D.7.1 Report on education and training needs

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Abstract

E-RIHS vision is to become a European research infrastructure that provides state-of-the-art tools and services by cross-disciplinary groups of researchers to cross-disciplinary users and scientific communities working to advance knowledge about heritage and to devise innovative strategies for its preservation and presentation. Such a unique vision demands also an efficient and effective training strategy.

The aim of this education and needs assessment was to provide an overview of current training provisions and needs of heritage science (HS) professionals in preparation for the research infrastructure. The project was conducted through a survey and qualitative interviews to elicit views on training gaps and priorities, and formats of training.

The objectives were to:
- Undertake a thorough landscaping exercise in the existing training provision to identify gaps;
- Build on existing experience learned from the current offer of education and training in HS;
- Identify current and future needs;
- Identify what worked, and what best practice might be for the future E-RIHS Academy.

Key messages include:
- develop a catalogue of HS skills and expected skills related to access to the infrastructure;
- develop training courses specifically focussing on the provision of interdisciplinary and transferable skills (such as research management, collaboration and ethics);
- develop a range of training channels, suited to the different training aims and research communities, with an emphasis on online delivery of training;
- improve training on research applications among the facility providers;
- develop training covering data science to support the development of E-RIHS DIGILAB;
- build a suite of training organised by individual access providers;
- establish partnerships with existing providers of heritage science education and specialist training.

The key findings of the report will inform the creation of the E-RIHS Education and Training strategy.
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</tbody>
</table>
# Table of contents

**Abstract** .......................................................................................................................... 2

**Document information** .................................................................................................... 3

**Abbreviations** .................................................................................................................... 7

1  Introduction .......................................................................................................................... 8

2  Methods of work ................................................................................................................... 8
   2.1  Survey ........................................................................................................................... 8
   2.2  Qualitative interviews .................................................................................................... 9

3  Results and discussion ......................................................................................................... 10
   3.1  Survey .......................................................................................................................... 10
       3.1.1  Users’ experience ............................................................................................... 11
       3.1.2  Provider experience .............................................................................................. 27
       3.1.3  Generally about attendees of the survey ............................................................... 43
   3.2  Qualitative interviews ................................................................................................... 48
       3.2.1  E-RIHS Academy training channels ................................................................. 48
       3.2.2  E-RIHS training and other educational settings .............................................. 48
       3.2.3  The E-RIHS Academy and training in the area of technical and scientific skills 49
       3.2.4  Skills in interdisciplinary knowledge production .............................................. 49
       3.2.5  The significance of ethics and management skills in working with heritage industries 50

4  Conclusions ........................................................................................................................ 51

5  References .......................................................................................................................... 52
List of figures

Figure 1: The percentage of the attendees as users and providers.................................................10
Figure 2: The percentage of users who have or have not attended a HS training course in the past 5 years. Number of answers: 50. ..............................................................11
Figure 3: Proportions of users with numbers of undertaken HS training courses. Number of answers: 39. ..............................................................11
Figure 4: Proportion of undertaken conservation/restoration, preventive conservation, conservation ethics/theory, or heritage management workshops or courses. Number of answers: 49. ..............................................................13
Figure 5: Proportion of research infrastructure access demanding a preliminary training. Number of answers: 37. ..............................14
Figure 6: Proportions of training providers. Number of answers: 43. ..............................15
Figure 7: Percentage of contexts of HS training courses. Number of answers: 41. ..............................16
Figure 8: Proportions of content in HS training courses for users. Number of answers: 238. ..............................17
Figure 9: Proportions of costs of the HS training courses fees. Number of answers: 32. ..............................19
Figure 10: Users happiness about the HS training fees. Number of answers: 32. ..............................19
Figure 11: Proportions of different HS training durations. Number of answers: 39. ..............................20
Figure 12: Agreement with duration of training. Number of answers: 35. ..............................21
Figure 13: Percentage of different methods of training used. Number of answers: 118. ..............................22
Figure 14: Training courses that did or did not include IPR. Number of answers: 36. ..............................23
Figure 15: Gaps of training, yes or no. Number of answers: 24. ..............................23
Figure 16: Proportions of users’ satisfaction with trainings. Number of answers: 37. ..............................24
Figure 17: Transnational access to HS services within previous EU projects. Number of answers: 39. ..............................24
Figure 18: Proportions of different services used. Number of answers: 17. ..............................25
Figure 19: The need for training to apply for access. Number of answers: 51. ..............................25
Figure 20: Percentage of providers who carry out their own development. Number of answers: 28. ..............................27
Figure 21: Percentage of providers who do or do not collaborate with industry. Number of answers: 20. ..............................28
Figure 22: The percentage of providers who did or did not organised a technical training course intended for conservators/restorers. Number of answers: 28. ..............................29
Figure 23: The percentage of providers who collaborate with potential users when developing new equipment or methods. Number of answers: 26. ..............................30
Figure 24: The proportion of providers who did or did not attend conservation oriented training. Number of answers: 26. ..............................31
Figure 25: Proportion of training courses, which were or were not in the context to access the RI. Number of answers: 12. ..............................33
Figure 26: Context of the HS training courses for providers. Number of answers: 25. ..............................33
Figure 27: Proportion of content in HS training courses for providers. Number of answers: 54. ..............................35
Figure 28: Proportion of HS training organisers for providers. Number of answers: 22. ..............................37
Figure 29: Proportion of HS courses, which did or did not address IPR. Number of answers: 14. ..............................37
Figure 30: Proportions of the costs of the training fee. Number of answers: 15. ..............................38
Figure 31: Satisfaction of the providers with the training fee costs. Number of answers: 12. ..............................38
Figure 32: Proportions of the methods of training used. Number of answers: 34. ..............................39
Figure 33: Satisfaction of providers with HS training courses. Number of answers: 14. ..............................40
Figure 34: Proportion of providers involved in previous EU infrastructure projects. Number of answers: 26. ..............................41
Figure 35: Proportion of providers offering MOLAB, FIXLAB or ARCHLAB services. Number of answers: 7.

Figure 36: Proportion of providers offering access to RI HS services not within IPERION CH project. Number of answers: 26.

Figure 37: Proportion of different backgrounds of both, users and providers. Number of answers: 115.

Figure 38: Proportions of age of the attendees. Number of answers: 73.

Figure 39: Proportions of job roles of the attendees. Number of answers: 108.

Figure 40: Proportions of countries of work/study of the attendees. Number of answers: 67.

Figure 41: Years of activities in the HS sector. Number of answers: 73.

Figure 42: Proportions of type of employment. Number of answers: 72.

Figure 43: Proportion of time dedicated to HS. Number of answers: 73.
Abbreviations

CPD - Continuing Professional Development
E-RIHS – European Research Infrastructure for Heritage Science
HS – Heritage Science
ICC - International Institute for Conservation of Historic and Artistic Works
ICCROM – International Centre for the Study of the Preservation and Restoration of Cultural Property
ICON – The Institute of Conservation
RI – Research Infrastructure
SEAHA - Science and Engineering in Arts, Heritage and Archaeology
SSH – Social Sciences and Humanities
1 Introduction

Heritage science is an inherently cross-disciplinary domain requiring knowledge of science and engineering as well as of arts and humanities and social sciences. Most researchers enter the field at a postgraduate level or at a post-doctoral level with a diverse range of academic backgrounds; therefore, training opportunities to develop a variety of complementary skills may be required. Additionally, heritage scientists need to work in diverse environments: in academia, heritage institutions as well as in business environments and significant transferable skills are required for research to have impact.

This survey aims to provide an insight into the needs of heritage scientists in the area of education and training for the purpose of access to research infrastructure in particular. The current education and training landscape was explored in order to identify the needs that will help us in the development of a strategy for education and training in E-RIHS.

Our starting premise was that there is an existing landscape of structured training provision at national levels, as well as provision of ad-hoc training courses associated with projects or research programmes, and, in some cases, already existing research infrastructures. The purpose of this report is to look for gaps in this provision, and at the expectations of both access providers and users.

In doing so, it has been our assumption that training of access providers in topics such as infrastructure management, will be a requirement for E-RIHS partners anyway, and the survey does not explore this topic.

An online questionnaire was developed in order to understand the landscape of heritage science training provision from the viewpoint of both users and providers of access to infrastructure services.

This report identifies and analyses the gaps, and will be used as the starting point in the development strategic planning of E-RIHS training. In conjunction with the survey, a series of qualitative interviews with a range of stakeholders such as representatives of research organisations providing heritage science training, facility providers and other key stakeholders will provide additional detail – this will feed into the development of the E-RIHS Training Strategy directly.

2 Methods of work

2.1 Survey

To design the questionnaire we liaised with partners within E-RIHS that have experience from previous EU infrastructure projects, as well as partners with experience of training provision e.g. in ARIADNE, Charisma, IPERION CH and other similar projects, as well as with ICCROM. This enabled us to build on extensive joint experience of designing and delivering training. As a result, 51 questions were developed, focusing on scientific and technical education as well as on training in cross-disciplinary skills. The aim of this questionnaire was to understand the needs and
expectations regarding heritage science training and the broader landscape of training provision in heritage science. In particular, the focus was on training in the use of analytical instruments and other physical and digital tools and data.

The questions were split into three sections: a section intended for users, a section for providers and a general section aimed at both users and providers. The following terms applied:

- **User**: a person who requires access to research infrastructure
- **Provider**: a person who provides access to research infrastructure
- **Research infrastructure**: facilities, resources and services used by the science community to conduct research and foster innovation. They include: mobile and major scientific equipment, resources such as collections, archives or scientific data, e-infrastructures such as data and computing systems, and communication networks; and other resources such as archaeological/historic sites, buildings, art and historical collections i.e. the subject material on which research is undertaken.

The survey was distributed online using SurveyMonkey. In order to distribute the questionnaire between users and providers we liaised with other providers of education and training in HS, museums, galleries, restoration/conservation institutions, and HS research institutions. Social media were used to disseminate the survey, and direct email notifications were sent to members of professional associations such as ICON – UK Institute of Conservation.

### 2.2 Qualitative interviews

We explored the need for provision of skills that may become essential in the near future, such as digital skills and digital humanities skills. To do so, we aimed to organise qualitative interviews consisting of selected industry (heritage and otherwise) professionals and academics, as well as representatives of professional bodies. The respondent group included four representatives of international heritage organisations (IIC, ICON, ICCROM, ICOM CC), two coordinators of early career research programmes in heritage science (SEAHA and Marie Curie Actions), and representatives of the provider community as well as national heritage boards. Due to scheduling constraints, the possibility of organising a focus group was limited. As individual interviews have been found to be as effective at generating a broad range of discussion topics as focus groups (Guest 2017), we have instead undertaken a series of qualitative interviews to discuss training needs.

The interview method has provided a unique opportunity to explore the matters of training and skill needs. Through in-depth discussions lasting between 30 mins and 1 hour, we were able to gain an understanding of the contextual factors that could affect skills development. First, the semi-structured interviews have predominantly focused on gaps in heritage science training. Second, they explored the need for provision of specific skills that may become essential in the day-to-day activities of the ERIC, and the most effective means by which E-RIHS training could be delivered. Last, they explored how the existing formal training responds to industry needs and how multidisciplinarity is addressed in formal academic education. Based on the first wave of discussions, preliminary findings were included in this deliverable (D.7.1)
3 Results and discussion

3.1 Survey
Overall, 282 participants responded to the questionnaire and gave answers to the questions. The results of the on-line survey are presented in Figures 1 – 43. In the following section, the responses presented are related to the user and provider experience. In addition, we have outlined some general information about the responders to the survey.

Proportion of users and providers

“I have accessed or provided access to research infrastructure in the past five years and will be responding to this questionnaire as a user or as a provider (Note: you can provide responses once as a user and once as a provider if you wish so).”

Figure 1 shows that 63% of the attendees provided answers as users of Heritage Science RI, while 37% of the attendees were those who provide the services related to HS.

There is a good and balanced split between the two and it should be mentioned that some respondents chose to provide responses twice, once as a user and once as a provider, which is what was encouraged. As is evident from Section 3.1.3, there was a good geographical distribution of the respondents, and although the survey was only available in English, the survey seems to be providing a reasonably balanced picture.
3.1.1 Users’ experience

“1. Have you undertaken a heritage science training course in the past five years?”

![Figure 2: The percentage of users who have or have not attended a HS training course in the past 5 years. Number of answers: 50.]

The survey found that 42% of users (Figure 2) have not undertaken a HS training course in the past 5 years. From the viewpoint of continuous professional development, it could be a concern that almost half of all users have not received any heritage science training and do not take care of keeping their knowledge updated, or there might be a potential public for courses different from those usually offered.

**Recommendation 1:** E-RIHS training strategy needs to explore mechanisms to attract more users to join HS training courses and diverse formulations of communicating data that might be called elsewhere than “training courses”.

“2. How many heritage science training courses did you attend in the past five years?”

![Figure 3: Proportions of users with numbers of undertaken HS training courses. Number of answers: 39.]

E-RIHS – GA n. 739503
Similarly as for the previous question; the percentage of users who attended only one training course related to HS (Figure 3) in the past 5 years appears to be high, meaning that the majority of respondents undertake significantly less than one course per year. Only about 20% of respondents attend one such course or more per year.

Given the rapid developments of the field, it would be advisable to increase participation in training. Whether E-RIHS could efficiently promote this as a day-to-day activity is questionable; however, it would be advisable that as part of continuous professional development of a heritage scientist, the notion is developed that training is an integral part of the professional life.

**Recommendation 2**: E-RIHS to develop or to enable the development of a CPD system for HS.

“3. Please list all heritage science training courses you attended.”

The following answers included:

- Use of NIR spectroscopy.
- Characterisation and stability of materials from cultural heritage
- Importance of public relations for preservation of heritage
- Providing a relationship in professional communication
- Photographic documentation of cultural heritage
- Few about paper and book, few about pictures in galleries, few about chemistry analysis of things, restorations
- Cultural Heritage analysis
- Characterisation and stability of materials from cultural heritage (3 responses)
- Training camp
- 3° Training Camp Iperion.CH (25-30 September 2016, Siracusa, Italy) Scuola di spettroscopia infrarossa applicata alla diagnostica dei Beni Culturali - VI Edizione (6-10 November 2017, Venaria Reale, Italy)
- AUNIRA 2015
- Metallurgy for Cultural heritage scientists by AIM Italy
- Experimental Archaeology by University of Siena
- Use of IBA at AGLAE; use of PGAA at BNC
- XII SoNS “Francesco Paolo Ricci” – “Introduction to the theory and techniques of neutron scattering and applications to Cultural Heritage” 30 April – 9 May 2014, Erice Italy
- classroom - during conservation-restoration studies, individual- during my project Analysis of different types of mortar, suitable for reconstruction of historical mortars.
- Cultural heritage university program Conference on cultural heritage
- Silversmithing techniques - 2x metalworking classes - electrolytic methods of museum conservation
- Radiocarbon in the Earth System 2017
- Regional Training Course on Dating of Cultural Heritage Artefacts using Nuclear Analytical Techniques
- Dry wall building and preservation techniques
- Workshop on acquiring samples for natural science research
- Archaeozoology, Archaeobotany, Palynology
- "Profilaktyka konserwatorska w muzeum"
- "Podstawy dokumentacji muzealnej"
- I’m an art historian and working at the museum at textile department.
The above list could be broken down into (i) technical skills training; (ii) Documentation skills; (iii) Communication and engagement. Of these, (i) dominates by a large margin. This could be due to the context in which the questionnaire was undertaken, i.e. in relation to provision of access. However, the complete lack of (i) digital skills training or (ii) collaborative working skills training, is a concern, at the very least.

Additionally, the list seems to indicate that the provision of technical skills training is relatively well developed and widespread. This is good, as it is relevant and necessary that such skills are delivered in national languages.

“4. Have you attended any courses or workshops on conservation/restoration, preventive conservation, conservation ethics/theory, or heritage management?”

Among users the proportion of undertaken conservation/restoration, preventive conservation, conservation ethics/theory, or heritage management workshops or courses is a bit higher (see Figure 4) than HS courses. This could be because users of infrastructures do not necessarily link conservation/restoration, preventive conservation, conservation ethics/theory, or heritage management workshops or courses with access.

Recommendation 3: E-RIHS should develop a catalogue of HS skills, starting with technical skills, but also emphasizing collaborative, communication and engagement, digital skills.
“5. Was this training course a prerequisite for using research infrastructure?”

Only 16% (Figure 5) respondents/users of RI infrastructure were requested to attend a training course prior to access. Two possible explanations can be provided: either (i) the questionnaire did not capture responses from the right target audience or (ii) providers of access truly require no training/may have considered that the pre-existing training was sufficient. Considering the dissemination channels that were used in the development of this questionnaire, we consider that option (i) is less likely, meaning that in the majority of cases access providers currently do not require any training, or provide 1-2-1 training ad hoc.

However, if the aim of E-RIHS is to develop cross-disciplinary teams and enable both users and providers to work jointly on cross-disciplinary research questions, then structured training and skills development should be pre-requisite in order to ensure quality of access and of research results, and to manage expectations.

**Recommendation 4**: E-RIHS should develop a clear catalogue of expected skills related to access to the infrastructure to manage expectations and ensure a high quality of the experience of access.
“6. Who organised this training course (multiple answers possible)?”

Figure 6: Proportions of training providers. Number of answers: 43.

Other (please specify):
- French Ministry of Culture
- National Metallurgy Society
- University
- School of Neutron Scattering - Francesco Paolo Ricci

It is shown (Figure 6) that the highest percentage of training in HS is provided by higher education institutions. However, professional organisations have played an almost equally important part in the provision of such training, which indicates that skills do not traditionally reside in higher education institutions. E-RIHS should carefully look at skills providers and ensure that the acquired skills of heritage scientists are adequately recorded and documented, so that repeated demands on skills development are avoided.
“7. What was the context of the training course?”

![Pie chart showing the percentage of contexts of HS training courses.](image)

**Figure 7: Percentage of contexts of HS training courses. Number of answers: 41.**

Other (please specify):
- invited lecture designed for employees of the institution
- face to face course for user
- Order of the Architects (planners, landscape, conservatories) of the provinces of Sassaria, Olbia-Tempio in collaboration with the Ministry of Cultural Heritage and Activities and Tourism.
- needed for assessment of collection

The results (Figure 7) show that the users most often attend HS courses at workshops/summer schools or similar. A much higher proportion of training courses are in the context of masters (27%) compared to the bachelors (10%). This shows that the training in HS usually starts at higher levels of University study, while professionals have probably the only opportunity for HS training through workshops/summer schools or similar.
“8. What content was covered by this training course (multiple answers possible)?”

Figure 8: Proportions of content in HS training courses for users. Number of answers: 238.
The results show that the highest percentage of the HS training courses focuses on natural science skills, while only 12% of the content was referring to SSH disciplines, 2% data and computer science, and 3% for digitalisation (see Figure 8). An equally low number of responses (3%) indicated transferrable skills.

“9. What specific skills did you gain during this training course that you could point out (e.g. analysis of cross-sections, 3D imaging etc.)?”

- Negotiation skills
- environmental management; analysis of causes of damage
- Instrumental methods of analysis and characterization
- correct lifting and sampling of biological artifacts
- How to correctly acquire samples for natural science researches.
- Luminescence dating, Raman spectroscopy, Dendrochronology
- calibrated dating with 14C
- analysis of pH value and degree of polymerization of paper
- Analysis of thin sections under microscope and cross-sections under SEM
- analysis of cross section handling of metallurgical working processes
- analysis of cross-sections; sampling; use of instrumentation such as colorimeter, XRF, IR spectroscope; imaging and mapping;
- I gained understanding of basic principles of cultural heritage materials terms of durability, degradation, lifetime, principles of degradation, processes and procedures for development of conservation procedures, application on real cases an practical use.
- 3D imaging, multispectral imaging, XRF analyses, tomography
- General knowledge for cultural heritage handling and methods that are in use for analysis
- GIS analysis
- new techniques, materials, approaches to clean the paintings
- advanced methods of electrolytic treatment
- learn how to present cultural heritage to public
- Knowing more about techniques for restoration of books... Something about techniques with X-rays...
- Inventory
- Understanding how specific conditions impact the materials and how to prevent further damage to those objects.
- familiarity with imaging
- various use of IBA facility at AGLAE; use of PGAA facility at BNC
- I participated as trainer
- neutron data analysis (for example scattering and imaging)
- practical skills on varnishing
- 1. Microscopy of textile fibers 2. Use of PLECO, new electrolytic tool for gilded metals, lead
- 3. History of museum conservation-restoration

The need for the development of technical scientific skills is entirely understandable. The lack of training courses in SSH and digital domains, as well as collaborative working skills could reflect a possible lack in the provision of such courses, which E-RIHS could address.

**Recommendation 5:** E-RIHS should develop training courses specifically focussing on the provision of SSH and digital skills, as well as transferable, collaborative working skills.
“10. What was the cost of this training course (fees only)?”

![Figure 9: Proportions of costs of the HS training courses fees. Number of answers: 32.](image)

Over 75% of survey respondents have attended courses that were free of charge, or in the range of 200 EUR. This might indicate that only a small proportion of E-RIHS users/providers might be willing to pay significant amounts of money for access to skills, and then only in exceptional circumstances.

“11. Do you feel that the cost was about right?”

![Figure 10: Users happiness about the HS training fees. Number of answers: 32.](image)

“If no, how much would you be happy to pay?”
- 200 EUR
- 100 EUR
Considering the results of both questions, 10. and 11. (see Figure 9 and 10), the HS training courses are most often free of charge, while the users would still be happy if the fee was between € 100 and € 200, but not more.

From a practical point of view, this would mean that E-RIHS training would in principle need to be provided online at no (or low) cost, although in some cases, paid training events are possible (either paid travel or attendance fees).

**Recommendation 6:** E-RIHS should focus on online delivery of training, although there is a place for face to face training that participants would be able to pay.

“12. How long was the training course (number of days)?”

![Figure 11: Proportions of different HS training durations. Number of answers: 39.](image)
“13. Do you feel that the duration was about right?”

Figure 12: Agreement with duration of training. Number of answers: 35.

“If not, what would in your opinion be the optimal duration?”
- One week
- Three days

One-day and 5-day training courses are prevailing (Figure 11), while only a few users (6%) were not happy with the duration of the course (Figure 12), suggesting one week or three days of training. If such training courses cannot be done online, there seems to be a general preference for shorter courses, that could possibly need to fit with other work responsibilities.

**Recommendation 7:** The typical duration of E-RIHS courses should be up to a week.
“14. What methods of training were used at the training course you attended?”

![Figure 13: Percentage of different methods of training used. Number of answers: 118.]

“Other (please specify):”
-   In museums, in laboratories...
-   Practical learning via visiting museums of national heritage, analytical laboratories...
-   Practice in the lab

The highest percentage of training methods used goes to hands on training, classroom teaching, case study learning and group learning activities, while only 3% of training goes to remote delivery (Figure 13). There is already a surprising diversity of delivery methods, which is excellent. Surprisingly, however, there is very little remote delivery of course contents, and surprisingly little hands-on training – given the need to mostly attend face-to-face training in the form of workshops, it is unusual that only 15% of the time is actually spent doing practical work for which contact teaching is most appropriate. In order to optimise teaching, E-RIHS should explore how to significantly push the balance towards online delivery in order to economise on resources, as well as to complement the currently prevailing face-to-face mode of delivery of training courses.

**Recommendation 8**: E-RIHS should focus on online delivery of courses.
“15. Was IPR (intellectual property rights) addressed in the training course (e.g. disclosure on the use of certain equipment/facility in case a prototype is still experimental; or use/reuse of material accessed during the training, etc.)?”

![Figure 14: Training courses that did or did not include IPR. Number of answers: 36.](image)

“16. Were there any gaps in the content of the training course you undertook (the gaps in the training related to necessary skills development to use heritage science research infrastructure)? Could the course be improved?”

![Figure 15: Gaps of training, yes or no. Number of answers: 24.](image)

Examples of listed gaps:
- I’m quite satisfied maybe a few more days I would have preferred
- we did a lot of theory and little practice; it would be useful to implement more hours in the laboratory and the first-person use of the equipment’s
- Yes (for example more training on a specific procedure of data analysis/software)
- it could be improved by more intense work and longer duration, including international experts

With respect to current course content, there is some room for improvement. The comments specifically mention more practical work, while question 15 highlighted the need for some training to increase the understanding of knowledge management, which is essential particularly in collaborative cross-disciplinary projects.
**Recommendation 9:** The content of E-RIHS courses should address some specifically identified gaps, such as knowledge management.

“17. To what extent did you find the course useful (related to necessary skills development to use heritage science research infrastructure)?”

![Figure 16: Proportions of users’ satisfaction with trainings. Number of answers: 37.](image)

Results of both questions (Figures 15 and 16) showed that the users were pleased with HS trainings provided to good and very good extent, mostly.

18. Have you used transnational access to heritage science services within previous EU infrastructure projects (EU-Artech, CHARISMA, IPERION CH, DARIAH, ESRF, Diamond, ISIS, etc.)?

![Figure 17: Transnational access to HS services within previous EU projects. Number of answers: 39.](image)
19. If you used transnational access to heritage science services within CHARISMA or IPERION CH, please specify which (multiple answers possible).

The responses to questions 18 and 19 (Figure 17) showed that only a third of the users have already had access to HS services within previous EU projects. From those who had transnational access to heritage science services within CHARISMA or IPERION CH, the highest proportion of usage was focused on FIXLAB services, as shown in Figure 18. As a result, this might suggest an identifiable lack of international or EU-wide collaboration skills among the majority of respondents.

**Recommendation 10:** E-RIHS Academy provision should include training in international collaboration.

20. Do you feel that training could be beneficial to help you prepare a proposal to win a project granting access to research infrastructure?

**Figure 18:** Proportions of different services used. Number of answers: 17.

**Figure 19:** The need for training to apply for access. Number of answers: 51.
An overwhelming majority of users (86%) feels that training to write a successful proposal could be beneficial (Figure 19). The key rationale for such a support were the value of general knowledge, efficiency, clarity, the potential benefit in terms of ability to fully grasp the capabilities of the infrastructure, as well as the skillset of early career researchers.

**Recommendation 11**: The training offer should incorporate courses supporting potential users in preparing proposals to win a project granting access to research infrastructure
3.1.2 Provider experience

1. What kind of infrastructure do you offer access to?

- separation techniques mass spectrometry climate chambers
- Mineralogical and microstructure characterization
- we host researchers to pursue projects using our tuition and instrumental facility
- Size Exclusion Chromatography, Electron Paramagnetic Spectroskopy
- Mobile equipment for X-ray CT analysis of archaeological findings and works of art
- X-ray tomography
- X-ray fluorescence spectroscopy, optical microscopy
- optical microscopy, spectroscopic methods
- Electron beam accelerator
- Electron beam accelerator
- Molab and Fixlab
- Laser Ablation ICP-MS, XRF, ICP-MS, (GF/F)CSAAS
- 3D scanning, 3D data processing, 3D data analysis and visualization
- IPERION CH, E-RIHS
- Mobile instrumentation
- IBA techniques
- PGAA instrument at the Budapest Research Reactor
- Sample preparation and diverse microscopic equipment
- AMS C-14 facility
- Chemical analysis (infrared and Raman spectrometers, optical microscope)
- Macroscopic (mechanical testing, chemical analysis, ...) and microscopical analysis.
- chemical analysis (infrared and Raman spectrometers, optical microscope)
- Ion beam analytical facility (accelerator based)
- Optical Coherence Tomography (OCT)
- MOLAB FIXLAB

(Number of answers: 25)

2. Do you carry out your own development, e.g. prototyping of instruments, software etc.?

Figure 20: Percentage of providers who carry out their own development. Number of answers: 28.
If yes, what kind of:
- Development of innovative systems for CT analysis of objects of different size and composition. Development of the software for tomographic reconstruction
- Software for data acquisition and its processing
- MOLAB: X-ray systems (XRF fluorescence, tomography, digital radiography), portable accelerator (collaboration with CERN), etc (e.g. time resolved lif...) FIXLAB: ion beam analysis (PIXE-PIGE imaging), neutron imaging, termoluminescence, radiocarbon DIGILAB: implementation of a new platform for data fruition (joint activity with ARIADNE)
- 3D processing software 3D visualization software
- prototype of VIS-NIR multispectral scanner; prototype of device for OCT (Optical Coherence Tomography); prototype of scanning microprofilometer.
- Non-invasive optical devices for the investigation of painted surfaces
- Software for evaluation of concentrations in PIXE-PIGE.
- Our instrument is under continuous development (detectors, shielding, sample environment)
- Sample preparation lines, enhancing sample preparation technique for better C-14 dating
- a whole OCT transportable instrument with dedicated software for in-situ examination
- Spectroscopy and imaging, sensing

3. If you answered "yes" to the previous question, are you currently collaborating with industry, with the aim to transform your developments into market-ready products? Please, provide specific comments.

![Figure 21: Percentage of providers who do or do not collaborate with industry. Number of answers: 20.](image)

Over 40 % of providers have been involved in a form of innovation in the areas of technical or software development. However, the proportion of providers who currently collaborate with industry, with the aim to transform their developments into market-ready products is quite low (see Figure 21). However, this could be understandable, as the market of HS instruments is often quite small. The respondents have mentioned different barriers to commercialisation such as cost and specialisation of the device. This suggests that there is a skill gap in the area of commercialisation of innovation activities in the context of heritage science facilities, their technical and software development.
**Recommendation 12:** There are opportunities for a training offer for providers that combine innovation and commercialisation of heritage science development.

4. Have you ever organised a training course with a technical focus but intended for conservators/restorers, curators etc., covering the provision of access to infrastructure?

![Pie chart showing 46% Yes and 54% No](image)

*Figure 22: The percentage of providers who did or did not organised a technical training course intended for conservators/restorers. Number of answers: 28.*

If yes, what was the topic of this training?
- we did several; "Conservation of stone"; "Conservation of cultural heritage" "materials for the restoration of glazed ceramic tiles"
- Application of radiography and X-ray Computed tomography in the field of cultural heritage.
- optical microscopy of textiles, microorganisms, paint layer samples
- diagnostic prior to a restoration process
- elemental analysis or isotopic analysis
- 3D data in cultural heritage: digitization, processing, use
- Non-invasive optical diagnostics of works of art
- Central European Training School on Neutron Techniques – annually
- enhanced C-14 sample preparation techniques for CH samples
- microscopic techniques, use of DRMS
- I had a lecture on natural dyes and methods of their study
- Optical Coherence Tomography
- Collection surveys using science methods, image analysis, material analysis etc.

Conservators/restorers are potential users of E-RIHS services. At the same time, our survey of providers demonstrated that only 54% (Figure 22) organised a training course intended for conservators/restorers, curators etc. This suggests that providers require more support in designing and delivering training for heritage practitioners.

**Recommendation 13:** Training offer needs to empower providers in skills enabling them to design and deliver courses aimed at heritage practitioners.
5. When developing new heritage science research equipment or methods, do you collaborate with potential users (e.g. conservation scientists, conservators/restorers, curators, other technical specialists and staff) during the process?

![Figure 23: The percentage of providers who collaborate with potential users when developing new equipment or methods. Number of answers: 26.](image)

Please let us know why and in what ways you collaborate:

- when developing or assessing products for conservation we start with an inquiry, follow with visits on-site and then diffuse with actions involving users.
- Discussion and consultation with conservators from universities and museums.
- It is usually vice versa: for example archaeologist asks us if we would be able to develop a method suitable for his artefacts. We are developing the method in cooperation with the archaeologist, showing him/her what are the results and discussing further development.
- From a scientist point of view collaboration is crucial, otherwise we risk "solving" problems that do not necessarily need solving or coming up with solutions (methods, instruments,...) that are difficult to implement and not very beneficial. We collaborate through everyday discussion.
- To have better results, everyone contributes from his point of view.
- Scientific meetings with conservators to introduce the method and its benefits. Presentation/lectures delivered on the CH preservation/conservation conferences
  - testing instrument in restoration laboratories (ex OPD) together with restorers
  - Discussion about usefulness of the proposed solutions, checking the understanding of the whole proposed analytical procedure
  - definition of requirements, test cases, testing
- We are currently collaborating with conservators/restorers. Conservators/restorers provide us their know-how in order to both interpret the results and have a feedback for making user-friendly interfaces.
- The conservation scientists and conservators/restorers provide an important feedback on the type of information is required as an output of the measurements. It is of utmost importance to have their opinion and advice in these terms.
- Collaboration in a research program with museum curators.
- To design the sample environment (sample holder, etc.)
- Cooperation between technical laboratory facilities and archaeologists. In order to promote the application of technical methods in the field of archaeology.
- we obtained information about: -the type of consolidant restorers are using, the quantity and the method of application, etc. -materials that are used in CH objects in order to simulate model substrates,.....
- yes, problematic samples arrived from our users are the reasons for developments
- Only strong collaboration with conservation scientists, conservators, restores etc can provide successful results.
- We do not develop new methods but we purchase new instruments based on the input from potential users (and our current users)
- I consult with the users what their needs are, what they want to investigate, what is the nature of the samples
- with the Institute for the Study, Conservation and Restoration of Cultural Heritage, Faculty of Fine Arts, Nicolaus Copernicus University on interpretation of results and development of practical applications
- Such development would be entirely useless without the involvement of users. Scientists usually have absolutely no idea how evidence and data need to be developed/presented to be of use to conservators, curators and the like, and usually do more damage than good if they don't work in collaboration.

6. As a provider of access to infrastructure, have you attended any courses on conservation/restoration, preventive conservation, conservation ethics/theory, or heritage management?

![Figure 24: The proportion of providers who did or did not attend conservation oriented training. Number of answers: 26.](image)

Although the majority of providers engage in collaboration with the potential users (92%), only less than half (46%) of providers attended conservation oriented training. Among those who did undertake such a training, this experience was predominantly respondents’ educational background, conferences and scholarly events, specific courses at their workplace and knowledge exchanges within teams.

Recommendation 14: E-RIHS training could address the lack of conservation-oriented training among the facility providers to enhance collaboration with heritage practitioners.
7. If you answered "yes" to the previous question, what were the benefits of such training? What gaps in the content of this training could you identify?

- From my experience as PhD and MSc supervisor, the first and most fundamental need is for people to understand the scientific approach, particularly in fields of the Humanities. Also to understand that no rules are absolute and the theoretical approach has to be based on decisions about which values MUST be conserved and which may be sacrificed.
- Better understanding of conservators' point of view.
- New information, compact. Gaps: would need more practice.
- Dissemination of technical information. Platform: interested scientists - museum and conservator school scientists
- I do not find this question relevant to my story, but there are many benefits of being both: conservator/restorer and scientist. There are also many drawbacks of it.
- Understanding their work procedure made easier the development of specific data processing and visualization tools
- General knowledge, mainly applied for teaching.
- Better knowledge of problems and tricks, sharing practice and experience
- Benefits: new knowledge, insight in the use of portable equipment.
- Benefits: new knowledge,
- I learned the construction of the examined objects, technical parameters and vocabulary related to the subject of historical fabrics
- It is essential to be trained in these topics in order to understand the implications of research in an art/heritage environment
8. If you answered "yes" to question 4, was this training course a prerequisite for access to infrastructure?

![Figure 25: Proportion of training courses, which were or were not in the context to access the RI. Number of answers: 12.](image)

Figure 25 shows that the current provision of training courses is somehow disconnected from the access to RI. These courses are generally seen as helpful, providing beneficial knowledge in the context of grasping diverse theoretical approaches, points of view, and gaining new knowledge and its applications in the heritage sector. At the same time, there is a clear need in linking such a training to applications within the RI context.

**Recommendation 15:** Training provision and catalogue of expected skills need to be clearly interrelated, ensuring that the experience of training is purposeful and directly relevant to the application within the research infrastructure.

9. If you have attended a heritage science training course (of any type), in what context was this training provided? Multiple answers are possible.

![Figure 26: Context of the HS training courses for providers. Number of answers: 25.](image)
Other (please specify):
- I have attended a Summer school on the certification of reference materials in instrumental analysis at the EU laboratory in Geel on the context of an interest in developing such materials in my institute.
- training camp
- conference workshop/event, 1-to-1 training
Please keep in mind the above heritage science course when responding to the following questions.

10. What content was covered by this training (multiple answers possible)?

Figure 27: Proportion of content in HS training courses for providers. Number of answers: 54.
The majority of learning environments were embedded in the university or workshop/summer school setting. At the same time, a fifth of the survey respondents has not attended any HS course (Figure 26).

Figure 27 shows that most of the content of HS courses attended by providers included from natural science, technical skills and material science. Only 3% of providers attended training courses covering data science content and only 1% visited courses with SSH content. In addition, the providers have pointed to low participation in courses offering transferrable skills (3%), suggesting a further skill gap in activities involving non-scientific applications of the instruments.

**Recommendation 16:** Provision of training covering data science, social science and transferable skills content needs to be improved to support the development of E-RIHS DIGILAB, and the enhancement of cross-disciplinary skills.

11. What were the general benefits of the course and what were the gaps in the content of this course?

- Be in contact with new findings, and opportunity to contact colleagues from other institutions
- Development of knowledge in the field, later used in my Habilitation thesis.
- Better understanding of the problems faced by conservators.
- Extension experience in equipment and in the application of techniques to the CH scientific problems
- Networking - main benefits. Lack of time for deep discussions - main gaps.
- Knowledge of methods that are not available in home lab.
- Benefits: real case studies. Gaps: not enough scientific (too little chemistry and physics behind it: how it works...)
- Benefit was more knowledge and shared experience
- Benefits: handling with offered equipment, collaboration with experienced scientist, transfer of the knowledge
- BENEFITS: collaboration with scientists, handling with new equipment,
- The course was about techniques which were not available in our institution. After this course, I understood better the chemical and optical techniques, and some instruments were purchased partly based on this experience. The course was a CHARISMA course, in view of MOLAB techniques
- In this respect, it covered all crucial areas.
- I learned the construction of the examined objects, technical parameters and vocabulary related to the subject of historical fabrics
- No gaps that I could identify
12. Who was the organiser of this training course?

![Figure 28: Proportion of HS training organisers for providers. Number of answers: 22.](image)

Other:
- Agreement between Mermayde (a private Dutch company) and EU's JRC in Geel.

13. Was IPR (intellectual property rights) addressed in the training course (e.g. disclosure on the use of certain equipment/facility in case a prototype is still experimental; or use/reuse of material accessed during the training, etc.)?

![Figure 29: Proportion of HS courses, which did or did not address IPR. Number of answers: 14.](image)

The survey of training for the providers of access suggests that only a fifth of the respondents (21%) have attended courses addressing IPR (see Figure 29).
**Recommendation 17:** In order to generate a collaborative research environment within the infrastructure, The E-RIHS Academy offer needs to build an understanding of the intellectual property rights issues among access providers.

14. What were the costs of this training course (fee only)?

![Figure 30: Proportions of the costs of the training fee. Number of answers: 15.](image)

15. Do you feel that the cost was about right?

![Figure 31: Satisfaction of the providers with the training fee costs. Number of answers: 12.](image)

If not, how much would you be happy to pay?

150-200 €

The survey responses among the providers indicate that while most of the training fees were free of charge (Figure 30), the cost between 150 – 200 Eur would still be acceptable for the attendees.
16. What methods of training course were used at the heritage science course you attended?

![Pie chart showing proportions of training methods]

**Figure 32: Proportions of the methods of training used. Number of answers: 34.**

17. Please comment the suitability of the training methods:

- Were OK
- Usually I was satisfied.
- it was ok.
- My students said those were fine.
- The course was based on real problems and showed how to approach them. This is the best way to learn. The basic theory can be found online, nowadays it is easy to find information. Obtaining practical knowledge that is difficult - in this respect, this course was excellent.
- The methods were satisfactory
- Very suitable, could be more online

Figure 32 shows that the highest percentage of the training methods used go to hands on training, classroom teaching and case study learning. Only 3% of the content was delivered on-line, even though the feedback to on-line courses is positive (see answers to question 19), the remote delivery is still underestimated. More attention needs to be put to the development of on-line courses and include them in the future E-RIHS training strategy.
18. To what extent did you find the heritage science course useful?

![Pie chart](image)

Figure 33: Satisfaction of providers with HS training courses. Number of answers: 14.

19. When/in what context is remote/on-line delivery of heritage science training meaningful/useful?

- I organized one lectured and followed at the same time in Lisbon and Sao Miguel in the Azores, some 2,000km away. students were satisfied but there were trained tutors in both rooms.
- Easy access.
- no experience
- Probabyl would be useful.
- when the location of the training is too far
- Long distance of training course.
- If it is something well-organised and built-up. Something compact. Not just what we can find using a search engine.
- Practically always, except for hands-on skills
To the following questions, please respond on the basis of your general experience.

20. Have you offered transnational access to heritage science services within previous EU infrastructure projects (CHARISMA, IPERION CH)?

![Figure 34: Proportion of providers involved in previous EU infrastructure projects. Number of answers: 26.]

21. If you answered yes, please specify which (multiple answers possible).

![Figure 35: Proportion of providers offering MOLAB, FIXLAB or ARCHLAB services. Number of answers: 7.]

Please specify the specific type of infrastructure:
- Budapest Neutron Centre
- AMS C-14 services
- Ion beam analysis based on an accelerator
- IPERION CH, MOLAB 3, Optical Coherence Tomography
22. Have you offered access to research infrastructure to heritage science services not related to IPERION CH project?

![Pie chart showing 50% Yes and 50% No.]

**Figure 36: Proportion of providers offering access to RIHS services not within IPERION CH project. Number of answers: 26.**

If yes, please specify:
- we run a local RI but access is different as under IPERION CH because we often integrate users in research groups for a period, explaining research and work in course, so that they gain as much as possible and become somewhat attached to us.
- We are not part of IPERION CH, so all the accesses to our infrastructure are outside IPERION
- as for CH we provide access for the Italian node of e-RIHS. we usually provide access to other infrastructures (but not CH), moreover we provide access for CH activities as follow up to specific agreement with museums soprintendenze etc...
- CHARISMA
- CHARISMA, NMI3, CERIC, national projects
- AMS C-14 services
- in the frame of different national and international projects
- Museums from the region
- E-RIHS.PL
- within E-RIHS.PL - Polish Distributed Research Infrastructure for Heritage Science
- Within SEAHA
3.1.3 Generally about attendees of the survey

1. What is your background? (multiple answers possible)

![Pie chart showing the proportion of different backgrounds of both, users and providers. Number of answers: 115.](image)

**Figure 37:** Proportion of different backgrounds of both, users and providers. Number of answers: 115.

Other (please specify):
- material science
- economy
- graphic design
- conservation – restoration
- conservator
- mathematics
- management.

Figure 37 shows that only 17% of users and providers were with SSH background. This urges the need to include more colleagues with SSH background in HS research/development/training.
2. What is your age?

![Age Distribution Graph]

**Figure 38: Proportions of age of the attendees. Number of answers: 73.**

3. What is mainly your job role (multiple answers possible)?

![Job Role Distribution Graph]

**Figure 39: Proportions of job roles of the attendees. Number of answers: 108.**

Other (please specify): bachelor assistant, Industrial Liaison Engineer, conservator – restorer, au-pair, free-lance conservator, field archaeologist, management and archiving of archaeological data, museum worker.
4. If a student, what is your area of study?

Polychrome sculpture, gilding, chemistry, analytical chemistry, chemistry analytical, chemistry, master, analytical chemistry, art history and industrial engineering

5. In what country do you work/study?

Figure 40: Proportions of countries of work/study of the attendees. Number of answers: 67.
6. How long have you been active in the sector?

Figure 41: Years of activities in the HS sector. Number of answers: 73.

7. What best describes your place of employment?

Figure 42: Proportions of type of employment. Number of answers: 72.

Other (please specify): still a student
8. What proportion of your time do you carry out scientific research (and related management/teaching activities) as part of your job?

![Pie chart showing time distribution for scientific research]

- 38% very occasionally
- 18% up to a quarter of my time
- 19% up to a half of my time
- 14% more than a half of my time
- 11% most of the time

**Figure 43: Proportion of time dedicated to HS. Number of answers: 73.**
3.2 Qualitative interviews

The first wave of qualitative interviews has been conducted in March and April 2018. These interviews were designed to complement the findings of the survey, and bring an insight into current training gaps, effective training channels and skills that will be needed for future E-RIHS provision. As the qualitative research phase was underway at the time of composing this report, the below findings represent preliminary insight. Final findings will be incorporated into the E-RIHS Training and Education Strategy. So far, the qualitative phase has determined the following:

3.2.1 E-RIHS Academy training channels

The aim of E-RIHS Academy is to enable training through a variety of activities, encompassing hands-on courses, remotely delivered training, as well as the hybrid delivery of training. The interview respondents felt that hands-on training should be small-scale, focused, and delivered on a regular basis by the access providers. Such on-site training activities and workshops could also help participants “to collaborate with each other”, as was indicated by a national heritage board respondent. Training for users from heritage organisation background should be organised in ways that are mindful of the busy schedules and limited resources of heritage practitioners that are potential users of the research infrastructure. In some contexts, online delivery could be a good way of providing general skills. These, however, should be supplemented with on-site training to create a community of users and to provide experience of practical use of the techniques and methods that are the focus of training.

**Recommendation 18:** The E-RIHS Academy requires a range of training channels, suited to the different training aims and research communities that the training activities might be focusing on.

3.2.2 E-RIHS training and other educational settings

As a world-leading European infrastructure delivering cross-disciplinary innovation in heritage science, E-RIHS aims to attract leading scientists to apply their expertise in different research settings. The interview respondents felt that the scientific preparation of E-RIHS users and providers does not need to be the core remit of the training provision in the infrastructure. As the Marie Curie Actions coordinator reflected, such a training “should not be designed to go deeper into the technical skills, this should be taught in the discipline area”. For the respondent, the various scientific communities accessing the infrastructure will be trained in their respective disciplines through a variety of existing training provision. It was argued that the core technical and scientific skills should remain the domain of the research organisations that provide scientific training, such as universities, doctoral colleges and postgraduate programmes. Therefore, the E-RIHS Academy should not be seen as predominantly a provider of technical and scientific education.

At the same time, E-RIHS should forge connections with other training providers, from heritage science courses in academia to specialist training of existing experts. For the international conservation body respondent, “interaction with conservation and conservation courses is fundamental because otherwise how are you going to reach the people you are going to do your work with”. The E-RIHS Academy should build on the expertise of the already existing courses and educational resources, to build on best practice, and to maximise knowledge exchange opportunities.
**Recommendation 19:** The E-RIHS Academy should not be treated as primarily providing core technical and scientific education of heritage scientists. It should create partnerships with existing providers of heritage science education and specialist training to share best practice and seek opportunities for training partnerships.

### 3.2.3 The E-RIHS Academy and training in the area of technical and scientific skills

Training is considered a core enabling activity within E-RIHS. As access to state-of-the-art heritage science infrastructure will require specific scientific and technical skills, the E-RIHS Academy will require training opportunities in delivering these expert abilities. As the previous section argued, the E-RIHS Academy should not be seen as a replacement of already existing training provision. At the same time, the infrastructure access might require highly specialised skills that might not be part of the previous scientific training.

Given the variety of skills required for the infrastructure, the interview respondents felt that a specific type of training in scientific and technical skills might pose a significant challenge. As the representative of a national heritage board stated, “the users are from so many backgrounds and are so varied that [training] is really case by case in basis”. As the coordinator of Marie Curie Actions reflected, “the structure of E-RIHS will be perfect to immediately have the right institution and the right person for specific training ... each laboratory that will be included in the network of EHIRS, will have specific skills and competences”. The respondent suggested that “in the ERIC there will be plenty of labs that could be hosting institutions for training courses”. This specific training is strongly related to access to particular instrumentation and research tool within the infrastructure. Therefore, where highly specialised skills were needed, these could be delivered directly by the access providers to exchange knowledge by the hosting institutions and the user accessing the infrastructure.

**Recommendation 20:** When specific technical and scientific skills are needed to access E-RIHS, training should be organised by individual access providers to ensure knowledge exchange and specialist skill building within the infrastructure.

### 3.2.4 Skills in interdisciplinary knowledge production

Heritage science is an intrinsically interdisciplinary endeavour, combining scientific research with social sciences, humanities and arts. This requires a unique skillset that enables researchers to design, conduct and deliver research in highly complex, interdisciplinary settings. The challenge of interdisciplinarity, according to our respondents, needs to be addressed at every stage. For the early career training coordinator, it was particularly “important to address the specific application of array of techniques to study art history, conservation problem... how to answer to the question that might arise on the part of curators and conservators in order to enhance the experience of the research”.

The formulation of interdisciplinary research questions was seen as a key enabler of heritage science dialogue. In this context, it is necessary to enhance skills in posing research “questions and answers between the disciplines and to favour dialogue”. This includes both heritage scientists to learn about the application of scientific skills in the cultural heritage field, and the heritage practitioners to formulate the type of questions that would be useful for the infrastructure. For example, a respondent representing one of the leading international conservation organisations pointed out that training could support conservators to understand that they could access the
 Deliverable D 7.1

infrastructure to seek solutions to address disciplinary challenges. Training could also help them ascertain what information would be necessary to help to solve their applied heritage problems in an interdisciplinary setting.

**Recommendation 21:** E-RIHS training should develop skills in designing interdisciplinary research, combining scientific and applied competence in the cultural heritage field.

Interdisciplinary heritage science demands collaborative knowledge production at all stages of the research process. As the process and practice of heritage science research is a dialogical and evolving process between experts, creating interdisciplinary outputs could be a challenge. In addition to research design, the interview respondents highlighted a need for skills that enhance the delivery of heritage science research. This includes publication and communications skills, addressing the different purposes of research in interdisciplinary projects and linking interdisciplinary research problems and solutions.

For example, as the employee of a national heritage board stated, some users of local research resources struggled with producing a scientific report. Similarly, scientists might find it difficult to link the outputs of research to specific applied solutions. As the member of IIC observed, “conservators need practical solutions tomorrow to problems they faced yesterday, they can’t wait for three years, for ten years, for the new nanomaterials to be developed”. The efficacy of the interdisciplinary research endeavour, therefore, is dependent on communicating these different purposes, managing expectations of different partners and building cross-disciplinary understanding and relevance. Therefore, in order to ensure that the research infrastructure enables all experts to generate relevant outputs, more training is required in delivering interdisciplinary research.

**Recommendation 22:** The E-RIHS training strategy needs to address gaps in interdisciplinary scientific communication skills to build purposeful relationships between different communities of heritage experts.

3.2.5 The significance of ethics and management skills in working with heritage industries

E-RIHS will be designed to empower researchers, organizations and industry to develop skills, knowledge and innovation to enable the appreciation and preservation of heritage. In the increasingly complex heritage industry environment across Europe, heritage scientists will require skills enabling them to operate internationally in partnerships with different heritage organisations, from small, volunteer-led museums and sites, to large-scale heritage institutions of international significance. For the provider of heritage science international training, “this pertains also to a different necessity – [insight into] the local arrangement of the different situation of curators in museums” and other heritage settings. This means that excellent heritage scientists will increasingly require management skills to create purposeful relations with public and commercial heritage organisations. These management skills are particularly important in international collaborations, empowering different actors in the collaboration, and developing efficient and well organised projects. In addition, working with heritage practitioners such as conservators, requires an understanding of principles of the discipline, as well as the ethical considerations that might be part of the research process on the heritage object or site. This could, for example, include “non-invasive aspects” of heritage science or “gathering as many results as possible from a single sample”, but also wider questions about ownership, cultural property and
relationships between scientists and the source communities or other stakeholders in the heritage context.

**Recommendation 23:** Ethics and management skills will be required from actors engaging with the research infrastructure to empower all providers and users, and ensure that the research process proceeds in an effective and efficient manner.

### 4 Conclusions

The outcomes of the landscaping on the current education and training in HS provided important information on the needs for training that will be included in the development of a strategy for education and training in E-RIHS.

The key findings of the consultation comprising of a survey and a qualitative study included:

- E-RIHS training strategy needs to explore mechanisms to attract more users to join HS training courses.
- E-RIHS to develop or to enable the development of a CPD system for HS.
- E-RIHS should develop a catalogue of HS skills, starting with technical skills, but also emphasizing collaborative, communication and engagement, digital skills.
- E-RIHS should develop a clear catalogue of expected skills related to access to infrastructure to manage expectations and ensure a high quality of the experience of access to infrastructure.
- E-RIHS should develop training courses specifically focusing on the provision of SSH and digital skills, as well as transferable, collaborative working skills.
- E-RIHS should focus on online delivery of training, although there is a place for face to face training that participants would be able to pay.
- The typical duration of E-RIHS courses should be up to a week.
- E-RIHS should focus on online delivery of courses.
- The content of E-RIHS courses should address some specifically identified gaps, such as knowledge management.
- E-RIHS Academy provision should include training in international collaboration.
- The training offer could incorporate courses supporting potential users in preparing proposals to win a project granting access to research infrastructure.
- There are opportunities for a training offer for providers that combine innovation and commercialisation within heritage science development.
- The training offer needs to empower providers in skills enabling them to design and deliver training aimed at heritage practitioners.
- E-RIHS training could address the lack of conservation-oriented training among the facility providers to enhance collaboration with heritage practitioners.
- The training provision and the catalogue of expected skills need to be clearly interrelated, ensuring that the experience of training is purposeful and directly relevant to the application within the research infrastructure.
• The provision of training covering data science, social science and transferable skills content needs to be improved to support the development of E-RIHS DIGILAB, and the enhancement of cross-disciplinary skills.
• The E-RIHS Academy should develop a range of training channels, suited to the different training aims and research communities that the training activities might be focusing on.
• The E-RIHS Academy should not be treated as primarily providing core technical and scientific education of heritage scientists. It should create partnerships with existing providers of heritage science education and specialist training to share best practice and seek opportunities for training partnerships.
• E-RIHS access should include training organised by individual access providers to ensure knowledge exchange and specialist skill building within the infrastructure.
• E-RIHS training should develop skills in designing interdisciplinary research, combining scientific and applied competence in the cultural heritage field.
• The E-RIHS training strategy needs to address gaps in interdisciplinary scientific communication skills to build purposeful relationships between different communities of heritage experts.
• E-RIHS training strategy should include training in ethics and management skills for actors engaging with the research infrastructure to empower all providers and users, and ensure that the research process proceeds in an effective and efficient manner.

5 References