ICCROM

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Enhancing Research Impact in Heritage Conservation

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ABSTRACT

This paper examines how research impact is defined, measured, and generated – with a view to understanding how it can be enhanced within heritage conservation. It examines what is meant by 'impact' and how it can be promoted within heritage science through effective interdisciplinary collaboration. Following a general examination of the current discourse concerning research impact, the study examined: (i) active research networks within heritage science; (ii) research planning and evaluation practices within heritage science; and (iii) the experiences of users (i.e. conservators and other heritage professionals) within research collaborations. Terminologies surrounding the notion of impact and the various phases of the research process were reviewed – from the initial identification of a knowledge gap to the eventual application of new findings in practice. Next, the reach and diversity of research collaborations (as identified through publication co-authorship) were studied to characterise the interdisciplinary nature of heritage science and its connectedness to users. Findings showed substantial growth in international research collaborations over recent years, predominantly involving academic- and research-oriented institutions – although the engagement of heritage institutions has proportionally decreased. In addition, a worldwide survey of institutional planning and evaluation practices revealed a general reliance on processes driven by the interests of researchers – the systematic consideration of stakeholder opinion and evaluation of research outcomes being less common. Finally, a series of semi-structured interviews with senior heritage professionals explored their experience of collaborative research. The results identified key areas where strategic support is needed to promote user participation and enhance impact. These include training for research readiness, engagement, and impact for both researchers and users; better methods for needs and outcome assessment; affordable open access options and greater diversity of knowledge exchange opportunities. Finally, the need for ethical guidelines for responsible research, and greater emphasis on non-academic impact within research rating systems are discussed

Introduction

Research is a communicative process, and achieves impact through sharing knowledge. Yet not all research reaches relevant audiences or is acknowledged in the same way or within the same timeframe. If the primary objective of research is to achieve impact, why then is it that researchers often feel unprepared to pursue impact beyond the conventional reporting of their research findings? In part this can be attributed to the fact that in general researchers are trained in how to do research, but not in how to achieve impact (Reed 2016). However, it also rests on a lack of clarity regarding what exactly research impact entails, and how it can be generated.

For an applied science field such as heritage science a number of factors affect impact including: (i) whether it addresses a priority need; (ii) whether it delivers knowledge that can be used, and (iii) whether the knowledge delivered is adequately shared and implemented. These are fundamentally reliant on a close working partnership with those that the research is intended to benefit. There is growing consensus that research activities within heritage science need to be more participatory, whereby interdisciplinary working and the active involvement of "users" (i.e. research knowledge users – including conservators, heritage professionals and other interest groups) are fostered within the research process (Heritage and Golfomitsou 2015).

To explore the extent to which research knowledge users are involved in heritage science, and how this affects impact, ICCROM undertook a series of studies to examine current research practices with a view to identifying strategic support needs for enhancing knowledge exchange and implementation. Aspects explored included: how research collaboration functions, the ways users participate, and the factors that facilitate knowledge translation into practice. It should be noted that the focus of this study was primarily on the impact of heritage science within heritage conservation. This paper gives an overview of recent findings.

Measuring impact

Demonstrating impact is important in many fields, especially when funding is scarce and demands for economy, efficiency and effectiveness are high. Funding agencies both governmental and philanthropic, are increasingly requesting statements of anticipated impact to be included within research applications and/or project proposals (see for instance European Commission, 2014). Hence, to leverage support – financial or otherwise – professionals are asked to track performance and provide evidence of the benefits their work delivers. To communicate these, a results-based language is adopted with the use of terms such as 'outputs', 'outcomes', and 'impact'.

Definitions vary, but for the purposes of this paper the above terms are defined as follows: outputs are products or services directly produced by an activity. An outcome is a short-to-medium term effect, generally finite and measurable, that can be attributable to outputs. By contrast, impact is a long-term effect that takes place on a broader scale, as a result of an outcome. Impact may be positive or negative, intended or unintended, direct or indirect (OECD 2002).

Further to the issue of defining impact, is the task of measuring it. Most typically, this is attempted through systematic, audit-like evaluation processes to assess projects or organisations in terms of their efficiency, effectiveness and accountability. Often viewed as tedious and bureaucratic, nevertheless if well designed, evaluation processes offer an opportunity to estimate the quality of achievements, identify gaps and guide planning to meet desired outcomes (Kaufman 2006). Tools and methods for measuring long or short-term outcomes differ substantially from quantifiable evidence gathered through 'bean counting' exercises, to collecting qualitative information through opinion polls and behaviour studies.

To explore if evaluation methods used in other fields could be useful within heritage science, in late 2015 ICCROM organised a think-tank meeting[1] with participants from heritage science, social sciences, and heritage statistics. A key difficulty discussed was that research impact beyond academic circles is notoriously difficult to nail down, since its effects are complex, indirect, nonlinear, and take place over extended timescales (see Luoma *et al* 2011; LSE PPG 2011). Existing indicators primarily based on publication citations provide a rather incomplete picture of impact. For example, citation metrics may indicate awareness of new knowledge by other scholars but do not measure its uptake outside academic communities or indeed influence on practice.

It is clear therefore that metrics and indicators should be handled with some degree of caution since they purport to offer an objective yardstick but are not neutral, and in line with the adage "what gets measured gets done' the risk is also that indicators can go from being a means to an end to being an end in themselves:

> *"The critical issues [indicators] raise go beyond realist ones of accuracy and methodology. Not least of them is their potential to present matters of value as matters of fact."* (Redden 2015)

In light of these challenges, the think tank concluded a good solution would be to follow a "theory of change" approach by which goals at a higher level (i.e. society or community) (see Kaufman 2005; Michalski 2015) are first established, and then the processes that lead to these are examined. In other words, to focus on tracing pathways to impact rather than impact itself (ICCROM 2015).[2]

Establishing higher and intermediate goals

> *"Rigour and excellence has always been – and will continue to be – a priority for researchers in academia. Yet relevance comes from addressing the bigger questions – those questions that reflect the needs and hopes of people, questions that promote shared stewardship [of heritage] and put the research to work for the benefit of the end-user."* (Cassar 2017)[3]

Heritage science supports the interpretation, use, management and preservation of cultural heritage, and in doing so contributes to the creation of "cultural value" (Holden 2004, 2006). The actual nature of the benefit delivered to society through cultural heritage is difficult to define in exact and measurable terms. Nevertheless it is clear that heritage science does not contribute to cultural value in isolation, but rather through its interaction with a diverse network stakeholders which includes professional peers, institutional actors (both public and private), non-expert groups, and the public (Golfomitsou *et al*. 2017).

Culture has been identified as a "driver for sustainable development" (UN 2010, UNESCO 2012), and as such the protection of cultural heritage has been included within the UN sustainable development goals.[4] Numerous attempts have been made to evaluate the contribution made by cultural heritage to society, albeit predominantly in economic terms. While this is an attractive path to take as it ostensibly offers

1 For more details see https://www.iccrom.org/news/measuring-impact-heritage-science
2 For more information on theory of change, see http://www.theoryofchange.org/what-is-theory-of-change/
3 Comment made during moderated panel discussion on Research impact, organised by ICCROM during the SEAHA17 conference held in Brighton 19-20 June 2017.
4 https://sustainabledevelopment.un.org/sdg11

a quantitative solution to the problem – and one that is likely to provide persuasive arguments – a key difficulty with trying to evaluate the benefits of culture using conventional economic terms is that the two do not really fit well together: as cultural value cannot only be expressed in terms of economic value (Carnworth and Brown 2014). Alternative routes can be taken via the environmental and social/cultural pillars of sustainability, and indeed it is encouraging to see that instances of environmental and social/cultural impact studies are increasing (CHCfE Consortium 2015).

Goals at this level may seem rather distant. Nevertheless this consideration serves to establish a principle that helps to guide us when setting the compass for determining more intermediate goals (Michalski 2015). Given that progression towards higher goals takes place through a chain of associations, maintaining the linkages in that chain is vital. Therefore for heritage science to come anywhere close to delivering societal benefit it must first and foremost support the work of other heritage professionals in caring for heritage and communicating its values. As such, the relevance and effectiveness of heritage science depend on how closely it aligns itself with the needs of its immediate users, and how well it engages and communicates with them (Brokerhof 2015). This requires an inclusive research process that is open to the participation of other stakeholders and ensures relevant, rigorous research, as well as effective knowledge exchange and implementation (Heritage and Golfomitsou 2015).

In the following section the research process is examined from the point of view of knowledge creation and exchange between diverse stakeholders engaged as knowledge producers and/or research beneficiaries.

The research process

The research process is not linear. Scientific inquiry is influenced by practice and professional interests, but it also shaped by policy and funding bodies, as well as trends or achievements in other disciplines. Similarly, knowledge diffusion does not follow an undisturbed route – the path of which rarely travels directly from the originating source to recipient audiences – and involves multiple transformations as information is re-processed, simplified, or repackaged (LSE Public Policy Group 2011).

Heritage science research covers a broad range of activities that span from exploring the materiality of heritage objects, their use, and interventions to inhibit or reverse change, to issues of perception, interpretation, risk assessment and decision-making. It can be lab, desk, or field based and is informed by the work, testimonies and opinions of an interwoven network of actors, from peers within the heritage sector to a wide array of other interest groups in other professional domains and beyond.

The typical arc of the research process can be broken down into a number of well recognised stages which include: planning; doing; interpreting; and dissemination. However, for most applied science fields, dissemination does not automatically lead to impact, since the integration of new evidence into practice also depends on how it is perceived (i.e. trusted) and what actions are taken to promote its incorporation into practice.

Green and Siefert (2005) characterise three distinct phases in the translation of new knowledge into practice, a.k.a.

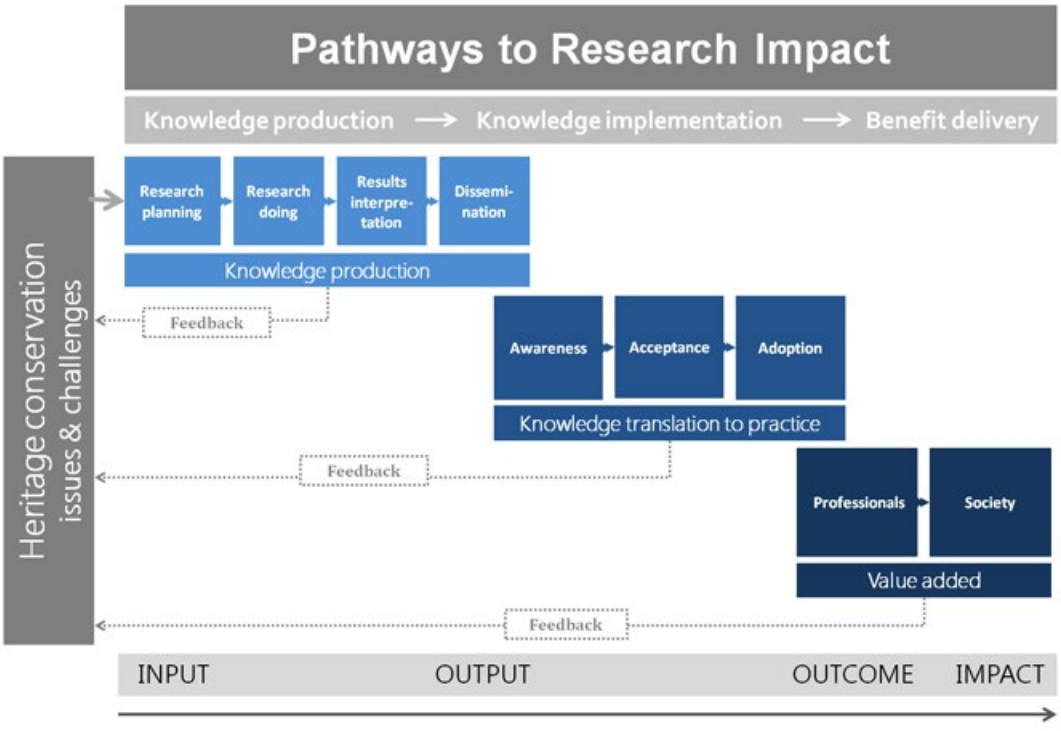

Figure 1. Pathways to research impact: From knowledge production to benefit delivery.

the three A's, which are: awareness (having knowledge of new research findings); acceptance (understanding and recognising the value of research evidence); and adoption (integrating new evidence into practice). Figure 1 provides a simplified schematic representation of the various stages in the impact pathway by which an idea that starts as a research proposal produces knowledge that eventually gets taken up by practice to deliver benefit.

The development of the three 'A' phases is dependent on cognitive and behavioural changes within the individual – who may become an agent of change themselves and in turn influence the work of others. Timescales for each stage differ, and progression from one stage to another is not automatic. As is the case for technology adoption, new knowledge in heritage conservation may follow a hype-cycle (personal communication, Odgers 2016), whereby: "a new invention may fluctuate from an initial inflated level of expectation to a trough of disillusionment, and only after a long period gradually receive acceptability – as per the hype cycle" (Gartner n.d.)[5]. Figure 2.

As a result, the implementation of research findings takes time. Studies in public health indicate that it takes approximately 17 years for new research findings to be integrated into clinical practice (Morris *et al* 2011) – which may refer to the time it takes to overcome personal and organisational barriers or for generational change to occur.

Evidence suggests for research to become more effective and implementation time-lags reduced, the research community has to shift from undertaking research for users to undertaking research with them (Reed 2016; Campbell and Vanderhoven 2016) . This implies shifting focus from knowledge transfer to knowledge exchange (i.e. knowledge is shared and enhanced rather than just transmitted) and embracing a more inclusive impact-targeted approach to research from its early stages (Johnson 2005; Mitton *et al* 2007; Reed 2016). This follows similar movements towards public engagement (e.g. citizen science). Based on the premise that new knowledge gets taken up faster if co-created and shared, current science policy paradigms centre around 'Open Science' (encompassing open access, open data, open educational resources and openness to collaboration), which represents a fundamental transition in the way research is conducted through cooperative work and shared using digital technologies and new collaborative tools (Bueno-de-la-Fuente 2016).

Pooling scientific, technological and human resources is pragmatic. Beyond the inherent value of teamwork to define shared objectives, interdisciplinary collaboration improves the quality of scientific discovery through complementary knowledge and exposure to different ways of thinking, ideas and concepts. However, 'team science'[6] requires substantial investment of time and effort to include stakeholders and develop good working relationships founded on trust. Drawing from studies on 'team effectiveness'[7], the model put forward by Stokols *et al* (2008) summarizes well the factors that determine the effectiveness of transdisciplinary collaboration (Figure 3).

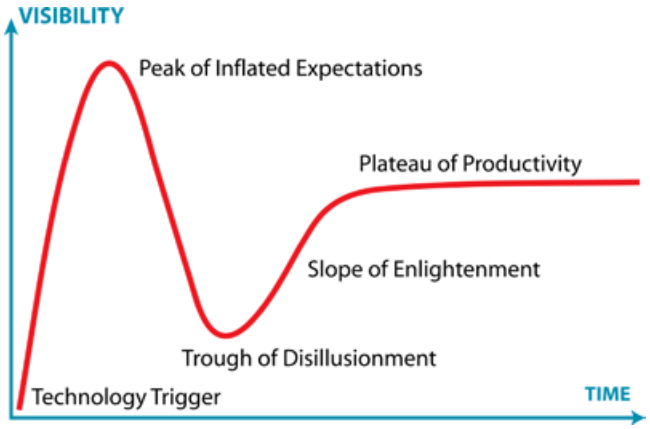

Figure 2. The hype cycle for technology, after Gartner, Inc. (n.d.)

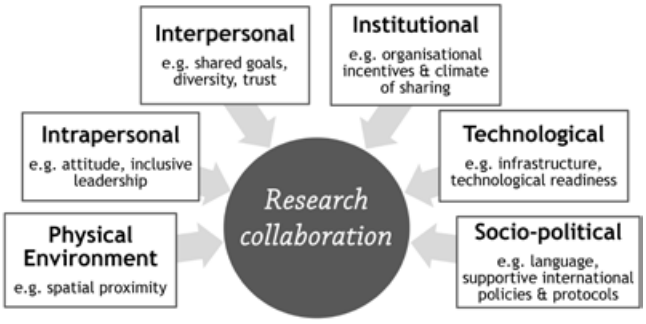

Figure 3. The ecology of team science: Enablers of effective trans-disciplinary collaboration, after Stokols, et al. (2008)

[5] https://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

[6] The term 'team science' refers to group research and/or "Scientific collaboration, i.e., research conducted by more than one individual in an interdependent fashion, including research conducted by small teams and larger groups". (National Research Council 2015, 2)

[7] The term 'team effectiveness' refers to "a team's capacity to achieve its goals and objectives. This capacity to achieve goals and objectives leads to improved outcomes for the team members (e.g., team member satisfaction and willingness to remain together), as well as outcomes produced or influenced by the team. In a science team or larger group, the outcomes include new research findings or methods and may also include translational applications of the research". (National Research Council 2015, 2)

Working together: research collaboration

> *In its broadest sense, research collaboration can be described as "a social process whereby human beings pool their experience, knowledge and social skills with the objective of producing new knowledge..."* (Bozeman & Broadman 2014, 2).

Despite the current emphasis on the importance of interdisciplinary research collaboration, there remains a distinct lack of clarity regarding what it ideally actually constitutes. Not all collaborations are equally inclusive, in particular with the regard to the involvement of stakeholders beyond the academy, and different collaborative practices will produce very different experiences and outcomes (see Figure 4). This is an important issue since meaningful knowledge exchange between researchers and practitioners is fundamental to achieving innovation and impact. This depends on the development of close working relationships between stakeholders based on mutual respect and trust – and hence the quality of collaboration merits close examination not only in terms of *who* is involved, but *how*.

Heritage science research: from input to impact

To better understand the current research landscape within heritage science three key aspects were examined: (i) the composition of research collaborations throughout the heritage science sector; (ii) current institutional practices with regard to needs and outcome assessment, and (iii) individual experiences of users within heritage science research. Together these provide insight into the manner in which heritage science research is conducted, in particular with regard to how issues of research relevance and impact are addressed, and the overall quality of research collaboration. The results are discussed below.

How collaborative is heritage science?

To map the reach and institutional diversity of collaborative networks within the broader field of heritage science, a bibliometric study[8] was undertaken which used co-authorship as a proxy indicator for research collaboration. The study examined bibliographic and citation metadata from a sample of almost 8000 peer-reviewed articles contained within the Web of Science (Core Collection)[9] with a topic focus in heritage science and published between 1996 and 2015. This was undertaken to gain a rough macroscopic overview of national and international collaborations in heritage science over a 20 year time period, as illustrated within the captured dataset. It must be acknowledged that the sample dataset does not cover heritage science publishing in its entirety. However, as one of the largest available bibliometric database for science research, the Web of Science contains a significant proportion of the heritage science literature appearing in both conservation specific and non-conservation specific publication sources. Therefore, while the sample obtained is not exhaustive it can be considered adequately representative of general publishing trends within the sector.

Authorship is the currency of the academic economy through which accomplishments are marked, reputation is grown and responsibility assigned (National Academy of Sciences 1992, 52; Wager 2009). Accordingly, researchers and institutions are strongly motivated to share their activities through publications – as this lies at the core of the research reward system. To this end, co-authorship patterns derived from publications metadata can provide an indication of institutional involvement – albeit approximate (since involvement in a project does not strictly infer co-

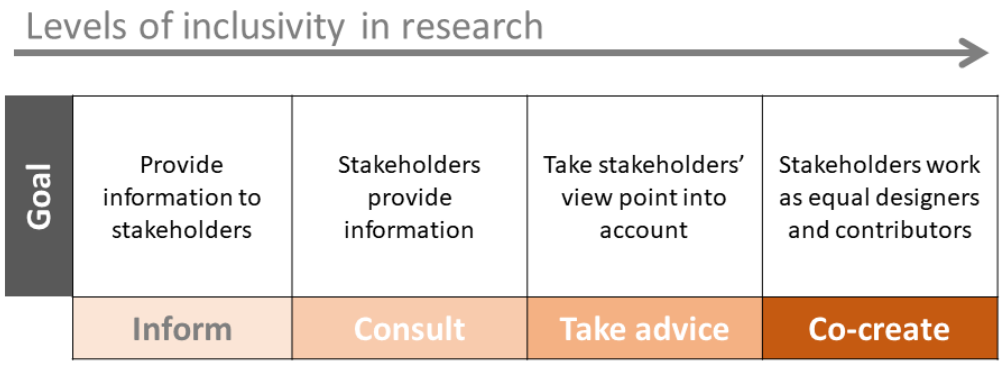

Figure 4. Stakeholder engagement in research. Adapted from IAP2's Public Participation Spectrum, http://c.ymcdn.com/sites/www.iap2.org/resource/resmgr/Core_Values/WEB_1510_IAP2_Core_Value_Awa.pdf

[8] Bibliometrics is defined by OECD as the 'statistical analysis of books, articles, or other publications"for further information see https://stats.oecd.org/glossary/detail.asp?ID=198

[9] See https://clarivate.com/products/web-of-science/web-science-form/web-science-core-collection/

authorship, and vice versa). This is of course also influenced by the fact that researchers in academic institutions are under greater pressure to publish than their peers outside academia. Nevertheless, while incentives to publish may differ from academic to non-academic (heritage custodial) institutions, it is fair to assume that institutions represented in a research project are unlikely to relinquish credit lightly in the dissemination process.

For this particular study, data were retrieved from the Web of Science by multiple Boolean searches[10]. Queries were not limited to publication sources within the cultural heritage and/or heritage science field but were rather widely applied to all sources indexed by Web of Science that could possibly contain published works concerning heritage science issues. To ensure all heritage science associated publication sources indexed in Web of Science were adequately covered, complimentary searches by publication sources were also carried out. Moreover, data review and curation was undertaken to remove irrelevant search results, duplicates, and incomplete data entries.

The curated dataset comprised ca. 8000 articles produced by individuals affiliated to more than 4000 institutions from 118 countries worldwide; it covers peer-reviewed journal articles and conference proceedings published in English between 1996 and 2015[11] (Table 1) and submitted to cultural heritage and heritage science focussed (60% of the identified articles) as well as to publication sources outside these fields (40% of the dataset).

Analysis of the dataset against time reveals significant overall growth in publishing over the past 20 years, with a ninefold increase in articles published in 2015 compared to 1996. The overall volume of co-authored papers has also risen: in 1996 multi-author articles outnumbered single-authored ones 2:1, while in 2015 the ratio increased to about 5:1, with an average of 4 authors per paper. Such increase is evident

Table 1. Heritage science bibliometric dataset profile

Heritage science literature dataset profile:	
Data source: Thomson Reuters, Core Collection of Web of Science **Data type**: Journals articles and conference proceedings (peer-reviewed) in English **Collection method*:** Boolean search queries for scientific studies applied to tangible cultural heritage (i.e. Heritage Science), using AATA classification and other search criteria (e.g. keywords). **Disclaimer: Pure archaeology and art history publications were excluded during data curation.*	
The dataset in numbers	
Number of identified articles	7913
Number of single author articles	1330
Number of multi-author articles	6583
Number of institutions represented in the dataset	4410
Number of countries represented in the dataset	118
Number of publication sources (e.g. journals) represented in the dataset	1195
Number of cultural heritage related publication sources	143
Number of publication sources outside cultural heritage	1052
Classification of institutional typologies (primary nature):	
ADMIN: Public national or regional agencies outside culture and cultural heritage; **FIN:** Financial Institution; **HEALTH:** National Health Agencies; **HEI:** Higher Education Institutes; **IHA:** Independent heritage agencies (non governmental); **IGO:** Intergovernmental organisations; **IND:** Independent organisations outside cultural heritage; **L&A:** Libraries & archives; **MGF:** Industry and product manufacturing enterprises; **MUS:** Museums, Galleries, art spaces; **NHA:** National Heritage Agencies; **PRIV/COM:** private practice, freelance etc.; **RI:** Research Agencies; **SITES:** Heritage Site.	

[10] For Boolean search protocol please see http://www.lib.berkeley.edu/TeachingLib/Guides/Internet/Boolean.pdf

[11] It is important to note that this sample is limited to literature published in English and thus provides an indicative but not exhaustive overview.

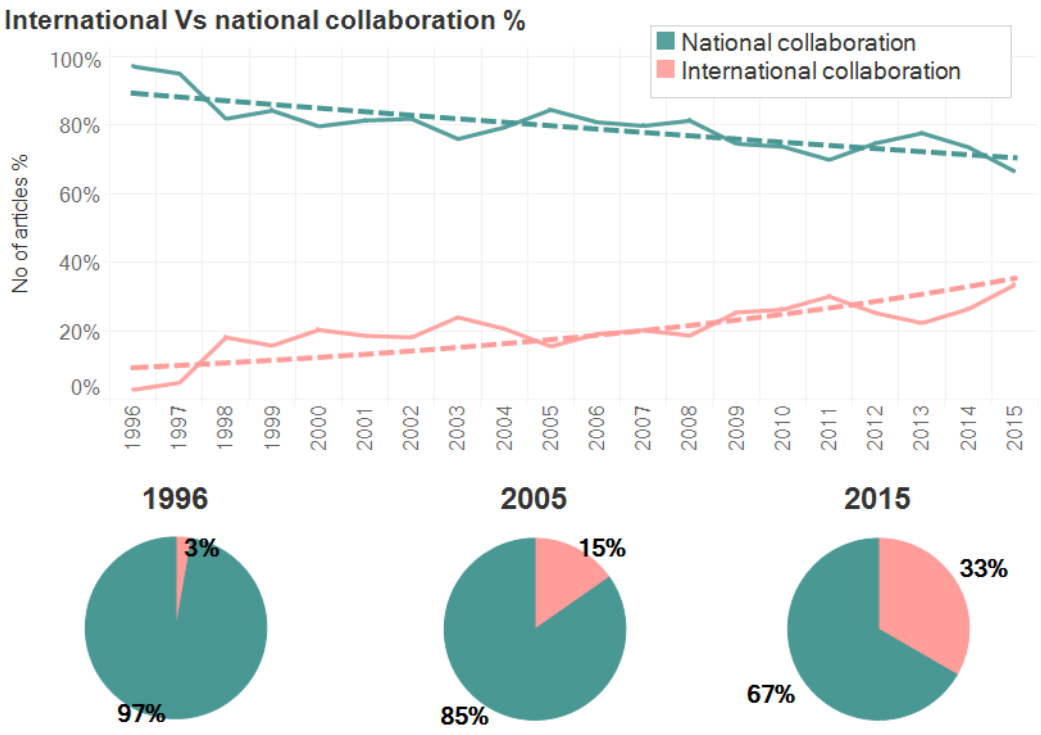

Figure 5. National versus international collaboration 1996-2015

both at national and international level. Internationally, the number of articles co-published by authors working in different countries has grown from 3% in 1996 to more than 30% in 2015 (Figure 5). Likewise at a national level, more than half of the co-authored articles published in 2015 are written in collaboration with another institution as opposed to 1996 where 9 out of 10 of co-authored articles were produced within a single institution.

In general, the volume of papers produced inter-institutionally is rising. To track how diverse these collaborations tend to be, all institutions in the data set were classified according to their primary nature (Table 1). Figure 6 depicts the proportion of articles produced collaboratively between institutions with similar mandates versus those produced between institutions with different mandates over time. The results show a proportional decrease in collaborative

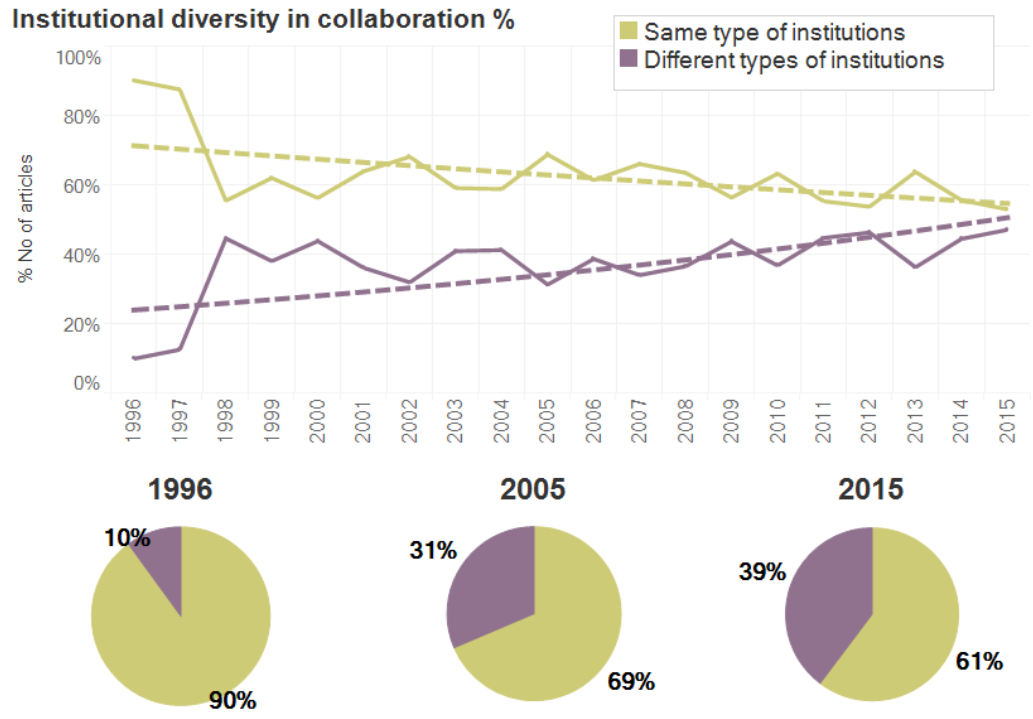

Figure 6. Institutional diversity in collaborative heritage science publications 1996-2015

publishing between authors from the same type institutions (from 90% of inter-institutionally produced publications in 1996 to about 61% in 2015) but still, currently 3 out of 5 collaborative articles are produced between institutions with similar mandates. Closer analysis shows higher education institutes (HEI) and research institutes (RI) are among the most frequent collaborators. The volume of papers produced collaboratively between purely research-oriented institutions (HEI and/or RI) currently accounts for around 50% of all collaborative papers – with very little change over the past twenty years. This indicates that although inter-institutional collaborative publishing is increasing, proportionally the participation of non-academic partners is not (Figure 7). Beyond research-orientated institutions, the most prevalent collaborations between institutions of different mandates involve museums (12% relative share in publications from 1996 to 2005), national heritage agencies (12% relative share in publications from 1996 to 2005), and private practice (7% relative share in articles from 1996 to 2005) – the common denominator in all being HEIs (Figure 8). The bibliometric evidence presented here indicates that around 80% of the heritage science literature published in the past 20 years has been produced in collaboration with at least one university – and about of 50% of it exclusively by one or more universities.

How are research needs assessed and outcomes evaluated?

As stated above, a key prerequisite for heritage science to have an impact is that it addresses a priority need. This, in turn, implies adequate needs assessment (as a more reliable alternative to relying on serendipity aka pot luck). Likewise, to know whether the research has achieved its goals effectively requires some form of outcome evaluation. To assess the extent to which this is undertaken at present ICCROM launched a worldwide survey in late 2015 to trace the ways in which institutions involved in heritage science research for conservation purposes identify research needs, plan their research activities and evaluate their performance. Particular emphasis was placed on how needs assessment is performed and who is engaged in it; how institutions evaluate and disseminate the results of their research; and what are the challenges that hinder such processes.

The survey questionnaire was distributed electronically (using an online survey tool) to 188 institutions from 60 countries that are actively involved in heritage science research for conservation purposes. The target sample comprised institutions identified via the ICCROM survey of Conservation Literature (1992-2012), the ICCROM database as well as through the consultation with the networks of ICCROM Programmes. From these, the survey received 94 responses from 89 individual institutions in 38 countries (57 institutions from Europe & North America; 22 institutions from Asia & the Pacific; 6 institutions from Latin America & the Caribbean; 2 institutions from Africa; and 2 institutions from Arab States). The majority of responding institutions were public, primarily funded by governmental and intergovernmental means.

Survey findings highlight that although research needs are often assessed within institutions as part of the research planning process, institutions tend to rely on expert-driven,

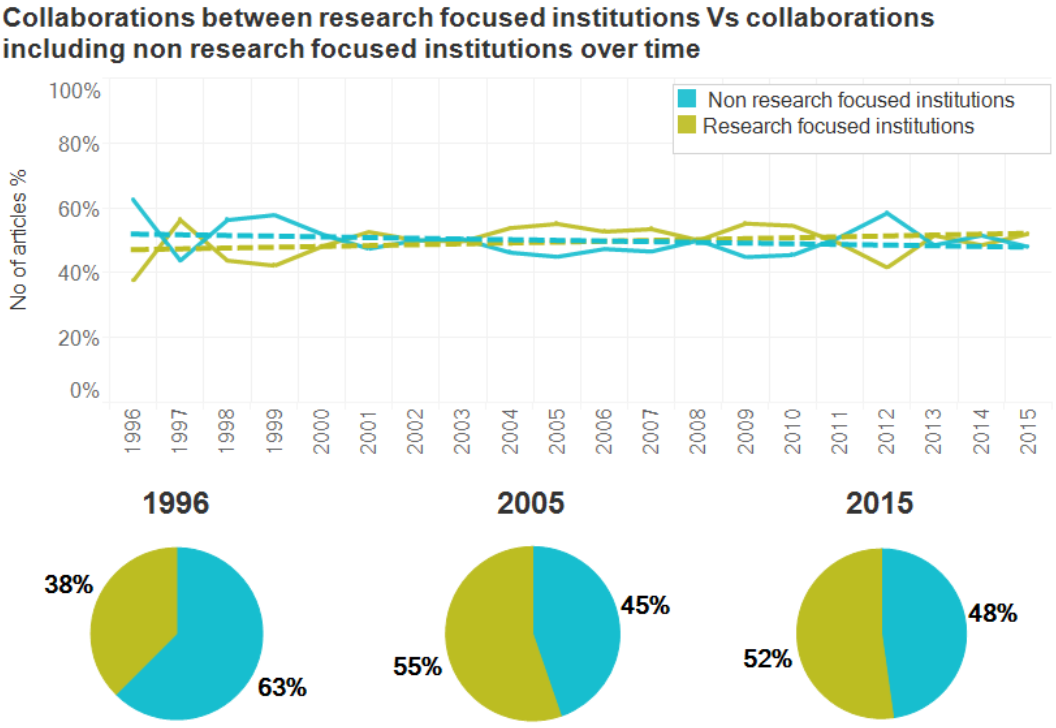

Figure 7. Collaboration between research focused institutions and collaborations including non research focused institutions

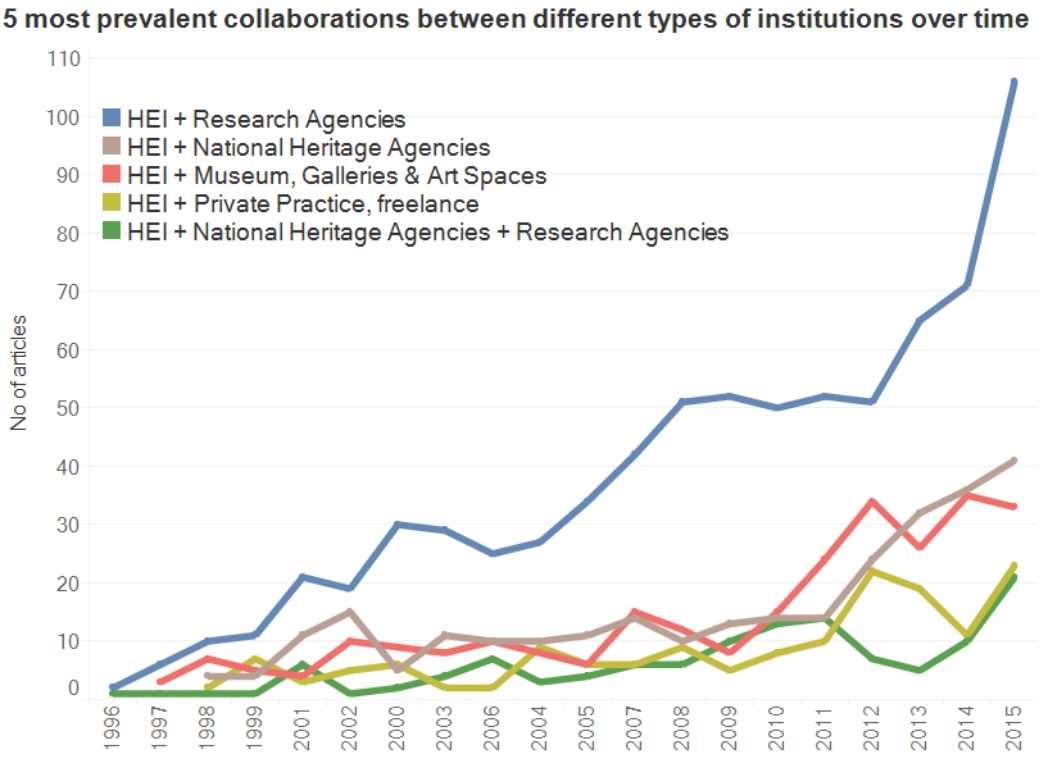

Figure 8. Most prevalent collaborations between different types of institution 1996-2015

producer-orientated practices to identify research priorities that rarely include systematic communications with primary clients and research users. Moreover, in terms of outcomes or impact of research, the results of research activities are rarely assessed beyond quantifying outputs such as publications. In particular, research is largely evaluated in terms of inputs and outputs such as the grants received, the number of publications produced and their citation counts, and the number of training activities delivered, while the evaluation of outcomes to research beneficiaries is neither regular nor systematic practice. Overall this illustrates an output-focused evaluation system with limited formal connection to the research beneficiaries (Figure 9).

Furthermore, needs and outcome evaluation is perceived as a complex and difficult task to undertake due to limited staff time and available financial resources (60% and 45% of respondents considering it as a significant obstacle respectively). Interestingly, 1out of 3 respondents reported lack of incentives at institutional and individual level (lack of foreseen benefit as main obstacles and evaluation not being mandatory) as a main obstacle, while about half stated that lack of in-house expertise was not a problem. Nevertheless, over 60% of respondents reported interest in national and international statistics for comparative benchmarking, and guidance to measure the results of their research.

To facilitate dissemination the full survey data are compiled into an interactive tool which can be accessed at http://www.iccrom.org/themes/heritage-science/sector-analysis/planning-and-performance.

How are users involved?

There is a body of research identifying the factors that affect the quality of scientific collaboration (Stokols *et al*. 2008; Bozeman *et al*. 2013). Quantitative survey research into UK collaborative heritage science has identified some variables associated with self-rated outcomes, impact and goal achievements in collaborative heritage science research in particular (Dillon *et al*. 2014). However, to date, little research in this field has looked in depth at the process of transferring research into practice (i.e. awareness, acceptance and adoption), and the experience of collaborative heritage conservation science from the user's perspective.

Hence, an interview study was undertaken to better understand the role of users within collaborative heritage science research projects and the factors that facilitate knowledge implementation. The aim was to track the user's involvement across collaborative research projects, and identify potential support needs for more effective collaborative research. A particular objective was to shed light on how research can be designed with end benefit in mind; how users of research evidence become aware of new knowledge; how they come to accept it (i.e. what makes it credible, relevant and usable); and then integrate it into practice (e.g. through new guidelines or advocacy within the field of conservation practice).

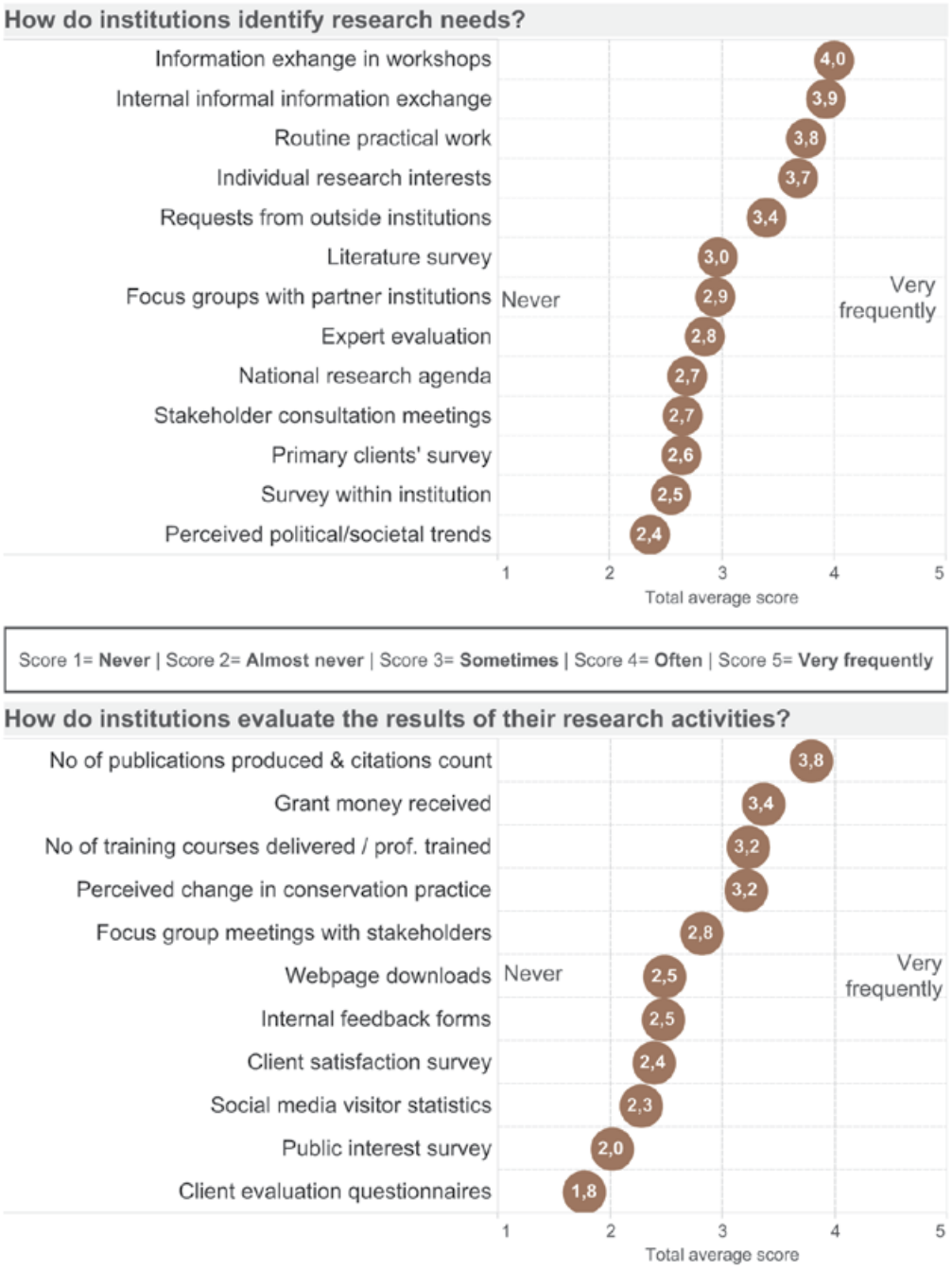

Figure 9. Needs and outcome evaluation of heritage science activities for conservation purposes

Sixteen semi-structured interviews were conducted[12] (see appendix). The sample size of sixteen was sufficient to identify unique features of heritage science in relation to the 'Team Science' model outlined above (see Figure 3) and common facilitators and barriers on the pathway to impact (Baker and Edwards 2012). Interviewees were identified from the literature dataset examined above and through the ICCROM professional network. The interview sample was intended to cover a broad range of research topics, institutions and types of collaboration within cultural heritage conservation. Conservators who had co-authored peer-review publications, had taken part in several projects (in particular international projects), and whose findings had had time to transfer to practice were of interest. Most interviewees were senior conservators, with experience of leading departments and major research projects, who were chosen for their overview of the research process from project initiation to knowledge transfer and who had experience of collaboration across

[12] Interviews were conducted by peers based at ICCROM, while analysis was undertaken by a social scientist (Independent researcher). Interviews were conducted by skype and landline, and lasted around 1 hour. Video and audio recordings were made with the prior consent of the interviewees.

disciplinary and institutional boundaries[13]. Conservators in private practice who had initiated partnerships with academic institutions were also represented.

Interviewees were asked to think about one or two research projects they had led, and were asked questions structured around the research phases outlined in Figure 1. In this way the pathway from production to implementation for particular projects was elicited from interviewees. They were asked about who the research had benefited and how, the role of the user in initiating, conducting, interpreting and disseminating the research, and the pathway from findings to application. Questioning was generally open, allowing interviewees to talk freely about their experiences of research, with some more targeted probes relating to factors found to influence the effectiveness of collaboration in previous research.

Framework analysis[14] was used to qualitatively assess the interview data using the 'Team Science' model of collaboration (see Figure 3) for each research phase. Themes in the data that converged or diverged from the model were identified, as were factors which interviewees felt had facilitated or hindered the pathway to impact.

Intended Benefit

Interviewees commented that it is important at an early stage to have a clear idea of who research projects intend to benefit, in what way, and how findings might be communicated. Some actively planned for impact and engagement on several levels: conservation, heritage sector, society. Whilst interviewees were often clear on intended benefit and knowledge production, the intermediary step of knowledge implementation was often more opaque.

> *"...the goal is that we benefit many people in many contexts, the point along the way was to have as many facets as possible, to try to educate with the project, to provide a service with the projects, and it resulted in substantial information that would be of value to many different people....I think that my understanding was that the information I was after was going to be applied, we intended it to be useful, we wanted it make a change in peoples understanding and the way people do their job..."* (Participant 11)

Level of Involvement

Interviewees described differing depths of user involvement (table 2). Generally, projects considered most successful were those where users had a high degree of influence over research topics and direction. A strong message was that users should be involved in heritage science projects from the outset to help identify conservation needs, point to gaps in research and maintain focus on applied goals, thus ensuring best use of resources and enhancing research quality.

"our contribution was primarily to identify this phenomenon in more [materials], to offer samples; it was also understanding the conservation history of the objects...we have lots of records that we then could handover and explain that's maybe where we could look; continuously drawing the attention of the scientists back to what happens with real materials all the time...the dialogue with the scientists and

Table 2. Different levels of user involvement in collaborative research

Level of Involvement	User role	Benefits	Risks
High	Leads: initiates, develops, funds, builds team, plans and coordinates	Focused on needs; High relevance and applicability; High autonomy	Resource intensive; Scientific goals secondary; Team management
Medium	Is part of an inter-disciplinary team; Links to collections, the field and applications	Practical skills and collection knowledge available to project; Advocacy for collections and applied goals; Gains access to equipment and resources; Cohesiveness	Maintaining focus on applied goals; Relationships and communication
Low	Is informed of or consulted on research design and results; Provides access to collections and case studies	Can pose research questions; research does not detract from day to day conservation priorities, or use internal resources	Does not address needs; No ownership of research direction, findings and further developments.

[13] Interviewees from four continents were represented in the sample, with most from Europe; conservators from Asia and Africa were invited, but due to time and institutional restrictions declined to participate.

[14] For more information on framework analysis, see https://www.surrey.ac.uk/sociology/research/researchcentres/caqdas/files/Session%201%20Introduction%20to%20Framework.pdf

drawing the attention of the scientists to how I translate this into action…. to create a bigger picture of what is going on here; say you had been gathering, slowly been gathering data which slowly becomes bigger data which you can make more of in research in the future…" (Participant 3)

Enablers of Collaboration

Enablers of effective collaboration identified in the literature (Stokols *et al* 2008; Dillon *et al* 2014) and outlined in Figure 3 were apparent within the participants' experiences (see table 3).

Interviewees commented on the tendency of research to lead to more questions and the preference of scientific partners to follow interesting findings rather than applied goals. Readiness for science, research and collaboration was an advantage in this respect, either gained through experience or preparatory training. Interviewees also often described a preference for working closely with a small number of key associates (e.g. conservation science, art history, building specialists) at a local or national level, on projects based around tangible problems. The influence of individual conservators may be lessened in larger more complex projects, which may have relevant but more distant goals.

Knowledge implementation

Peer-review publications were widely viewed as measures of project success, and many described knowledge sharing in a linear way: research-publication-application. On deeper

Table 3. Enablers of effective collaboration from the interviewees' perspective

'Team Science' Factors	Enablers of collaborative heritage conservation science	
Intrapersonal	**Readiness** for scientific research collaboration (gained through experience or preparatory training); practical skills **Attitude:** prepared for the effort of interdisciplinary and inter-institutional work; high motivation to participate **Personal goals:** clarity of applied reasons for participating **Leadership:** participatory leadership, but focused on applied goals.	
Interpersonal	**Goals** are applied, shared, mutually beneficial, clear and strategic **Diverse perspectives** from complementary disciplines and other stakeholders **Communication:** regular, inclusive and respectful communication to develop common ground, trust, familiarity and cohesion **Flexibility** to amend plans, but maintaining focus on applications **Forward planning** for impac t, engagement and dissemination	
	Length of project	***Longer:*** time for ideas and relationships to develop ***Shorter:*** focused, suitable for students, can be iterative
	Size of project	***Smaller:*** informal, autonomous, participatory, open ***Larger:*** structured, formal, clear plans, goals and accountabilities
Institutional	**Access** to equipment, collections and expertise within home or partner institutions **Climate of sharing** within and between institutions (e.g. information, credit, decision making, dissemination) **Incentives and institutional support** to participate in research, including dissemination (e.g. time) **Culture:** accounting for differing working practices, differing institutional goals and differing goals of science and practice	
Technological	**Development and adaptation** of technologies for the purposes of research in the context of practice **Infrastructure for material analysis** and data sharing **Sharing of analysis equipment and expertise** between institutions	
Physical Environment	**Proximity** allows informal project initiation and communication throughout **Applied setting** helps focus goals **Access to a laboratory** (e.g. for smaller institutions and private practice)	
Societal- Political	**Responsiveness** to societal and global challenges and crises **Funding:** inclusive; available; long enough to develop research and disseminate **Policies/Guidelines** for the inclusion of users from the outset of projects, open science and collaborative relationships **Strategic support** to increase the readiness of users for collaboration and to support their participation	

questioning peer-review publications were not considered the most influential agents of change. Instead interviewees described two-way, iterative and multi-stranded processes of change, as more effective (Table 4).

Knowledge exchange events were considered important for discussing and 'debugging'[15] new knowledge and applications. In particular, face-to-face hands-on practical workshops were cited as the most influential way of changing conservation practices. Alternative publication types, such as practical guides and databases, were valued, especially if accompanied by training. Interviewees sometimes perceived conservators as resistant to change. Comprehensible, relevant messages from influential practitioners and institutions were considered more easily accepted.

> *"... it's not just like its published there and it's not like it's a kind of bible there, if you come together and re-discuss these things, there is an easier way of shaping these results and to developing these results and going further, its published somewhere and then it's discussed and then it's changing..."* (Participant 2)

> *"Of course just reading about it, gives you a certain amount of information, but unless you've been with people who've used it, who've tried to use it, who've experimented with using it...we had a symposium, well attended, we were basically disseminating the experiences we have had, but also listening to the experiences that conservators have had out in the field ...there were three groups in the afternoon, people moved between these things, looking at various aspects of the material and its use ... using that and the stuff from the research project, putting it altogether in this technical advice note, I would hope that in years to come that would be seen as a useful document.... people still come up to me and say that was the best one I've been to because you felt as though what you said mattered."* (Participant 5)

Open science

Throughout the interviews there were references to research practices that come under the umbrella of 'open science'. Inclusivity in funding and decision making were considered very important, as was the means to share expertise and resources across institutions. Making results accessible to all was often a strong motivator. However, there were limits around access to data and low take up of open access routes to dissemination. Commercial and reputational goals can appear to be threatened by open science and there may be resistance from institutions. Unmoderated access to large amounts of unstructured and un-interpreted data was also a concern, with datasets requiring a great deal of preparation and explanation before dissemination. The need for security, protection against misuse (e.g. fraud), agreements and protocols was also highlighted. Overall, the effort and risk versus the rewards of open access and open data appear to be imbalanced at this time.

> *"I'm trying to set up a network for sharing of [topic] data, I can see that other institutes are very cautious about joining this...it's an area that needs thinking, because they all treat their data very carefully, especially the raw data you never see it ....all over the world [researchers] are sitting on their raw data... policies for sharing data are absent, only one place and that was in [country] I believe, and they were forced by law to put it all up on the online and that was because of open access to state owned objects."* (Participant 3)

Table 4. Research outputs from the user's perspective

	Reach	Relevance	Comprehension/ Ease of use	Trust	Resource Use (audience)
Subscription/membership publications & conference proceedings	Low	Low	Low	High	High
Open access publications	High	Low	Low	High	Low
Knowledge exchange events	Medium	High	Medium	High	Medium
Practical resources	High	High	High	Medium	Low
Practical workshops & other outreach	Low	High	High	High	High
Online resources	High	Medium	High	Low	Low

[15] See Green and Siefert (2005)

Implications for enhancing impact

As this study has shown, heritage science research is becoming increasingly productive, collaborative, and international. However, the increasing level of collaboration does not at present appear to equate to a greater partnership between non-academic and research-oriented institutions. To improve the delivery of non-academic impact, greater participation of diverse institutional stakeholders within heritage science change is needed. To support this, open collaborative practices and meaningful user inclusion are key. These can be promoted through policy and strategy development, but also require an attitude and behavioural change, recognising that the time and effort invested in building working relationships between researchers and users can translate into win-win benefits for all.

To reduce current impact gaps, strategic support is needed:

Training: Research and practice should not be seen as adversaries as they share the same goals, and in particular higher education institutes (HEIs) are powerful agents of change in many ways. The evidence presented here illustrates the decisive role played by HEIs in knowledge production for heritage science, with 8 out of 10 indexed articles produced in collaboration with a university. The increase in international collaborations promotes the exchange of ideas and research findings beyond national boundaries. In addition, a large proportion of heritage science research is published in international scientific journals which enhances visibility beyond national and disciplinary boundaries. However, such channels may be inaccessible to end-users who do not usually consult these sources, particularly on account of barriers imposed by journal subscription charges and (for non-native English speakers) language. Open access publications and alternative platforms (e.g. university portals, ResearchGate, Academia.edu, etc) to some extent help to mitigate this situation.

Nevertheless, HEIs can and should do more to promote participation of end-users in research projects from the initial stages of drafting research agendas. As training institutions, HEIs contribute significantly to shaping the professional values and attitudes of prospective heritage professionals, thereby engendering long-term changes in research collaboration. The adoption of team science approaches within learning programmes can help to build greater research preparedness amongst end-users, and promote a culture of collaboration and sharing (Golfomitsou *et al* 2017). To this end, research-based learning contributes not only to the development of research skills and critical thinking, but also provides training and experience for early career researchers in methods to improve stakeholder engagement and non-academic impact. In these ways, HEIs can prepare future professionals in conservation and heritage science who can not only collaborate effectively but also advocate for the field. When research-based learning becomes part of an educational programme, students become 'producers rather than consumers' challenging educational norms and changing the relationship between research and practice (Lambert, 2009).

Needs and outcomes assessment: More rigorous processes are required to link research needs assessments with real-world challenges experienced by users, with greater emphasis on evaluating research outcomes, rather than counting outputs. A favourable stance towards this is indicated by the work of policy and funding bodies to include systematic planning for impact at the early stages of research design (e.g. as in the case of the Higher Education Funding Council for England, HEFCE[16]). Beyond this, to enhance support at the level of research and/or heritage agencies development of guidance material and self-evaluation/assessment tools are needed. In their simplest form these tools could range from exercises on current realities and future desires[17] to guidance on human-centred design, interest group mapping and consultation processes. Michalski (2015) sets out a number of useful considerations on the dimensions of impact and ways of measuring it, and notes these tools can potentially provide the means to make persuasive arguments regarding the contribution of heritage conservation to society and its grand challenges.

Dissemination: To achieve impact, publications are not enough. Finding the right routes to reach desired audiences is essential and requires greater engagement through knowledge exchange events and practical workshops. Past emphasis has been placed on making research accessible by packaging it better, but instead of attempting to use the right words, a more direct (and arguably more genuine) approach would be to involve the right people – since the working relationships built thereby would naturally lead to the development of a common language.

Open science: The open science movement has gained momentum over the past years, yet there is a need for greater awareness of its potential, as well as its current shortfalls. With regards to dissemination of research, open access publishing is a significant step forwards in reducing barriers to knowledge and is increasingly underpinned by national and institutional policies worldwide[18]. Nevertheless, a number of issues associated with the business model that governs open access are a cause for concern. Publication fees (i.e. Article Processing Charge, APC) set by mainstream publishers

[16] See for example http://www.hefce.ac.uk/rsrch/REFimpact/#index
[17] See for example http://www.e-valuate-it.com/instruments/rka/Strategic_Thinking_and_Planning.aspx
[18] See for example http://roarmap.eprints.org/dataviz.html

are very high for fully accessible open access articles. For example, the current (i.e. May 2018) APC charged for Gold Open Access by Taylor and Francis is set at 2150 euros, while that of Elsevier ranges from 500 to 5000 euros depending on the journal. In fields like heritage science where funding is limited, the shift from post-publication charges (traditionally covered by thousands of libraries around the world) to a pay-to-say model is likely to exchange barriers-to-readers with barriers-to-authors. This raises significant concerns as to who gets to publish via open access, where, and under which criteria[19] [20]. Waivers to APC costs for the not-so-privileged exist but more interventions are needed to encourage grant-giving, institutional subsidy schemes and journals to adopt low fee arrangements in order to make open access attainable to a broader base. Nevertheless, it is also important that actions are taken to raise awareness of the plurality of commercial or non-commercial choices for open publishing and sharing.

In terms of open data sharing practices (e.g. accessibility, reuse, redistribution, participation), disclosure of research data remains a challenge (OECD 2015). Current work at policy and advisory level is focussed on setting the framework and creating incentives to facilitate this further (European Commission 2015). Looking closer to home, collective work on definitions and guidelines is required to capitalise on the potential of heritage data interoperability of for the use and the benefit of many. Initiatives such as the European Research Infrastructure for Heritage Science (E-RIHS) in Europe present an opportunity to bring this dialogue a step further.

Guidelines that promote the inclusion of users from the outset within research projects, and which recognize outcomes other than peer-review publications could facilitate knowledge exchange and benefit delivery. Research funders should also provide greater flexibility and funding to encourage end-user engagement in projects. Recognition of contributions in kind can facilitate the incorporation of end-users within research, however, this does not overcome the fact that many museums and heritage institutions operate with extremely limited resources, which may preclude staff from participating in research. In addition, the ground rules for collaboration in terms of decision-making, ownership of results, sharing of credit, access to resources and application of findings need to be defined.

Conclusions

> *"If networked science is to reach its potential, scientists will have to embrace and reward the open sharing of all forms of scientific knowledge, not just the traditional journal publication. Networked science must be open science. But how to get there?"* (Nielsen 2011, https://www.novim.org/the-new-einsteins-will-be-scientists-who-share/)

This statement aptly summarises the desire for a new reality within the knowledge industry. Yet, as international science paradigms call for increasing openness in research – including the engagement of non-professional stakeholders within "crowd science" initiatives – and as policy requirements for open access and open data become more common, greater preparedness amongst researchers and user participants in heritage science is needed. New ethical issues come to the fore regarding the fair and appropriate handling of people, heritage assets and data within research.

To catalyze the capacity of the sector to generate more impactful research, there is a need for greater discussion and action regarding what constitutes responsible research within the heritage sector, and how this can be better supported. For instance, the provision of guidance tools to help researchers manage ethical dilemmas in heritage science – such as correct handling of data and the acknowledgement of research participants – would be useful. Established codes of practice for research exist at the institutional level, however they are not specifically developed for heritage science, nor are they shared at international level – which can present challenges for collaboration across institutional, disciplinary and geographic borders. In some research fields – particularly the life sciences[21] – international ethical frameworks exist which could provide a useful starting point for engaged individuals within heritage science to advocate and work towards developing something similar for heritage science research.

Additionally, there is an increasing need for heritage science and conservation institutions to engage in knowledge dissemination pathways that extend beyond traditional journal article publishing to new models of research sharing and knowledge exchange. At the same time key players within the heritage sector including publishing institutions and journals need to negotiate affordable and sustainable open access options for all. This requires lobbying publishers to

[19] See for example https://blogs.openaire.eu/wp-content/uploads/2017/03/OA-market-report-28Final-13-March-201729-1.pdf

[20] Owing to the level of the APC levied by Taylor and Francis for Gold Open Access in Studies in Conservation, the authors will endeavour to make this paper available by Green Open Access on publication. For further details please see www.iccrom.org.

[21] See for example UNESCO Bioethics http://www.unesco.org/new/en/social-and-human-sciences/themes/bioethics/call-for-advice-revision-of-unesco-recommendation-on-the-status-of-scientific-researchers/

reduce open access fees to journals, and approaching funders and institutions to endorse tangible support schemes to cover publishing costs and incentivise alternative publishing options (e.g. ubiquity press, F1000Research etc.).

Perhaps though, the greatest change needs to come from within the heritage science community itself through a reappraisal of the true goals of research: moving from an emphasis on academic impact achieved through publications towards non academic impact achieved through working closely with research beneficiaries. This can only be realised through the active contribution of individuals who are prepared to step out of established ways of working, devote time and energy to building creative partnerships outside academia, and take risks. It also requires top-down change to rewrite the rules of the academic reward system such that research value is measured as much in terms of the diversity of engaged partners and quality of knowledge exchange as journal impact factors and citation counts. If this were to happen it might even pave the way towards the much needed revolution in publishing mentioned above since impact factor would no longer be worth the premiums currently charged. It would also support a healthy and more vibrant research community which through creative discovery can deliver greater societal benefit – leading to greater public support and new horizons for heritage science.

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References

Baker, S. E., and Edwards, R. (eds.) 2012. *How Many Qualitative Interviews is Enough? Expert Voices and Early Career Reflections on Sampling and Cases in Qualitative Research*, Southampton: National Centre for Research Methods, accessed May 24, 2017 http://eprints.ncrm.ac.uk/2273/

Bozeman, B., Fay, D., and Slade, C.P. 2013. "Research collaboration in universities and academic entrepreneurship: the-state-of-the-art." *Journal of Technology Transfer* 38: 1–67. doi:10.1007/s10961-012-9281-8

Bozeman, B., and Broadman, C., 2014. *Research Collaboration and Team Science: A State of the Art Review & Agenda*, Springer: London.

Brokerhof, A.W., 2015. "How Can Science Connect With and Contribute to Conservation? Recommendations and Reflections." *Studies in Conservation* 60 (S2): 7-13. http://dx.doi.org/10.1080/00393630.2015.1117859

Bueno-de-la-Fuente, G. 2016. "What is Open Science? Introduction". *FOSTER* accessed October 15, 2016 https://www.fosteropenscience.eu/content/what-open-science-introduction

Campbell, H., and Vanderhoven, D., 2016. *Knowledge That Matters: Realising the Potential of Co-Production. N8/ESRC Research Programme*, accessed November 20, 2017 http://www.n8research.org.uk/view/5163/Final-Report-Co-Production-2016-01-20.pdf

Carnworth, J.D., and Brown, A.S., 2014. *Understanding the Value and Impacts of Cultural Experiences*, A Literature Review. Manchester: Arts Council England.

Cassar, M. 2017. 19 June. [personal communication]. London: University College London.

CHCfE Consortium, 2015. *Cultural Heritage Counts for Europe*. Full Report, accessed May 5, 2017 http://www.historic-towns.org/html/originals/CHCfE_FULL-REPORT_v2.pdf

Dillon, C., Bell, N., Fouseki, K., Laurenson, P., Thompson, A. and Strlič, M. 2014. "Mind the Gap: Rigour and Relevance in Heritage Science Research." *Heritage Science*, 2 (11): 1-22. DOI: 10.1186/2050-7445-2-11.

European Commission, 2014. *Guidance for evaluators of Horizon 2020 proposals*, accessed July 5, 2017 http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-evaluation-faq_en.pdf

European Commission, 2015. *The Knowledge Future: Intelligent policy choices for Europe 2050*, accessed 9 November 2016 https://ec.europa.eu/research/foresight/pdf/knowledge_future_2050.pdf

Gartner, n.d. *Gartner Hype Cycle, Interpreting Technology Hype*. Accessed July 1, 2017 http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp.

Golfomitsou, S., Katrakazis, T., and Heritage, A., 2017. "The role of educators in promoting collaborative research." *CeROArt*, accessed June 26, 2017 http://ceroart.revues.org/5051.

Green, L.A., and Seifert, C.M., 2005. "Translation of Research Into Practice: Why We Can't Just Do It." *Journal of the American Board of Family Medicine* 18 (6): 541-545. DOI: 10.3122/jabfm.18.6.541

Heritage, A., and Golfomitsou, S., 2015. "Conservation Science: Reflections and Future Perspectives." *Studies in Conservation* 60 (S2): 2-4. http://dx.doi.org/10.1080/00393630.2015.1117858

Holden, J., 2004. *Capturing Cultural Value*. London: Demos.

Holden, J., 2006. *Cultural Value and the Crisis of Legitimacy.* London: Demos.

ICCROM, 2015. I*CCROM 2013 Forum follow-up: Evaluating the Outcomes of Heritage Conservation Science*, accessed October 20, 2016 http://www.iccrom.org/wp-content/uploads/ICCROM-Forum-Follow-up-synthesis-web.pdf .

Johnson, L.S., 2005. "From Knowledge transfer to knowledge translation: Applying Research to Practice". *Occupational Therapy Now*, July/August:11–14, accessed November 4, 2016 http://www.caot.ca/otnow/july05/OTNowJuly05_KnowledgeTransfer.pdf .

Kaufman, R., 2005. "Defining and Delivering Measurable Value: A Mega Thinking and Planning Primer." *Performance Improvement Quarterly* 18 (3): 6-16. DOI: 10.1111/j.1937-8327.2005.tb00337.

Kaufman, R., 2006. *Change, Choices, and Consequences: A Guide to Mega Thinking and Planning*, Amherst: HRD Press.

Lambert, C. 2009. "Pedagogies of participation in higher education: a case for research-based learning. Pedagogy". *Culture & Society* 17 (3): 295-309, DOI: 10.1080/14681360903194327

LSE Public Policy Group, 2011. "Maximising the Impacts of Your Research: A Handbook for Social Scientists". *LSE Impact Blog*, accessed October 10, 2016 http://blogs.lse.ac.uk/impactofsocialsciences/the-handbook/#comment-921732.

Luoma, P., Raivio, T., Tommila, P., Lunabba, J., Halme, K., Viljamaa, K., and Lahtinen, H., 2011. *Better Results, More Value. A Framework for Analysing the Societal Impact of Research and Innovation*. Helsinki: Tekes.

Michalski, S., 2015. "Tools for Assessing Needs and Impacts". *Studies in Conservation* 60 (S2): 23-31. http://dx.doi.org/10.1080/00393630.2015.1117862

Mitton, C., Adair, E.C., McKenzie, E., Pattern, B.S., and Waye Perry, B., 2007. "Knowledge Transfer and Exchange: Review and Synthesis of the Literature", *The MilBank Quaterly*, 85(4) : 729–768 accessed November 20, 2017 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2690353/

Morris, Z.S., Wooding, S., and Grant, J. 2011. "The Answer is 17 Years, What is the Question: Understanding Time Lags in Translational Research." *Journal of the Royal Society of Medicine* 104 (12): 510-520. DOI: 10.1258/jrsm.2011.110180

National Academy of Sciences, 1992. *Responsible science, Ensuring the integrity of the research process*. Washington, D.C: National Academy Press.

National Research Council, 2015. *Enhancing the Effectiveness of Team Science*. Washington: The National Academies Press accessed at November 20, 2017 http://www.nap.edu/catalog/19007/enhancing-the-effectiveness-of-team-science

Nielson, M., 2011. "The New Einsteins Will Be Scientists Who Share". *The Wall Street Journal*, accessed May 10, 2017 http://www.novim.org/the-new-einsteins-will-be-scientists-who-share/

Odgers, D., 2016. Odgers Conservation Consultants, Personal communication, 13 October 2016.

OECD, 2002. *Glossary of Key Terms in Evaluation and Results Based Management*, accessed November 13, 2016 http://www.oecd.org/dac/2754804.pdf.

OECD, 2015. *Making Open Science a Reality*. OECD Science, Technology and Industry Policy Papers, 25, accessed November 9, 2016. http://www.oecd-ilibrary.org/docserver/download/5jrs2f963zs1.pdf?expires=1458996723&id=id&accname=guest&checksum=0A8CD32CD2D483D63FC235D5418FA2C3

Redden, G. 2015. "Culture, Value and Commensuration: The Knowledge Politics of Indicators". *In Making Culture Count: The Politics of Cultural Measurement*, edited by. L. MacDowall, M. Badham, E. Blomkamp, and K. Dunphy, 27-41.

Reed, M.S., 2016. *The Research Impact Handbook. Fast Track Impact*. Abeerdenshire: Fast Track Impact.

Stokols, D., Misra, S., Moser, R.P., Hall, K.L., and Taylor, B.K., 2008. "The Ecology of Team Science: Understanding Contextual Influences on Transdisciplinary Collaboration". *Journal of Preventive Medicine*, 35 (2): 96-115. DOI: 10.1016/j.amepre.2008.05.003

UN, 2010. *United Nations General Assembly, Outcome Document of the 2010 Millennium Summit, Keeping the promise: united to achieve the Millennium Development Goals*, A/65/L.1 (New York, 2010), accessed July 5, 2017 http://www.un.org/en/mdg/summit2010/pdf/mdg%20outcome%20document.pdf

UNESCO, 2012. *Culture: a driver and an enabler of sustainable development, Thematic Think Piece*, report to the UN System Task Team on the Post-2015 UN Development Agenda, accessed July 5, 2017 http://www.un.org/millenniumgoals/pdf/Think%20Pieces/2_culture.pdf

Wager, E., 2009. Recognition, reward and responsibility: "Why the authorship of scientific papers matters". *Maturitas* 62 (2), pp. 109–112. Available online at: http://www.sciencedirect.com/science/article/pii/S0378512208003678.

Appendix: Interviewees profiles

Table 5. Interviewees profiles

Region	Type of Institution	Role
Oceania (1)	Private Practice	Owner, conservator
Europe (10)	National Heritage Agency	Conservator
	National Heritage Agency	Head of Preventive Conservation
	Independent Heritage Agency	Senior Conservator/ Senior Management
	Museum	Head of Conservation x3
	Museum & Research Institute	Head of Conservation/ Research Director
	Private practice	Owner, conservator x 3
North America (3)	Museum & Higher Education Institute	Conservator; Educator
	Independent Heritage Agency	Senior Conservator
	Museum	Senior Conservator
South America (2)	Higher Education Institute	Head of Conservation / Course Leader
	Independent Heritage Agency	Building Specialist / Research Group Leader