests that contribute to the museums' commercial income. Additionally, the equipment has been used to create appealing online content that can have an indirect commercial impact in the longer term driven by increased web traffic and engagement.

To respond to the increasing demand for the new equipment, GLAM implemented a commercial charging model for the use of this equipment, applying different rates for external users and users within GLAM. This model not only generates additional income but also opens up opportunities for users to contribute to the ongoing research and development around the equipment's use.

Societal Benefits

There has been increased public engagement, facilitated by the new equipment purchased through the grant. Efforts were made by GLAM to promote the rich heritage of its collections and make it accessible to a broader audience, fostering a deeper connection and understanding of cultural and scientific heritage.

For example, there have been a range of workshops and events organised to directly engage both the public and specialists GLAM has sought to demystify the scientific processes behind archaeological discoveries and conservation efforts through public exhibitions and displays. These activities showcase the results of research that has been conducted using the funded equipment, reaching a wide range of audiences from schoolchildren to local communities, to international visitors. At the local level, GLAM has collaborated with local educational institutions, such as Greyfriars Catholic School, to showcase the analytical equipment funded through the grant. These activities aim to promote heritage science to schoolchildren, whilst also aiming to enhance teachers' abilities to engage students with cultural heritage and science. Initiatives such as the digitisation of collections and the creation of 3D models of diverse specimens and objects for digital platforms are ensuring that GLAM's work can become more accessible to a global audience.

Conclusions

The CapCo grant awarded to GLAM has catalysed enhanced research and conservation capabilities. It has facilitated better synergies and collaboration amongst the University's museums and the Bodleian Library, as well as facilitating closer research and teaching ties between academic departments.

GLAM's enhanced research capability has not only enhanced internal interdisciplinary research and collaboration but also expanded its network nationally and internationally. This was achieved through focused partnerships with academic institutions and other museums and archives.

The equipment acquired through the grant has opened new commercial avenues for GLAM, generating £28.5K in 2022. The grant has also increased GLAM's impact on public engagement, facilitating workshops, exhibitions, and digital initiatives that have reached millions of users globally.

The CapCo grant has transformed the scope and quality of projects undertaken within the realm of heritage science. This has allowed GLAM to tackle research projects that were previously impossible due to the large, fragile, or sensitive nature of certain objects, which could not withstand travel or the invasive sampling. As such, the equipment has done more than enhance functional capabilities, it made a notable advancement in the recognition and development of heritage science within the university.

Looking ahead, the equipment will continue to play a pivotal role in the expansion of the University of Oxford's research and conservation capabilities. The equipment is set to be influential in the operational capabilities of the new multi-million-pound Collections and Teaching Research Centre scheduled to open in the 2025. It has also fostered a new broader collaborative network for heritage science across Oxford University: Oxford Collaboration for Heritage science Research and Engagement (OCHRE). Thanks to the work kickstarted

through the support of the CapCo grant, the grant holder aspires to transform the CTRC into a leading centre for heritage science in Oxford and beyond.

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B.5 Refresh and upgrade of analytical optical microscopy and associated imaging capabilities for heritage science research

Summary

Historic England was awarded a CapCo grant to purchase equipment that would enhance their abilities in optical microscopy and dendrochronology, with the acquisition of a Keyence 3D digital microscope and Lintab 6 tree-ring measuring system. These advancements have significantly enhanced internal research capabilities while also supporting the work of the wider archaeological and heritage science community.

The focus on equipment accessibility and user-friendliness has been essential to ensure that Historic England's support can be readily and efficiently accessed by others in the sector and beyond. As such, their ability to assist the broader archaeological science community has been significantly improved. This has facilitated both new and enhanced collaborations in the UK and Europe, as well as closer ties between the organisation and the public through a range of projects and activities enabled, or enhanced, by the new equipment.

A significant impact of the project lies in its ability to upskill team members and offer comprehensive training and professional development opportunities in heritage science. Notable impacts on skills include the ability to train and support entry-level specialists, as well as advancing accessibility and inclusivity in the sector.

The economic benefits of the grant have also been significant. The acquisition of faster, more efficient equipment, has increased the organisation's capacity to handle research queries, improving access to advanced scientific resources for both academic and commercial users.

The grant

The grant was awarded to Historic England, which along with its sister organisation the English Heritage Trust forms, the Historic Buildings and Monuments Commission for England. Historic England is the statutory adviser to the government on the management, protection and advancement of understanding of the historic environment whether built, buried or on the seabed. They hold research and reference collections of international importance at their research establishment at Fort Cumberland, Portsmouth[28]. These collections include archaeological materials, animal remains, human skeletal remains, plant remains, geoarchaeological thin sections, and dendrochronological samples. The collections are routinely used by staff and are available for consultation by external researchers via monthly Open Collections Days and by arrangement.

The CapCo funding has allowed Historic England to finance new equipment that significantly enhances the workflow and operational capabilities of the organisation. Historic England operates within a funding framework centred around grant-in-aid from the government. This requires diligent allocation of resources across the extensive, and often ageing, inventory of specialist equipment. This financial environment prioritises infrastructure of immediate need and criticality, limiting Historic England's capacity to make more proactive upgrades that, while beneficial in terms of efficiency and cost-effectiveness, are beyond their current financial flexibility.

The CapCo grant has enabled Historic England to update and enhance its optical microscopy equipment by purchasing a Keyence 3D microscope and tree-ring analysis systems (Lintab 6 Expert Scientific Package). This initiative was driven by the need to advance the organisation's capability in researching, managing, and protecting England's historic environment.

As well as enhancing the internal capability of the organisation through this new equipment, Historic England also wanted to foster a broader vision of supporting the archaeological sector at large. By upgrading its equipment, the organisation has been able to offer enhanced imaging services to partners who might otherwise lack access to such technology, thereby developing the sector's overall capacity for archaeological science.

Research

[28] https://historicengland.org.uk/about/contact-us/fort-cumberland/

The CapCo grant has improved Historic England's research capabilities. This has led to enhanced efficiency in supporting the repair and maintenance of historic buildings and regeneration programmes across England.

Noticeably, the new equipment has improved the organisation's research facilities for dendrochronological investigations, particularly with respect to the statutory designation of historic assets and supporting grant-aided repair programmes, along with establishing the significance of historic assets on the Heritage at Risk Register[29]. The new system is used on a weekly basis to support both casework and wider projects. For instance, Kings Farm, Wiltshire was listed as Grade II*[30] as a result of a combined dendrochronological and historic building assessment, whilst the emergency investigation of an unexpected discovery of a Tudor wreck at Denge Quarry, Lydd[31], recently featured on the BBC *Digging for Britain* series, was enhanced by the provision of dendrochronological dating evidence.

Grant funding has facilitated the expansion into new research areas**.** The Keyence 3-D digital microscope has opened up new avenues for research across all disciplines represented at the Fort Cumberland Laboratories. For example, the microscope was used to analyse woven wall panels from the Wem Chapel, Shropshire to inform their conservation and restoration, a project that was shortlisted for the Museums and Heritage Awards 2023: Restoration or Conservation Project of the Year. Additional research initiatives include the Khipu project, which is exploring this Andean method of communication, with access provided via the IPERION-HS project, and analysis of archaeological finds including a child's leather shoe from Shrewsbury Flaxmill Maltings[32] and auditory ossicles from Northamptonshire.

The grant's impact on research will likely extend into the future as more diverse research projects are undertaken by a wider range of experts, including potential applications in historic building conservation and archaeological science.

Skills

Upskilling team members and offering comprehensive training and professional development opportunities in heritage science have had a significant impact on the project. Notable impacts on skills include the ability to train and support entry-level specialists, as well as advancing accessibility and inclusivity in the sector.

The equipment has supported the continued professional development of early career dendrochronologists made it easier to collaborate internationally and has enhanced the ability to conduct high-quality research. The new system has demonstrated the value of access to cutting-edge technology to the wider dendrochronological community, thus encouraging upskilling and the training of a new generation of dendrochronologists.

The introduction of the 3D digital microscope has been especially transformative for researchers with visual impairments, overcoming limitations faced with traditional microscopes. This was particularly highlighted in the case of a visually impaired student from the University of Bristol, who, after beginning a collaboration with the grant holder during her undergraduate second year, was able to advance her research into postgraduate studies. Access to the microscope, mentorship, and expertise, as well as the ability to reference the

[29] https://historicengland.org.uk/advice/heritage-at-risk/

[30] https://historicengland.org.uk/research/results/reports/8795/KingsFarmLiveryRoadWestWinterslowWiltshire_Tree-ringAnalysisofOakTimbers#:~:text=It%20was%20subsequently%20listed%20in,%2D%20bay%20cruck%2Dframed%20range.

[31] https://www.wessexarch.co.uk/news/rare-elizabethan-ship-discovered-quarry-300-metres-coast

[32] https://historicengland.org.uk/research/results/reports/67-2022

organisation's collections, significantly accelerated the student's learning and skill development in archaeobotany. She was recently awarded the Faculty Commendation Award for Academic Citizenship for her work on the project which was also featured in the TV show *Digging for Britain*.

Looking forward, Historic England is planning to create more opportunities for post-graduate dissertations, placements, and advanced continuous professional development opportunities. However, staff capacity creates a barrier to expanding upskilling and training. There is a need for additional resources and staff to expand access to the infrastructure and expertise and transform the volume of engagement and support the organisation can provide to the sector.

Collaborations & Partnerships

Grant funding supported the enhancement of existing and new collaborators in the UK and Europe, both in terms of academic partners and wider researchers. For example, alongside enhancing existing relationships with Swansea University and St Andrews University, focussing on technical developments with respect to dendrochronology, new research collaborations have been formed with Sheffield University to conduct isotope analysis in archaeobotany. The Beyond the Silos project is a Knowledge Exchange project funded by the University of Sheffield targeted towards the commercial archaeobotany sector. It is promoting the use of the Keyence microscope as a tool for recording specimens prior to their destruction as part of cutting-edge isotope analysis. The lead for this project noted that the use of the equipment in this project can, in the longer run, help promote it, with commercial uses of the microscope being expected to increase.

Additionally, Historic England has jointly collaborated with the University of St Andrews and the Swedish National Heritage Board to understand more about the Khipus, an Andean communication medium made of colourful knotted cords. Elsewhere, a research project with Prof. Ingrid Mainland of the University of the Highlands and Islands and Orkney College compared methodologies for studying dental microwear using the 3-D microscope, SEM, and conventional high-power light microscopy.

Beyond academia, the equipment acquired through the CapCo grant has helped Historic England enhance its relationships with freelance researchers engaging in cutting-edge research. The services provided by the organisation, such as carrying out sample analysis and photographing the results, have been particularly valuable to freelance researchers who have been able to mitigate the usual financial constraints they face (such as travel costs and time for skills acquisition) by remotely accessing services directly from Historic England for free. In these cases, the Historic England staff have helped carry out the analysis of samples that has provided groundbreaking findings in archaeology and archaeobotany, creating knowledge within the sector and contributing to high-calibre publications.

The equipment acquired through the grant has enhanced the ability of Historic England to work with international colleagues. For instance, through one recent project dendrochronologists in the UK collaborated with their North American counterparts to establish the presence of, and securely date, oak timbers imported from North America in historic assets in the British Isles, thus not only enhancing understanding of such historic assets but also providing information about the historical trade between North America and the British Isles.

Innovation & Economic Benefits

The grant holder is a public sector research establishment with a stated purpose of providing services and access to infrastructure. Although a not-for-profit organisation, Historic England

does implement a commercial model to recover costs, which are then reinvested, in this case by charging bench fees and day rates for the use of its heritage science infrastructure. This includes costs for the wear and tear on the equipment where it is used in externally funded projects.

The new equipment purchased particularly lends itself to a successful commercial model, without impeding the meaningful work that the grant holder does internally. The speed with which the equipment operates, especially compared to the previously available technology, allows the organisation to respond to more queries than ever before.

Innovation and economic benefits are a direct result of the financial model. This enhances support for the archaeological science sector by providing access to high-end scientific equipment that many commercial units might not afford otherwise. Additionally, Historic England has introduced a tiered charging structure for academic researchers and commercial entities. This system aims to be straightforward and equitable, encouraging early career researchers with lower day rates and charging more for those with higher day rates.

Overall, the pricing structure provides a simple model for recovering costs and diversifying income. It reflects the effort to make efficient use of resources while supporting the broader archaeological community and commercial partners.

Societal Benefits

Grant funding has facilitated closer ties between Historic England and the public through a range of engagement activities enabled by the new equipment.

The nature of the 3D microscope allows it to be much more easily used in public engagement activities. For instance, the organisation conducts tours for groups such as U3A (a UK-wide group of charities that provides group activities for those no longer in work) and historical societies, whilst over 60 participants have the opportunity to use the 3D microscope during monthly Open Collections days. These events offer free access to the scientific reference collections to students, professionals, community groups and researchers, alongside expert advice from the specialists. Being able to view images on a high-definition screen rather than taking turns looking through a microscope has created more inclusive engagement and facilitates better visualisation and understanding of the materials being studied. This inclusive approach promotes wider societal engagement, sparking different and more in-depth conversations about the materials and their historical significance.

Dendrochronology has been one of the supporting elements of the £95 million High Street Heritage Action Zone (HS HAZ) programme funded by the government and executed by Historic England. The programme plays a pivotal role in leveraging heritage for the economic and social revitalisation of high streets. Dendrochronology, enhanced by the Lintab 6 system, has been used by the programme to enhance the understanding and highlight the significance of over 20 historic buildings across seven HS HAZ locations in England, achieving valuable contributions to the rejuvenation of high streets through heritage-led regeneration.

Conclusions

The CapCo grant awarded to Historic England has strengthened the organisation's ability to pursue applied research and improve the efficiency of their contributions to standard casework, informing future management and repair of England's historic buildings and hence restoring local historic character and improving the public realm. Access to state-of-the-art equipment has not only improved the organisation's internal research capabilities but also its contributions to the work of the wider archaeological and heritage science community. The grant holder noted that accessing CapCo funding and investing in new equipment has been a positive change, opening up opportunities that could not otherwise have been realised.

Grant funding has supported the training of early-career dendrochronologists and democratised access to cutting-edge optical microscopy technology for researchers and students, including those with visual impairments. Moreover, the grant has fostered collaborations and partnerships both within the UK and internationally, enhancing the organisation's ability to engage in more interdisciplinary archaeological science projects.

From an economic perspective, the new equipment has supported a commercial model that aids cost recovery and the appropriate maintenance of these resources. This model has enabled Historic England to increase its operational efficiency and respond to more queries, thus enhancing its support for the archaeological science sector. Finally, the grant has facilitated greater public engagement and societal impact, making heritage science more accessible and inclusive.

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B.6 Enhancement of equipment-based research and conservation capability for Amgueddfa Cymru-National Museum Wales.

Summary

Amgueddfa Cymru (AC) was awarded a CapCo grant to purchase and upgrade equipment in four operational areas: the Art Conservation Studio, the Digitisation Studio (2-D imaging), the Imaging Laboratory (imaging of 3-D objects, including 3-D scanning), and the Materials Laboratory.

This investment has rejuvenated the museum's conservation and research infrastructure, making it the only facility in Wales capable of providing advanced analytical capabilities at this level. The updated and expanded equipment has enhanced the reputation of the museum and elevated its capacity for in-depth technical analyses and conservation projects.

In the broader societal context, the grant has facilitated a diverse array of initiatives aimed at enhancing public access and interpretation of the museum's collections, as well as fostering collaboration with various communities.

While challenges remain, notably in staffing and the commercial exploitation of these enhanced capabilities, the museum's trajectory is headed towards greater innovation, engagement, and impact, both within Wales and on the international stage.

The grant

Amgueddfa Cymru (AC) is a multidisciplinary museum with sites across Wales. It holds over 5 million objects and specimens across its archaeology, art, social and industrial history collections. The museum has a proven track record of enhancing collections through conservation and research activity and AC is the main centre for collection-based conservation and research in Wales.

Sustained cuts to the organisation's grant-in-aid have impacted on its ability to update key items of equipment in research and conservation, particularly more expensive items which were heading towards obsolescence.

AHRC's CapCo grant was used to purchase and upgrade equipment in four operational areas: the Art Conservation Studio, the Digitisation Studio (focused on 2-D imaging), the Imaging Laboratory (focused on imaging of 3-D objects, including 3-D scanning), and the Materials Laboratory. The funding was utilised for four major pieces of equipment, a suite of microscopes and eight other pieces of medium-scale equipment.

Research

Grant funding has facilitated the acquisition of cutting-edge equipment and resources, elevated the quality and precision of the museum's research activities and enhanced conservation practice.

Access to advanced equipment has opened new avenues for research and exploration. Noteworthy projects include the conservation and analysis of a late portrait by Édouard Manet[33], which underwent detailed examination and conservation. By conducting in-depth technical examinations and conservation internally, AC was able to reveal the painting's true colours and brushwork which had been obscured by decades of dirt and varnish. This initiative also leveraged additional funding from TEFAF, The Finnis Scott Foundation, and the Friends of AC to conserve the painting and frame.

CapCo funded facilities have also enhanced the quality of several aspects of the collection's investigation, conservation and research work. Examples include: 3-D scanning of human

[33] https://museum.wales/cardiff/whatson/11839/Revealing-douard-Manets-Portrait-of-Monsieur-Jules-Dejouy/#:~:text=%C3%89douard%20Manet's%20(1832%2D1883),in%20a%20relatively%20untouched%20condition.

teeth from a medieval site prior to isotopic destructive analysis, imaging of botany specimens for virtual audiences in collection decolonisation work, and FTIR analysis of recently acquired tattoo flashes from Jessie Knight, thought to be one of the UK's first female tattoo artists[34].

The main barrier highlighted by the grant holder to maximising the impact on research is the lack of sufficient staffing. Greater capacity would allow for the exploration of non-essential routes to analysis and investigation which often underpin developing new research projects or methodologies. The museum's current economic situation following a reduction of Grant in Aid from the Welsh Government has led to a reduction in staffing in some areas. However, the museum has identified opportunities to refocus and bring a new emphasis to research (particularly with community groups and local museums) across the museum and is hopeful that this will ensure the continued beneficial impact of the equipment.

Skills

The purchase of accessible and user-friendly equipment has been one of the main elements impacting skills development within AC, fostering a culture of confidence among staff while also building research capability.

The museum has established a formal Technical Services Group[35] that has contributed to a structured learning environment. The group has played a crucial role in enhancing the institution's research and conservation work by promoting the use of the equipment and ensuring it is managed sustainably. This initiative has led to the development of an internal peer support network, facilitating the exchange of knowledge and skills among staff, which created an uplift in the baseline of internal expertise.

So far, approximately 35 staff members, placement students, and collaborators have received training, becoming competent in the use of the equipment. This training has enhanced their technical skills and facilitated their creative application of the equipment in various projects. PhD and PTY students have benefitted from enriched skills development opportunities, better preparing them for future careers in the heritage sector by instilling a deep understanding of both the practical and theoretical aspects of conservation and research.

Collaborations & Partnerships

The grant holder noted that the acquisition of state-of-the-art equipment for AC has transformed the institution into a more attractive partner with more to offer in collaborative projects. The museum's enhanced capabilities have allowed it to contribute more effectively to high-profile collaborations, forging new partnerships.

A notable example of AC's enhanced collaborative efforts is the deepened relationship with the Wales Portable Antiquities Scheme (PAS)[36]. This scheme encourages the reporting of archaeological items found by metal detectorists and other members of the public in England and Wales which are not covered by the Treasure Act 1996. The improved imaging and analysis capabilities have supported the scheme in artefact identification, evaluation, and the wider dissemination of findings.

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[34] https://museum.wales/blog/2564/Jessie-Knight---The-Lady-Tattoo-Artist/

[35] https://museum.wales/curatorial/natural-sciences/technical-facilities/

[36] https://museum.wales/portable-antiquities-scheme-in-wales/#:~:text=The%20Portable%20Antiquities%20Scheme%20in,by%20the%20Treasure%20Act%201996.

New collaborations include activity with the Van Gogh Museum and Frans Hals Museum in the analysis and treatment of works by Van Gogh and Maerten van Heemskerck. These projects, which allow the museum's conservation team to contribute its expertise internationally, position the institution as a reputable and capable partner in the global museum community. These collaborations have leveraged AC's enhanced analytical capabilities, enabling contributions that were previously out of reach. This has elevated the institution's profile, opening doors to future projects and partnerships.

Innovation & Economic Benefits

The grant holder reported that currently outcomes related to innovation and economic benefits are limited. However, there are tentative steps that have been taken towards leveraging the equipment for broader economic impact.

The grant holder and project stakeholders noted that the acquisition of this state-of-the-art equipment has been a substantial development for AC, making it the only facility in Wales capable of providing advanced analytical capabilities at this level. There is an awareness that this is offering unique opportunities for leveraging economic impact. The challenge now lies in managing the equipment's potential within the context of the museum's reduced staffing levels. However, the process of establishing a service provision is in its early stages with staff currently exploring the logistical, legal, and operational resources required to advance this offer.

The grant holder is cautious in this process, being aware that the transition from internal use to external service provision introduces complexities, particularly around liabilities and legal obligations. Additionally, ensuring the integrity of the equipment while engaging with external users presents a delicate balance between economic gain and the risk of damage to the equipment.

Societal Benefits

The societal impact of the grant has been achieved through a diversity of means, ranging from enhancing public access and interpretation of the collections to collaboration with various communities.

One of the standout societal contributions has been observed through the *Rites & Rights* project[37], funded through the CapCo Impact Awards. The initiative focused on the examination of cultural materials by the Indian community in Wales. AC utilised digital imaging equipment purchased through the grant to explore the museum's economic botany collection, using the research to foster a dialogue with the local Indian diaspora. Access to the collection is being enhanced by digitising the South Asian specimens in the collection and by producing 3D scans of these specimens. The collaboration was designed to understand the cultural context of the specimens, providing a platform for the community to contribute their insights and perspectives.

The societal impact achieved through grant funding is also enhancing public access and interpretation of the museum's collections. The conservation of Édouard Manet's portrait demonstrates how equipment-based treatment can deepen public engagement, especially when the results are purposefully disseminated. Through the project AC hosted workshops,

[37] https://museum.wales/blog/2490/Rights-and-Rites-a-new-project-to-digitise-and-investigate-botanical-specimens-from-South-Asia/

published videos and developed web articles and displays that connected audiences with the technical and historical narratives behind the conservation work.

Conclusions

The CapCo grant awarded to AC has impacted multiple facets of its operation. This investment has not only rejuvenated the museum's conservation and research infrastructure but has also been a catalyst for skills enhancements, better positioning the museum in the field for future work and collaborations.

At the heart of this transformation is the enhancement of the museum's conservation and research capabilities. This updated and expanded equipment has enabled the museum to undertake ambitious projects, promoting the museum's elevated capacity for in-depth technical analyses and conservation projects.

AC's augmented capabilities, realised through the CapCo grant, have also positioned it as a more attractive partner for high-profile collaborative projects, such as international research. In the broader societal context, the grant has supported AC to foster increased collaborations with local communities, enhancing public access and the interpretation of the museum's collections.

The new equipment has supported skills development across the museum, fostering increased confidence and competence among staff. As a result of the funding, the base level of internal expertise has been raised, with approximately 35 staff members, students, and collaborators now skilled in the operation of the new equipment.

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B.7 Building networks for creative and cultural responses to historic pollution and climate change research

Summary

The Department of Classics and Archaeology at the University of Nottingham applied for CResCa funding to refurbish and improve the capacity of the archaeology laboratories. This allowed them to install state-of-the-art heritage science equipment, bringing their existing spaces up to date. The department is already benefiting from more comprehensive, sustainable, resilient workflows, particularly in relation to its work around historical pollution and climate change research.

A major output of the CResCa funding has been the establishment of the Nottingham Materials and Environment Science and Heritage Laboratories Network (N-MESH), which draws together heritage science researchers from across the university. This has allowed previously disparate disciplinary units that were operating in siloes to take a joined up and cohesive approach to heritage science research. New partnerships are already forming, including with the Ancient DNA lab and the Biosciences department. In the longer term, the expectation is to grow the network beyond the university to include industry, creative, and cultural sector groups, providing increased opportunities for research partnerships.

The purchase of new equipment has allowed for significant upskilling, for the archaeology department, for N-MESH network partners, and creative and cultural partners. For example, one of the archaeological technicians has been able to disseminate learning further through the UK Institute of Technical Skills and Strategy, running workshops and events for peers across other institutions.

The CResCa grant has been the accelerator which has drawn together the disparate parts of Nottingham's heritage science capabilities. Whilst the current focus for activity is structured around creating a strong foundational base for the capabilities and the network, the expectation is that in the longer term the grant will create a significant impact and allow for greater recognition of the breadth of research carried out at Nottingham.

The grant

The University of Nottingham's Department of Classics and Archaeology applied to CResCa for funding to refurbish and improve laboratory capacity, bringing existing spaces up to date and installing state-of-the-art heritage science capabilities. To coincide with the launch of the new facilities, the department developed a new initiative: the Nottingham Materials and Environment Science and Heritage Laboratories, also known as the N-MESH Labs. N-MESH draws together a network of heritage science capabilities from across the university, including Life Sciences and Medicine and Health Sciences, with a longer-term ambition to engage with partners from across the creative and cultural sectors.

The decision to apply for CResCa was in part motivated by witnessing the capacity building enabled at other peer organisations who had successfully applied for CapCo funding. This identified that there was an opportunity for capacity building at the university. When CResCa was subsequently announced, it became clear that the fund would provide a mechanism to address historic gaps in capability, prompting the decision to apply for the fund.

When funding was awarded, the short time frame between receipt of the grant and the deadline for making purchases meant that Nottingham was not able to purchase all the infrastructure initially applied for. This has led to a modification of the capabilities that they had hoped to be able to offer access to, limiting capabilities to some extent. Despite this, there have already been a range of outcomes arising from the funded equipment and the development of N-MESH.

Research

Prior to the CResCa funding, a lot of heritage science research at the University of Nottingham was disparate and siloed across the university, being delivered by individual researchers within their own disciplinary units and lacking a joined up cohesive approach.

The CResCa money allowed for the labs in archaeology to be enhanced and developed. The department capitalised on this by hosting a large open lab launch meeting. They invited relevant researchers from across the university to tour the lab, hear about the new equipment being funded, and speak about how the lab might support and interact with their work. This launch meeting became the catalyst for creating the N-MESH network across the university.

The improved facilities and the development of N-MESH has allowed researchers across the university to be excited by the wealth of heritage science research taking place at Nottingham. Previously, whilst the department would have benefitted from the development of a similar network, there was a recognition that it didn't necessarily 'bring much to the table' in terms of the return offer it could make to other departments around the university. Now, they can provide equal capabilities, and can leverage these capabilities to establish collaborations. Thea team attribute this success directly back to the benefits created by the CResCa grant.

On a practical level, the CResCa funding has enhanced the archaeology labs through the new equipment and capabilities, allowing for the development of comprehensive, sustainable, resilient workflows that enable high quality historical pollution and climate change research. These have facilitated increased reach and significance of the archaeology labs to interdisciplinary groups across the university. This has demonstrated a clear research need for interdisciplinary networking and partnership, to allow for infrastructure access and collaboration for innovation.

The programme of work has only been operating for nine months, and so the real benefits of the investment and networks has not yet been realised. The team expect research outputs to be forthcoming in the medium and long term and have already found that the enhanced internal network allows for mass communication with potential partners and collaborators. New partnerships have already been identified, including work with the Ancient DNA lab, and work developing a new approach to proteomics – the proteins in human bodies – in collaboration with the Biosciences department. This has allowed the teams to identify significant crossovers in their work, implementing new techniques and applications across different research projects, creating benefits and efficiencies for all parties. Meanwhile, the focus on the heritage science capabilities across the university has allowed the identification of areas of strength, enabling concentrated effort to build these strengths further. This helps departments to complement each other, rather than creating a competitive environment within the wider university.

However, there are barriers to progressing interdisciplinary research due to the structure of the university. Whilst at an individual level there is an appetite for working in an interdisciplinary way, cutting across different departments, the wider financial structures make it difficult to gain approval for cross-cutting workflows at an organisational level. If funding for bioscience research is being used to teach students in arts and humanities, structural and financial barriers can prevail. It is important to recognise that this is something that is not unique to Nottingham and would be an issue in any institution seeking to work across different disciplines, however it does create difficulties in progressing collaborative research. Working with the central R&I team and finance the team hopes that to remove barriers to interdisciplinary research and research-led training/teaching.

Similarly, whilst CResCa has funded the infrastructure that the archaeology labs needed, it has not been able to fund the staff time to go alongside this due to the nature of the grant. This has

meant that the academics leading the award are trying to develop new results and impacts in addition to pre-existing full time roles. This has had a limiting impact on the amount of research that can be delivered by the team so far, however there is a hope that in the mid-term, as the network becomes more established and the enhanced capabilities of the archaeology lab deliver more outputs, additional funding can be found to support staff to engage with the capabilities further.

Skills

The new equipment purchased through the CResCa grant has allowed the archaeology department to develop new capabilities across its staff, and across wider partners. The team have been able to offer training to centre staff, N-MESH network partners and creative and cultural sector partners. To date this accounts for over 30 hours of training to around100 participants, with more expected over the next 12 months.

Of particular note has been the skills development for the departmental technician who has been engaged with learning to use every piece of equipment bought through CResCA. This technician is a part of the UK Institute of Technical Skills and Strategy, based at Nottingham. Funded by UKRI, the institute focuses on technical skills, roles and careers, and the contributions made by technical professionals across research and innovation. The archaeology technician has been running workshops and networking events for her colleagues across the university and across the archaeological discipline, transferring the skills that she has acquired through the CResCa funding more broadly to realise benefits for other departments and other institutions.

Additionally, the new equipment has allowed for training with students. For example, the 3D scanner and printer funded by CResCa has been used to develop object handling and collection management skills for students. This allows the department to support student learning, as well as ensuring that the capabilities enabled by the CResCa investment are distributed more widely.

Collaborations & Partnerships

The key success already realised by the CResCa funding has been the development and establishment of the N-MESH labs network. This would not have been launched without the grant funding and has already significantly grown collaborations across disciplines at the university. Where previously heritage science capabilities were being delivered across the university, but in siloes with minimal collaboration and awareness of activities, N-MESH has facilitated a more collaborative and creative approach. Different departments work to combine their efforts, and the equipment funded by CResCA has played an integral role in facilitating these collaborations.

Looking to the future, the university expects to grow the N-MESH network to include partners and collaborators from outside the university. There has already been interest in the heritage science research carried out by the network. For example, Nottingham City Museums and Galleries have approached the network for support in understanding more about the provenance and history of two taxidermy animals within its collection.

The expectation is that as it grows the network will include partnerships with industry, creative, and cultural sector groups, as well as local interest groups. This will provide increased opportunities for research partnerships and new insight and understanding about archaeological objects.

Innovation & Economic benefits

The development of N-MESH has already supported innovation at the University, allowing collaborative opportunities and new applications of existing approaches in historically

disconnected fields of research. During this initial period of the network, there is a focus on creating a strong base for activities, leading to increased efficiencies and better ways of working between disciplines that had previously been siloed.

Once this has been firmly established, N-MESH will have a strengthened offer around its capabilities and capacity that can be made available to a broad range of groups, including industry partners, small local heritage and/or archaeology units, and private individuals with collections of interest. This will generate income on a sliding scale, and the economic benefits derived from the most profitable collaborations will support the University to offer funding in kind to those with less resource available.

In the longer term, the expectation is that the establishment of N-MESH will lead to increased innovations across the university. Currently the archaeology labs are testing and piloting a range of innovative techniques using the new equipment, with the plan to make this available to heritage science and forensic science practitioners once the concept has been proven. Similarly, by joining up researchers across the University, N-MESH provides opportunities to increase efficiencies and generate cost savings as more research can be done more effectively through shared resources.

Societal Benefits

In the mid to longer term, there are ambitions for N-MESH to provide opportunities for increased public engagement across the lab's activities with support for business engagement. However, in the interim a lack of support for administrative personnel in the current structure has meant that the team are taking an ad-hoc approach to outreach activities, rather than working in a more targeted way. Whilst this does make it more difficult to achieve consistent impact, the expectation is that as the lab becomes more established there will be an increase in building networks, organising events, and raising awareness of the breadth of research carried out at the lab.

There is also an intention for N-MESH to increase opportunities for smaller institutions to engage with the enhanced capabilities provided by the lab. This would operate on a sliding scale, whereby funds generated from work with industry partners can be used to supplement and support research with smaller museums and institutions without their own capabilities to do similar work. Additionally, the expectation is that N-MESH would enhance this offer further by allowing for collaboration across different areas of the university – rather than just working with the archaeology team, for example – increasing the understanding that can be gained and generating interesting and culturally significant research about objects held by institutions locally and nationally.

Conclusions

Without CResCa, the developments at Nottingham would not have been possible, the grant has been instrumental in the successes already achieved and the outcomes expected over the coming years. Whilst there may have been some level of collaboration, this is likely to have continued to be ad-hoc and disparate. Thanks to the funding, a more integrated collaborative approach has been made possible most notably through the establishment of N-MESH.

The long-term impact of the grant is likely to be hugely significant. The development of the network has gained attention from university leadership, demonstrating in a practical way how interdisciplinary research can realised greater benefits. It has also attracted greater attention from organisations outside of the University, demonstrating the breadth of research support that Nottingham has to offer and making it a more attractive prospect for academic and institutional partners. With greater time and investment, the network will become impactful and sustainable. This is only possible due to the strong foundation of its initial development, which has been facilitated by CResCa.

Sources:

- Interview with Holly Miller, Lecturer in Archaeology, University of Nottingham
- AHRC Monitoring Survey, collected in December 2023
- Evaluation of AHRC WCL – grant holder survey (Technopolis and BOP), January 2024
- New collaboration will help researchers discover more about our cultural and national heritage, University of Nottingham. Available at: https://www.nottingham.ac.uk/news/n-mesh-labs [Date accessed: 24/4/2024]

B.8 On-Demand Design & Manufacturing of Customised 3D Fashion & Textile Products

Summary

Leeds Institute of Textiles and Colour (LITAC) received a CResCa grant to purchase equipment to support their innovative research into textile design and manufacturing. Covering a range of different activities at the cutting edge of textile research, the work is contributing towards the development of viable circular economies for the UK's fashion and textile industry.

The funded equipment has helped LITAC to increase its capabilities as a 'micro factory', providing creative manufacturing services to the industry on a much smaller scale than can be found commercially. This provides an enhanced offer to its growing network of over 600 industry partners, made up of SMEs, startups, and established multinationals, whilst also enabling the Institute to extend its experimental, applied research through PhDs and funded research projects.

Key projects facilitated by the new equipment include research into innovative recycling approaches for textile materials including the creation of new fibres that can be traced across their lifespan, and improved abilities for sorting of textile materials. Additionally, work to design manufacturing-on-demand models that can be customised has been enhanced through the new equipment.

Through its enhanced capabilities, LITAC has seen, and expects to continue to see, an increase in collaborations and partnerships both within the sector and with other institutions, including collaborative research to develop new processes and product prototypes. This will lead to greater innovation and a range of economic benefits, both for the University and for industry, through a combination of direct revenue generation as industry partners make use of the CResCa funded facilities, and longer-term impact as innovations and spin-out opportunities develop.

In the longer term, the work at LITAC seeks to support the development of viable circular economies, where post-consumer textile waste is transformed into a resource and production is based on need and environmentally sustainable demand. This will support greater opportunities for manufacturing in the UK, as well as reducing landfill and emissions as the techniques being pioneered at LITAC become standard processes across the industry.

The grant

The Leeds Institute of Textiles and Colour (LITAC) at the University of Leeds has been at the forefront of research to shift the fashion and textile industry from its traditional linear economy – a "take, make, dispose" approach to fashion and textile products – towards circular economies that improve resource efficiency and make the UK textile industry more competitive on a global scale, now, and into the future.

In contrast to traditional institutes that form around research and/or funding groups, LITAC's purpose is to serve identified industry needs, which it can do through its close collaborative links with industry bodies including the UK Fashion and Textile Association (UKFT), the British Fashion Council (BFC) as well as large network of UK companies. By taking an industry focused approach, LITAC's research takes account of the technical complexities faced by business, rather than approaching issues of sustainable development from only an academic standpoint.

LITAC was awarded a CResCa grant to purchase new pieces of equipment that can support innovative research into textile design and manufacturing as the Institute works towards supporting the development of viable circular economies in the UK textile industry. The equipment covers four areas of activity: the installation of an industrially-relevant melt-spinning system for fibre extrusion; additional state-of-the-art equipment for 3D weaving, including a multi-shuttle loom and warp creel delivery system; a spectrophotometer, for the analysis of recycled polymer material compositions, including colourants; and a 3D body scanner, to enable digital design and customised fit-to-subject garments, that can reduce wastage and allow for a fully-digital prototyping process.

In applying for the grant, LITAC wanted to explore different approaches to the design and manufacture of fashion products, working to move the sector towards a data-driven manufacturing model that can help to address historic issues of overproduction and increase customisation as part of the process. CResCa has facilitated this by allowing LITAC to augment its existing facilities through the purchase of new equipment. This in turn has helped with the development of a new platform for research in innovation and sustainable design and manufacturing operations. This has been achieved by extending whole supply chain capabilities, integrating the production of functional fibres from textile waste and additional practice-based 3D design and manufacturing capabilities with LITAC's existing high-quality facilities, helping to address unmet needs of the industry. The combination of the Institute's existing academic design and technology research expertise, state-of-the-art facilities and long-established industry partnerships provides an excellent foundation for successful innovation and translation of the new research findings into industrial strategy and commercialisation.

Research

LITAC is described by its researchers as providing 'micro factory' facilities, with different capabilities and functions that take the form of highly versatile lab-scale manufacturing processes. The equipment funded by CResCa provides LITAC with the missing links in its capabilities, enabling the Institute to action proof of concept studies and extend its research. Researchers are now able to test new design and manufacturing methods that could close the loop in textile production, developing on a small scale, new approaches that could work on a commercial scale in the future.

The enhanced capabilities at LITAC allow industry to evaluate new ways of manufacturing in much smaller volumes and with shorter lead times than are usually possible on a commercial basis. This has significant benefits both in terms of the breadth of potential partners who can engage with the research at LITAC and for its abilities to develop and evaluate new materials that may not be practical in larger operations. This allows LITAC to carry out applied research in an environment that can be experimental, something that can be challenging for industry considering large-scale manufacturing lines dedicated to production are complex and expensive to operate. This facility also allows LITAC to explore alternative ways of producing textiles and finished garments by reducing the number of processing steps, increasing opportunities for onshoring and pursuing ideas through PhDs, UKRI funded, or EU funded projects that can enable more ambitious, higher risk projects.

Since receiving funding, the investment has enabled the formulation of new academic research proposals to external funders, including work directly funded by industry and contract research. The Institute has also been able to develop new PhD and PDRA projects that will lead to academic journal/conference outputs.

In one example of the application of the CResCa funded equipment, the team at LITAC are working alongside a UK-based swimwear manufacturer. Using the bicomponent melt extruder, they are exploring the recycling potential of waste textile materials extracted from mixed

polymer feedstocks containing elastane that have previously not been recyclable. The project aims to separate, recycle, and spin polymers into new yarns, with the added ability of being tracked through the embedding of traceable particles. This will support verification of provenance and enable tracking of the lifecycle journey of the resulting products. Meanwhile, a collaborative project with the UK Fashion and Textile Association seeks to improve the ability for auto-sorting circular textiles, and the new CResCa funded equipment will enable separated and sorted materials to be evaluated for fibre production, facilitating their onward processing.

As a result of the grant, future developments are likely by leveraging additional externally funded research income, in collaboration with industry (involving micros, SMEs and PLCs) including contract research, EU and UKRI proposals. LITAC also anticipates harnessing the new equipment in the development of international research collaborations, such as future EU projects, and deriving academic outputs with data obtained from the newly installed equipment.

Skills

The new equipment has enabled LITAC to further develop and enhance its CPD provision for the industry, both nationally and internationally through a combination of digital and in person training opportunities. The increased learning and insights made possible by the equipment acquisition is being disseminated to a much wider audience further increasing LITAC's engagement with the industry and enhancing its knowledge exchange capabilities.

At a more localised level, significant upskilling of multiple PDRAs, PhD students, lab technicians and academic group leaders has been established via specialist training delivered by industrial equipment providers. This includes an enhanced ability to undertake the digital design of customised 3D fashion products based on individual subjects and computer-aided weaving of seamless fashion products and high-performance textiles with complex 3D shapes and geometries, including the production of new fibres from textile waste and associated closed loop recycling.

Additionally, LITAC intends to integrate the equipment into course delivery for the new industry co-developed BSc in Textile Innovation and Sustainability (which is available from September 2024) and the existing MSc Textile Sustainability and Innovation course, as well as utilising the body scanning equipment in the existing MA Fashion Enterprise and Society programme. There are also opportunities for further integration of the equipment into other Fashion MA programmes, resulting in skills benefits for students across the breadth of LITAC's activities.

Collaborations & Partnerships

LITAC works with a broad range of collaborators across the fashion and textile industry, particularly through a large network of SMEs and start-ups to deliver research and innovation. LITAC's industry network numbers into the hundreds, with c.600 partners including some of the UK's largest PLCs in fashion and textiles, to many SMEs and emerging start-ups. A key tenant of the way that LITAC operates is the principle that partners are "for life", and the greatest benefits can be realised from (industry) partners who return over and over, creating sustained longer-term impacts from their activity.

There has already been a breadth of new initiatives and opportunities emerging because of this investment. The detail of this work is largely subject to NDAs, however opportunities to work creatively with industrial partners have included the development of new prototypes and ways of working. These would not have been possible without the CResCa funded equipment, as many of these specialist lab-scale facilities and the technical know-how to use them to the best of their capabilities are not normally available in many companies.

Additionally, the grant is supporting significantly increased industry engagement and enabling new research enquiries and expressions of interest from UK industry and academic researchers,

based in other UK academic institutions, to be serviced. This is facilitating research collaborations that would otherwise not be possible, helping to develop new approaches that can drive the future sustainability of the fashion and textiles industry by exploring activities at the cutting edge of industry practice.

The LITAC team describe the Institute as being a large 'cog in the machine' in which multidisciplinary collaborations and partnerships are essential to creating an innovation ecosystem that works holistically. Initiatives such as the £15M UKRI Circular Fashion and Textile programme is helping to support vital collaborative research activity and engagement between universities, industry and NGOs that will influence the longer-term direction of the industry.

Innovation & Economic benefits

With its focus on working collaboratively with industry partners to improve the fashion and textile industry for the better, LITAC is well positioned to realise innovation and economic benefits from the CResCa grant. The increased capabilities realised through the equipment are already providing a strengthened offer for industry users and there has been an increased use of, and interest in the use of, the facilities by industry partners.

The realities of working with industry partners means that time and other practical constraints are attached to specific projects due to the complexities inherent when working with commercial organisations. The experience at LITAC is that all companies are different, with their own strategies, supply chains, and specific innovation needs. As such, achieving technical, environmental, and economically viable solutions cannot be approached using a one-size-fits all approach. The concept of "triple bottom line thinking", encompassing the technical, environmental, and economical impact of activity, runs across all engagement activities at the Institute, helping to generate economic benefits in the longer term for both the University and for industry partners.

One innovation already emerging has been work towards the development of fibres that will allow textile products to be fully traceable, allowing for authenticity checking and verification of the source materials. This has been a missing component in efforts to close the loop and enable full life cycle physical track and trace capabilities.

Societal Benefits

LITAC is working in an industrial sector that is experiencing regulatory change, with significant legislative updates impacting the global fashion and textile industry, with more to come in the near future – the main driver for these changes being the climate emergency and the required transition to Net Zero. The experience of the team is that this is accelerating demand for innovation, including among smaller SMEs that are able to respond quickly to find creative solutions to issues such as waste reduction and improved resource utilisation. By collaborating with these smaller SMEs as well as larger organisations, LITAC is enabling new products to be prototyped, tested and further developed more quickly, ahead of potential future scale-up. One area of development concerns manufacturing on demand to reduce over-production, rather than creating inventory and warehouses full of stock that could later require discounting.

By working towards an industry that doesn't overproduce and which prevents textile materials from being wasted, there is an opportunity for LITAC to support the sector to significantly reduce its large global environmental impacts, aligned with a Net Zero compliant future. Some of new approaches to manufacturing being pioneered at LITAC will create greater opportunities for onshoring, reducing the length of the supply chains and increasing the opportunities for design and manufacture by UK industry. Similarly, by working to keep products in long-term circulation, the levels of landfill and incinerated waste in the UK can be reduced, in turn reducing overall emissions created by the industry.

In the longer term, the consequences of a 'global race to the bottom' where the focus has been on generating the lowest costs of production will continue to be a major challenge. This will create new infrastructure challenges, and there is a longer-term debate about where and how this should happen, including the need for a globally coordinated effort which is mindful of the need for a just transition. Drawing these ideas together will be one of the biggest challenges faced by LITAC and the wider industry as it strives to make progress in these areas.

Conclusions

The CResCa grant has created substantial additional capacity within LITAC to support industry-led, collaborative R&D, focused on sustainable development of the fashion and textile sector, and the transition to circular economies. It has forged new collaborative relationships with industry and is enabling new approaches to the design and manufacturing of fashion and textile products to be evaluated, in collaboration with industry. The grant has also enabled LITAC to lever core academic expertise and catalysed new externally funded research proposals, including a successful KTP submission that was only made possible by the grant. There has been a marked increase in requests for collaboration, both with academic and industry partners, and there are regular industry visits to the Institute to see what is possible using the equipment and discuss its practical application in future projects.

The facilities have significantly enhanced the resources available for training and CPD opportunities in fashion and textiles and will be generating benefits for students through increased exposure to the breadth of equipment available on courses from September 2024.

This year marks 150 years since textile education and research began at the University of Leeds, originally established to support Yorkshire's developing textile industry. With the support of CResCa, LITAC can continue its journey, contributing towards its goal of the development of a closed-loop circular textile economy for the UK.

Sources:

- Interview with:
  - Stephen Russell, Professor of Textile Materials & Technology, University of Leeds
  - Muhammed Tausif, Professor of Sustainable Textile Manufacturing and Deputy Head of School: Academic and Enterprise, University of Leeds
  - Sue Rainton, Associate Director, LITAC, University of Leeds
- AHRC Monitoring Survey, collected in December 2023
- Evaluation of AHRC WCL – grant holder survey (Technopolis and BOP), January 2024
- Leeds Institute of Textiles and Colour (LITAC) website. Available at: https://www.leeds.ac.uk/leeds-institute-textiles-colour [Date accessed: 24/4/2024]

B.9 Performance Lab: Innovating Practice-led Research and Development in Immersive and Digital Technologies in Theatre and Performance

Summary

The Royal Central School of Speech and Drama was awarded CResCa funding to establish Performance Lab, a centre for practice-led research and development in theatre, performance, and digital technologies. To do this, Central purchased a range of equipment with the funding, including a d&b Soundscape and a similar, portable kit from Timax.

The establishment of Performance Lab successfully improved the research capabilities of the awardee, galvanising their teams and activities in and outside of their research. Having cutting-edge facilities improved the visibility of Central, leading to enhanced collaborations and partnerships in the cultural industries and beyond. The institution was also able to develop its offer in professional development for staff and learning for students, as well as providing upskilling opportunities for staff at partner organisations.

Additional funding will transform Performance Lab into the Centre for Performance, Technology, and Equity (PTEQ), where Central aims to conduct interdisciplinary research promoting inclusivity, diversity, and sustainability in the performing arts.

The grant

The Royal Central School of Speech and Drama (Central) is a leading London conservatoire for training and research in drama, theatre, and performance. The institution was the top-ranking small specialist institution (SSI) in the Research Excellence Framework 2021 and supports research and development projects around new forms of immersive sound and XR (VR/AR/MR) for performance. The institution works with partners in and outside the theatre and performance industry to conduct and develop its research activities.

Through the CResCa grant, Central renewed and upgraded its facilities, and launched Performance Lab – a hub for challenge-led research in immersive and digital technologies in theatre and performance.[38] The grant holder invested in a soundscape by d&b audiotechnik, an Optitrack Motion Capture system, large-scale projectors, VR headsets, 360 cameras, and a new Mac editing suite, enhancing their practice-led research and development capabilities in immersive and digital technologies in applied theatre and performance, immersive and participatory practices, sound and audio performance, and digital performer training. The funding allowed for the consolidation and synthesis of existing research at Central, increasing its impact and visibility. This supported the promotion of the external use of Central's facilities for industry research and development.

Through the infrastructure upgrades and increased organisational visibility, the institution strengthened its existing partnerships and established new connections for collaboration in the cultural industries. The grant holder was also able to provide training opportunities for staff and students focusing on the utilisation and commercialisation of creative outputs.

Following on from the success of the Performance Lab and drawing on its new partnerships, Central is set to further develop its capabilities through £5.3 million of additional Expanding Excellence in England (E3) grant funding over the coming years, transforming the Performance Lab into the Centre for Performance, Technology and Equity (PTEQ).

Research

The CResCa funding allowed Central to develop its capabilities and consolidate its research activities in applied theatre and performance, immersive practices, and sound performance. The grant holder reported that the bidding process invited cooperation among departments

[38] https://www.cssd.ac.uk/news/central-receives-investment-performance-lab

and was, as such, instrumental in galvanising the research environment at the institution. Without this funding, staff members working in and outside traditionally defined research teams at the institution would have remained isolated, limiting the ability to leverage Central's capabilities and, by extension, technological advancement.

The upgraded facilities enabled cutting-edge practice-led research to be conducted in immersive and digital technologies, which resulted in both written and practice-research outputs. The grant holder reported that the acquisition of the equipment increased its visibility within and beyond the cultural industries, and enhanced collaboration with external partners. Collaborative projects include creating immersive sound exhibitions at the Manchester Jewish Museum and the Berlin Exilmuseum, and working on productions at the National Theatre and the Almeida Theatre. In these projects, Central were able to explore themes of wellbeing, accessibility, and gender identity through the use of the acquired digital technologies.

The grant holder also reported that the funding had enhanced their knowledge exchange efforts, encouraged more individuals to apply for research bids, and supported the establishment of PhD studentships that Central would not have had otherwise.

The success of Performance Lab led to further funding that will see it transform into the Centre for Performance, Technology, and Equity (PTEQ). Consisting of the Sonic Lab, Motion Lab, and Media Lab, PTEQ is intended to act as a hub for interdisciplinary research promoting diversity in academic research. The establishment of PTEQ is expected to realise further benefits for Central's practice-research capabilities and knowledge exchange over the next five years. Without the WCL investment, the formation of Performance Lab and subsequent grants, including the E3 grant that will fund the transformation, PTEQ would not have been possible.

The grant holder reported that it was challenging to work around the short timeframe for spending the funding, especially as a small specialist institution with small teams. According to Professor Lease, this was overcome by hiring a Project Manager to support the spending. However, it was suggested that the spending period would have benefitted a more robust tendering process and enabled Central, as an SSI with a high number of contact hours, to install equipment in holiday periods.

Skills

The grant facilitated skills development in the use of design programmes and complex motion capture systems. Since any community user was allowed to experiment with the equipment, the institution conducted research into optimising the deployment of the technology across cultural industries sub-sectors. This informed their understanding of the possibilities of the kit and contributed to the professional development of staff members.

Researchers were able to acquire the skills required to handle such equipment through monthly sessions with experts in digital technology and theatre performance. These opportunities introduced research staff with a traditional PhD training background and limited knowledge of digital technologies to the possible applications of these tools in their field. The CResCa funding enabled Central to provide further professional development opportunities in the areas of utilisation and commercial exploitation of creative outputs and develop short courses in performance technology.

When established, PTEQ will follow on from the skills development outcomes of Performance Lab to nurture future talent through specialised vocational courses, a Master of Fine Arts (MFA) programme in digital performance technologies, and equity-focused researcher development. The grant holder aims to ensure and enhance the financial sustainability of PTEQ via income from student enrolment, short courses, and facility hire.

Since the equipment is available to partner organisations, their capabilities are also expected to develop through their use of the kit. While the grant holder reported that it is difficult to ensure

research space is always available for partners, the creation of the new Media Lab in PTEQ, funded by E3, should help to overcome this challenge, allowing for further upskilling of their staff.

Collaborations & Partnerships

The installation of cutting-edge equipment in Central has increased the visibility and network of the institution, both within and outside the creative industries. Various partnerships were established or expanded to support the delivery of activities at Performance Lab, including with the Association for Sound Design & Production (ASDP), c&t, d&b audiotechnik, Donmar Warehouse, and Queen's Theatre Hornchurch. Central have also developed new performances for the National Theatre, partnered with Digital Theatre Plus on productions at the institution, and collaborated with ScanLab for a performance of the Berliner Ensemble.

Organising conferences and sandpits (non-outcome-driven, collaborative networking events) provided an opportunity for external parties to explore the new and upgraded facilities that Central offered and ways to use these for their own research and development. Making equipment available for partners to use further strengthened relationships, considering equipment like the d&b Soundscape is costly and would not otherwise be available for use.

While the d&b Soundscape was fully installed in Central, a second system was acquired from Timax that offers similar capabilities in a portable format. This equipment was paired with kit that was decommissioned from Central to create a portable research package. As such, Central can now offer both an in-house and a portable research facility, which allows for greater flexibility in making the equipment available to industry partners.

c&t, an applied theatre and digital technology company, leveraged their existing relationship with Central and partnered with the Trust for African Rock Art (TARA) and The National Museums of Kenya (NMK) to digitally capture Kenya's most important rock art sites with cutting-edge equipment. Using 360-degree cameras, drones, binaural microphones, steady-cams and other state of the art technology, they created a mobile accessible, digitally interactive rock art safari, to be used as an educational resource across Kenya through workshops led by local practitioner Peter Mwashi Litonde, in partnership with c&t. c&t were able to leverage their existing relationship with a community social justice group in Korogocho to deliver the project and facilitate new partnerships between Central and the participating Kenyan entities. The collaboration has led to written research outputs by Central's Professor Selina Busby, as well as ongoing conversations between c&t and Central to develop similar work in Rajasthan, India. c&t reported that the CResCa grant transformed their previously more ad hoc partnership with Central into a long-term, developmental relationship, which supports c&t's R&D activities and increases their visibility in the applied theatre and digital technology research community.

Queens' Theatre Hornchurch has had a long-standing partnership with Central, working regularly with artist and Central researcher and lecturer Dr David Shearing. Queen's Theatre Hornchurch worked with Central and Dr Shearing's practice Variable Matter to develop their digital theatre production *New Beginning* over a series of labs, co-creating the piece with more than two hundred young people. The collaborators used CResCa-funded equipment from Central to create the piece, in particular two EPSON projectors of the latest model designed specifically for theatre, to create multi layered effects on stage, and new Mac Studio devices to enable working with 4k video. To explore the full potential of the projectors, the team was also able to hold training with EPSON at Central. Dr Shearing reported that a collaboration with digital specialist Lab-Meta was made possible by the CResCa investment, as the new equipment matched the scope of the company's usual creative output.

The project provided an opportunity for the staff at Queen's Theatre Hornchurch to work with practitioners and researchers at Central, training on cutting-edge equipment and collaborating across different teams. Mathew Russell, Executive Director of Queen's Theatre

Hornchurch, reported that mid-scale theatres often struggle to collaborate with higher education institutions (HEIs) and have sufficient resource and expertise to engage in digital developments. The collaboration on *New Beginning* was, therefore, significant for the theatre in further developing its relationship with Central and its digital capabilities across teams. Mr Russell reported that the opportunity enhanced the visibility of the theatre and their ability to promote the impact of their work. They were able to partner with Little Ilford School to provide opportunities for young people to get involved in the work. In addition, advancing their partnership with Les Théâtres de la Ville de Luxembourg, the production will be remade and staged in Luxemburg.

When developing their bid for E3 funding to establish PTEQ, Central was able to draw on the new partnerships they have developed through the facility upgrades that the CResCa grant funded. The grant holder reported that their visibility as a hub for performance technologies facilitated their collaboration with the Association of British Theatre Technicians, who were an important partner on the successful E3 bid. Once launched, PTEQ is set to act as a hub for collaborations and partnerships with industry leaders, enabling the exploration and advancement of performance technology research.

Innovation & Economic Benefits

Through engaging with industry and a range of partners, a skills gap in creativity emerged among technology companies, which led Central to identify an opportunity in providing short courses in this area. This shaped the short course offering of the institution and enabled them to develop their thinking around the commercialisation of these activities. The grant holder reported this would help them increase their income and become more financially sustainable.

To manage capital expenditure at the institution, Central hired a full-time Project Manager. The grant holder emphasised that AHRC's flexibility in allowing the use of some of the funding for staff expenses was critical to the success of the project. Professor Lease reported that due to technical and production teams being at full capacity overseeing curriculum, productions, and facility hire, meeting the deadlines for purchasing the equipment would not have been possible otherwise.

Once established, PTEQ is expected to contribute to local economic growth, create new jobs, and ensure its financial sustainability through increased income from facility hire and short courses.

Societal Benefits

Central have been approached with a number of opportunities to develop work centred around communities, including a project of the Greater London Authority to make London a creative health hub, and initiatives by Battersea Arts Centre and Hoxton Hall.

Staff from Central have also worked with Leeds City Council on a youth theatre production and collaborated with Havering Council on their London Borough of Culture bid. Professor Lease sees these initiatives as opportunities for the institution to fulfil its civic mission and support the wellbeing of local communities.

In addition, the grant holder reported the partnership established with the NHS by Central academic Dr Nicola Abraham was upscaling due to the development of capabilities at Central. Dr Abraham has delivered a series of training workshops around the relationship between dementia care and VR and performance. According to Professor Lease, this has contributed to an increased recognition among research staff of the policy impact they can have.

Outside the UK, Central's collaboration with c&t on their work with TARA and the National Museum of Kenya offered new insights into the effects of climate change, increased public engagement, and expanded educational opportunities for school children.

In the future, Central is hoping to promote and incorporate into its work inclusivity, workforce diversity, and sustainability in the performing arts through activities of PTEQ.

Conclusions

Through the CResCa grant, the Royal Central School of Speech and Drama upgraded its facilities and launched the Performance Lab for research in immersive technologies. The investment expanded the institution's research capabilities in emerging performance technologies, enhancing Central's visibility and supporting the development of existing and new partnerships. It also contributed to upskilling efforts across staff and students at the institution, as well as providing training opportunities for partners.

Additional funding will transform Performance Lab into the Centre for Performance, Technology, and Equity (PTEQ), where Central aims to conduct interdisciplinary research that promotes inclusivity, diversity, and sustainability in the performing arts.

Without the WCL investment, it would not have been possible to form the Performance Lab and apply for a multitude of grants from local councils, the Arts Council, and UKRI's E3 Fund. Central staff would have fewer skills around technologies, which would negatively impact the research capacity of the institution. They would have fewer partnerships, diminishing their knowledge base around the cultural industries. Furthermore, Central would have less visibility without the funding, which would also mean less capacity to build collaborative partnerships.

Sources:

- Interviews with:
  - Bryce Lease, Principal Investigator and Head of Knowledge Exchange, Royal Central School of Speech and Drama
  - Peter Rice, Lecturer and Course Leader for Theatre Sound, Royal Central School of Speech and Drama
  - Paul Sutton, Founder, c&t
  - Matthew Russell, Chief Executive, Queen's Theatre Hornchurch
- Email exchange with Dr David Shearing, Artist, Variable Matter, and Researcher and Lecturer, Royal Central School of Speech and Drama
- AHRC Monitoring Survey, collected in December 2023
- Evaluation of AHRC WCL – grant holder survey (Technopolis and BOP), January 2024

References:

- Central receives £1.35 million investment from UKRI to create Performance Lab that will enhance and develop immersive and digital technologies, Royal Central School of Speech and Drama. Available at: https://www.cssd.ac.uk/news/central-receives-investment-performance-lab [Date accessed: 5/3/2024]

B.10 Creating Immersive Experiences / Eternal Connections

Summary

Historic Environment Scotland (HES) was awarded a CResCa grant and an Impact Award to expand their digital capabilities and deliver a range of community engagement initiatives, following on from prior investment in their facilities and equipment through CapCo.

With the CResCa grant, HES acquired a range of equipment including two immersive experience systems (IESs), a 270-degree immersive cylinder, a 360-degree immersive cube, and a large-scale video wall. The new kit allowed the organisation to enhance their immersive experience offer, develop their research capabilities, upskill researchers and practitioners in the heritage sector, broaden their audience pool, and increase their engagement with industry. It has been a step-change for HES to be recognised as a World Class Lab, which enhanced their capabilities and their relationships across the heritage sector.

The CapCo Impact Award enabled HES to support a series of community engagement sessions between creative practitioners and community groups, which brought a range of positive outcomes for participants and supported the development of ongoing engagement between HES and local communities.

The grant holder is now looking to allocate staff time and resources, to be able to explore the full potential of the equipment and maximise its benefits.

The grant

Historic Environment Scotland (HES) is the lead public body established to investigate, care for and promote Scotland's historic environment.[39] The Engine Shed, located in Stirling, Scotland, is HES's dedicated building conservation centre, with a focus on traditional skills and materials, heritage science and digital innovation.[40] The centre houses specialist labs for their teams in heritage science and digital innovation and is a hub for the heritage sector to come together to collaborate, share knowledge and skills. HES secured funding from all three WCL grants, building on their CapCo investment to further develop their capabilities through CResCa and the CapCo Impact Award.

With the CResCa grant, the organisation saw an opportunity to shift their focus to supporting the heritage sector and provide a space for the capability development of researchers and practitioners in heritage. To better engage visitors and enhance learning opportunities, HES procured two immersive experience systems (IESs). Complete with the necessary equipment to enable the effective use of these systems, the new capability enabled them to increase the number of users engaged through VR at one time, as well as providing more accessible and inclusive access to this content.

The state-of-the-art equipment funded through CResCa allowed for upskilling staff in new and emerging techniques, as well as training them in procurement and fundraising skills. In addition, facility and equipment upgrades funded through CResCa helped HES to enhance their collaborations and partnerships across the sector. This emerged from an increased capacity to host events and experiences on their site and to conduct training and innovation with collaborators and partners, including fellow WCL awardees.

HES also received a CapCo Impact Award following facility and equipment upgrades funded through CapCo. This enabled the organisation to run Eternal Connections, an initiative for engaging marginalised and underrepresented groups with heritage science using digital and innovative technologies.[41] Within this project, HES and its partners collaborated with Scottish Muslim community groups to explore and stimulate creative practice around their heritage.

[39] https://www.historicenvironment.scot/

[40] https://www.engineshed.scot/

[41] https://www.thinglink.com/card/1604051920832430081

This engagement contributed to increasing the wellbeing of participants and built the confidence of HES to use their heritage science expertise for community engagement, broadening their organisational reach and audience.

Going forward, HES is looking to maximise their use of the facilities, allocating staff time and resources to explore the full potential of their equipment.

Research

With the funding from CResCa, HES purchased a 270-degree immersive cylinder for their Engine Shed centre, which allows groups of people at a time to experience a historic place or building. This new open environment replaced the use of VR headsets and an AR app that were previously used for immersive experiences at the Engine Shed, enabling HES to cater to a wider audience including children, families, and people with additional access needs at regular public open days held throughout the year. In addition, it removed some of the health and safety obligations that VR headsets necessitated, such as regular sanitation of the devices or children under 13 not being able to use the equipment.

Alongside the immersive cylinder, HES were able to acquire a mobile 360-degree immersive cube, which allows people to have a virtual experience of sites across Scotland and around the world in an immersive environment. This cube will travel to various sites to facilitate these immersive experiences, making use of 3D assets that HES had captured through previous digital documentation work.[42] This includes places like the Sydney Opera House, and other World Heritage Sites in China, Japan and India. The immersive cube thus allows for people not only to see sites in new ways but to experience places that they might never be able to see in person. According to Dr Wilson, this supports organisational efforts to promote responsible tourism in line with HES's Climate Action Plan.[43] While it may never fully replace physical visits, offering virtual tours allows people to experience places without the associated carbon emissions. Going forward, HES will continue developing their thinking around delivering immersive experiences and the societal impacts their research can have on visitors as a result.

The positioning and profile of the Engine Shed as a World Class Lab has contributed to its continued delivery of strategic research activity. Besides the awards, the subsequent role of WCL equipment in delivering high-profile corporate activity elevated the reputation of the organisation, leading to enhanced partnerships and supporting the development of their future vision for the facilities and offering of the Engine Shed. In addition, the grant contributed to improving support for research students and HES research methodologies, as well as supporting the development of the organisation's existing Research Strategy.[44]

According to the grant holder, the challenge with both grants is finding the time to use the equipment for blue sky research, as opposed to core research and analytical functions. While the equipment has significantly enhanced HES's capability to conduct applied research to inform conservation decisions, the volume of demand means it can be hard for staff focused on this activity to invest in more strategic scientific investigation. Finding ways to support this, whether through adding new capacity or building new partnerships, will therefore be key in future.

Skills

The CResCa grant allowed for investment in staffing and postdoctoral opportunities at HES and for the development of institutional knowledge and skills in procurement, funding, and

[42] https://www.engineshed.scot/about-us/teams/digital-documentation-and-innovation/the-rae-project/

[43] https://www.historicenvironment.scot/about-us/what-we-do/climate-change/climate-action-plan/

[44] https://www.historicenvironment.scot/archives-and-research/our-research/our-research-strategy/

equipment use. The grant funding enabled the upskilling of staff and students, which increased productivity and streamlined workflows in the organisation. The grant holder reported that showing other HES teams the available opportunities for development was an important outcome of the investment, leading to others building capability into plans for future work. In addition, HES was also able to train Innovate UK funded Museums in the Metaverse (MiM) research staff on HES's World Class Labs equipment, which the MiM team also procured.

Ongoing training initiatives conducted at the Engine Shed have focused on developing traditional skills via immersive virtual environments. For example, the 360-degree video camera obtained through the CResCa grant is being utilised to record footage of people working at height (e.g., scaffolders, cherry pickers), with the IESs then used to facilitate training utilising this footage in a safe, virtual environment.

With the grant funding, HES were also able to procure a large-scale LED video wall, which enhanced their events facility offer and their capability to deliver impactful events. Dr Wilson reported that without CResCa funding, hire of this equipment would have been cost prohibitive. Such events include conferences and workshops targeting those working or interested in the heritage sector, recently covering topics such as volunteering across the heritage sector, climate impacts, and the pathway to net zero in heritage. Dr Wilson reported this facility was made accessible to the wider heritage sector, with the venue fully booked for the coming eight months at the time of reporting. Events in the space are often organised in collaboration with partners of HES and reflect the commitment of the organisation to fostering knowledge exchange and collaboration within the sector. The grant holder reported they aimed to continue providing valuable resources and opportunities to the heritage sector and beyond through these efforts.

Collaborations & Partnerships

CResCa funding supported the development of partnerships, and the grant holder expects to see continued enhancement of collaborations as they maximise the use of the new facilities. As a partner in the Innovate UK 'Museums in the Metaverse' research project, HES were able to use WCL equipment to strengthen their collaboration with project participants. The grant holder is looking to expand its offer of site-based events and experiences, bringing together researchers, practitioners, and organisation across the heritage sector.

With discussions underway, HES plans to collaborate with fellow WCL grantee the University of Bradford. The awardees see a potential for collaboration around Bradford's 3D capture of Saltaire, a World Heritage Site similar to New Lanark in Scotland which HES has also captured in 3D. HES reported there were plans to develop this work and explore the possibilities of the immersive spaces that both organisations had procured through WCL. Among industry partners, HES has engaged with Morgan Sindall who ran a construction taster session at the Engine Shed using the new digital immersive systems and the LED video wall.

HES were able to establish a new connection with the Kurdish Women's Group through Eternal Connections, their CapCo Impact Award project. According to Dr Wilson, working with creative wellbeing practitioner Vicky Mohieddeen enabled the organisation to advance their broader community engagement efforts and develop ongoing engagement with the Kurdish community group.

The grant holder also noted the potential benefits of an enabling environment for collaboration between awardees, such as initiating research challenges for grant holders to work together on.

Innovation & Economic Benefits

Building on the acquisition of new equipment through CapCo, the CResCa grant has enabled HES to further increase their productivity by facilitating the efficient dissemination of their data.

The organisation is committed to creating 3D models of all 336 properties and approximately 40,000 collection objects in their care. New equipment and streamlined workflows allowed HES to upscale its operation despite limitations to resource. Going forward, this remains an important area of development for the organisation.

Societal Benefits

The CResCa upgrades allowed HES to increase the accessibility of their facilities and engage a wider audience group. The grant holder reported that their enhanced offer of immersive experiences serves to raise awareness about responsible tourism, in alignment with HES's Climate Action Plan. According to Dr Wilson, an expanded offer of knowledge exchange events served and would continue to serve as opportunities for discussion around the heritage sector and its societal responsibilities.

Through the Impact Award funding, HES were able to build a collaborative community project, using CapCo-funded equipment to uncover the story of fragments of a medieval Islamic glass drinking beaker that was discovered near Dumfries in the 1990s. Following scientific analysis and 3D modelling of the glass, the grant holder worked with creative practitioners and community groups to use both the scientific and the digital data to explore new ways of understanding the contemporary and historic connections between Scotland and Islamic communities. HES were able to run a series of workshops around scientific analysis and digital capture, as well as collaborate with creative wellbeing practitioner Vicky Mohieddeen and artist Alice Martin to deliver community engagement sessions with the Amina Muslim Women's Resource Centre.

HES approached the Amina Muslim Women's Resource Centre (Amina MWRC) with the opportunity to develop and deliver community engagement sessions around the Islamic glass fragment in their collection. Vicky Mohieddeen came to be involved in the project through Amina MWRC and worked with the Kurdish Women's Group in Glasgow, to explore issues of belonging and uncertainty through creative reflection. The group visited the excavation site, saw the artefacts at the Engine Shed and spoke to scientists and digital innovators about the background of the glass fragment. They were also able to speak with 3D artist Alice Martin, who created the reconstruction of the beaker. Ms Mohieddeen valued the trust and space given by HES to explore the right form of engagement for the purposes of the project. She noted the tangible impact that learning about the past can have on wellbeing. According to participants, working with Ms Mohieddeen on this research project enhanced their sense of community and purpose, reduced their sense of isolation, supported their learning and improved their English proficiency, as well as developing life skills and their ability for self-expression.

Following the initial, 6-week engagement, the group was able to come together again for further sessions delving deeper into the themes that had emerged previously. Ms Mohieddeen has also been invited to speak at the Spring School event of UNESCO's research body Refugee Integration through Languages and the Arts (RILA) at the University of Glasgow, where she will be joined by members of the Kurdish Women's Group to share their experiences of participating in the initiative. Furthermore, the Kurdish Women's Group and HES now have an ongoing engagement thanks to Eternal Connections and co-organise events such as field trips. To ensure community engagement projects have time and space to explore possibilities for engagement with participants, Ms Mohieddeen noted the importance of core funding and exploratory bids being made available for such initiatives.

Findings from this project will feed into the next iteration of Equality Outcomes of Historic Environment Scotland, due to be published in 2025. Dr Wilson highlighted that this project had a lasting impact on the organisation, empowering them to channel heritage expertise into a wider range of creative and community engagement initiatives, fostering inclusivity and

cultural enrichment. It has also led to follow-on and spin-off activity by both Alice and Vicky, supported and facilitated by HES.

The grant holder noted that it would be positive to have more opportunities with small funding pots, centred around community engagement and impact, as these projects can bring significant value to an organisation regardless of the smaller amount of funding.

Conclusions

Historic Environment Scotland has significantly enhanced its capabilities through funding obtained from three World Class Labs (WCL) grants, including a CResCa grant and a CapCo Impact Award. These grants have allowed HES to shift its focus to supporting the heritage sector and provide specialist resources for the development of researchers and practitioners in the field.

The CResCa grant facilitated the acquisition of two immersive experience systems (IESs), used for showcasing Scotland's heritage and enhancing visitor engagement and training opportunities. This technology has advanced HES's ability to engage more users and cater to diverse audiences, including those with additional access needs. The cutting-edge equipment elevated the profile and visibility of the organisation and enhanced their collaborations and partnerships in and outside the sector.

The CapCo Impact Award made it possible for HES to support the delivery of community engagement sessions between creative practitioners and community groups. This brought positive outcomes for participants, as well as establishing new connections between HES and local communities and enhancing their outreach to audience groups.

Looking ahead, HES hopes to maximise the potential of its facilities through partnerships with fellow WCL grantees like the University of Bradford and UCL. HES will also build on existing partnerships with other IROs, such as National Museums of Scotland and Historic Royal Palaces. HES hopes to further strengthen its position as a leader and innovator in the heritage sector, a driver of positive societal change, and a promoter of cultural enrichment.

Sources:

- Interviews with:
  - Dr Lyn Wilson, Principal Investigator, Digital Documentation Manager, Historic Environment Scotland
  - Vicky Mohieddeen, Creative Wellbeing Practitioner
- AHRC Monitoring Survey, collected in December 2023
- Evaluation of AHRC WCL – grant holder survey (Technopolis and BOP), January 2024

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- The Rae Project, Engine Shed. Available at: https://www.engineshed.scot/about-us/teams/digital-documentation-and-innovation/the-rae-project/ [Date accessed: 10/4/2024]
- Climate Action Plan, Historic Environment Scotland. Available at: https://www.historicenvironment.scot/about-us/what-we-do/climate-change/climate-action-plan/ [Date accessed: 10/4/2024]

- Our Research Strategy, Historic Environment Scotland. Available at: https://www.historicenvironment.scot/archives-and-research/our-research/our-research-strategy/ [Date accessed: 10/4/2024]

Appendix C Stakeholder Interviews

Table 9 Interviewees: system-level stakeholders

Name	Role	Organisation
Rebecca Bailey	Towards a National Collection Programme Director	AHRC
Andrew Chitty	Director of CoSTAR and former director of Audience of the Future and the Creative Industries Cluster programme	AHRC
Sophie Cummings	Senior Investment Manager, AHRC RICHeS programme lead	AHRC
Helena Grant	Deputy Head	Conservatoires UK
Caroline Peach	Consultant Development Director	National Heritage Science Forum
Rachel Persad	Policy Manager (Research and Innovation)	Guild HE
Barney Sloane	National Specialist Services Director	Historic England

Table 10 Interviewees: case studies

Case study	Name	Role	Organisation
Equipping the vision of Kelvin Hall	Cristina Young	Grant PI	School of Culture & Creative Arts, University of Glasgow
	Emma Troubridge	Partner/Stakeholder	Royal Opera House
	Rosalyn McKenna	Partner/Stakeholder	CHARTS Argyll and the Isles
	Lola Sanchez- Jauregui	Partner/Stakeholder	The Hunterian, University of Glasgow
Capability for Human Bioarchaeology and Digital Collections	Andrew Wilson	Grant PI	University of Bradford
Historic Royal Palaces' Heritage Science Laboratory Equipment Upgrade	Constantina Vlachou – Mogire	Grant PI	Historic Royal Palaces
GLAMTech: Technologies for Gardens, Libraries and Museums	Daniel Bone	Grant PI	University of Oxford
	Ricardo Perez-de la Fuente	User	OUM
Refresh and upgrade of analytical optical microscopy and associated imaging capabilities for heritage science research	Jen Heathcote	Grant PI	Historic England
	Cathy Tyers	User	
	Gill Campbell	User	
	Catheringe Longford	Stakeholder	
	Charlotte Harman	Stakeholder	

	Wendy Carruthers	Stakeholder	
Enhancement of equipment-based research and conservation capability for Amgueddfa Cymru-National Museum Wales.	Jana Horak	Grant PI	National Museum Wales
	Adam Webster	Stakeholder	
Building networks for creative and cultural responses to historic pollution and climate change research	Holly Miller	Grant PI	University of Nottingham
On-Demand Design & Manufacturing of Customised 3D Fashion & Textile Products	Stephen Russell	Grant PI	University of Leeds
Performance Lab: Innovation in Practice-Led Research and Development in Immersive Research and Development in Immersive and Digital Technologies in Theatre and Performance	Bryce Lease	Grant PI	Royal Central School of Speech and Drama
	Peter Rice	Stakeholder	Royal Central School of Speech and Drama
	Paul Sutton	Stakeholder	c&t
	Matthew Russel	Stakeholder	Queen's Theatre Hornchurch
Creating Immersive Experiences / Eternal Connections	Lyn Wilson	Grant PI	Historic Environment Scotland
	Vicky Mohieddeen	Partner	n/a: creative wellbeing practitioner
	Rachel Topping	User	Morgan Sindall
	Gary Hogg	User	Morgan Sindall

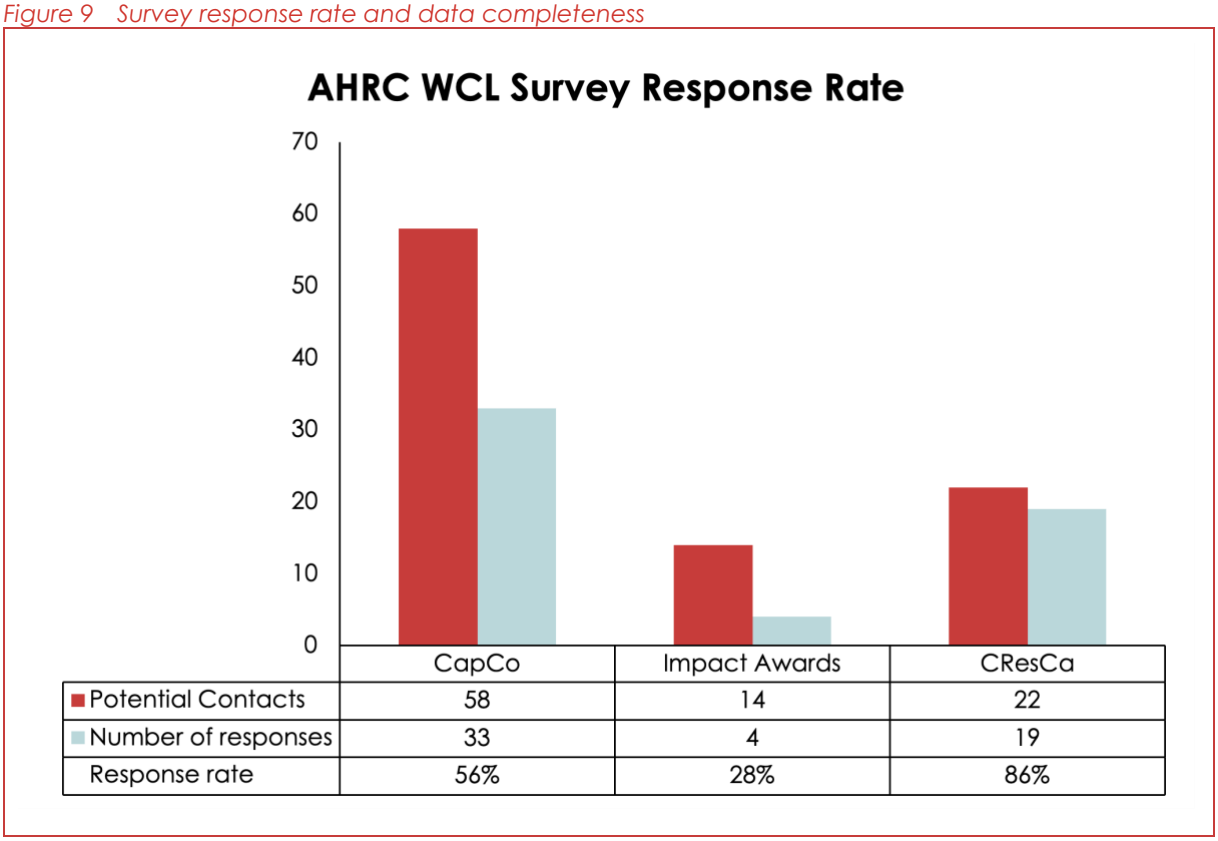
Appendix D Beneficiary Survey

The survey was designed for the lead principal investigator (PI) to answer questions about the grant they had been awarded. For PIs that had been awarded multiple grants (for example a CapCo award and a follow-on Impact Award) only one survey was sent to avoid duplication. As such, the number of potential contacts that were sent an invitation to the survey was less than the number of grants awarded under the AHRC WCL investment.

D.1 Profile of respondents

The survey questionnaire was launched to 94 WCL grant holders on the 9th of January 2024 and closed on the 30th of January 2024. An overall response rate of 62% (56, N=94) was achieved. Survey data for CResCa investments were the most complete at 86% (33, N=58) and Impact Awards survey data was the least complete at 28% (4, N=14).

Figure 9 Survey response rate and data completeness



	CapCo	Impact Awards	CResCa
Potential Contacts	58	14	22
Number of responses	33	4	19
Response rate	56%	28%	86%

The majority of survey responses (60%, n=56) were CapCo grant holders, with CResCa (35%) and Impact Awards (5%) constituting the remainder. Only two respondents were double grant award holders. Survey respondents were predominantly grant holders from universities (70%, n=56), with museums, public bodies and charities making up the remainder of survey responses (see figures below). A wide regional distribution of survey respondents was obtained, with the majority of responses from London-based organisations (33%, 19) and Scotland (16%, 9). A full regional distribution can be found in Table 11.

Figure 10 Survey response rate and data completeness

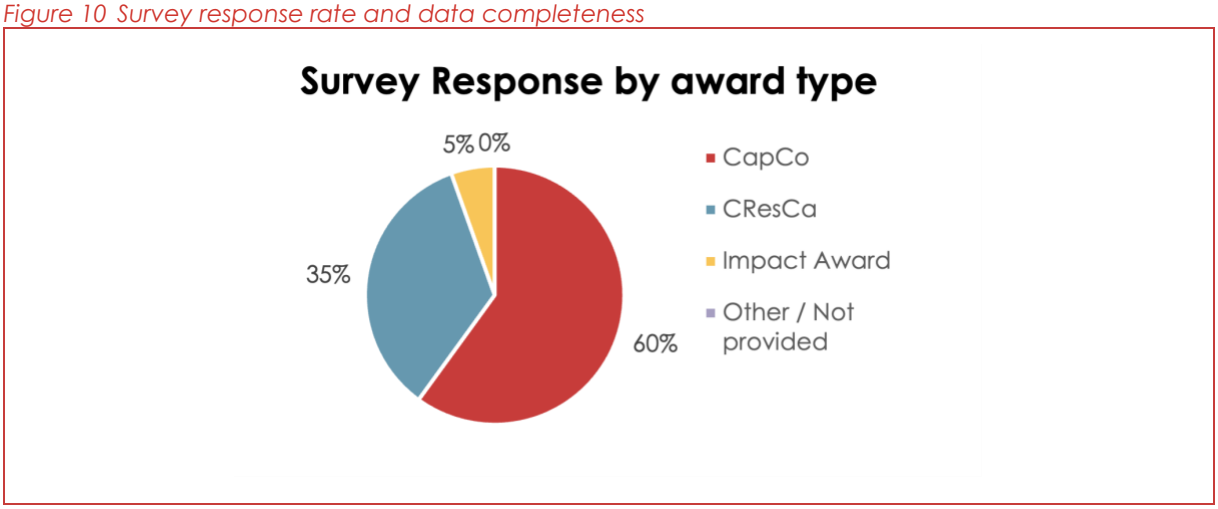
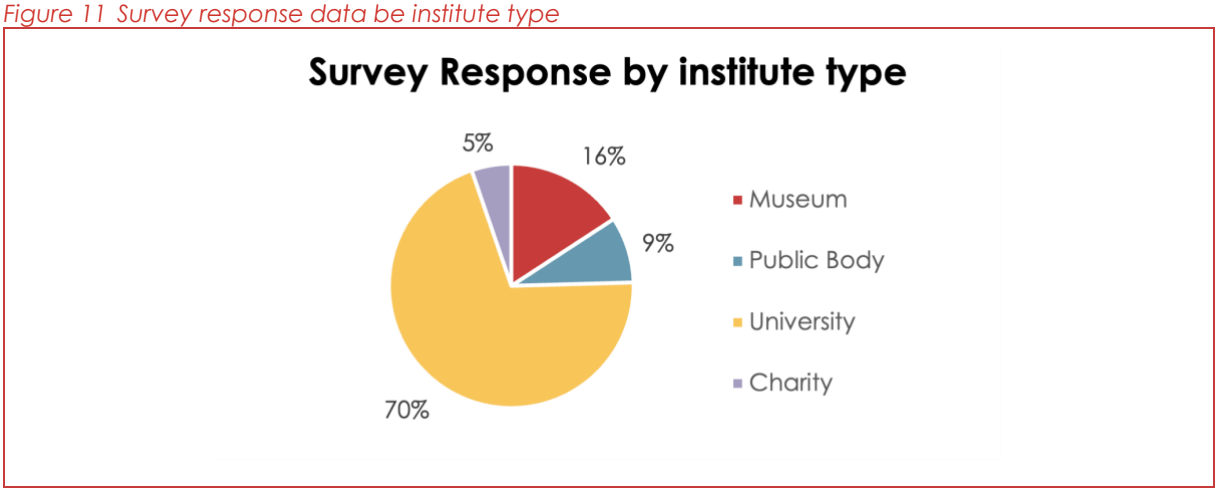


Figure 11 Survey response data be institute type



Analysis of the survey **integrated data captured via a monitoring exercise carried out by AHRC in December 2023.** The monitoring data captured 50% (N=62) of CapCo grant holders and 64% (N=22) of CResCa grant holders.

Table 11 Regional distribution of survey respondents

Region	Survey response per region	Survey response per region (%) (n=56)
North East	2	4%
East Anglia	3	5%
London	19	33%
Midlands	3	5%
Scotland	9	16%
Yorkshire	3	5%
South West	7	12%
North West	2	4%

Northern Ireland	1	2%
South	2	4%
South East	2	4%
Wales	2	4%
East Midlands	2	4%

D.2 Benefits to organisation

To explore and identify the main results of the programme, we used an impact/outcome harvesting approach. This was an iterative process, whereby we identified the breadth of outputs, outcomes and impacts emerging from the WCL investments.

Based on a review of programme documentation and a review of the research outcomes presented with Gateway to Research (detailed analysis presented in Appendix A), we mapped out high-level impact areas, which included research, skills, collaboration and partnerships, innovation and the economy and society. We used these initial outcomes to inform and shape the consultation tools.

Using these initial high-level impact areas, we used an analytical framework to qualitatively code survey data from grant holders, integrating monitoring data collected from AHRC in June of 2023. Monitoring data consisted of questions regarding:

- The number of jobs created
- The number of staff upskilled or trained
- The number of events or externally held activities and the number of attendees
- New partnerships and collaborations
- Value and source of leveraged funding
- A narrative of the outcomes/impacts realised from grant funding

Analysis and coding of this data was an iterative process. Emerging outcomes were cross-checked with qualitative findings from interviews with wider stakeholders, before being re-coded in the analytical framework. Analysis was focused not only on the emerging outcomes, but also on how these outcomes were achieved through the AHRC WCL investments. A summary of the outcomes relating to research, skills, collaboration, innovation and economic benefits and broader societal benefits are summarised in the following sections.

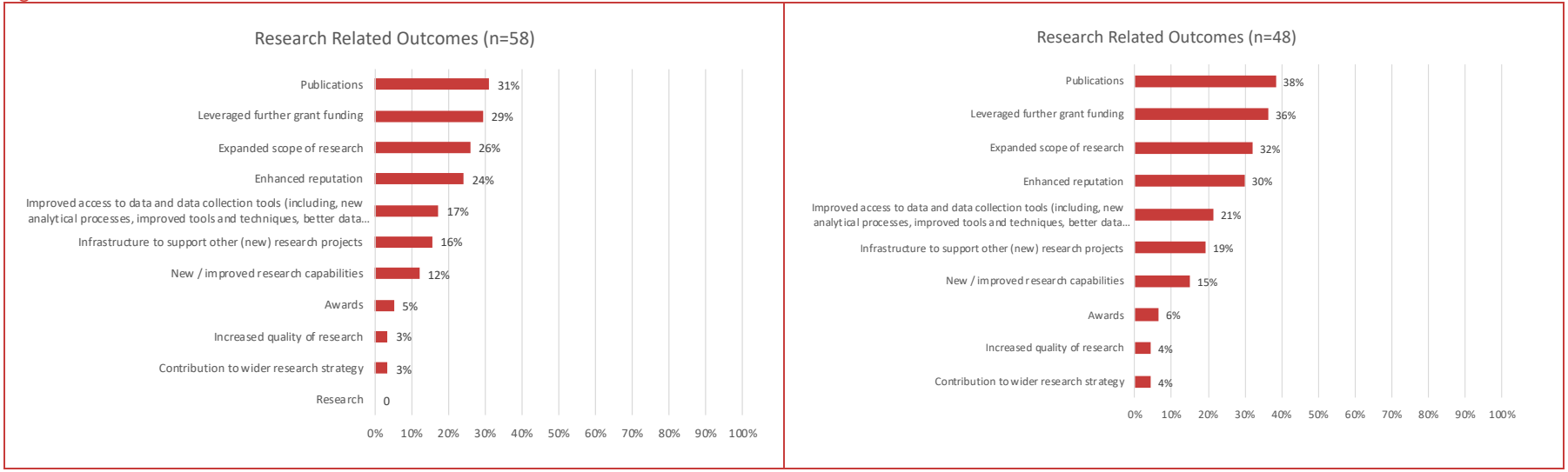
A.1.1 Research benefits grant holder survey

Table 12 Outcomes relating to research

Outcome area	Count	% of all respondents (n=58)	% of those marked yes (n= 48)	Description	Examples
Commonly cited benefits					
Publications	18	31%	38%	Publication of peer-reviewed journal articles. *N.B Publications came from CapCo grant recipients, with one CResCa grant recipient reporting publications.*	• **Tate Britain** published a paper entitled "Exploring the Materials and Condition of 20th-Century Dolls in Zoe Leonard's *Mouth Open, Teeth Showing* 2000 • The **Manchester Fashion Institute** published papers on the role of robotics in sustainable fashion
Enhanced Reputation	14	24%	30%	Enhanced reputation within the heritage science and creative sectors (e.g. with partner organisations and with industry). Increased attractiveness of universities to researchers and students, resulting in increased recruitment to heritage science and creative programmes.	• The confidence that the AHRC showed in investing **CHERISH** has provided them with vital advocacy, internally and with other funders, enabling us to build our research capabilities and capacities. • Being seen as a 'World Class Lab' helps with positioning and profile of **Historic Environment Scotland** with stakeholders and international partners, raised their research by both hosting the equipment and enabling high profile corporate activity
Expanded scope of research	15	26%	32%	New equipment and facilities enable projects that otherwise would not have been possible without grant funding. Previous research projects were not feasible due to the lack of financial capacity to hire equipment or pay for analysis with external partners.	• The new equipment and facilities are also available to community groups who previously did not have the financial means to hire specialist equipment. • **The University of Dundee** hopes to broaden the scope of research in documenting performance and installation art through the ambitious expansion of our capacities in VR/XR
Leveraged further grant funding	17	29%	36%	Follow-on funding is predominantly public funding (e.g. research grants) but there are some examples of future industry co-funding emerging from projects.	• Many examples of further funding applications were for RICHeS from CapCo grant recipients • Examples of further funding leveraged in the creative sector include Cotton Textiles Research Trust, UKRI cross research council responsive mode pilot scheme, CoSTAR, Expanding Excellence in England (E3)

Improved access to data and data collection tools (including, new analytical processes, improved tools and techniques, better data sources)	10	17%	21%	More reliable data sets and improved data collection methods are enabled by upgraded equipment. The ability to re-visit existing data sets in innovative ways and make use of new technologies for analysis and research.	• **BFI** bringing instruments to support QA of digitalisation onsite • Improved data storage systems • Portable equipment enables consistency of approach throughout the data collection and research process (e.g. **Natural History Museum's** visits to collections in Cambridge and Israel.
Less commonly cited benefits					
Infrastructure to support other (new) research projects	9	16%	19%	New equipment and infrastructure were attributed in part to the WCL investments that supported other (new) research projects. The new infrastructure is supporting research projects that were previously not available to research organisations	• **The University of Liverpool** anticipates expanding their research projects through the use of new infrastructure for the next 1-3 years.
New / improved research capabilities	7	12%	15%	WCL funded equipment underpinning the provision of new research capabilities within the grant holding organisation.	•
Awards	3	5%	6%	Grant holders made reference to awards that had been made to researchers within the organisation, which were in part attributed to the WCL investments.	• **English Heritage** shared that the WCL project contributed to their winning a Marsh award for conservation science excellence • **The University of Bristol** WCL grant underpinned research that was subsequently shortlisted for the 'M+H Awards Best Use of Digital UK'
Contribution to wider research strategy	2	3%	4%	New equipment and infrastructure positions organisations strategically for the initiation of new projects	• **Historic Environment Scotland** shared that new equipment facilitate the continuation of existing strategic research delivery
Increased quality of research	2	3%	4%	The acquisition of cutting-edge instruments and their analytical capabilities improve the quality of research	• **The National Archives** reported that new instruments have played a central role in the success of recent papers, contributing significantly to their quality and precision.

Figure 12 Research Related Outcomes



Source: Technopolis and BOP AHRC WCL Grant Holder Survey, 2024. Outcomes reported by all respondents (n=58) and those who responded yes to research outcomes (n=48)

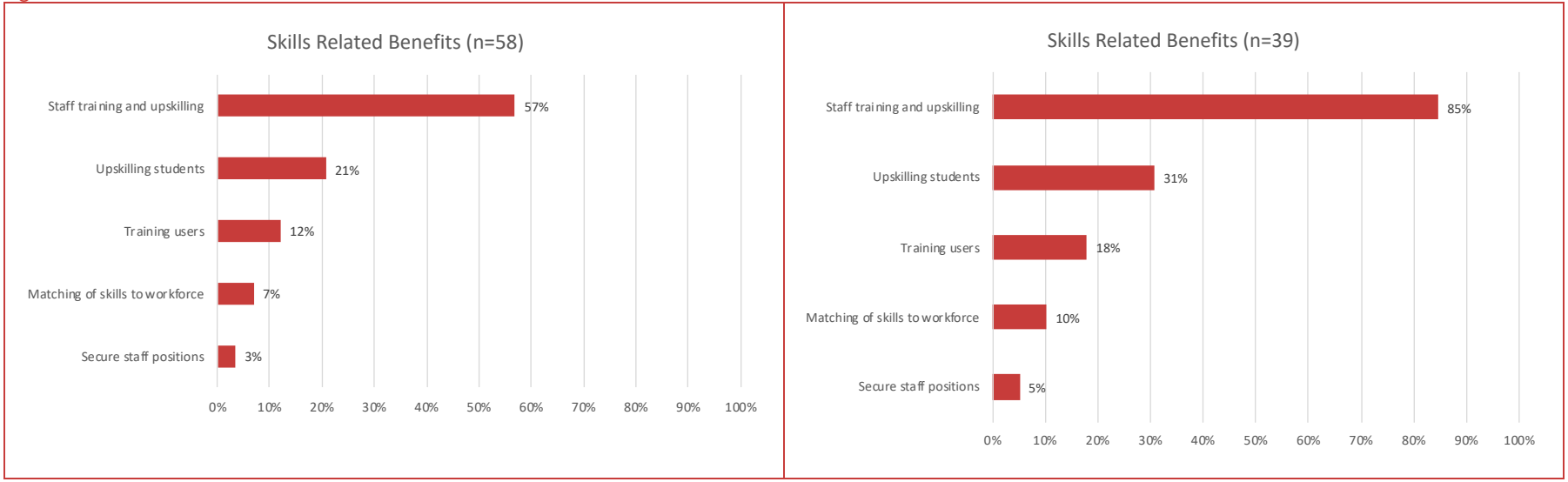
A.1.2 *Skills benefits - grant holder survey*

Table 13 Outcomes relating to skills

Outcome area	Count	% of all respondents (n=58)	% of those marked yes (n= 39)	Description	Examples
Commonly cited benefits					
Training and upskilling staff	33	57%	85%	New equipment supported the training of staff and technical upskilling	• **The Natural History Museum** reported laboratory staff training on both the Alicona IFM G5+ and the Alicona Portable RL has taken place and all research staff at the NHM who previously used the older Alicona G3 system, that the G5+ replaced, have now been trained to use the new instrument (3 staff)
Training users and upskilling collaborators	7	12%	18%	Training is provided to upskill new users on equipment, as well as providing training to collaborators and partner organisations.	• **The Historic Buildings and Monuments Commission for England** have a 3D microscope is used by participants (> 60) during monthly Open Collections days. These events offer free access to scientific reference collections to students, professionals, community groups and researchers, alongside expert advice from specialists.
Training students	12	21%	31%	New educational programmes, including training courses, are in development that make use of upgraded equipment and facilities. The increased attractiveness of universities also increased recruitment to heritage science and creative programmes.	• Recruitment of new researchers, including post-doctoral, PhD and MA students • **Bishop Grosseteste University** is validating England's first Level 7 Archaeological Specialist Apprenticeship
Less commonly cited benefits					
Matching of skills to workforce	4	7%	10%	Increased technical capabilities of researchers and students better matched the needs of the creative and cultural workforce, and made employees more competitive.	• At **Cardiff University** advanced capabilities in FTIR microscopy are being taught to students, which is producing graduate skills for the archaeological and conservation workplace
Secure staff positions	2	3%	5%	While AHRC funding did not support operational expenditure to fund research or technical staff, new equipment was used by organisations to make the case for new permanent	• **Tate** set up a new team of 3 people focused on Preventive Conservation, building capacity for research and programmes in this area

				staff members to support ongoing research	

Figure 13 Skills Related Outcomes



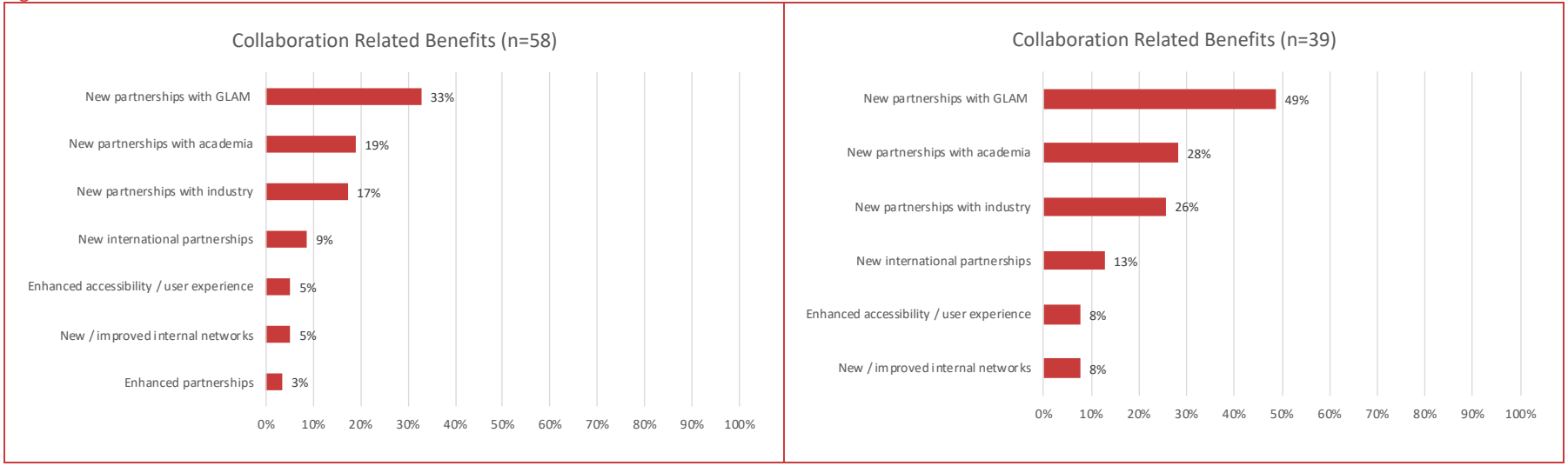
Source: Technopolis and BOP AHRC WCL Grant Holder Survey, 2024. Outcomes reported by all respondents (n=58) and those who responded yes to skills outcomes (n=39).

A.1.3 Collaboration benefits - grant holder survey

Table 14 Outcomes relating to collaboration

Outcome area	Count	% of all respondents (n=58)	% of those marked yes (n= 39)	Description	Examples
Commonly cited benefits					
New or strengthened partnerships with GLAM	19	33%	49%	New regional and national partnerships with GLAM institutions and charitable trusts have developed	• **The Museum of London Archaeology** have developed a new partnership with the Creating Tomorrow Trust in the context of engaging local communities with their Roman past using ceramic radiography
New or strengthened partnerships with academia	11	19%	28%	New partnerships have developed with academic institutions, which also make reference to new applications for grant funding	• As part of a collaborative project between the National Archives and Trinity College Dublin, the Institute for Sustainable Heritage and UCL Digitisation Suite, University College London, Historic Royal Palaces and ClydeHSI, **Historic Royal Palace's** hyperspectral imaging scanner as was to read galled documents
New or strengthened partnerships with industry	10	17%	26%	New partnerships with industry organisations have developed. It is important to note that there were more industrial partnerships reported by CResCa grant recipients than CapCo which is perhaps unsurprising considering the limited industrial base for heritage science as compared to the creative arts.	• The **Guildhall School of Music and Drama** established a partnership with Target 4D, an industry expert in volumetric capture. This partnership is geared around the application of new technologies in industry contexts.
Less commonly cited benefits					
Increased internal networks	3	5%	8%	Departments and teams that were previously working on heritage science and creative research in a siloed fashion are increasingly working together, with a more strategic focus.	• The **University of Nottingham** has developed a new collaborative network of heritage science capabilities from across the institution – N-MESH
New international partnerships	5	9%	13%	Increased visibility in the creative and cultural heritage sectors facilitates collaborations with international partners, including galleries, museums and universities.	• Signing of an MoU between **Durham University** and the Universities of Malay and Singapore • **The Courthald Institute of Art** developed new relationships with the Kode Museum in Bergen, Norway, the Van Gogh Museum, the Netherlands, and the Kunsthaus Zurich in Switzerland

Figure 14 Collaboration Related Outcomes



Source: Technopolis and BOP AHRC WCL Grant Holder Survey, 2024. Outcomes reported by all respondents (n=58) and those who responded yes to collaboration related outcomes (n=39)

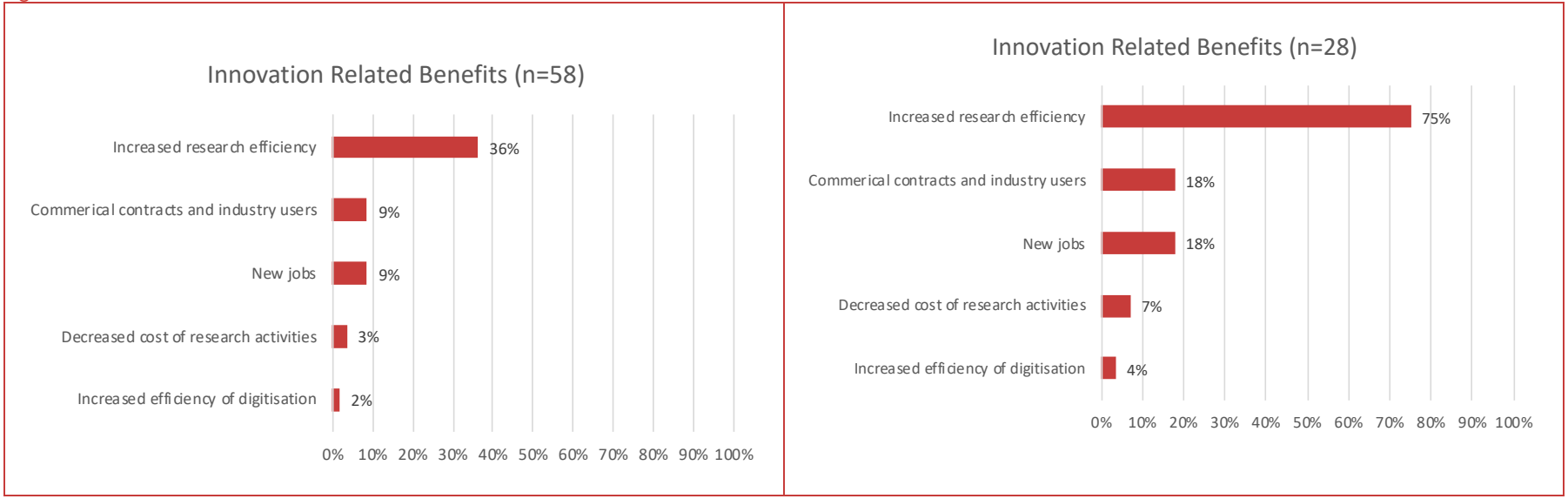
A.1.4 Innovation and economic benefits - grant holder survey

Table 15 Outcomes relating to innovation and economic benefits

Outcome area	Count	% of all respondents (n=58)	% of those marked yes (n= 28)	Description	Examples
Commonly cited benefits					
Increased efficiency of research	21	36%	75%	New equipment is faster and more reliable, decreasing the time required to produce research outputs. Research does not require outsourcing to external, specialist organisations and saves time by carrying out work in-house.	• Many pieces of equipment upgraded at the **University of Oxford** are significantly quicker and easier to use than the pieces they replaced, allowing more staff and students to be trained in their use. • **English Heritage** now have a dedicated space to more efficiently undertake research which enables collaborations with visiting researchers which had previously been severely limited.
Commercial contracts and new products and services	11	19%	39%	Organisations can offer new products and services with updated or new equipment, resulting in commercial contracts and access to new industry users.	• In partnership with industry leaders, **the Centre for Performance, Technology and Equity** (PTEQ) will enable to exploration of spatial audio, motion capture, and extended reality • **Manchester Metropolitan University** are in the process of signing an agreement with Burberry and other large-scale luxury brands
Less commonly cited benefits					
New jobs	5	9%	18%		•
Decreased cost of their research activities	2	3%	7%	In-house equipment and facilities decrease reliance on external contractors or partner organisations and therefore decreases the costs of research (e.g. packing and shipping materials, pay-for-use equipment)	• **The University of Exeter** estimates that in-house analytical capabilities, that were previously outsourced, saved them £15,000 in research expenditure
Increase in the efficiency of digitisation	1	2%	4%	Museums and galleries can digitise collections more efficiently, to preserve and curate material.	• **The University of Liverpool** can digitise and manage museum's collections more efficiently. They can

					preserve and curate heritage materials with greater precision and accessibility.

Figure 15 Innovation and Economic Related Outcomes



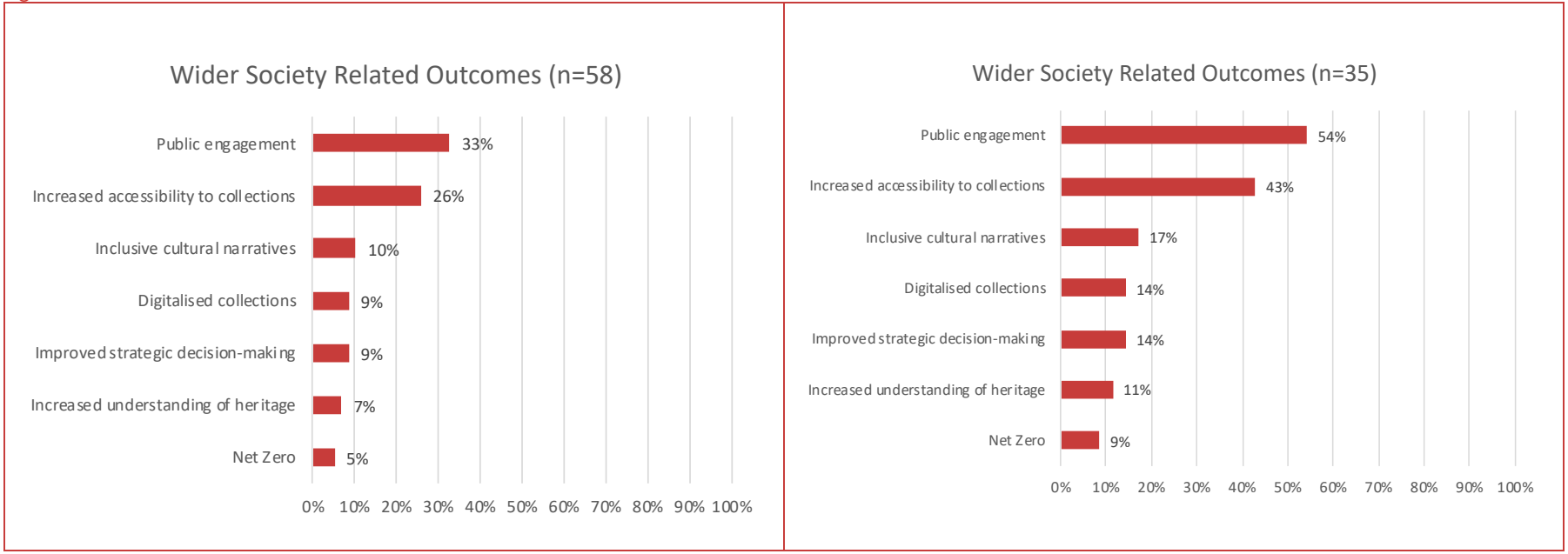
Source: Technopolis and BOP AHRC WCL Grant Holder Survey, 2024. Outcomes reported by all respondents (n=58) and those who responded yes to innovation and economic outcomes (n=28)

A.1.5 Societal benefits - grant holder survey

Table 16 Outcomes relating to wider society

Outcome area	Count	% of all respondents (n=58)	% of those marked yes (n= 35)	Description	Examples
Commonly cited benefits					
Increased or improved public engagement	19	33%	54%	The display of new collections increased engagement from the public in both the creative and heritage cultural sectors.	• The **National Museum of Scotland** held a Science Saturday event attended by 6,000 people.
Increased accessibility of data	15	26%	43%	Organisations were able to improve their routes for sharing data and information with wider audiences. In addition, organisations improved their mechanisms through which members of the public could engage with their work.	• The **Natural History Museum** scaled up and made tactile prints that allow people to grasp more concretely how they are used by scientists to understand environmental change
Less commonly cited benefits					
More inclusive cultural narratives	6	10%	17%	Creative and cultural sectors that have been previously underexplored or under engaged are explored using new equipment and facilities.	• **Royal Central School of Speech and Drama** delivered a project focused on Black dance and motion capture, which supported collaborative cultural co-production
Improved understanding of historic materials	4	7%	11%	New equipment and facilities enabled a greater depth of analysis of cultural materials, resulting in improved understandings. Old research projects can be revisited with new techniques and tools to learn new details and gain better insights.	• **National Museum Wales** has used equipment to examine cultural materials by the Indian community in Wales • New equipment enabled the **University of Oxford** to revisit earlier investigations that used older versions of the same kit to give new results.
Digitalised collections	5	9%	14%	Grant holders were able to digitalise collections for preservation purposes.	•
Improved sustainability of research and conservation practices	3	5%	9%	Equipment contributes to the increased sustainability of practices (e.g. less destructive analysis techniques).	• **Tate** used equipment to support projects exploring more sustainable collections management practices

Figure 16 Wider Societal Outcomes



Source: Technopolis and BOP AHRC WCL Grant Holder Survey, 2024. Outcomes reported by all respondents (n=58) and those who responded yes to innovation and economic outcomes (n=28)

Appendix E AHRC Monitoring Data

AHRC conducted quarterly monitoring exercises to collect data on the progress of projects funded under the WCL investments. These monitoring exercises were conducted in April, June, and December of 2023. To supplement both the survey data and the findings from stakeholder interviews, monitoring data from December 2023 (the most recent at the time of the evaluation) were analysed. A summary of the results of the monitoring data, disaggregated by WCL strand, is presented below.

Table 17 Summary of AHRC Monitoring Data

AHRC WCL Strand	**Number of jobs created**	**Number of staff trained up**	**Events externally held**	**Attendees at events**	**Leveraged funding**	**Partnerships and Collaborations**
CapCo	43	763	763	356,832	£9,850,809	236
CResCa	15	194	162	5803	£9,204.012	412
Impact Awards	0	2	11	80,000	£11,000	1
Total	58	959	937	442,635	£19,020,821	649

Source: AHRC WCL Monitoring Data, December 2023

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