Mind the Gap

Rigour and Relevance in Heritage Science Research

Arts & Humanities Research Council

Science and Heritage Programme

The National Archives

UNIVERSITY OF EXETER

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Executive Summary:
Overview, Key Findings and Recommendations

Overview

The aim of *Mind the Gap: Rigour and Relevance in Heritage Science Research* was to examine in detail the perceived hindrances to, as well as the enablers of, collaboration across academic and practice-focused research communities. The need for better understanding of the working culture of collaborative research was an issue emerging from the AHRC/EPSRC Science and Heritage Programme sponsored Research Clusters in 2008. Differences in language, research methodologies, expectations and priorities were cited as hindering the success of collaborative research projects, which in turn could potentially limit the effectiveness and impact of publicly funded research.

Collaborative research and practice offer a way of closing the gap between researchers' and users' interests. In this study we define the term 'researcher' as academic researchers, and 'user' as those who use research evidence in practice. However, difficulties in bridging the knowledge gap between cross-disciplinary research and practice persist, not only in heritage science but also in other practice-led research disciplines such as law, medicine, education and organizational theory, where the relationship and relevance of research and practice has been questioned.[1]

Understanding how the economic and societal impacts of heritage science research are achieved is crucial. Research Councils UK (RCUK) is clear about changing organizational culture and practice to ensure the right research-base is delivered and the culture necessary to achieve it is in place, but how these aims can be achieved is less clear.[2]

To gain a better understanding of the working culture within the heritage science community in the UK, a quantitative study was undertaken to assess the experiences of academic researchers and practice-focused researchers among UK-based researchers engaged in collaborative projects funded both nationally and internationally. An attitude survey was the basis of this evaluation. Further insights were provided by the Project Partners, representing a broad base of experienced collections-based researchers and scientists and academics in the fields of linguistics, anthropology, education, organizational theory, information management, conservation science and archaeology.

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[1] Lee, S. and Bozeman, B. The impact of research collaboration on scientific productivity. S*oc.Stud.Science*, 35 (2005): 673-702.
Kieser, A. and Leiner, L. Collaborate with users: but beware of collaborative research. *Journal of Management Inquiry*, 2012, 21: 14-28.

[2] http://www.rcuk.ac.uk/kei/Pages/home.aspx

Our aim was to address three interrelated questions:

1. Is there a gap between academic research and user communities, sometimes referred to as the 'rigour and relevance gap'?
2. What are the distinctive features defining a working culture that will support effective research collaboration?
3. What framework is required to engage communities of practice and research cultures to optimise the outcomes of collaborative research, and to develop sustainable collaborative relationships across disciplines?

While this study is based on the experiences of a limited number of respondents (210) drawn from the heritage science community in the UK, interest in the study has been considerable, suggesting that it has a much wider resonance. For this reason the findings are presented not as pure data reporting, but as an attempt to capture the complexity of the collaborative research landscape, provide deeper insights into the collaborative dynamic and make recommendations aimed at increasing the impact of research.

Selected Key Findings

Is there a rigour and relevance gap?

Research impact is less assured than meeting project aims

- Most respondents reported a positive experience of collaborative research and aspired to both academic rigour and relevance in their projects. However, while most respondents (84%) were satisfied that the aims of their project were achieved, fewer than half (49%) were satisfied that the impact of the project would be realized. Practice-focused goals were particularly associated with lower levels of achievement. Users were typically less satisfied with project outcomes and achievements than researchers.

- A sharp distinction between researchers and users is inappropriate: the boundaries between the two, which are often blurred, need to be better understood. Approximately one-third of respondents reported dual roles (researcher and user) in collaborative projects.

What are the distinctive features defining a working culture that will support effective research collaboration?

A good dynamic is essential

- The opportunity to meet other professionals for knowledge exchange is an important incentive to engage in collaborative projects. Responsiveness to multidisciplinary perspectives adds considerable value to the outcome of research and was cited as the main motivation for collaboration. Nevertheless, a sizeable minority of respondents reported that collaboration had been challenging (28%), or that they lacked collaborative skills (20%).

- When respondents were asked 'What do you think helped your project?', most responses (78%) referred to a healthy collaborative dynamic where team members shared interests, goals and an enthusiasm for collaboration. These qualities were deemed essential to satisfaction and achievement.

Collaborative research promotes complementary goals

- While shared goals were considered to be an essential enabler of collaborative research, researchers and users had significantly different goals. Academic researchers seek impact largely through publications, while practice-focused researchers aim to improve practice and influence policy.

- Importantly, collaborative research promotes complementary goals: it supports users in gaining access to experts and improving care for the heritage, while enabling researchers to develop professionally and apply their knowledge in new contexts.

Size and complexity shape success

- The size and complexity of a project also shaped its success. Larger projects were found to present challenges in terms of the dynamic, maintaining research quality, establishing mutual understanding and dealing with bureaucracy.

- While recognising that a multidisciplinary team often yields the best outcomes, six or more subject specialisms can make project management very complex and impede the success of the project.

Collaboration takes time

- Effective collaboration takes time to incubate, grow and mature, a process sometimes compromised by insufficient attention to capacity-building at the front-end of projects, and the short-term nature of funding calls. Too often the collaboration comes to an abrupt end. Results suggest that follow-on funding to take research further is often lacking exactly at the point when it would be most useful.[3]

What framework needs to be put in place? What are the essential mechanisms for delivery?

Strong organizational support

- Projects closely aligned with organizational priorities were most valued by organizations and were found to be better supported throughout the life of the project.

- A lack of institutional recognition and internal support were cited as the most common hindrances to effective collaboration. Respondents from Higher Education Institutions (HEIs) reported that they received less institutional recognition for their

[3] Resource issues emerged as a hindrance to effective collaboration in 59% of comments. Respondents commented that the length of projects was too short and time was needed to develop projects and relationships.

participation in collaborative research than their partners from non-HEIs, where collaboration was regarded more positively. This suggests a need to make expectations clear.

- Discovery of unexpected commonalities or the contribution of an entirely new vision or new approaches can result from a well-resourced structure that encourages and supports exploration.

Careful project management

- The more partners, subject specialisms and individual researchers are involved in collaborative projects, the stronger the need for careful project management. Defining the roles, responsibilities and expectations of team members and the milestones for delivery were cited as enablers of a good research project, but these were not always made explicit post-Award.

- Clear objectives, good project design and effective project management, unambiguous reporting lines and clarity of roles and responsibilities were reported as too often overlooked once projects were underway, and as a significant hindrance to effective collaboration.

Building an effective team

- The mix of the team was regarded as important: it should include a good spread of experience and expertise. Findings suggest that as the experience of respondents increased, so did their preference for a collaborative working style, their interest in bridging disciplines, their understanding of partners' research approaches and their satisfaction with research quality.

Roles and responsibilities

Early career researchers

- Early career researchers benefit from access to resources and develop specialist expertise, skills and networks in collaborative projects; however, the challenge of multidisciplinarity at this stage in their careers can present particular challenges.

- Junior and student researchers demonstrated a less collaborative working style and were more likely to have strong career and professional development goals. Collaborative projects should be designed to accommodate these needs.

Managing expectations

- Responses suggest that users' goals were not met, suggesting that they have high expectations for achieving practice-focused goals. The likelihood of a time-lag in moving from basic research to application needs to be better understood by practice-focused communities.

- Some comments from non-HEI partners suggested that academic research takes too much time, while academic researchers felt that practice-led goals needed to be realistic and that users sometimes lacked research skills.

The role of knowledge exchange and transfer in collaborative research projects

Industry and Small to Medium Enterprises (SMEs):

- Findings suggest that while engagement between HEIs and non-HEIs is solid, there is less engagement with businesses than with heritage and other non-commercial organizations. The long-held belief that knowledge transfer will lead to innovation and business performance represents too simplistic a view. The opportunity for engagement across many disciplines and many users highlights other reasons for engaging e.g. adding another source of knowledge or connecting with others to enhance organizational performance.

- The notion that knowledge transfer is largely driven by commercial interests, as reported elsewhere, was not found in this study. Knowledge sharing, access to expertise and building relationships were considered key enablers of collaboration. The interest of SMEs in collaborative projects might be affected by funding bodies' regulations, as Technology Strategy Board (TSB), RCUK and EU Framework rules for SME participation are very different. However, the small number of SME responses does not allow for a more detailed analysis of this issue.[4]

Conclusions

Increasingly, research funders are championing multidisciplinary research, recognising that the potential of multidisiciplinary teams will be vital in addressing the complex challenges facing society. The research landscape is also evolving. As a result of rapidly expanding global technological networks, researchers are more often working across diverse group organizations, across geographical boundaries and across very different cultures. While technology is helping to make new modes of research possible, people remain at the core of research. The quality of collaboration will be even more important in the delivery of effective research and impactful research outcomes.

We have learned that the successful rewards of collaboration are achieved through a complex and dynamic process, requiring sufficient time and upfront planning to establish clear paths and mutual respect and understanding among the partners. Our recommendations address these themes with specific guidance for research organizations, researchers and funding bodies.

[4] 'Lack of follow-on funding to allow further use and implementation of outcomes. In summary – short termism in funding does not provide efficient use of short term research.....' Respondent Attitude Survey, Open-Box Comments.

Recommendations

To ensure the right culture and practices are in place to deliver impactful research, we offer the following recommendations for stakeholders:

Organizations engaging in collaborative research should**:**

- publicize their research strategies, and have a clear idea of how research feeds into practice and policy. This will help project proposals to clarify how different project goals are complementary and will be met.
- have suitable research support (administrative and infrastructural) for collaborative projects.
- provide organizational support for collaborative projects that does not curb creative and visionary results, which may develop unexpectedly.
- consider developing training packages to be offered to collaborative researchers or those planning to get involved in such research.

Applicants developing collaborative proposals should:

- make clear how the proposals will meet the goals of research institutions.
- build in periods of secondment of researchers in user institutions and vice versa, to foster development of hybrid researchers, i.e. researcher-users.
- build sufficient meeting and interaction time into projects to develop a mutual understanding and common language.
- consider less conventional research practices such as co-production[5], participatory research[6] and action research[7].
- consider having clear skills and career development plans for early career researchers where they are involved in a project.
- take into account that the larger the team, the more diversity there should be in the research or other experience of the members. Hybrid researchers with good experience should be considered as likely team members.

[5] Wenger, E. *Communities of practice: learning, meaning, and identity*. Cambridge: Cambridge University Press, 1998.
[6] Balazs, C.L. and Morello-Frosch, R. The three Rs: how community-based participatory research strengthens the rigor, relevance, and reach of science. *Environmental Justice*, 2013, 6 (1): 9-16.
Roux, D.J., Stirzaker, R.J., Breen, C.M., Lefroy, E.C. and Cresswell, H.P. Framework for participative reflection on the accomplishment of transdisciplinary research programs. *Environmental Science and Policy*, 2010, 13 (8): 733-741.
[7] Lewin, K. Action research and minority problems. *Journal of Social Issues*, 1946, 2(4): 34–46.

Research funding bodies should:

- prior to funding complex collaborative projects, develop short cluster/networking projects to allow collaborative teams to develop trust and establish long-term relationships.

- develop a mechanism to evaluate practice-oriented goals of collaborative projects involving appropriately qualified experts in addition to academic experts.

- recognize that less complex projects are generally preferred by the research community, and are associated with a more pronounced sense of achievement. Generally, teams with more than 15 individual researchers/users, or six partner institutions or subject specialisations should be avoided.

- consider that large collaborative projects may require new or innovative project management mechanisms for dealing with multidisciplinarity and knowledge flow.

- consider developing training packages to be offered to collaborative researchers or those planning to get involved in such research.

- consider a study looking at transfer of research evidence into practice and policy, to develop case-studies demonstrating how such impact is achieved. Developing quantifiable measures would be useful.

- consider a study looking at the economic as well as non-economic value of collaborative research to clarify how business and non-business impact could be measured and ensured.

Responding to the Challenge: Next Steps

We believe we have presented a number of clear messages and recommendations that, if addressed by funders and research organizations, would deliver a more effective and resilient research culture able to deliver impactful research.

The following next steps are proposed:

- Explore the potential of the UK's Institute for Collaborative Working, supported by the Department of Business, Innovation and Skills (BIS) and the British Standards Institute (BSI), to develop their existing tools, training and standards for research organizations. Having the infrastructure in place to deliver the necessary skills and networks to improve understanding of the nature of collaboration would make a significant contribution to stimulating innovation and realizing greater impact from heritage research. It would speak directly to AHRC's strategic priorities of heritage research, developing national capability in this area, building on current major

initiatives (e.g. the Science and Heritage Programme) and furthering the UK's international leadership in this field.

- Provide pre-project Partnership funding to establish stronger foundations for collaborative research.

- Provide incentives for researchers to engage with collaborative research. This would require additional metrics for evaluating research outcomes, e.g. value-based appraisal of research impact, while also redressing the current weighting toward academic outputs over other forms of impact.

- Place greater emphasis in research evaluation on the value of collaborative research and develop value-based appraisals of research outcomes to make it more attractive to HEIs and academic researchers.

- Support research into the contribution of hybrid researchers who traverse both worlds. While they play an important role, they are not well understood at present and should be given a higher profile as the evolving dynamics of collaboration are explored.

- Promote inward secondments and visiting fellowships and placements from the heritage sector in HEIs.

The Research Study

Introduction

The Mind the Gap research study explores whether there is a rigour and relevance gap in heritage science research and, if so, what could help to bridge the gap. The study focused on recent collaborative research in the UK, but it has relevance beyond the UK and beyond the heritage science field.

A mixed methods[8] approach was employed to explore attitudes towards collaborative research. Project partners from a range of disciplines were first consulted on their experiences and attitudes. The results of this consultation were used in the design of a quantitative attitudes survey, which also included some qualitative questions. The qualitative and quantitative research methods complemented each other by allowing results to emerge from the heritage science community and related disciplines, while at the same time the prevalence and structure of attitudes in this community could be assessed in a statistically robust and reliable way.

Respondents were asked to think about one collaborative project they had worked on in the UK in the previous five years. They were then asked about their personal goals at the outset of the project and whether these were achieved, their level of satisfaction with project outcomes and impact, their level of agreement with a series of attitude statements about what helped or hindered their project, their background (specialism, experience, place of work and role) and their project (size and complexity).

Segmentation and profiling techniques were used to summarize and explore the relationships between these variables. Factor analysis is used to reduce and identify structure in attitude data and can be used to create attitude measures. As a further technique, cluster analysis can be used to isolate groups of people with similar attitudes and then clusters are profiled on other variables, such as demographics, in order to explore how attitudes affect behaviour or vice versa. These two types of analyses were applied in this study to create measures of the enablers of, and impediments to, effective collaboration, and then explore the reasons for varying experiences of collaborative research. The results were complemented by thematic analysis of respondents' comments.

The questionnaire was analysed to examine evidence for:

1. a rigour and relevance gap;

2. differences between researchers and users; and

3. enablers of, and impediments to, effective collaboration.

[8] Brannen, J. *Mixed methods research: a discussion paper*. ESRC National Centre for Research Methods, NCRM Methods Review Paper, 2005 (NCRM/005).

Evidence for a rigour and relevance gap would include findings relating to challenges in the collaborative process and in translation of research into practice.

Differences in the experiences and attitudes of academic researchers and users of research evidence in practice would also point to a rigour and relevance gap.

Finally, the analysis sought to identify enablers of, and impediments to, effective collaboration.

Charts and tables illustrating the main findings are included in Annex A. The full data and results of statistical tests are available on request from the Centre for Sustainable Heritage (see page 23 for contact details). A paper on the questionnaire study has been submitted to *Heritage Science*.

Method

The research was concerned with inter-institutional collaborative heritage science research between academic researchers ('researchers') and users of research evidence in practice ('users'). Academic researchers could be based at a higher education institution (HEI) or an independent research organization (IRO). Users could be based at a museum, library, archive or gallery (MLAG), a heritage organization, in industry, in a small to medium enterprise (SME), in self-employment or at an HEI-based MLAG. Users of research evidence included conservators, curators, librarians, archivists, collection managers, policy-makers and those seeking to exploit research findings in business and product development. For the purposes of the questionnaire study, collaborative research referred only to collaborations that involved both academic researchers and users. Multidisciplinary projects involving only academic researchers from different disciplines but no users, were not of interest to this study.

Examples of collaborative activities included, but were not restricted to, formal funded research projects with multiple partners, sharing of expertise and resources between institutions, collaborative development of products, policy and new ways of working, co-supervision of research students, case-studies and other research and science projects where researchers collaborated with users.

Questionnaire

The development of the questionnaire followed an established process[9,10], in which qualitative and desk research are used to gather information about topics of interest and then converted into questionnaire format and piloted. Focus groups with the Project Partners took place in February 2013. The data were recorded and transcribed, and then organized into themes, cross-referenced with the literature and used in the design of the questionnaire.

The questionnaire was distributed online via Survey Monkey (www.surveymonkey.com) for six weeks from April-June 2013. There was a good return rate of 210 eligible responses. Around half of respondents were based at HEIs and half at non-HEIs (e.g. MLAGs, heritage

[9] Oppenheim, A.N. *Questionnaire design, interviewing and attitude measurement.* London: Continuum, 1992.
[10] Jenkins, C. and Dillman, D. Towards a theory of self-administered questionnaire design. In: *Survey Measurement and Process Quality*. Lyberg, L., Biemer, P. et al. (ed.) New York: Wiley-Interscience, 1997.

organizations, industry/SMEs and self-employed). Around half of respondents said they represented a STEM (science, technology, engineering or mathematics) discipline during their project, and there were 50 responses from arts and humanities disciplines. Around half of respondents identified strongly as researchers, and the remainder were split between users and respondents with dual roles. See Annex A, Figure 1 for further details.

Analysis methods

Exploratory factor analysis: Factor analysis was used to reduce 50 attitude statements about what helps and hinders collaborative research down to a small set of factors classified as enablers of, and impediments to, collaborative research.

Cluster analysis: The intention was to find clusters of respondents who differed in their attitudes to collaborative research (using their factor scores) and then explore whether these clusters also varied according to other variables such as their goals, satisfaction and achievement ratings and personal characteristics.

Cluster profiles: Profiling the clusters helped to elucidate reasons for varying levels of project satisfaction.

Inferential statistics: Statistical analysis was used to compare 'respondent groupings'.

Thematic analysis: There were three open-box questions where respondents could give free-text responses. Detailed coding of the text was used to identify overarching themes within respondents' comments. Initial coding was conducted independently by two researchers, who arrived at very similar thematic structures. A revised coding scheme was applied to the data. Occurrence of themes and codes was then quantified using frequency analysis.

Rigour and relevance gap in heritage science

Questionnaire respondents were asked how satisfied they were with the outcomes (the results of the project and project aims) and impact (communicating research to users and translating results into practice) of their project (Annex A, Figure 2). Most respondents were satisfied with outcomes (64% of respondents gave a rating of 6 or more and 86% gave a rating of 5 or more). Many were also satisfied with impact (49% gave a rating of 5 or more). However, ratings were statistically significantly higher for project outcomes in comparison with impact. Respondents were satisfied that the aims of their project were achieved, but less satisfied that the impact of the project would be realized.

Personal goals

Respondents were asked to pick five goals from a list of 24 in which they were personally most interested at the outset of their project (Annex A, Figure 3). Exchange of ideas and expertise between different fields, relevance to practice (conservation and understanding of cultural heritage), new knowledge and a high-quality evidence base were most important. This suggests that the heritage science field seeks both rigour and relevance in research and that both practice-focused and academic goals are widely held. However, two of the goals that were least likely to be chosen related to management ('standards and guidelines' and 'policy and strategy'). Respondents were thus more likely to hold some types of practice-focused goals, such as conservation of cultural heritage and understanding of cultural heritage, rather than management goals.

The findings for personal goals were corroborated by open-box comments in response to the question 'What else interested you about this project?' (Annex A, Figure 4). Of the 102 comments, the most frequent responses concerned the collaborative process (34%), particularly multidisciplinarity and working with diverse people and institutions. This was closely followed by comments about research and practice (33%), particularly evidence-based practice (including challenging, critiquing and evaluating current practice); providing a better evidence base; improving practice through new applications and processes; practice-focused research through problem solving, and ensuring relevance and a deeper understanding of practice.

Achievement of goals

For each of the five goals they chose, respondents were asked to rate whether they felt the goal had been achieved, partially achieved or not achieved (Annex A, Figure 5). The most frequently held goals were also amongst those most likely to be achieved. This was with the exception of one of the key goals of heritage science research: 'better care and conservation of cultural heritage'. Management goals (such as 'improved collection management' and 'standards and guidelines') also received low achievement ratings. Participants in collaborative heritage science research sought both rigour and relevance in their research, but were more likely to achieve learning or academic goals than to achieve translation of research into practice.

Attitudes towards collaborative research

The ratings for 50 attitude statements about collaborative research were entered into a factor analysis. An eight-factor solution was assessed as the most reliable, using a number of statistical criteria, and yielded the most consistent factor structure. The eight factors represented different aspects of respondents' experience of, and approach to, collaborative research. Each factor was given a name representing an underlying theme linking the statements in that factor.

Table 1 gives details of the eight-factor solution. See also Annex A, Figure 6.

Table 1. The factor solution

The factor name, a description of the factor, and keywords from the statements are provided.

Factor 1 – Ease of Collaboration
This factor contains statements relating to the quality of the collaborative relationship with partners. In particular, whether the partnership felt open, trusting and natural and whether there were shared goals and interests. The factor also refers to the ease/difficulties of multidisciplinary working, including establishing a shared language. **Keywords:** Trust, naturally, easily, open, common ground, interests, common understanding, aligned, share, felt, found, partners, people, other disciplines and practices, terminologies and concepts.
Factor 2 - Collaborative Working Style
Statements in this factor relate to a respondent's preference for working in collaboration or as an individual, and whether they were interested in collaborating and felt it was needed. **Keywords:** contact, collaboration, essential, required, only, wanted, preferred, alone, sole/co-authorship.
Factor 3 – Interest in Bridging Disciplines
This factor represents a theme that emerged consistently during the analysis, but is less reliable than other factors. The factor relates to an interest in the process of collaboration, multidisciplinarity and communications, as opposed to the products of collaboration. **Keywords:** Interested, language, bridge, between, partners, different disciplines and practices.
Factor 4 – Institutional Recognition
Statements in this factor relate to institutional recognition of, and reward for, a project, related to an institution perceiving a project as relevant to them. **Keywords:** Project, recognized, institution, positive, relevant, rewarded.
Factor 5 – Internal Procedures & Working Practices
Statements in this factor relate to real or perceived impediments to research due to working practices (particularly academic research) and users' understanding of academic research processes. **Keywords:** Intellectual property protection, got in the way, internal procedures, users, didn't understand, time-consuming, understanding, how academic research works, negotiation.
Factor 6 – Practice-Focused Research
Respondents with high scores on this factor wanted their project to be inspired by practical problems and communicated in non-academic terms. Their preference was for practice-focused applied research rather than research focused on generating new knowledge. This factor is not as statistically reliable as other factors and overlaps with questions on goals. **Keywords:** Inspired, practical problems, communicate, non-academic terms, generating new knowledge, practical solutions.
Factor 7 –Research Quality
Statements in this factor relate to the quality of research in a project. Research quality appears to encompass both academic rigour and relevance to users. **Keywords:** Results, research, credible, uncomfortable with, research approaches, academic research, did not deliver, what users needed, lacked the depth, commitment, high quality.
Factor 8 – Understanding Partners' Research Approaches
Statements in this factor related to partners' understanding of each other's methods, goals and culture (e.g. language and ways of working). If a respondent agreed with statements in this factor, that might imply a lack of mutual understanding, competing goals or dissatisfaction with both academics' and users' approaches (reflected in perceptions that academic methods were too complex and users too focused on applied outcomes). This factor also suggests that opportunities for knowledge exchange could facilitate mutual understanding. **Keywords:** Methodologies, academic researchers, complex, users, focused, applied outcomes, language, impenetrable, opportunities to interact, knowledge exchange, project partners, stick, established, way of working.

Once a factor solution has been found, the structure can be used in further analysis. In this study, the eight factors were used as measures of the enablers of, and impediments to, collaborative research. Each respondent's factor scores were computed by taking their mean score across all the statements in each factor, and in such a way that positive scores indicated enabling and negative scores indicated impediments.

Researchers and users: personal goals

The three groups of respondents, ('researchers', 'researcher-users' and 'users') were compared in terms of their personal goals (Annex A, Figure 7). Some of the most frequently held goals were shared by researchers and users. These encompassed aspects of both rigour and relevance: knowledge exchange, taking part in research that is relevant to practice, insights and new knowledge and high quality research evidence. However, users were significantly more likely to have practice-focused goals than researchers, who were significantly more likely to have career development, intellectual and publication goals.

Personal goals reflected institutional goals, and individuals sought impact for their respective institutions in different ways (e.g. improved practice vs. publications). Users had high expectations that research would improve practice. However, users viewed projects as less successful than researchers, possibly because of the types of goals they held.

Researchers and users: satisfaction and achievement ratings

Users and researcher-users combined gave lower ratings of outcome satisfaction than researchers (Annex A, Figure 8). Researcher-users gave the lowest ratings. The same trend was observed for impact satisfaction ratings. Similarly, users and researcher-users combined had significantly lower achievement ratings than researchers (Annex A, Figure 9). The results suggest that some users were less satisfied with the results of projects than purely academic researchers.

Researchers and users: attitudes

Researchers and users also had different profiles on the eight factor scores (Annex A, Figure 10). Users and researcher-users combined were shown to have significantly greater institutional recognition, but more concerns about research quality than researchers.

Comments suggested that institutional support and recognition of collaborative research may depend on whether research reflects an institution's goals and priorities, and that research may be not supported otherwise (e.g. through time given for research). Comments also pointed to differences in working practices and cultures, suggesting that users sometimes consider that academic research takes too much time whereas academic researchers sometimes consider that expectations about practice-led goals need to be realistic and that users may lack research experience.

Enablers of and impediments to effective collaboration

The questionnaire collected a wide range of information about the background of respondents, their projects and their experience of collaborative research. Profiling respondents using cluster analysis helped to illustrate the aspects of collaborative research and the characteristics of participants and projects which were most strongly associated with project satisfaction, achievement and the collaborative process.

Questionnaire respondents were clustered into groups using their factor scores, i.e. their attitudes to collaborative research. The analysis yielded three reliable clusters (Annex A, Figure 11 and Table 2).

The analysis usefully separated respondents who had a very positive experience of collaborative research (Cluster 2, 52%), from respondents who found collaboration more challenging and experienced more impediments (Cluster 1, 28%) and respondents whose were less interested in multidisciplinarity and less practice-focused than the other clusters (Cluster 3, 20%). In addition to varying according to factor scores, the three groups varied according to their outcome satisfaction ratings. The same pattern was also observed for impact satisfaction and achievement of goals.

The cluster analysis helped to identify the other attitudes and characteristics of projects that were related to project success and pointed to a strong relationship between some of the factor scores and project satisfaction and achievement ratings.

Compared to other clusters, the least satisfied group (Cluster 1) scored lower on ease of collaboration, had more concerns about research quality, more difficulties with understanding partners' research approaches and more impediments due to internal procedures and working practices. They were also working on the largest projects and more likely to hold management and strategic goals, particularly in the area of standards and guidelines. Non-significant trends indicated that this cluster were slightly more likely to be managers and researcher-users.

Conversely, when satisfaction ratings were highest (Cluster 2) there were also very high ratings for ease of collaboration. This factor measures aspects of the dynamic of collaboration such as trust, openness, relationships, shared goals and communication. When the dynamic was strong, there were fewer impediments due to internal procedures and working practices, fewer concerns about research quality and a greater understanding of partners' research approaches. Respondents with this profile tended to be working on smaller than average projects and were least likely to have collection management goals.

This pattern of results was corroborated by the finding that there were correlations between some factor scores and satisfaction and achievement ratings. In particular, factor scores for ease of collaboration and research quality were strongly correlated with satisfaction and achievement ratings (Annex A, Table 3).

Content analysis of comments supported this finding. When respondents were asked 'What else do you think helped your project?' their comments most frequently related to 'people' (78% of 128 comments): shared interests, a collaborative nature, enthusiasm, a good mix of experience and expertise within the team, good communication and opportunities for meeting and knowledge exchange were all important. Similarly, when respondents were asked 'What else do you think hindered your research?', 'people' was also a frequent category of response (41%): in this case, a clash of working cultures, lack of opportunities to meet, a lack of experience or expertise within the team, a lack of interest and communication challenges were noted (Annex A, Figure 12).

Project size

Project size was measured in three ways: the number of people, the number of partner organizations and the number of subjects represented in a project. Respondents were split into quartile groups for each of these measures and then factor scores were compared between projects of different size (Annex A, Figure 13).

As the number of people in a project increased, so did concerns about research quality, while understanding of partners' research approaches decreased. This suggests that rigour and relevance issues are more prevalent in larger projects and that this may be related to communication and mutual understanding.

As the number of partner organizations increased, so did reports of impediments due to internal procedures and working practices. This may be due to more complex bureaucracy and also a greater need to manage cross-institutional relationships – as evidenced by lower scores for ease of collaboration and understanding partners' research approaches.

Multidisciplinarity

There were significant non-linear relationships between the number of subjects in a project and three factor scores. As the number of subjects increased, so did concerns about research quality and difficulties in understanding partners' research approaches, while ease of collaboration decreased. This trend was observed up to four or five other subjects, after which the trend levelled off or reversed (six or more other subjects). This suggests that increased multidisciplinarity was associated with increased communication and rigour and relevance challenges, but only up to a certain point, after which it did not create more impediments and may even have been an enabler. The most multidisciplinary projects did not necessarily involve the most people or partners and may have been constructed from several smaller teams.

Interest in collaborating

Self-ratings of project satisfaction and achievement of goals are one way of measuring the success of projects. However, the benefits of collaboration are not always linked to achievement of goals such as translating research into practice. The questionnaire also allowed a more in-depth look at the collaborative process itself and what may enable or impede this.

For example, cluster analysis identified a group of respondents (Cluster 3, 21%) who were satisfied with their project but who, in comparison to other clusters, reported a less collaborative working style, a lower level of interest in bridging disciplines, less understanding of partners' research approaches and less institutional recognition. This cluster were the most likely of the three clusters to be academic researchers (particularly STEM researchers), focused on academic goals (such as journal articles) and less practice-focused. They were also the least experienced cluster. The questionnaire results helped to identify areas where the collaborative process can be better supported by, for example, having a good balance between collaborative skills and a range of experience.

This potentially suggests a skills or experience gap for a sizeable minority of participants in collaborative heritage science research. The questionnaire results helped to identify areas where the collaborative process can be better supported, as explained in the discussion of results below. Project satisfaction and achievement appeared to be closely related to the

dynamic of collaboration, whereas collaborative skills and interests appeared to be more closely related to level of experience and role.

Project roles

In addition to goals differing between organizations and between researchers and users, those with different roles within a project may also have distinct aims and aspirations. Respondents were asked what their role was in their project. The three largest groups were compared in terms of their personal goals at the outset of their project, their factor scores and satisfaction and achievement ratings. The three groups were project managers/supervisors (including principal investigators, task leaders, project managers, PhD/KTP (knowledge transfer partnership) supervisors and post-doctoral fellows with management responsibilities); partners (including partners, co-investigators and steering committee/advisory group members), and junior and student researchers (post-doctoral researchers without management responsibilities, research associates/assistants and PhD/KTP students).

The goals of senior and junior roles reflected their stage of career – as evidenced by the finding that junior and student researchers were more likely to have personal and career development goals than those in senior roles, who were more focused on project goals such as access to resources (Annex A, Figure 14).

Attitudes to collaboration reflected the types of research activities in which respondents with different roles were engaged. Project managers and supervisors reported more impediments due to working practices, but a more collaborative working style than junior and student researchers. Junior and student researchers gave positive ratings for collaborative working style, indicating that this was also their preference, but their ratings were significantly lower than those given by respondents in senior roles (Annex A, Figure 15).

All three groups (managers, juniors, partners) gave high ratings to a preference for a collaborative working style, but junior and student researchers had significantly lower ratings than the other groups. While they were interested in collaborative working, it was not to the same extent as those in more senior roles.

The differences between senior and junior researchers suggest a skills gap, which may be related to stage of career, the types of activities each is engaged in and their level of experience. Respondents were asked about their level of experience in terms of number of years working on collaborative research and number of collaborative research projects worked on. As the experience of respondents increased in terms of number of years, so did their preference for a collaborative working style and their interest in bridging disciplines (Annex A, Figure 16).

A similar pattern of findings was observed for number of projects: the more projects a respondent had worked on, the greater their preference for a collaborative working style, the higher their ratings of research quality and the fewer challenges they found in understanding partners' research approaches. Whereas length of experience in years was related to interest and motivation, breadth of experience in terms of numbers of projects appeared to be related to collaborative skills and quality.

The analysis also pointed to a non-linear relationship between experience and collaborative skills. As the experience of respondents increased, so did their interest in collaboration and their collaborative skills, but this was with the exception of some of the most experienced respondents (those with more than 20 years' experience; those involved in more than 10 projects).

When respondents were asked what else had helped or hindered their project, the experience and expertise of team members emerged as a theme. Teams that included a mix of respondents in terms of experience of collaborative projects and expertise in a particular field were highly valued. A number of comments suggested that an expert involvement or overview of projects could be helpful, for example a practice-focused researcher or other expert on the advisory board. A small number of respondents commented that collaboration could be impeded by very experienced researchers.

Language and communication

Language and communication appear in the literature as significant impediments to collaboration but did not emerge as separate issues in the factor analysis of the questionnaire. Instead, language and communication issues emerged across many areas of the results. For example, statements relating to language and communication were distributed across the factor solution, demonstrating that language and communication underpin many aspects of effective collaborative research.

Resources

Statements about resources did not relate to any single factor or were distributed across the factor structure, suggesting that resource issues may be associated with a number of aspects of the experience of collaboration. However, comparisons of clusters showed that access to resources was a goal that distinguished between Clusters 2 and 3, being needed least frequently by Cluster 2, who had the highest satisfaction and achievement ratings and also very high scores on factors such as ease of collaboration and research quality. The finding is mirrored in responses to the open box question 'What else do you think hindered your project?' where resource issues emerged as the main theme (in 59% of comments), particularly 'time'. There was a link between resources and other aspects of effective collaboration: respondents commented that that time is needed to develop projects and relationships.

Barriers to participation in collaborative heritage science research

The impediments to, and enablers of, effective collaboration reported in this paper may be valid for respondents to the questionnaire, who were made up of recent participants in collaborative heritage science research. The findings address enablers of, and impediments to, the collaborative process and project success. However, the paper does not address barriers to participation in collaborative research, as those who had chosen not to, were not aware of or were unable to participate in recent projects were not surveyed.

As an example, there were only nine respondents from industry/SMEs. 69 respondents said they had an industry/SME partner in their project, but HEIs were much more likely to have collaborated with MLAGs and heritage organizations (90%) than industry/SMEs (30%). Comments from industry/SME respondents and research partners pointed to barriers to industry/SME engagement in collaborative research, despite an interest from both groups in collaboration. There might be a number of reasons for this. Academic research might not

be viewed as relevant to industry/SME goals and expectations; there may be little institutional support in industry/SMEs for dedicating time to collaborative research; there may be few opportunities to make connections between researchers and industry/SMEs; there are differences in working cultures between different types of institution, and there may be differences between funding schemes.

Conclusions

While the questionnaire respondents reported many positive experiences, there remains clear evidence for a gap between researchers and users in terms of their expectations and achievements in collaborative heritage science research. This study has also challenged the validity of definitions, as the evidence suggests that the boundaries between researchers and users are blurred. The survey results have a significant contribution to make to questions of what constitutes achievement in collaborative research, and how it is valued. It also points up areas where the expectations and cultures of different institutions and individuals may become barriers to effective collaboration. In particular, a wider view of the real benefits of collaboration, beyond translating research into practice and shaping policy, needs to be developed.

The findings of this study are in line with other research identifying differences between research and practice-focused communities, which appear to stem from different expectations about research and differing institutional cultures. The questionnaire also provided information about ways to bridge the rigour and relevance gap and increase the quality and effectiveness of collaboration. The results suggest a number of areas which could be examined further, such as the ways in which knowledge flows between communities and how non-verbal exchanges of knowledge and experience are shared.

The questionnaire findings have highlighted a number of areas for action in the context of the future of collaborative heritage science research. A more in-depth look at each of these areas in order to identify best practice within collaborative heritage science research is now required. The outcomes of this project reflect the views of respondents with experience of collaborative working and provide a significant resource on which to draw in developing effective collaborative research for the future.

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Annex A

Charts and tables showing questionnaire results

The full data tables and results of statistical tests from the survey are available on request from Dr Matija Strlič at the Centre for Sustainable Heritage (m.strlic@ucl.ac.uk).

Details of the questionnaire development and analysis are given in a paper submitted to *Heritage Science* in January 2014:

Dillon, C., Bell, N., Fouseki, K., Laurenson, P. and Thompson, A. *Mind the gap: rigour and relevance in collaborative heritage science research*, (submitted, 2014).

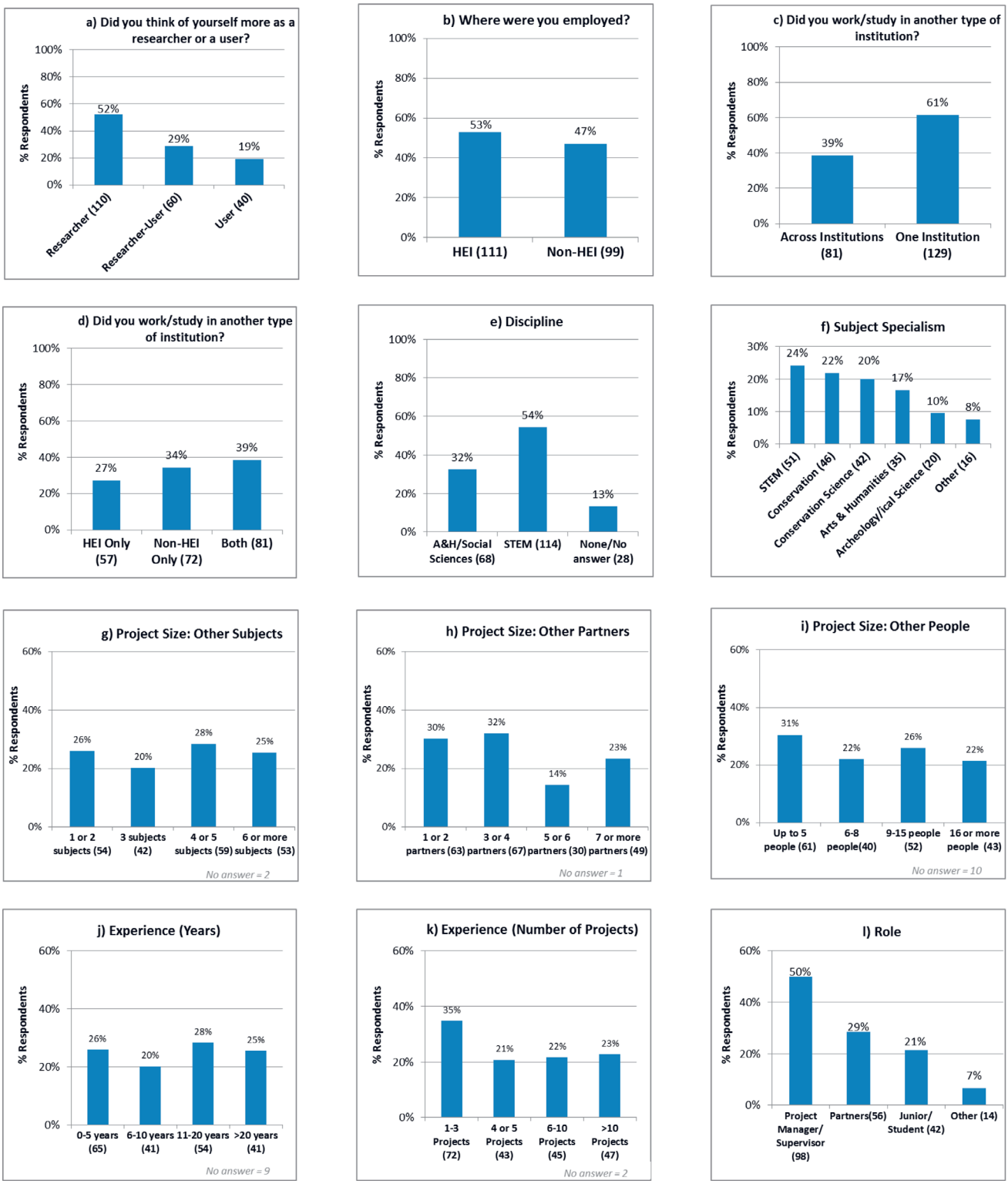


Figure 1: Characteristics of the Mind the Gap questionnaire sample.
Personal and project characteristics as self-reported by questionnaire respondents. Numbers in parentheses represent the number of respondents in each category of response.

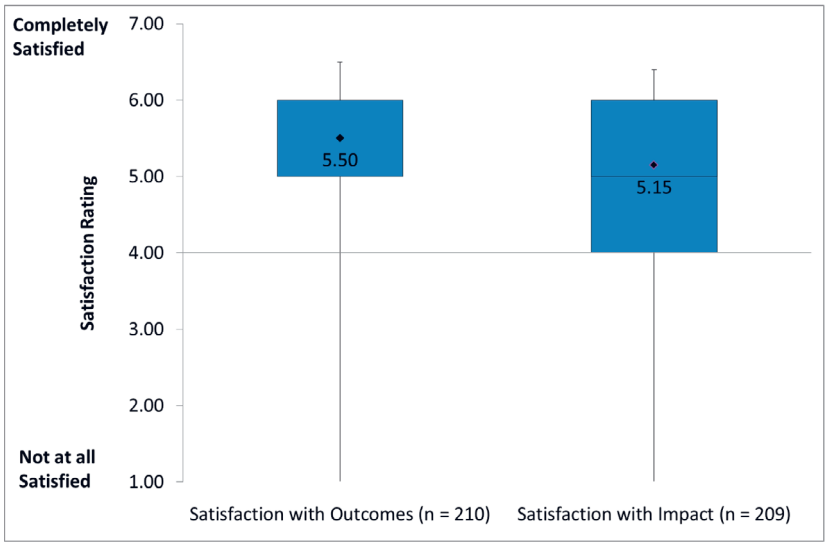


Figure 2. Box-plots of outcome and impact satisfaction ratings.
Chart shows box plots of quartiles, the medians and the means. Note that for the outcome satisfaction ratings, 64% of respondents gave a rating of 6 or more and 84% gave a rating of 5 or more (hence the median and 75th percentile markers are in the same position).

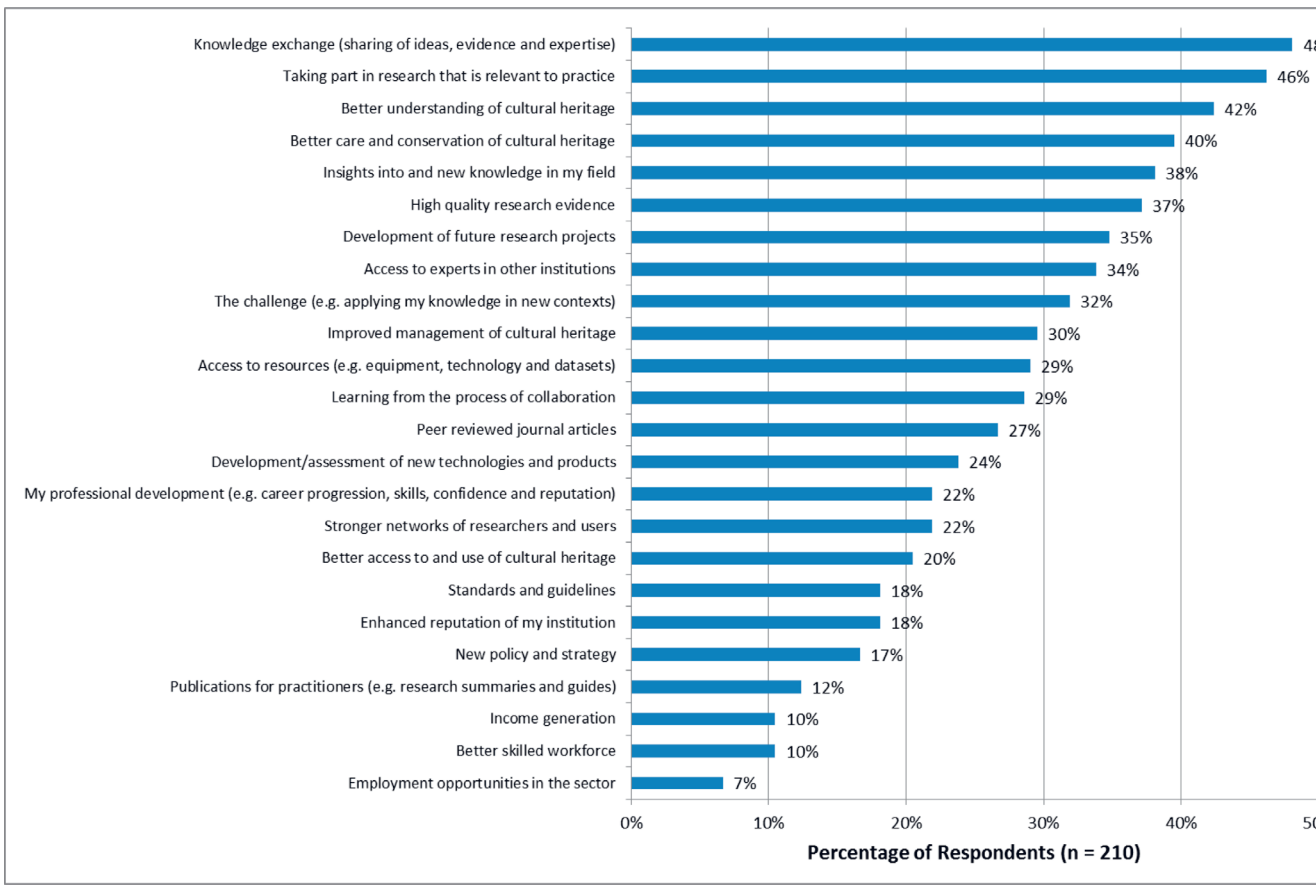


Figure 3. Personal Goals.
Percentage of respondents who chose each of 24 goals as one of their five main personal interests at the outset of their project.

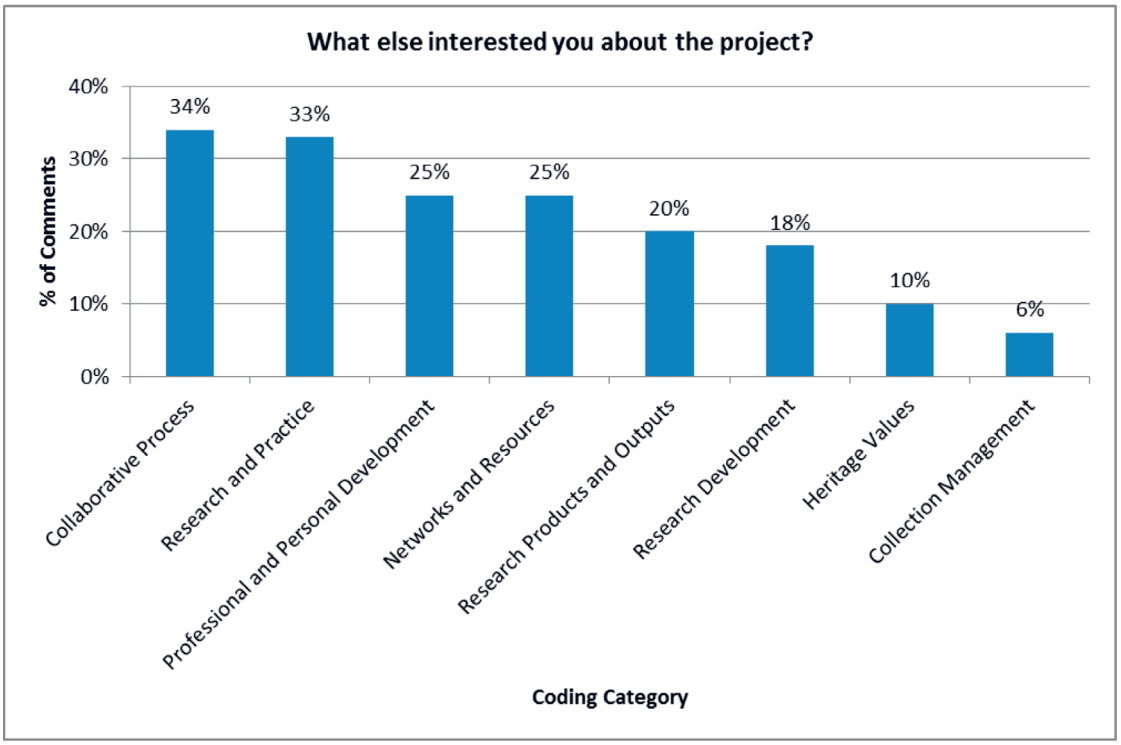


Figure 4. Main themes in responses to the question 'What else interested you about the project'?

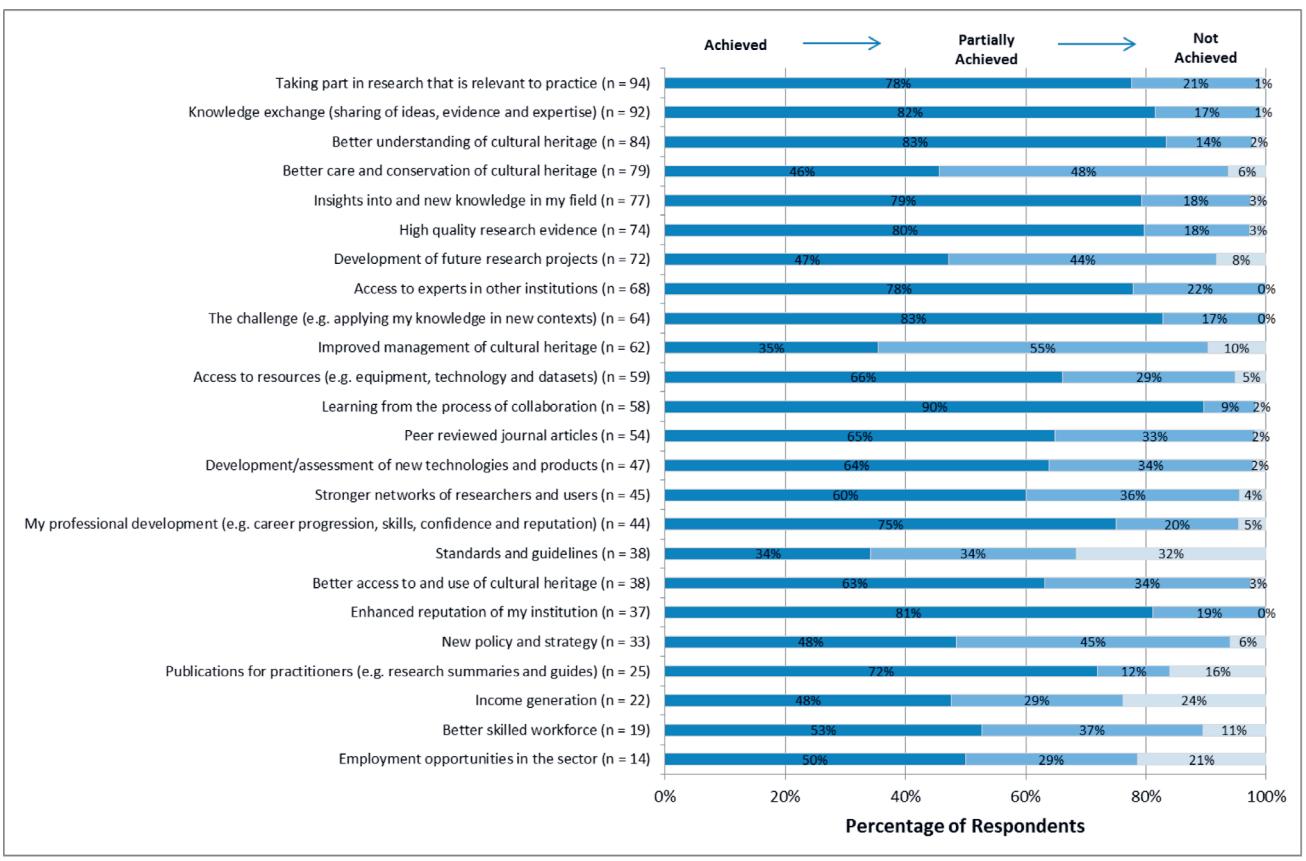


Figure 5. Achievement of goals.
Percentage of respondents who reported that they had 'achieved', 'partially achieved' or 'not achieved' their goals.

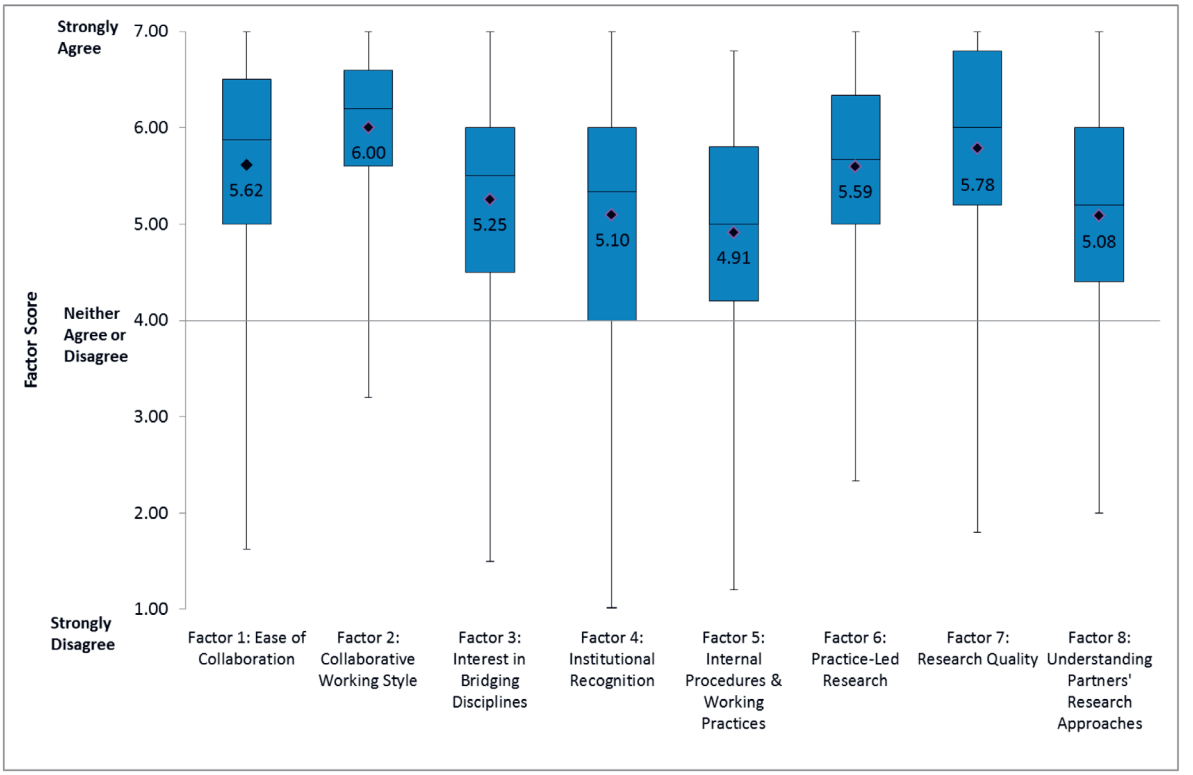


Figure 6. Box plots of factor scores.
Chart shows quartiles, medians and means for each factor.

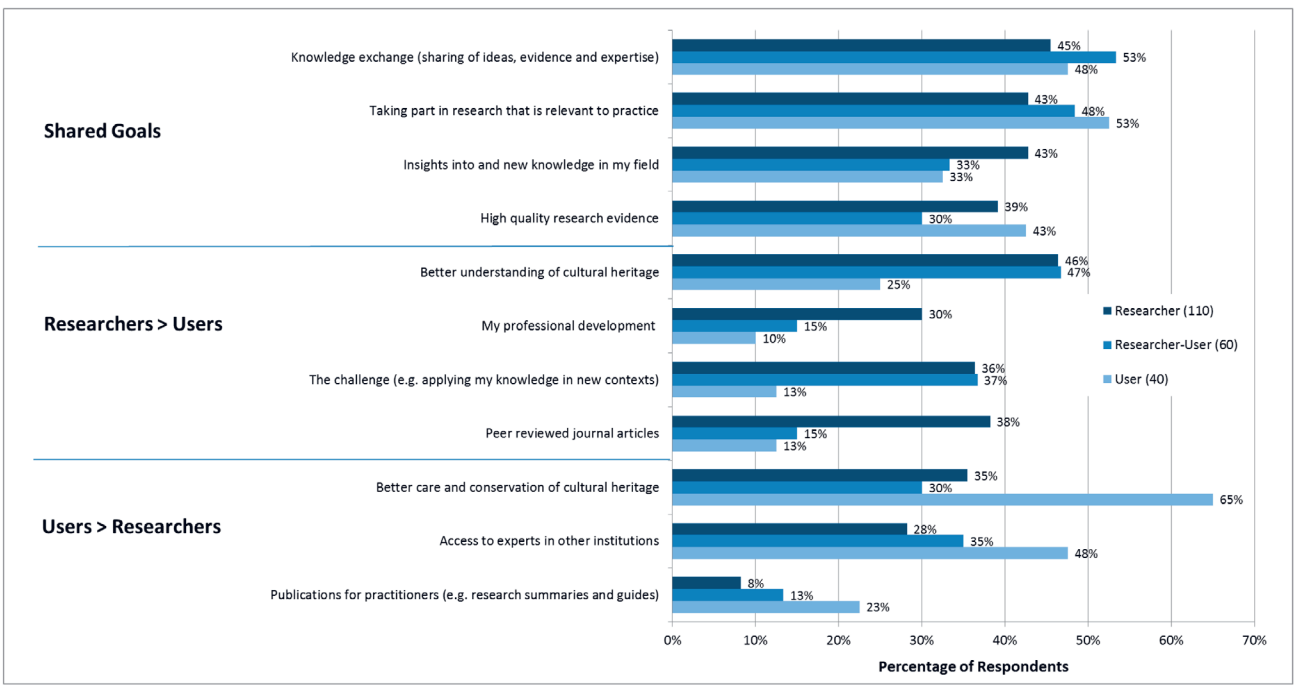
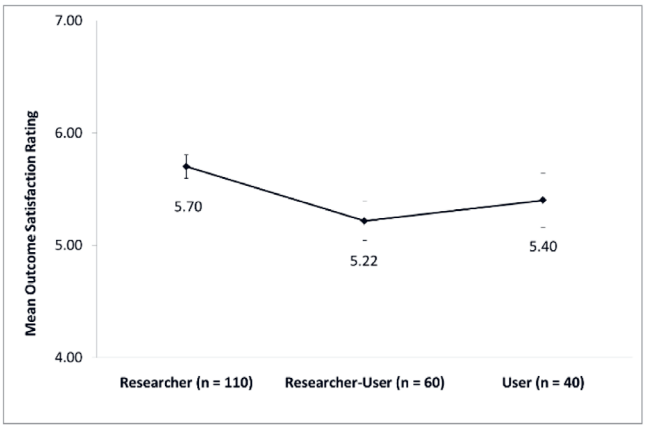
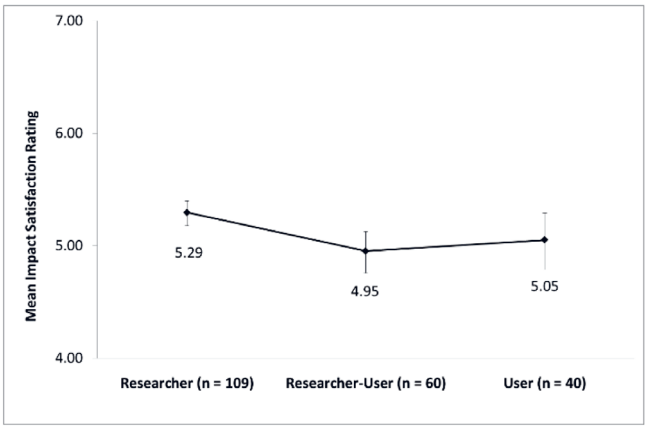


Figure 7. Goals of researchers, researcher-users and users.
Some of the most frequently held goals across the sample were shared by researchers, researcher-users and users. The chart also shows goals that differed significantly between the three groups of respondents (tested using chi-square).



a) Outcomes



b) Impact

Figure 8. Project satisfaction ratings for researchers, researcher-users and users.
a) outcomes satisfaction ratings and b) project impact satisfaction ratings. The charts show mean ratings and standard errors.

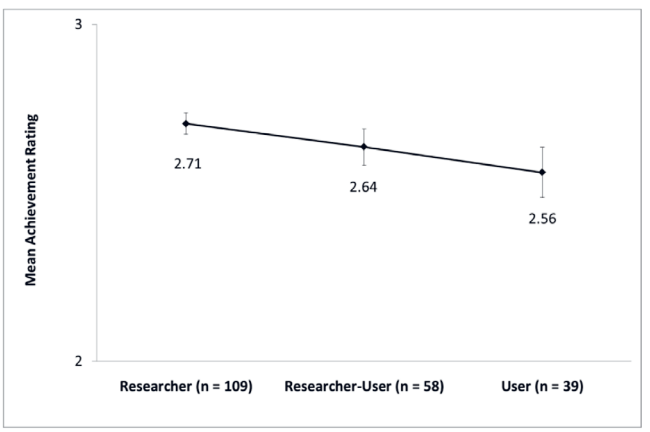


Figure 9. Composite achievement ratings for researchers, researcher-users and users.
The chart shows the mean achievement rating across the five goals that each respondent chose and standard errors.

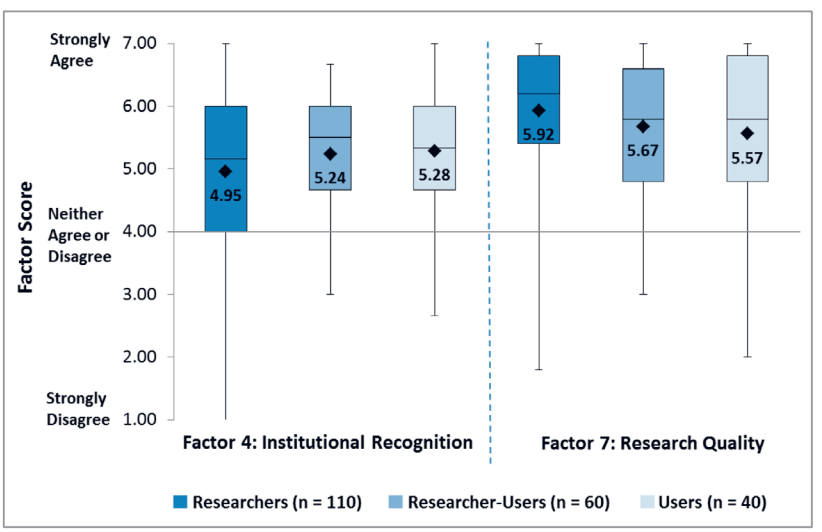


Figure 10. Factor scores that differed significantly between researchers, researcher-users and users.
Tested using one-way ANOVAs with post-hoc comparisons.

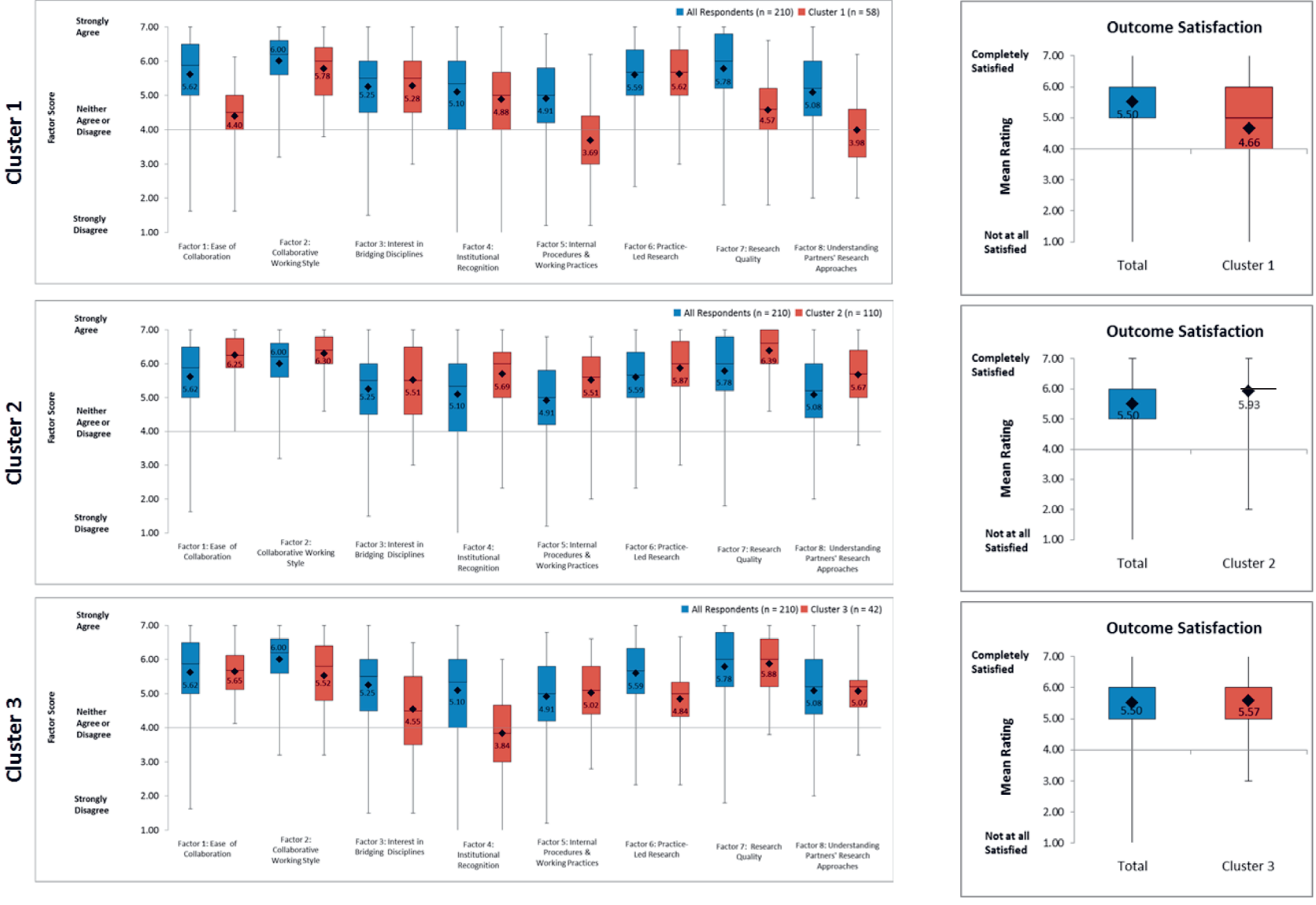


Figure 11. Factor scores and satisfaction ratings for three clusters of respondents

Table 2. Summary of the cluster profiles.

Significant differences between clusters are shown in bold. Non-bold text describes trends used to interpret the profiles.

Variable	Cluster 1 (n = 58; 28% of respondents)	Cluster 2 (n = 110; 52% of respondents)	Cluster 3 (n = 42; 20% of respondents)
Satisfaction/ Achievement	**Lowest**	**Highest**	**High (Average – Above Average)**
Factor Scores	**Lowest scores for: 'ease of collaboration', 'internal procedures & working practices', 'research quality' and 'understanding partners' research approaches'**	**High scores on all factors**	**Lowest scores for: 'collaborative working style', 'interest in bridging disciplines', 'institutional recognition' and 'practice-focused research'**
Goals	**Most likely to have collections management goals ('standards and guidelines', 'improved management of cultural heritage')** Least likely to have 'better understanding of cultural heritage' as a goal	Least likely to have 'access to resources' goal	**Most likely to have 'access to resources' goal** Most likely to have 'peer reviewed journal articles' as a goal and least likely to have 'improved management of cultural heritage'
Role	Most likely to be in a management role, and slightly more likely to be a researcher-user	Slightly more likely to be researcher-users or users	Most likely to identify as a 'researcher', and least likely to be in a management role
Discipline and Specialism	Most likely to be a conservation scientist	Most likely to be from an Arts & Humanities discipline and/or conservation	Most likely to have a STEM subject specialism
Project Size	**Largest projects**	**Small-medium sized projects**	**Smallest projects**
Experience	**Less experienced (but a range of experience)**	**Most experienced (but a range of experience)**	**Least experienced**

Table 3. Pearson correlations of factor scores with satisfaction and achievement ratings

		Outcome Satisfaction Rating	Impact Satisfaction Rating	Mean Achievement Rating
Factor 1: Ease of Collaboration	Pearson Correlation	.508**	.434**	.514**
	Sig. (2-tailed)	.000	.000	.000
	N	210	209	206
Factor 2: Collaborative Working Style	Pearson Correlation	.243**	.161*	.179*
	Sig. (2-tailed)	.000	.020	.010
	N	210	209	206
Factor 3: Interest in Bridging Disciplines	Pearson Correlation	.058	.042	.031
	Sig. (2-tailed)	.403	.550	.660
	N	210	209	206
Factor 4: Institutional Recognition	Pearson Correlation	.222**	.232**	.131
	Sig. (2-tailed)	.001	.001	.062
	N	210	209	206
Factor 5: Internal Procedures & Working Practices	Pearson Correlation	.217**	.162*	.225**
	Sig. (2-tailed)	.002	.019	.001
	N	210	209	206
Factor 6: Practice-Led Research	Pearson Correlation	.118	.100	.093
	Sig. (2-tailed)	.089	.148	.184
	N	210	209	206
Factor 7: Research Quality	Pearson Correlation	.622**	.534**	.500**
	Sig. (2-tailed)	.000	.000	.000
	N	210	209	206
Factor 8: Understanding Partners' Research Approaches	Pearson Correlation	.359**	.292**	.295**
	Sig. (2-tailed)	.000	.000	.000
	N	210	209	206

Notes: **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

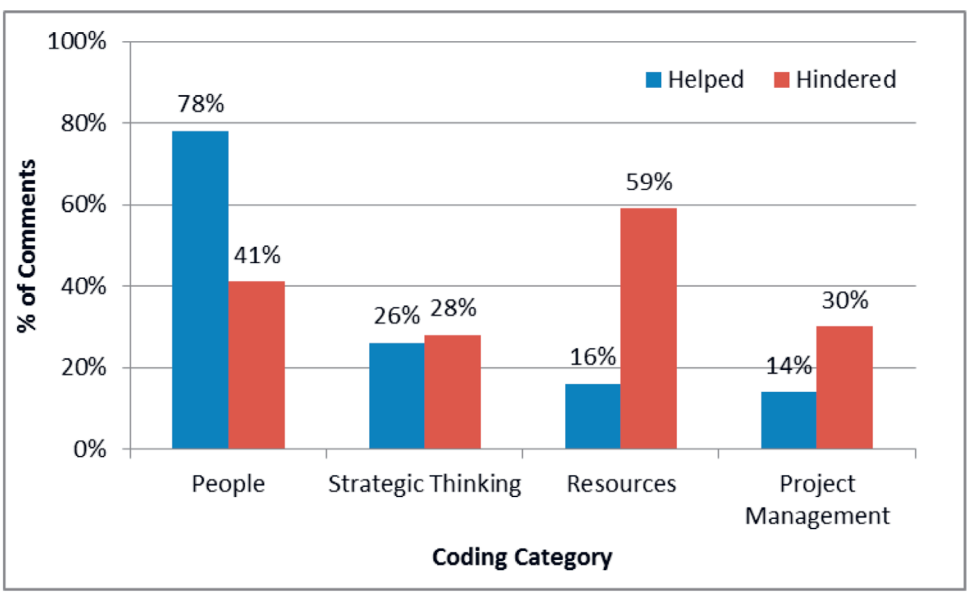


Figure 12. Main themes in responses to the questions 'What else do you think helped/hindered the project?'

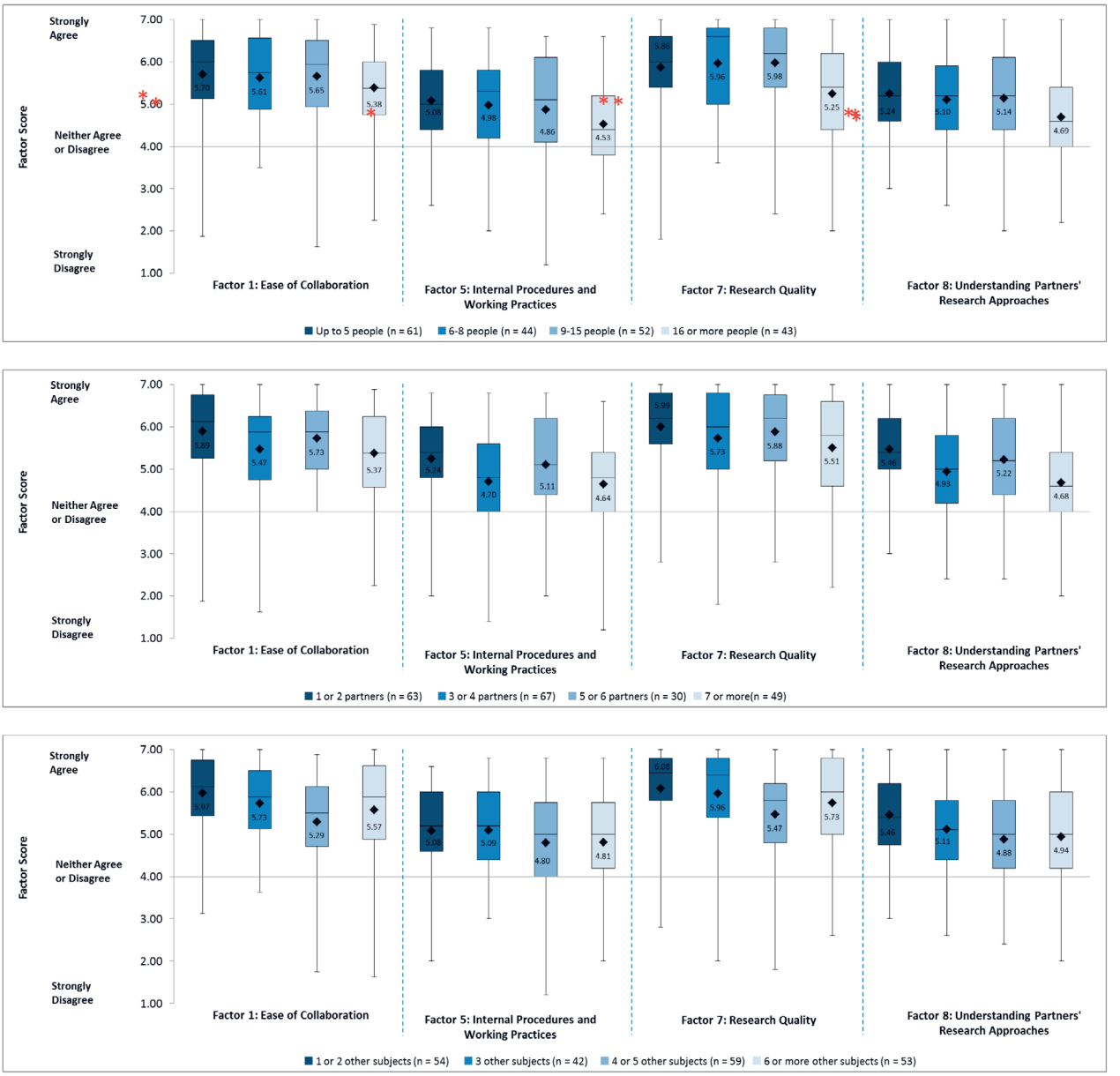


Figure 13. Relationships between three measures of project size and four factor scores. Significant findings are marked with an asterisk (based on the results of one-way ANOVAs with post hoc comparisons). Top: Number of other people involved. Middle: Number of other partner organizations. Bottom: Number of other subjects represented in the project.

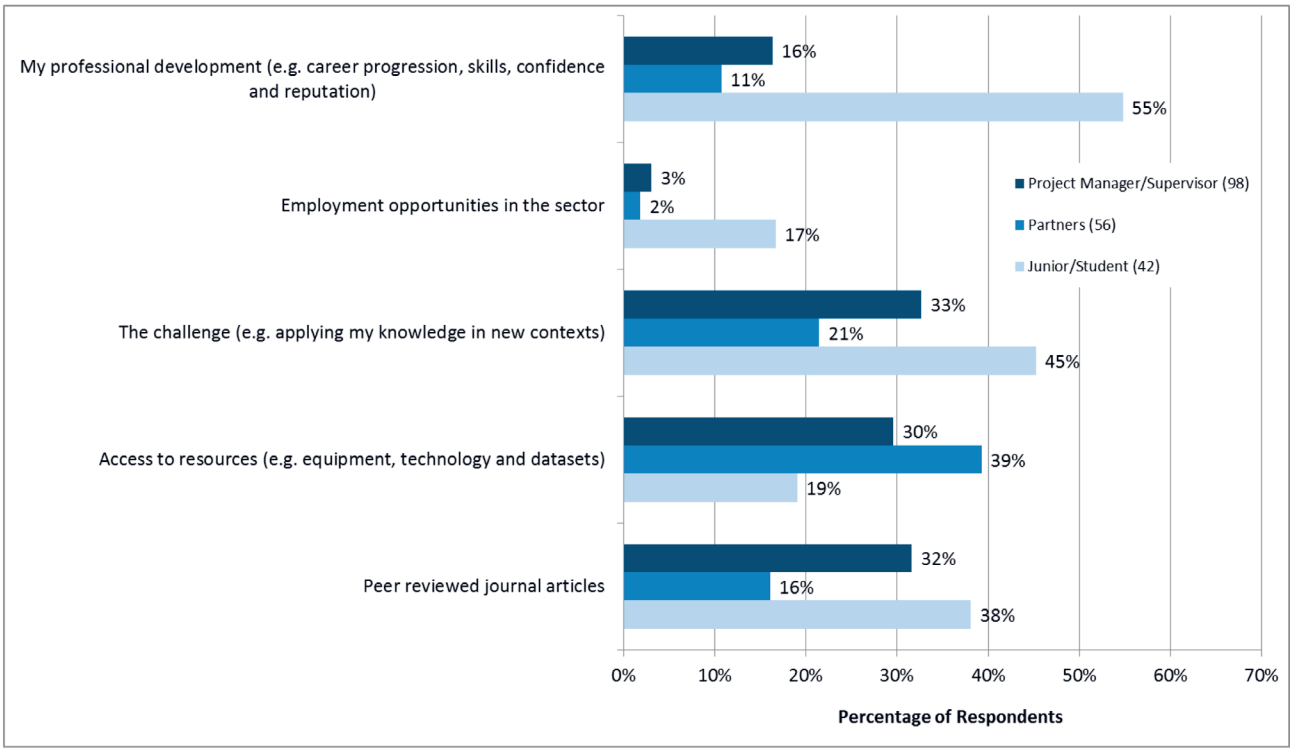


Figure 14. Significant differences between project roles in terms of personal goals.
Tested using chi-square.

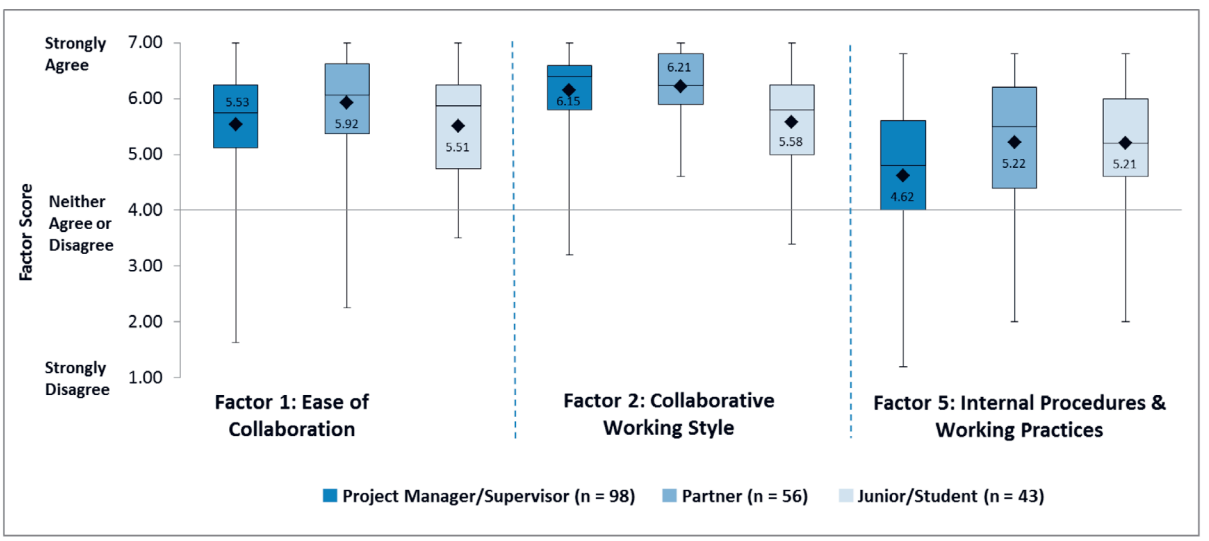


Figure 15. Significant differences between project roles in terms of factor scores.
Tested using one-way ANOVAs with post-hoc comparisons.

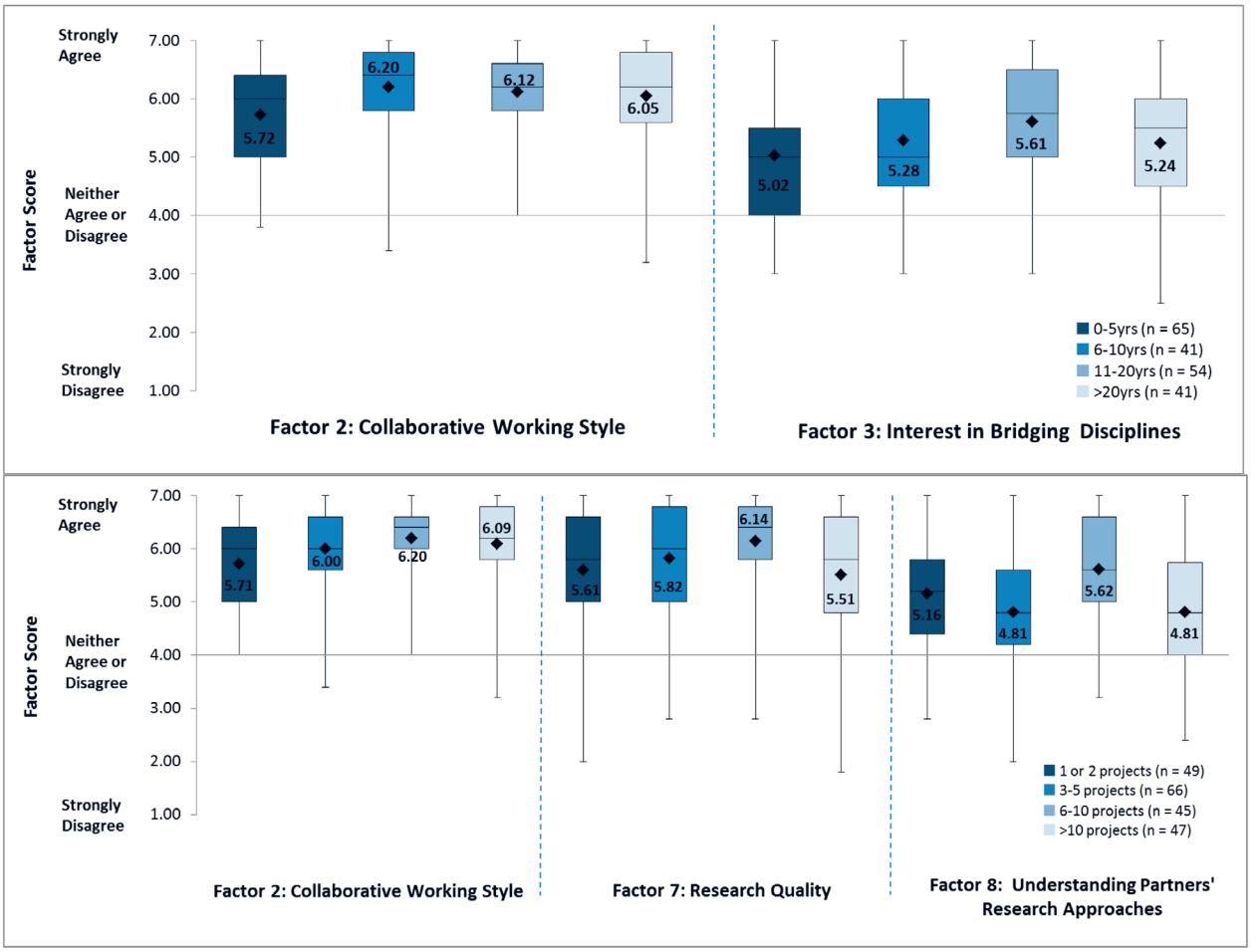


Figure 16. Significant associations between experience and factor scores.
Tested using one-way ANOVAs with post-hoc comparisons. Top: Experience (Years) . Bottom: Experience (Projects).

Annex B

Project Partners

Dr Haidy Geismar, University College London
Dr Julie Harvey, Centre for Arts and Humanities, Natural History Museum
Dr Geraldine Horan, University College London
Dr John Hughes, University of the West of Scotland
Professor Alfred Kieser, Zeppelin University, Friedrichshafen, Germany
Professor Roger Kneebone, Imperial College London
Katy Lithgow, National Trust
Professor Michael Moss, University of Glasgow
Kostas Ntanos, The National Archives and Institute of Conservation Science Group
Jerry Podany, Getty Museum
Dr Boris Pretzel, Victoria and Albert Museum
Professor Ben Rampton, Kings College London
Dr Dean Sully, Institute of Archaeology, University College London