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The Hidden Face of Cultural Heritage: a science window for the dissemination of elementary knowledge of risk and vulnerability in cultural heritage

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Abstract

The dissemination of research in cultural heritage preservation to the public is a task that needs new models and expressions, to capture the attention of the public and the assessment of results. With this purpose, a new educational experience in Parque de las Ciencias (Science Park of Granada, Spain) was developed. The science window titled Hidden Face of Cultural Heritage (ScW-CH) was an exhibition to show the risks (hazards + vulnerability) associated to different artworks and materials of our cultural heritage (CH). ScW-CH was led by the researchers themselves, in collaboration with museum specialists, in order to develop a new model that makes their research accessible to all demographics. An innovative methodology based into simulating a showcase, was designed to study hazards and vulnerability in CH. Therefore, the montage contained materials, equipment, information sheets, and guides to accompany visitors as storytellers. The aim of the exhibition, was for the visitors to understand the risks posed to our monuments and artworks from a scientific point of view, and to raise awareness about the care that we should give to our CH. The ScW-CH was held for 6 months and visited by 8226 visitors. During the exhibition, a survey about the opinion of visitors was carried out to study the impact of the designed new model and assess the results of the experience. The collected data was analysed by the Statistical Package for the Social Sciences (version 22.0). Visitors usually presented a medium–high initial interest about visiting this exhibition, and a medium–low level of knowledge of this subject. Thanks to ScW-CH, 92% of visitors showed a very high learning level after the experience. The ratio of interest and learning in the ScW-CH in relationship with the level of study showed that secondary school pupils had the highest degree of interest and learning.

Keywords: Dissemination, Assessment, Science museum, Risk and cultural heritage, Heritage education

Introduction

Since ancient times the scientific method has been applied to the creation of works of art. For example, Pliny the Elder narrated the discovery of glass in his writings. This rapport between science and art has been intensified since the nineteenth century with the objective of developing new methods of diagnosis and conservation that allow us to know and conserve cultural heritage (CH).

The need to communicate about science and technology to a growing interested public has resulted in the creation of scientific journals in different fields in which researchers explain their results [1]. However, dissemination is often more complicated and beyond researchers' reach even though it is a social imperative. In order to prepare the science window titled Hidden Face of

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Cultural Heritage (ScW-CH), it was taken into account that the dissemination of science and CH is a hard task and it is becoming more necessary given the lack of science vocations in recent years [2]. The need to explain investment in R&D+i and CH conservation to the society during a global recession is very important, increasing science literacy in a variety of forms, from blogs to newspapers, from museums to public events, from films to radio shows. Besides, communication of science makes developing a scientific culture in society, improving scientific literacy and motivating talent surrounding scientific research, possible. Various authors present tools and programmes to improve the diffusion of scientific careers [3, 4] and arouse interest in children, teenagers and young people, or to disseminate the principles of cultural fields [5, 6]. The actions of dissemination can generate a rise of about 6% in the number of young people wanting to study science or technology [7]. Roigé [8] evaluated that these methodologies could be applied from the point of view of the design of other exhibitions, highlighting the power of a good museography to get the immersion, leisure and fun of the visitants. In Spain and Portugal, countries with a cultural tradition centred in literature and arts, the promotion of scientific education in every field and its relationship with the arts is especially relevant. The social relevance of diffusion in all education levels is quoted by numerous authors focused on science dissemination [9]. Moreover, safeguarding and fully developing CH produces a great set of heterogeneous historical data, which are enriching a new virtual framework often based on open-source software [10, 11]. The results of these methods for dissemination are rarely explained and assessed, because of this, our paper presents the methodology employed for the design of the exhibition and evaluation of the satisfaction results of end-users.

ScW-CH was designed as an exhibition of artworks, their constructive materials and their vulnerability in the Science Park of Granada (Spain). This exhibition, part of a R&D+i project, was funded by Junta de Andalucía (Economy, Innovation, Science and Employment), the Science Park of Granada and different Andalusian universities. The main objective was to reveal to demographics the Andalusian research project HUM-6775 (http://www.upo.es/tym/en_rivuph.html) for the study of risk, as a function of hazards and vulnerability in CH. Other objectives were: to focus on our researchers and their activity in society, to raise awareness of the importance of R&D+i in a modern, sustainable and democratic society in order to preserve their CH, to promote scientific vocations in relationship with CH protection, to highlight the role of women on CH research, as well as to showcase collaborations between universities and companies to generate and share knowledge on CH conservation.

The exhibition had a large window, through which visitors could see a minilab to understand the artworks and their life. Once they decided to enter, they could carry out activities, meet our researchers, work with laboratory equipment and feel artwork materials, listen to the guide's explanations or play a game about weathering forms of CH. In this manner, in the same space, our work gathers models of diffusion that could be helpful to children, teenagers and university students because the expressions were adapted according to the recommendations of Forbes [12]. Furthermore, there were modules to pique the scientific curiosity of professionals and researchers towards the science applied to CH and new information and communications technologies (ICT). This design tried to connect to the new museography, where museums have evolved from spaces exhibiting artwork collections to dynamic spaces where people go through eye-opening experiences. This leisure experiences were based on researching and learning with help from new technologies [13, 14], especially in the case of children and teenagers.

This model seeks to connect science with CH, which involves the development of more creative exhibition methodologies that can encourage society to visit our ScW-CH to understand the risk of CH. With that aim, common discourses of current museums such as the hand-on exhibition approach, interactive technology exhibition and storytellers, were selected according to Ahmad et al. [15], Hashim et al. [16], Palombini [17] and Alanazi [18]. As the research conducted was in CH, the typical sensitivities of art museums also had to be taken into account for the exhibition. Furthermore, the exhibition focused on the multidisciplinary nature of diagnosis, with a space called "the researchers' corner" where visitors could meet the researcher, and find out more about their careers: physicists, chemists, geologists, architects, biologists, archaeologists, historians, restorers, etc. working together as a team in order to preserve artworks. The role of women in this context was noted by the fact that most of these researchers were female, as well as the team leader.

This hands-on lab was awarded as the second prize of the Reach.Out! competition 2015 held by the European Materials Research Society as a public outreach activity whose main aim was to reveal, to the non-specialists, applications related to advanced materials, their impact on the creation of sustainable societies, their impact on the economy, the people behind the scenes and the complexity of the work performed (http://www.emrs-strasbourg.com/index.php?option=com_content&task=view&id=748&Itemid=1641).

Methodology and materials

"The Hidden Face of Cultural Heritage" was built up as a science window that explains the research and collaborations in a real project RIVUHP (HUM-6775), aiming to develop a new model that makes its research accessible to all demographics. This exhibition at the Science Park of Granada (Spain) was held from July 2014 until January 2015. During this time period, the museum space explained the way to study the risks of our CH from the point of view of science and analytical techniques.

Design of exhibition

In the design of the exhibition space, it was taken into account that the study of risks as a function of hazards and vulnerability for CH requires an exhaustive understanding of four levels of knowledge:

1. Materials: stones, wood, metals, pigments, ceramics, varnishes, etc. and weathering forms.
2. Artworks as a complex mixture of materials with historical and artistic value.
3. The analytical techniques and methods available for diagnosis [optical microscopy, scanning electron microscope/energy-dispersive x-ray (SEM–EDX), infrared reflectography, ultrasound, laser-induced breakdown spectroscopy (LIBS), laser-induced fluorescence (LIF),…] and/or restoration (decontamination, laser cleaning, consolidating treatments including nanoparticles…).
4. Hazard assessment and vulnerability models to know the risks of our CH.

The exhibition was based on an instructive design of learning and the evaluation of the dissemination results. This model consisted of five stages (Fig. 1) to get the audience to understand the four levels of diagnosis in cultural heritage: meetings to evaluate the space and the examples to be shown, writing of the guide files using expressions accessible to different levels, assembly of the exhibition with the training of guides, inauguration and exposition, and finally, evaluation of results.

The first phase of the model was the design of the exhibition space and its contents. The exposition was designed like a big showcase that captured the interest of the visitors of the Science Park and allowed them to see a minilab. Once the visitor decided to enter, they found an exhibition space that was understood as a unique space where the visitor could walk around the Researchers' Corner, where they could become a researcher and carried out their activities, watched videos or mini documentaries, surfed web links, used laboratory equipments and materials, listened to the guide's experimental explanation, or played a game of weathering forms, to understand the researchers' work.

The second phase of the model consisted of writing explanatory brochures. The guide files had a maximum length of one page and were made to cover the four levels of difficulty.

For 1 week the researchers and museum specialists assembled the exhibition, which had to be evaluated at a visual and scientific level before inauguration. During this third phase, the exhibition guides were trained by the researchers so that they could understand the research done on science for CH and act as storytellers during the guided visits.

Public and statistical studies

The participants were 8226 visitors of the museum, from children to the elderly, with different knowledge levels.

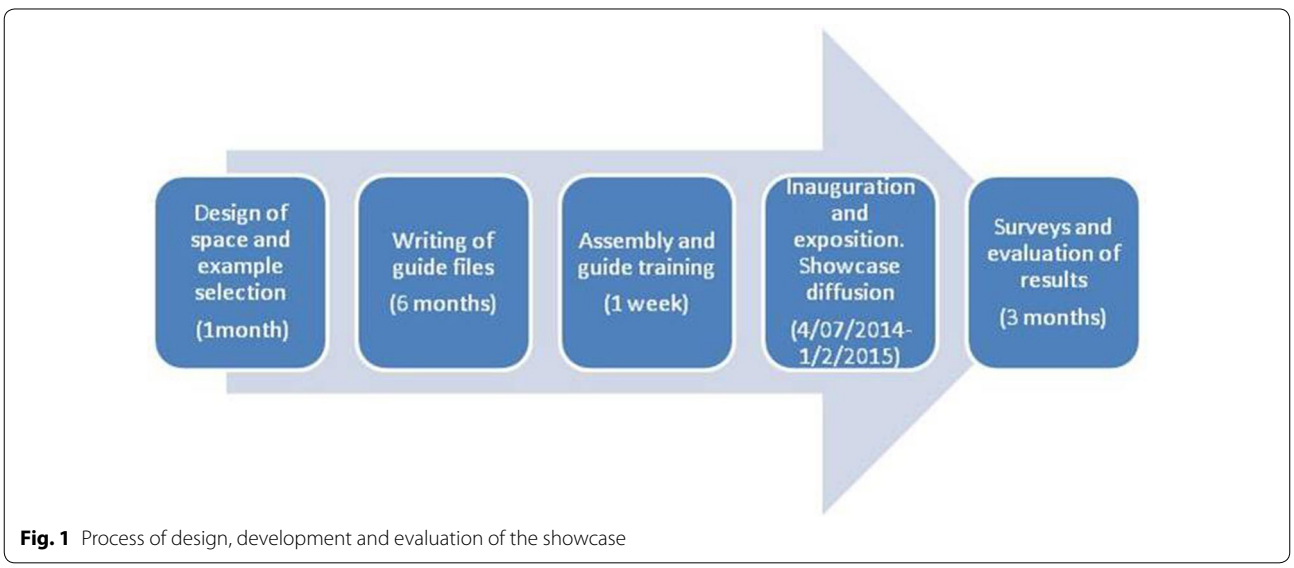

Fig. 1 Process of design, development and evaluation of the showcase

Visitors learnt to evaluate the vulnerability of CH studying the original materials, their weathering forms, as well as hazards and risks associated to CH.

The inauguration was held on 4th July 2014, and the model was exhibited for 6 months, in that time period the guides showed the model and carried out a survey about the opinion of visitors. 260 visitors or teams of visitors (families, friends, etc.) answered the survey, which means 3.1% of the visitors. The collected data was analysed by Statistical Package for the Social Sciences (SPSS) (version 22.0). Given the discrete nature of some variables studied on the survey, a non-parametric test, the medium equality test, was employed to compare the behaviour of different age and interest groups. The signification level set was 5%. Data analysis and impact of the dissemination were study to assess the results of the experience.

Results

ScW-CH: application of a new exhibition methodology. Implantation and exhibition

The science Windows "The Hidden Face of Cultural Heritage" ScW-CH was developed as a place where visitors could enter a unique laboratory to explore different aspect to conform the research about CH from the constructive materials (pigments of a painting, cathedral stones, alloy cannons,...), the principal altering agents and their consequences on monuments (biological attacks on wood, wind action over stone,....) up to the processes to eliminate them, for example, how biological attacks on wood can be eliminated using inert gas by anoxia treatment.

To reach the most advanced level of knowledge in the models of hazards and vulnerability, the visitors must understand the ecosystem made up by the environment and CH. Indeed, these influences define the risks of CH. The scale of these risks ranges from cities and their problems (e.g. earthquakes that affect monuments) to humidity–temperature conditions and biological factors that can damage artworks.

As can be seen in the 3D blueprints (Figs. 2, 3), the minilab was designed among artworks, while a diffusion screen showed an image loop of the four levels of knowledge and photographs of the researchers working in the lab or in the monuments. In addition, this wall contains two big posters: the first was a collage to attract potential

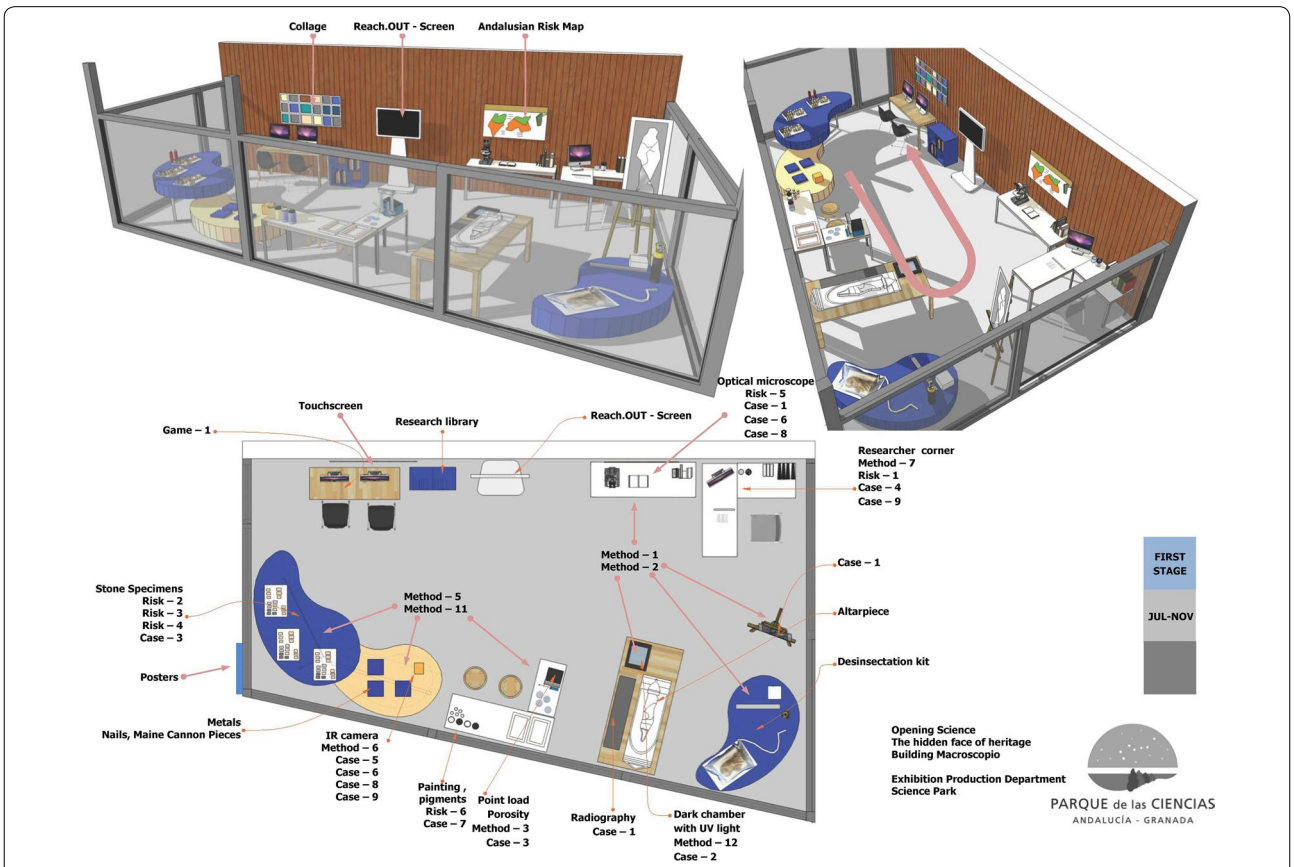

Fig. 2 Distribution of the exhibition space from July to October. Public organizations were responsible for this period

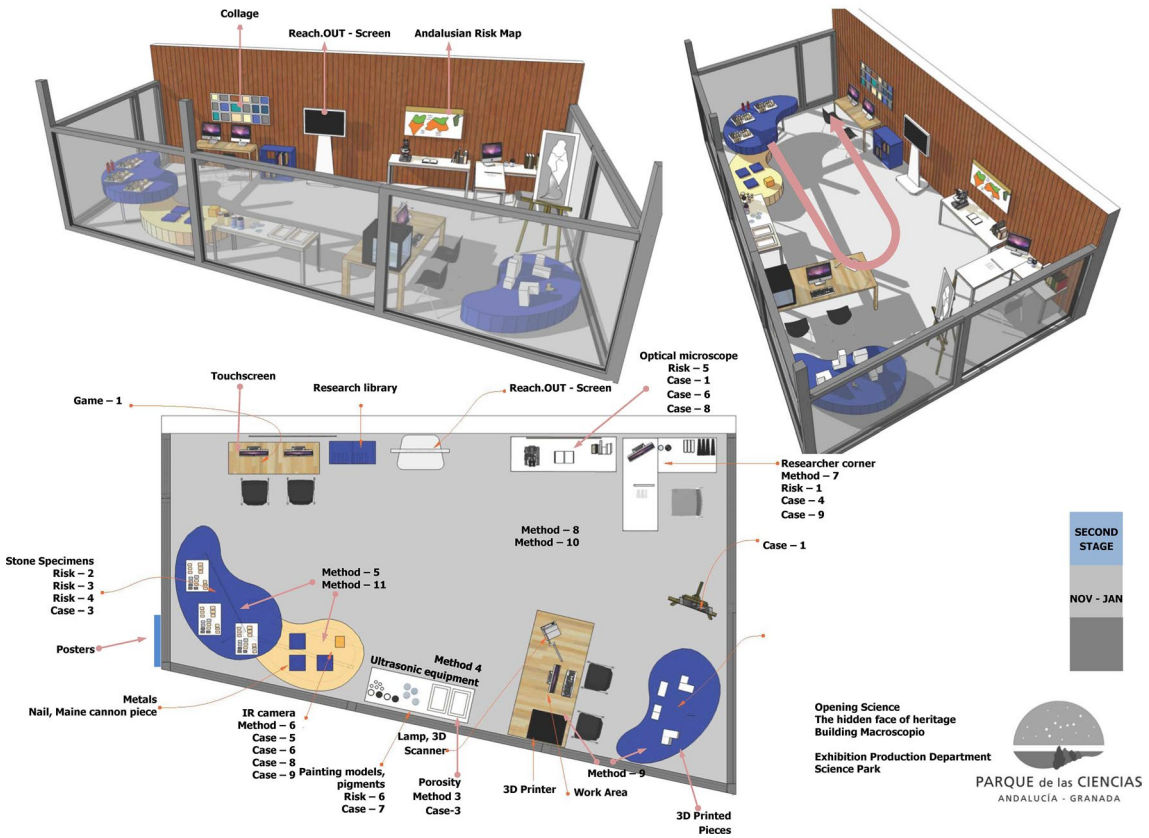

Fig. 3 Distribution of the exhibition space from October to January. Results and the opportunities of collaboration between private and public companies were shown in this period

visitors and the other contains the results of the research project (a cultural heritage risk map of Andalusia). The space was complemented with activities, exhibition elements, books, articles, congress posters, etc. The design of the exhibition space was modified according to the evolution of the files that had been written, as well as the opinion of everyone involved in the assembly. Finally, 27 guide brochures were made: 6 files about risks, 13 files about methods and 8 files about real cases. A pairing game for children was also made. In general, these files have been classified according to their exhibition method, as active, which implies that interaction is needed by the visitor: (a) manually, mainly related with equipment and laboratory management, or (b) using computers and their selection of programmes or multimedia content. Other files are passive, and the visitor must listen to the guide's explanation while observing CH materials, methods and results.

From the target audience's point of view there were zones for all types of public, from specific games for children to a book of posters of scientific sessions for researchers. Table 1 shows a summary of the content and the activities carried out during the exhibition.

In that regard, this model of work allows us to design a visual and attractive exhibition zone to catch the attention and interest of visitors. One of the most complicated aims of this exhibition was to make it accessible and interesting for all kind of visitors. It was achieved by the participation on its design of a multidisciplinary team that ranged from exhibitions designers to researchers. The exhibition was adapted to different groups of visitors (children, youth and adults) depending on their predicted interest and previous knowledge on the subject.

In order to show the personality and proximity of researchers, introduction videos of all participants were recorded. As it has already been mentioned, images of working researchers were shown on the screens and the researcher's profile could be looked up in the Researchers' Corner. The research team is mainly composed of women, so the image for the poster announcing the showcase was centred in a mosaic in which women are protagonists. This subtle detail also seeks to empower the role of women in this sector.

Besides, one of the key points was to show the multidisciplinary nature and the need for collaborations between organizations. In this sense, the researchers' corner

revealed the diversity of professions required: physicists, chemists, geologists, architects, biologists, restorers, archaeologists, historians, etc. In order to explain the work carried out in public research centres and private companies, the exhibition was divided into two different time periods, where the space was modified according to Figs. 2 and 3. Both figures explain the equipment, zones and guide files of the two exhibition periods. The same file could be used by monitors for different exhibition zones, and in this way continue through the area that captivated the visitor's attention the most.

In summary, thanks to the application of this methodology to design the exhibition and the proposed resources, visitors could learn to evaluate the vulnerability of CH. In this way, the aim was that the public studied with a guide how our ancestors painted, made their tools or built their buildings, and moreover visitors were encouraged to analyse the risks posed to our monuments and the artworks they contain, to understand the care we should give to our CH.

Data analysis and impact of the dissemination

8226 visitors entered our showcase from July 2014 to January 2015, an average of 1175 visitors per month; that is 2.7% of visitors to the Science Park in Granada. A survey was carried out in order to evaluate the opinion of those people whom the project had reached, their aims and how they were met, the social and economic aspects, the stakeholders' gain and feedback.

The survey data shows a very close proportion of men/women (53/47), with the number of men visiting the exhibition being slightly higher than that of women.

Around 45% of the visitors were younger than 19 years of age, one of the target audiences for the dissemination of science and scientific careers. The rest of the visitors, 25–30%, were aged between 20 and 29 years, possibly university students or postgraduates. A similar percentage of visitors was aged between 30 and 60 years of age. People over the age of 60 represented only a small percentage of around 2% (Table 2) of those who answered the survey. For this reason, they have been removed from the statistical correlation analysis.

Table 3 shows the study level of the people surveyed. Around 45% of the visitors had university studies, followed by those with secondary studies which make up around 32% of the total. Visitors with university studies were homogeneously spread between all those groups who are old enough, resulting in around one out of every two visitors for those aged between 20 and 60 years old. Taking into account that the percentage of university students in Spain is 41.1%, this means that the surveys reflect the type of Spanish population, even if there is a greater trend to visit the exhibition among people with higher studies.

Approximately 6 out of 10 visitors were from Granada or its province (Tables 2 and 4) while 25% were from the rest of Andalusia and the remaining 15% came from other Spanish regions. The foreigners visiting the showcase were scarce (1%) according to the survey, and if they did visit it they did not fill out the survey. This piece of information may be related to the fact that the survey is only in Spanish.

This regional distribution corresponds with the 42% of visitors who completed the survey and said that they visit the park on a regular basis (Table 2), due to its geographical proximity (Table 4).

The visit is supposedly ludic for 80% of the people surveyed, who visited with friends (Table 2). However, contrary to expectations the weekend only makes up about 34% of visits (Table 2).

The visitors surveyed showed a medium–high initial interest (values 3–5) in coming to this exhibition space, with the interest being very high in 32% of the people surveyed (Table 2). The interest in this exhibit varies significantly between different age groups (p-value < 0.5 in the medium equality test), with those younger than 19 presenting a greater interest (Table 5, Fig. 4). In contrast, the visitors surveyed present medium–low knowledge of the exhibition, with up to 18% of visitors stating that they did not know anything about the field of risk, hazard and vulnerability in CH. After the experience, 92% valued their level of learning between 8 and 10 on a scale of 10. The average level of learning by ages is shown in Table 5, where, although differences are only a half point away from the others, under-19s acknowledge learning the most.

The relationship between interest and learning in the showcase and the level of studies shows that primary students present the highest degree of interest and learning (4.02, average interest-9.5 average learning. Table 5).

Regarding the analysis of the exhibition space and the resources employed, 9 out of 10 visitors surveyed considered the exhibition to be well signalled (Table 2) and 62% evaluated the assembly as excellent.

The communication skill was evaluated as excellent by around 73% of the people surveyed (Table 2) and the quality of the texts and audio-visual resources were assessed as good–excellent by around 80% of those surveyed (Table 2). The workshop was valued as excellent by 66% of those surveyed (Table 2).

In addition to the direct impact generated by visitors, the local and national press talked about this science showcase, as can be seen on Table 6. However, people who visited the showcase admitted that they became

Table 1 Advanced materials and technologies studied

Map code	Explanation file title	Elements in the exhibition	Aims	Science involved (materials and methods)	Concept 1: materials 2: heritage pieces 3: analytical techniques 4: systems risk/ vulnerability	Target audience A: all publics C: children R: researchers	Type of activity H: handwork C: computer use R: reading L: listening
Risk-1	Risks in cultural heritage	Guide file Andalusian risk map Software (vulnerability matrix and fuzzy) Webpage and videos Scientific session posters	Explaining the differences between hazard and risk	Geographic information systems and vulnerability assessment applied to the analysis of hazards and degree of conservation in cultural heritage. Risk Maps	4	A, R	C, R, L
Risk-2	From cheers to graffiti	Guide file Samples of stone with different types of graffiti and cleaning tests Optical microscope images with cuts of marble with graffiti before and after cleaning Web page Scientific session posters	Explaining the chromatic alterations caused by graffiti Concern about the hazards of vandalism	Characterization of stone materials and weathering forms due to graffiti Cleaning methods (laser ablation, chemical cleaning, water jet…)	1, 3	A, C, R	H, C, R, L
Risk-3	Damage due to soluble salts on porous materials.	Guide file Stones after salt weathering tests Web page Scientific session posters	Explaining efflorescence damage Concern about hazards associated with saline mediums	Characterization of stone materials and efflorescence Accelerated weathering tests	1, 3	A, C, R	C, R, L
Risk-4	Did you know that…? Salts can crystallize forming different minerals depending on the temperature and humidity conditions	Guide file Stones after salt weathering tests Web page Scientific session posters	Explaining efflorescence damage Concern about hazards associated with saline mediums in different thermo-hygrometric conditions	Characterisation of stone materials and efflorescence Accelerated weathering tests depending on humidity and temperature conditions. Vulnerability associated with salts and thermo-hygrometric conditions	1, 2, 3, 4	A, R	C, R, L
Risk-5	Deposits and black crusts	Guide file Stratigraphies of stone and mortars with crust and deposits due to atmospheric pollution Web page Optical microscope Web page Scientific session posters	Explaining the alteration by black crusts and deposits Concern about the hazards associated with pollution in cities	Characterization of mortar and stone with black crust and deposits Vulnerability associated with atmospheric contamination	1, 2, 3, 4	A, R	H, C, R, L

Table 1 (continued)

Map code	Explanation file title	Elements in the exhibition	Aims	Science involved (materials and methods)	Concept 1: materials 2: heritage pieces 3: analytical techniques 4: systems risk/ vulnerability	Target audience A: all publics C: children R: researchers	Type of activity H: handwork C: computer use R: reading L: listening
Risk-6	Did you know that…? Some pigments cannot be used on frescoes because they change colour	Guide file Pigments and laboratory materials to produce colour changes Stratigraphies Optic microscope	Study of the vulnerability of wall paintings, especially frescoes Need to know the stratigraphies in restoration processes to avoid damage	Study of the vulnerability of fresco paintings and the necessity of knowing the stratigraphies in restoration processes to avoid damage	1, 3, 4	A, C. R	H, R, L
Method-1	Non-destructive techniques applied to the study of risk in cultural heritage	Guide file Web page IT equipment Scientific session posters	Study of vulnerability by non-destructive techniques	Explanation of the use of accelerometers, ultrasounds or FBG sensors (fiber Bragg grating)	3	A, R	C, R, L
Method-2	Technology applied to restoration	Guide file Inert gas treatment for wooden sculpture in a plastic bag DNA identification for biological materials Web page IT equipment	Explaining the study of vulnerability by non-destructive or minimally invasive techniques that allow materials and their pathologies to be characterized Explaining the use of inert gas to stop bio-deterioration	Explanation of γ-graphics, radiographies, digital image analysis, infrared and ultraviolet reflectography and ultrasound waves during the restoration process Biology identification using molecular biology (PCR) Explanation of a real case in situ, biology attack on wood, and how it can be eliminated using inert gas by anoxia	3	A, R	H, C, R, L
Method-3	Porosity	Guide file Tests of different materials Weights and water Point-load equipment Web page Scientific session posters	Explaining porosity and its role in cultural heritage vulnerability	Explaining the method of measuring porosity by capillarity in atmospheric conditions Assess the relationship between porosity and comprehensive resistance	1, 3	A, C, R	H, C, R, L
Method-4	Ultrasound (US) analysis	Guide file Tests of different materials US equipment Web page Scientific session posters	Explaining the speed of propagation of ultrasounds Assess the vulnerability of materials by US propagation	Explaining the method of measuring vulnerability by auscultation the speed of US propagation Evaluating porosity by US propagation speed	1, 3	A, R	H, C, R, L
Method-5	Accelerated weathering tests	Guide file Trials of samples in different environments Web page Scientific session poster	Explaining simulated atmosphere tests and their role in the study of vulnerability	Explaining accelerated weathering tests and the way of evaluating the restoration products	1, 3	A, R	C, R, L

Table 1 (continued)

Map code	Explanation file title	Elements in the exhibition	Aims	Science involved (materials and methods)	Concept 1: materials 2: heritage pieces 3: analytical techniques 4: systems risk/ vulnerability	Target audience A: all publics C: children R: researchers	Type of activity H: handwork C: computer use R: reading L: listening
Method-6	Thermographic analysis	Guide file Thermographic equipment Web page Scientific session posters	Explaining thermography and its role in cultural heritage vulnerability	Explaining the thermographic method and its relationship with freezing cycles	3, 4	A, R	H, C, R, L
Method-7	Did you know that…? Digital processing techniques were first applied in journalism	Guide file Software Web page Scientific session posters	Digital analysis image in diagnosis	Explaining vulnerability and its evaluation using digital image analysis The study of the lions of the Alhambra (Granada)	3	A, R	C, R, L
Method-8	Building crack monitoring	Guide file IT equipment and camera	Explaining the study of vulnerability using non-destructive techniques	Explaining the laser equipment used in 3D scan	3	A, R	C, R, L
Method-9	3D Technology	Guide file IT equipment 3D printer 3D prints	Explaining the study of vulnerability using non-destructive techniques Possibilities of 3D printing for the dissemination of CH for blinders	Explaining the application of digitalizing, printing and 3D construction techniques in the cultural heritage field	3	A, R	H, C, R, L
Method-10	Augmented reality	Guide file IT equipment	Explaining the application of non-destructive techniques in the diagnosis process	Explaining the merging of real and virtual worlds through a technological process and its use in archaeological sites	3	A, R	C, R, L
Method-11	Did you know that…? There are standards to certify the freezing resistance of ceramic materials	Guide file IT equipment	Understanding the objectives of quality standards in diagnosis	Need for quality standards to be able to guarantee and compare the results of characterisation	3	A, R	C, R, L
Method-12	Did you know that…? In Rafael's original drawing there was a dog instead of a unicorn?	Guide file Web page	To discover hidden drawings, signatures, …	Infrared light can pass through painting film. When it hits black carbon particles (underdrawings) it is absorbed and a camera with an IR detector can see underdrawings as a dark area. It can be used in paintings/manuscripts/documents	1, 2, 3	A, R	C, R, L
Method-13	Did you know that?… UV radiation does not only enable us to detect counterfeit notes.	Guide file Dark room and UV light to see the altarpiece of Saint Therese	Identification of original and added layers of varnishes	Aged varnishes can be detected under UV light because they light up. Retouches appear as dark areas and original varnishes appear as bright areas	3	A, R	H, C, R, L

Table 1 (continued)

Map code	Explanation file title	Elements in the exhibition	Aims	Science involved (materials and methods)	Concept 1: materials 2: heritage pieces 3: analytical techniques 4: systems risk/ vulnerability	Target audience A: all publics C: children R: researchers	Type of activity H: handwork C: computer use R: reading L: listening
Case-1	*Virgen de la Antigua* restoration	Guide file Optical microscope UV light, IR, radiography and surface light studio Optical microscope Stratigraphy Altarpiece of Saint Therese Project memories	Characterisation of artworks for diagnosis Finding out the layers of paintings	UV and IR applications (Methods 12 and 13) X-ray radiation can go through materials depending on their composition. X-ray images show dark areas when materials are made of elements with low atomic weight and bright areas when materials are made of elements with a high atomic weight Special imaging technique to identify defects in masterpieces lit from a low angle Identification of the components of the paint layers by optic microscopy using high magnification	2	A, R	H, C, R, L
Case-2	Cadiz Cathedral	Guide file Web page Scientific session posters Project memories	Knowing the vulnerability of a real case related to efflorescence, relative humidity and temperature	Applications of microclimatic control and SEM–EDX for vulnerability studies by efflorescence, relative humidity and temperature	2, 4	A, R	C, R. L
Case-3	The Chapel of Falla Cadiz Cathedral	Guide file Software Web page Scientific session posters Project memories	Composition and extension of efflorescence Quantification of weathering degrees	Application of digital image processing to evaluate damages by efflorescence	2, 4	A, R	C, R. L
Case-4	The courtyard of the lions, Alhambra (Granada, Spain)	Guide file Infrared camera Web page Scientific session posters Project memories	Relationship between thermal changes and surface decay	Thermography applied to the columns and Lions in the Alhambra (Granada). Explaining thermography in a real case	2, 4	A, R	H, C, R. L
Case-5	Did you know that…? A lot of silver objects are made of lead or copper with a thin layer of silver	Guide file Metallic pieces and stratigraphies Web page Scientific session poster Project memories	Application of SEM–EDX to the study of metallic materials and their alterations	Patent Concept "Plata Ruolz" SEM–EDX facilitates the chemical analysis of small pieces	3, 4	A, R	C, R. L

Table 1 (continued)

Map code	Explanation file title	Elements in the exhibition	Aims	Science involved (materials and methods)	Concept 1: materials 2: heritage pieces 3: analytical techniques 4: systems risk/ vulnerability	Target audience A: all publics C: children R: researchers	Type of activity H: handwork C: computer use R: reading L: listening
Case-6	Did you know that…? The use of Prussian blue in the composition of a painting can indicate the date it was painted?	Guide file Optic microscope and stratigraphies Web page Project memories	Characterisation of artworks Dating	Dating with pigments Microscope on the study of stratigraphies of paintings	2, 3, 4	A, R	H, C, R. L
Case-7	Restoration of *Virgen del Rosario* (Santo Domingo Church, Granada)	Guide file Optic Microscope UV lighting room Gemstones and metallic studies. GvSIG Application Scientific session posters Project memories	Characterization and diagnosis of artworks	Characterization and database referencing techniques in diagnosis	2, 4	A, R	C, R. L
Case-8	Restoration of a canopy (*Virgen del Mayor Dolor*, Aracena, Huelva)	Guide file Optic Microscope, SEM–EDX, LIBS Scientific session posters Project memories	Characterization and diagnosis of artworks	Characterization and diagnosis of artworks	2, 4	A, R	C, R. L
Game-1	Card games	ICOMOS glossary about the identification of material pathologies Image screen and collage Scientific session posters Pairing game for kids with weathering forms	Study of vulnerability by the identification of pathologies	Explaining the analysis in situ of weathering forms, their relationship with agents and the physical–chemical mechanisms	3, 4	C	H, L

Table 2 Survey answers of visitors (number of surveys analysed 260)

Visitors Age	<19	20–29		30–60		>60
	44.02	25.48		29.34		1.16
Study level	Primary	Secondary	Pre-University		Professional training	University student
	5.02	13.13	6.56		32.05	43.24
Visitors' place of residence	Spain	Andalusia	Granada		Granada Province	Other countries
	15.06	28.48	25.48		33.59	0.39
Visiting the park	For one particular exhibition	Sporadically		Regularly		For the first time
	5.81	31.01		41.86		21.32
With whom is he/she visiting	Friends		Alone		Guided	
	77.99		9.27		12.74	
When is the visit	Tuesday/Friday			Weekend		
	65.64			34.36		
Initial interest	INT1	INT2	INT3		INT4	INT5
	6.18	8.88	27.03		25.87	32.05
Previous knowledge	CON1	CON2	CON3		CON4	CON5
	17.44	31.78	31.78		10.85	8.14
Evaluation of learning	APREN5	APREN6	APREN7	APREN8	APREN9	APREN10
	0.39	0.39	5.86	15.63	31.25	46.48
Quality of the space's signposting	Excellent	Good		Normal		Bad
	48.45	39.53		11.24		0.78
General space assembly	Excellent	Good		Normal		Bad
	62.55	33.98		3.47		__
Quality of communication	Excellent	Good		Normal		Bad
	72.97	25.48		1.54		__
Quality of texts (files)	Excellent	Good		Normal		Bad
	44.19	43.41		11.24		1.16
Quality of audio-visuals	Excellent	Good		Normal		Bad
	41.25	38.91		16.73		3.11
Quality of the workshop	Excellent	Good		Normal		Bad
	66.41	30.50		3.09		_
Found out about the exhibition through	Friends and relatives	Web	Press		Diffusion agency	Radio
	47.49	39.00	6.95		4.63	1.93

Int 1, low interest, Int 5, high interest; Con 1, previous knowledge low, Con 5, previous knowledge high; Apren 1, very low evaluation of learning, Apren 10, very high evaluation of learning

Table 3 University student distribution by age group

Age	Percentage (%)
< 19	6.4
20–29	41.3
30–60	52.3
Total	100

Table 4 Distribution according to visitors' place of residence

Residence	Percentage (%)
Andalusia	15.60
Spain	2.75
Granada	42.20
Province	39.45

aware of the park through friends in 47% of the visitors surveyed, followed by an important group that found out about it on the internet (39%). Therefore, the conclusion is that the press did not directly affect their decision of going to the park.

The findings of this study imply that catching the interest of youth about preservation of cultural heritage is easy, perhaps due to their curiosity. Nevertheless, these results may be worthwhile for decision-makers in science and art education to consider in order to design experiences that increase the interest surrounding CH preservation and meanwhile raise scientific vocations, especially among a young public.

Table 5 Interest and average learning according to the age and study levels of the visitors

Age	Average interest	Average learning	Level of studies	Average interest	Average learning
< 19	3.96 (4)	9.42 (10)	Primary	4.02 (4)	9.5 (10)
20–29	3.45 (3)	8.97 (9)	Secondary	3.59 (3)	8.8 (9)
30–60	3.51 (3)	9.03 (9)	Pre-university student	3.92 (4)	8.3 (8)
			Professional training	3.82 (4)	8.9 (9)
			University student	3.44 (3)	9.1 (9)
Statistic indicator 3	p = 0.011	p = 0.003	Statistic indicator	p = 0.038	p = 0.001

Measurement scale: 1–5. Measuring range from 1 to 10. Median equality test between groups

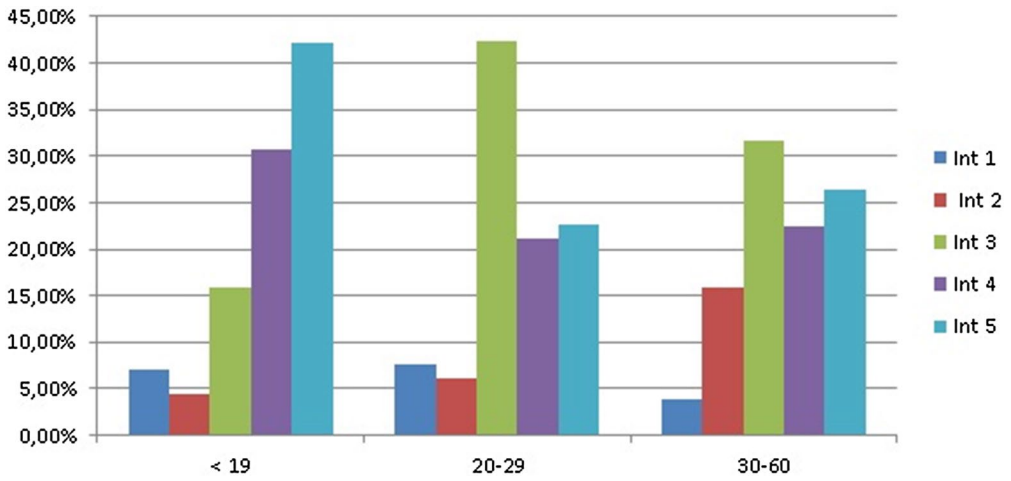

Fig. 4 Initial interest in exhibition according to age

Table 6 Diffusion of the showcase to science in the press

Medium	Range	Title of the article	Date
Web	International	The IAPH in the informative project "Showcase to science"	04/07/14
Facebook	International	The IAPH in the informative project "Showcase to science"	05/07/14
Granada hoy	Regional	A showcase to heritage	07/07/14
Ideal de Granada	Regional	How to calculate the risk of cultural heritage, in the Science Park of Granada	07/07/14
ABC de Sevilla	Regional	Doctors of Heritage	15/09/14
Europa press	Regional	The UPO opens a showcase to show how to calculate the risk of heritage	07/07/14
Ahora Granada.com	Provincial	The art of calculating the risk of cultural heritage	07/07/14
Granada Digital	Provincial	Science Park a year full of activities	13/09/14
Granada en la Red.com	Provincial	How to calculate the risk of cultural heritage	07/07/14
La información.com	Provincial	The UPO opens a showcase to show how to calculate the risk of heritage	04/07/14
Teleprensa. Periódico Digital de Granada	Provincial	How to calculate the risk of cultural heritage, in the Science Park of Granada	04/07/14
Universidad Pablo de Olavide	Provincial	How to calculate the risk of cultural heritage	07/07/14
Ciencia y restauración	National	The hidden face of cultural heritage	08/07/14
Facebook IAPH	International		21/05/15

Conclusions

The Hidden Face of Cultural Heritage (ScW-CH) is a model designed for the dissemination of knowledge about risk in cultural heritage, led by researchers in collaboration with museum specialists in order to make their studies about science and cultural heritage accessible to all demographics. An innovative methodology that simulates a showcase was designed to study the four levels of hazards and vulnerability knowledge in cultural heritage, that involves a thorough understanding of materials, artworks, analytical techniques, methods, and model of risks. The exhibition spread the multidisciplinary nature of cultural heritage preservation with "the Researchers' Corner" where visitors could discover that the researchers are physicists, chemists, geologists, architects, biologists, archaeologists, historians, restorers… working together as a team. The exhibition contained materials, equipments and information sheets to help the guides to accompany visitors as storytellers. All the contents were adapted to different types of visitors, achieving their interest about this subject.

8226 visitors explored the exhibition for a period of 6 months. A survey was filled out by 260 visitors; respondents presented a medium–high initial interest in visiting this exhibition, 32% of respondents had very high interest. In contrast, respondents presented a medium–low level of knowledge of the research, with 17% saying they did not know anything about it. After the experience, 92% showed a very high learning level. Teenagers and children proved to be the group which had learned the most. The ratio of interest and learning in the window with the level of study shows that secondary school pupils had the highest degree of interest and learning (4.02/5, 9.5/10 average interest-learning). The evaluation of the impact highlights that the model developed is accepted by the public and valued as excellent by 6 of every 10 people surveyed. Young people showed the most interest and learned the most from this type of work, partly because of their natural curiosity. This data can be used by decision-makers in science and art education to increase scientific vocations and at the same time raise awareness about CH preservation in the future.

This new design, based on place-making and storytelling, is forward-thinking in achieving better awareness on cultural heritage issues and new technologies applied to the study of risk and vulnerability in cultural heritage. The project designs a holistic experience for the visitors, where science applied to art research tries to attract their emotions. Nowadays, where research dissemination to the public is a key issue in society, this approach for cultural heritage preservation needs new models and expressions similar to those shown in this paper to capture the attention of the public. Accordingly, this design may be employed for other exhibitions to improve the knowledge of society in this field of science.

Abbreviations

CH: cultural heritage; ICT: information and communications technologies; LIBS: laser-induced breakdown spectroscopy; LIF: laser-induced fluorescence; R&D + i: Research & Development & Innovation; ScW-CH: science window titled Hidden Face of Cultural Heritage; SEM–EDX: scanning electron microscope/energy-dispersive x-ray; SPSS: Statistical Package for the Social Sciences.

Authors' contributions

PO: Head of RIVUPH Project, has participated in the instructive design of the exhibition in both phases, especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1–5; Method 1, 3–6, 8–10; Case 2, 4, 5, 7, 8 and Game 1). She was a major contributor in writing the manuscript and the analysis and evaluation of results. She participated in storyteller formation and inauguration. She has written guide files in a language accessible to different levels. RO: researcher of RIVUPH Project, has participated in the instructive design of the exhibition in both phases and especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1–5, Method 1, 3–5, 7–9; Case 5, 7, 8 and Game 1). She was a major contributor in writing the manuscript and the analysis and evaluation of results. She participated in storyteller formation and inauguration. She has written guide files in a language accessible to different levels. JMM: researcher of RIVUPH Project, has participate in the instructive design of the exhibition in both phases and especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1–5; Method 1, 3–5; Case 7, 8 and Game 1). He participated in storyteller formation and inauguration. He has written guide files in a language accessible to different levels. RRG: statistic, researcher of UPO. She was in charge of the social analysis of the surveys. MAV: researcher of RIVUPH Project, has participate in the instructive design of the exhibition in both phases and especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1, 3–5; Method 1, 3, 4, 6, 7 and Case 2–4). She participated in storyteller formation and inauguration. She has written guide files in a language accessible to different levels. MAGM: researcher of RIVUPH Project, has participated in the instructive design of the exhibition in the first phase and especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1, 2, 6; Method 11–13 and Case 1, 5–8). She participated in storyteller formation and inauguration. She has written guide files in a language accessible to different levels. MS: researcher of IAPH, has participated in the instructive design of the exhibition in the first phase and especially in the dissemination of advanced materials and technologies of Table 1 (Method 2). She participated in storyteller formation and inauguration. She has written guide files in a language accessible to different levels. LL: specialist in dissemination of IAPH has participate in the instructive design of the exhibition in the first phases and oversaw the state of art. She participated in the inauguration. She has overseen guide files in a language accessible to different levels. CG: member of museum Science Park of Granada and leader of the meetings to evaluate the space and the examples to be shown, she has participated in the instructive design of the exhibition in both phases and in the design of the space, formation of storyteller, head of development of the dissemination materials, she was in charge to collect the surveys, assembly of the exhibition with the training of guides, inauguration and exposition. JMGB: researcher of RIVUPH Project, has participate in the instructive design of the exhibition in both phases and especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1). He participates in storyteller formation and the inauguration. JB: researcher of UPO, has participate in the instructive design of the exhibition in both phases and especially in the dissemination of advanced materials and technologies of Table 1 (Risk 1, 3, 4 and Method 3). All authors read and approved the final manuscript.

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