Deliverable No. 2.3

Guidelines for PERSEIA adaptation to science museums

Project acronym:
PERFORM

Project Title:
Participatory Engagement with Scientific and Technological Research through Performance

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SUMMARY

This deliverable corresponds to task 2.3 “Pilot PERSEIA scaled up into informal context: implementation in science museums”. In order to transfer the results of the PERFORM project into informal learning environments, TBVT implemented a series of activities in CosmoCaixa Science Museum in Barcelona, Spain, that included: **reviewing 6 guided tours** addressed to secondary school students carried out by science museum facilitators, delivering a **knowledge sharing workshop** with 18 science museum facilitators, and generating and delivering a **workshop for 15 novel science museum facilitators** in order to create drama-based scientific guided tours at CosmoCaixa Science Museum. As the final outcome of this process, this report includes a Toolkit called: **“PERFORM: Guidelines for including values related to science through performance-based science communication in museums”** in section 4 (Guidelines for PERSEIA adaptation to science museums).

1. INTRODUCTION

A considerable percentage of young people in Europe are not interested in STEM careers. The international study on "Social Perception of Science" conducted by the BBVA Foundation (2012)[1] reported that the percentage of young people who consider a scientific career as an option varies from 25.2% in UK to 16.4% in Spain or 18.8% in France. Indeed, in recent years numerous authors have raised the alarm about the decline of scientific vocations in the European context[2,3].

The notion that research and innovation (R&I) should address major societal challenges has become salient in contemporary research and innovation (R&I) policy. It has become one of three main pillars of the Horizon 2020 programme. The emergence of the term 'societal challenges' and its incorporation to R&I policies reveal new goals and priorities: new approaches to collaboration and governance, but also new actors and instruments in R&I practices[4,5]. The PERFORM project takes the term 'societal challenges' and its goals as the pivot of its pedagogical approach.

On the other hand, Responsible Research and Innovation (RRI) is a wide field connecting different aspects of the relationship between R&I and society: public engagement, open access, gender equality, science education, ethics, and governance. PERFORM is connected to RRI in the regard that it is a research project in the area of science education tackling gender, ethics and public engagement issues. In order to get a broader approach, PERFORM considers RRI issues, and specifically gender equality, as key variables to take into account when designing science education methods based on performing arts.

Moreover, numerous studies in the European Union and other countries, including Canada and the United States, have reported the persistence of gender difference regarding the choice of scientific careers for decades; especially STEM degrees and occupations[6]. Particularly in physics and engineering[7,8] as well as in mathematics

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[1] BBVA Foundation (2012). *Estudio Internacional de Cultura Científica*. Madrid: BBVA Foundation. Avaiable at http://www.fbbva.es/TLFU/dat/comprension.pdf

[2] Convert, B., & Gugenheim, F. (2005). Scientific Vocations in Crisis in France: explanatory social developments and mechanisms. *European Journal of Education*, *40*(4), 417-431.

[3] Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walwerg-Heriksson, H., & Hemmo, V. (2007). *Science Education Now: A Renewed Pedagogy for the Future of Europe*. Brussels: Office for Official Publications of the European Communities.

[4] Mowery, D. C., Nelson, R. R., & Martin, B. R. (2010). Technology policy and global warming: Why new policy models are needed (or why putting new wine in old bottles won't work). *Research Policy*, *39*(8), 1011-1023.

[5] Weber, K. M., & Rohracher, H. (2012). Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. *Research Policy*, *41*(6), 1037-1047.

[6] Hango*, D. (2013).Gender differences in science, technology, engineering, mathematics and computer science (STEM) programmes at university*. Ontario: Minister of Industry.

[7] Smith, E. (2010a). Do we need more scientists? A long-term view of patterns ofparticipation in UK undergraduate science programmes. *Cambridge Journal of Education*,40, 281–98.

[8] Smith, E. (2010b). Is there a crisis in school science education in the UK?*Educational Review*62 (2), 189–202.

women remain under-represented. For example, the 'She Figures[9]' report, published in 2016, which contains the most recent available European data on the involvement of women in science, reveals that the probability of men choosing careers in engineering, manufacturing and construction is twice as high in comparison with women, whereas the probability of women pursuing an educational degree is twice as high in comparison with men. Furthermore, the European Commission has a clear vision about the important role of ethics with regard to science. As most of the students' concerns regard animal and environmental issues, private life and health issues, the PERFORM project addresses the students' perception on ethical standards on these topics in the research process.

To summarise, within a previous stage of the PERFORM project we developed an integrated methodological protocol aim to address RRI-related values and societal challenges within science education at secondary schools. In this protocol we tested methods to transform performance-based activities into PERformance-based Science Education and Innovative Activities (PERSEIA) to foster young people's interest in science. This protocol was tested in three countries: France, Spain and the UK.

Through PERSEIAs, the PERFORM project engaged secondary school students by reflecting during scientific drama-based activities about the human dimension of science and the values embedded in RRI, i.e. the gender dimension in science, STEM jobs and career opportunities, societal challenges with regard to science and ethical issues in the research process.

In order to scale up the results of PERFORM to informal educational contexts, TBVT conducted a pilot in Spain through establishing collaboration with CosmoCaixa Science Museum in Barcelona. This collaboration allowed the PERFORM team to adapt the PERSEIAs protocol into the context of science museums. TBVT developed a proposal of **Guidelines for including values related to science** (i.e. *How Science is related with EU - Societal Challenges, Critical Thinking in STEM, and Ethical issues and gender barriers in STEM*) **through performance-based science communication in museums.**

[9] European Comission (2016) *She Figures 2015*. Brussels: European Comission.

2. OBJECTIVES

The general objective of this deliverable is to scale up the resulting PERSEIA methodological approach to informal science learning contexts, specifically to science museums.

This general objective is subdivided in the following specific objectives:

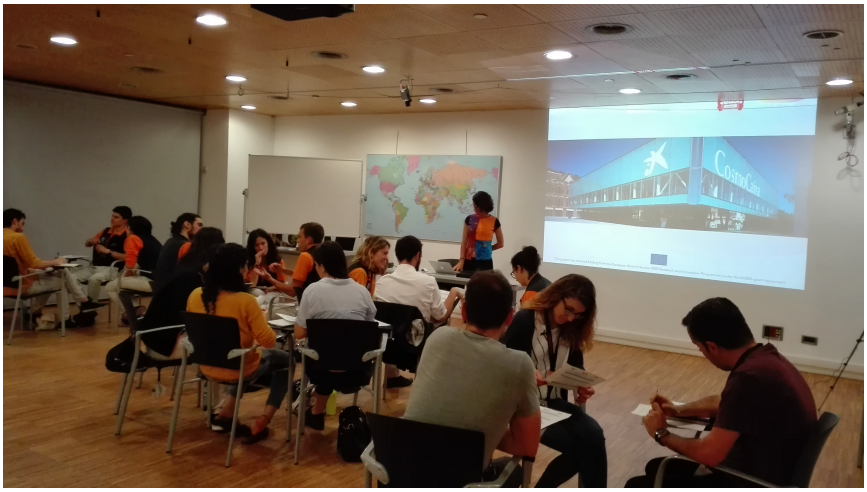
1. To review activities currently implemented in science museums and guided by science museum facilitators.
2. To discuss good practices with science museum facilitators including values related to science (i.e. *How Science is related with EU - Societal Challenges, Critical Thinking in STEM, and Ethical issues and gender barriers in STEM*).
3. To test performance-based science communication activities including these values related to science at science museums.
4. To generate a toolkit for implementing PERSEIAs in science museums **PERFORM: Guidelines for including values related to science through performance-based science communication in museums.**

3. METHODOLOGY

In order to adapt the PERFORM methodology for generating PERSEIAs into the context of science museums, the PERFORM consortium established a collaboration with CosmoCaixa Science Museum in Barcelona. Due to this collaboration, the PERFORM consortium was able to access the processes of the museum, in order to find the best formulas for adapting the pedagogical methodology developed in PERFORM to the context of non-formal education used in science museums.

The first action was to review the dissemination activities carried out at CosmoCaixa by science museum facilitators addressed to secondary schools (i.e. guided tours). TBVT reviewed 6-guided tours inside the CosmoCaixa facilities. Each guided tour was focused on a specific exhibition: Forest Sustainability; Life & Evolution; Antarctic Base; Brains; Trix, the best conserved T-Rex in Europe & Fossils. These activities were reviewed in order to explore the best approach to adapt PERSEIAs to an informal learning setting for visitors, mainly thinking in secondary school students.

The second action was to deliver a knowledge transfer workshop with the facilitators of CosmoCaixa. During this workshop, TBVT presented the methodologies and activities developed in PERFORM project to the CosmoCaixa facilitators. After that, TBVT conducted a participatory discussion to explore how to include the values embedded in RRI; *How Science is related with EU - Societal Challenges, Critical Thinking in STEM and Ethical issues and gender barriers in STEM* (that we have called values related to science in order to avoid technical term) in CosmoCaixa activities. Through these discussions, a first draft of guidelines on how to adapt the PERFORM methodology to science museums was generated.



Knowledge Transfer Workshop held at CosmoCaixa, Barcelona.

The third action implemented consisted of testing the first draft of guidelines with science museum facilitators to generate drama-based activities including the values related to science.

To do that, TBVT designed a training for novel museum facilitators according to the first draft of guidelines obtained in the knowledge transfer workshop.

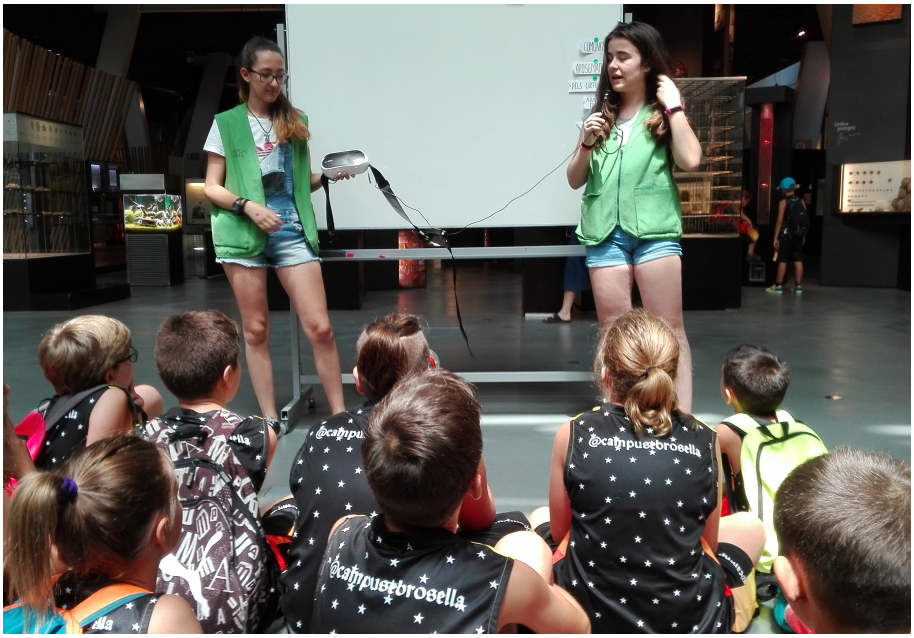
The training was organised in four sessions of four hours each (a total of 16 hours) and was delivered to 15 CosmoCaixa novel science museum facilitators. Each session was adapted from the activities previously tested and carried out in the participatory workshops conducted with secondary school students, their teachers, and early career researchers at school settings, and are described for consultation in Deliverable 2.2: Final protocol of tested methods to generate a transformative participatory educational process by using science and arts-based education approaches.

The topics, objectives and related participatory workshops of the sessions of this training addressed to science museum facilitators are described in the next table:

Session	Topic	Objective	Participatory Workshop
1	*How Science is related with EU - Societal Challenges*	To relate real Societal Challenges with Science Museums exhibitions	PW 1: Reflect on societal challenges and selection of the scientific topic
2	*Critical Thinking in STEM*	To define the content of science museum activities	PW2: Critical thinking and self-reflection.
3	*Ethical issues and gender barriers in STEM*	To include an ethical vision in science museum activities	PW3: Gender and stereotypes.
4	*Performing skills in oral science-communication*	To rehearse the science museum activities focusing on storytelling and body language	PW4: Script writing and performance skills.

Topics, objectives and related participatory workshops of the training delivered by PERFORM consortium to novel science museum facilitators at CosmoCaixa.

The novel science museum facilitators that attended the four-days training developed drama-based activities including the values related to science and presented them in front of a general public, i.e. the visitors of the CosmoCaixa museum on a Saturday morning.



Drama-based activities including the values related to science delivered at CosmoCaixa by novel facilitators.

Out of these three actions, TBVT generated a Toolkit version of **Guidelines for PERSEIA adaptation to science-museums**, shown in section 4.

4. GUIDELINES FOR PERSEIA ADAPTATION TO SCIENCE MUSEUMS

The guidelines we present below aim to describe how to create activities at science museums including values related to science (ethics, critical thinking, gender issues and societal challenges) through performance-based science communication. The following guidelines are not intended to be a "to do" list. Learning in a non-formal context is a complex process, and in a museum setting, where knowledge relates with experience and creativity, it becomes quite challenging.

We define three themes based on previous experience and the research results obtained in previous tasks of the PERFORM project to inform about the museum facilitators' approach. We aim for a skeletal approach that frames key points to include the above-mentioned values related to science in science museums activities, using a drama-based approach.

PERFORM: Guidelines for including values related to science using performance-based science communication in museums

In the PERFORM project, we have designed a methodology to include students' concerns, perceptions and interests about STEM careers and values related to science (ethics, critical thinking, gender issues and societal challenges) in performance-based activities. We designed a toolkit to implement this methodology that can be consulted here.

We adapted this methodology to be used in the context of a science museum. Through a review of the activities currently conducted at the science museum, as well as a knowledge transfer workshop and a training with science museum facilitators and members of the PERFORM team, we developed a series of steps to disseminate not only scientific content, but also the values related to science in science museums (i.e. i.e. *How Science is related with EU - Societal Challenges, Critical Thinking in STEM, and Ethical issues and gender barriers in STEM*), using a drama-based science communication approach.

If you want to **convert your science museum activities into drama-based activities addressing some of the key values related to science (**i.e. *How Science is related with EU - Societal Challenges, Critical Thinking in STEM, and Ethical issues and gender barriers in STEM***),** follow the next steps.

Let's PERFORM!

1.- Science Museums for new societal challenges: reframing the scientific content.

Museums are spaces that can promote free, critical and complex thinking required for modern citizens; they can stimulate new ideas as well as intellectual, critical and ethical enrichment. A good opportunity is to "reframe" and redefine the content of some of the activities carried out in Science Museums to match real contextual perspectives in view of present and future societal challenges and ethical controversies of scientific and technological developments. Museums have the role to provide a fundamental contribution to public knowledge and culture. Thus, they can be powerful resources to raise awareness and address solutions for societal challenges by their activities, topics and relationship with communities and the public. Surprisingly, most activities reviewed for the purpose of these guidelines are not yet thinking explicitly about societal challenges and/or ethical issues neither promoting a critical thinking. The scientific content of these activities should address how to meet the expectations of fast-changing societies.

Here, we propose a methodology to design activities to be developed at science museums exhibitions that not only include STEM content, but also values related to science.

1) The first step is to **select an activity that is running in a science museum**. It can be a hands-on activity, a science talk or a guided tour.
2) Once you have selected the activity, **think about the core scientific concepts** that you aim to deliver. It may be useful to answer the following question in just one sentence: *what will my audience learn today?*
3) Now it's time to include **science related values (ethics, societal challenges, gender issues, critical thinking)** in your activity. Those should be related to your scientific concepts. As a museum facilitator, you can play a fundamental role in in drawing the attention of museum visitors to these science related values by proposing controversial topics, inquiring questions, etc**.** Here is a list of ideas:

- Include in your speech a discussion about some of these societal challenges

- ✓ Health, demographic change and wellbeing
- ✓ Climate action, and environment
- ✓ Secure societies, freedom and security

- Include in your speech a discussion about ethical issues in the research process

- ✓ Good /bad considerations about genetically modified organism (GMO), Artificial Intelligence (AI), Robots, medical advances (cloning, genetic modifications in humans)
- ✓ Discoveries that improve/ impair the environmental quality
- ✓ Social inclusive/ exclusive new technologies

- Introduce in your speech new ideas and role models that can break science related stereotypes related to gender

- ✓ Break social related stereotypes about scientists: highlight positive considerations of science and scientists, like external recognition, knowledge motivation, the "power of knowledge"…
- ✓ Break gender related stereotypes about scientists: Give special mention to female physicists, engineers and computational scientists.

- Promote critical thinking among your audience

- ✓ Include controversial scientific claims and promote debates and discussions on how the science knowledge is generating, tackling important concepts as:
  - *Who is making the claim?*
  - *What is the scientific evidence for the claim?*
  - *How does the claim fit with established science?*

2.- Promote participation: listen to what visitors have to say.

Science museums and science centres have a long history of interactive display techniques, which makes them naturally suited to encourage visitor participation. The PERFORM project wants to go beyond the "facilitator as expert"-approach, in which the visitor is only focused on following protocols, to a "facilitator listens to opinions and contributions from audiences"-approach, in which visitors can have an opinion about the present and future of STEM & Societal challenges.

Nevertheless, we have identified two main barriers for visitors' participation in science dialogue at science museums:

Barrier 1: Visitors' expectations: Some visitors shy away from controversial topics that might be perceived as too complicated. This can be the case with groups of teenagers.

To overcome this barrier, we propose to promote participation with activities that include games or hands-on activities. Some examples are:

Card games.- Cards can feature different scientists profiles. The facilitator can ask the audience to play the role of a "Scientist" to explain how, with his/her skills, he or she can contribute to address some societal challenges (some examples in annex

1). Cards can also feature organisms contained within the museum. Audience can play the interactions between them. What will happen if one of these organisms disappears?

Performing activities.- Visitors can play different roles and discuss certain scientific topics. For example, in a Climate Change Alliance, half of the visitors could play the role of businessmen of the automobile industry and the other half the role of indigenous populations in South America.

Breaking News.- Present the visitors opposite pieces of science news about a chosen topic. Try to have live news. Ask your audience: Which one is more reliable? Why? What clues does the museum give us to say so? It can be a good start to discuss science reliability.

- Barrier 2: The atmosphere of a science museum: Science museums normally have a busy and noisy atmosphere and can be difficult to find quiet spaces to promote self-reflection and participation in dialogues.

To overcome this barrier, it's important to keep in mind the quiet spaces within the science museum. Visit them with your audience and promote dialogue delivering the activities proposed in the previous section.

3.- Integrate drama-based activity.

For the PERFORM project, one of the key ideas is to engage visitors by generating a drama-based story that catches their attention while developing an activity. The story will allow science museum facilitators to maintain the conceptual coherence and to connect with the young audience, humanising the scientific topics explained and tackle the values related to science.

To generate a story, follow these simple steps:

- Look for an introduction that catches the attention of the visitors. It is important to take into account who they are (visitors can be students, families, kids…), using something related to their daily life that they can easily identify with.
- Combine the scientific explanations of each exhibitionwith emotional content embedded in the story. It will be useful to tell stories about real scientists, fictional characters or maybe stories that happened directly to museum facilitators. Talk and reflect about important topics and values, such as societal challenges, stereotypes in STEM, gender barriers in science, ethical issues in the research process or STEM careers job opportunities. This will catch the attention of the visitors by connecting with issues they can comment on.

- Allow the visitors to actively participate in the story. We recommend asking questions that they can easily answer, not related to science content but related to emotions. Some examples are: Have you ever tried to have a bath in iced water? Would you like to fly? What would you do in my place?

Practical example

Exhibition name: Fossils (permanent exhibition at CosmoCaixa)

Stand			
Science Content	Fossils can tell us about… feeding habits	… locomotion.	… natural disasters. --- evolution.

Science content (key concepts to be delivered).

By studying the fossil record we can tell how life was in the past and use this information to find out about ancient environments.

Possible discussion about science related values.

Societal challenges: Climatic changes are recorded in fossils. Do you think the climate change nowadays is also due to natural conditions? How do you think fossils in the future can register our current climate change?

Stereotypes: Talk about real scientists who work reconstructing the history of fossils. Think about women (ex. Nieves López Martínez).

Possible story.

What can an old photograph tell us? Show a photograph of your grandmother:

or

What kind of information can you extract from this photo? (clothes, technology, cultural context, behaviour …)
Compare fossils with the old photos of your grandparents. Fossils are more ancient photographs, imprinted in sediments, instead of photograph paper. What kind of information can we extract from fossils? (feeding habits, way of movement, natural disasters etc.)

4.- Rehearse, perform and rehearse again.

Generation of a PERSEIA is a *trial and error* process. Allow you to create, to explore, and to make mistakes. Create your PERSEIA as a living process. Rehearse first with your science museum colleagues, and when you deliver it to real visitors, do not hesitate to change and update the story, according to their reactions. This is the best way to get an authentic PERSEIA.

LET'S PERFORM

To generate a PERSEIA-Guided-Tour to be delivered in a Science Museum looks more difficult than it actually is! Within the PERFORM project we have designed an entire TOOLKIT to generate, these kinds of stories step by step.

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ANNEX 1

1.- Examples of cards to be used to promote participation