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Including Responsible Research and innovation in cutting Edge Science
and Inquiry-based Science education to improve Teacher's Ability of
Bridging Learning Environments

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education through the construction of exhibitions

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EXECUTIVE SUMMARY

During the Work Package 3 of the IRRESISTIBLE Project, groups of teachers and students were involved (and supported by the local Community of Learners - CoL) in the development of interactive exhibitions addressing the concept of Responsible Research and Innovation. The process of development of such exhibitions is closely related to the Exchange phase of the extended 5E IBSE model approach used within the Project. The construction and presentation of exhibits functioned as a pretext and a context to study the impact of this process on teachers' personal and professional development and students' competences. Each partner was responsible for finding teachers and groups of their students willing to participate in this process. The partners, the scientists and the science centre experts were responsible for following and supporting the work of each group and studying the impact of this process on teachers and students.

Work Package 3 had four important objectives to accomplish during the three years of the Project. In order to do so, several activities were developed – either by the WP3 coordination team, either by all IRRESISTIBLE partners. Hence, the main purpose of Deliverable 3.4 is to present, describe and reflect on the activities implemented within WP3, which allowed for the development of valuable knowledge in what concerns the impact of student-curated exhibitions addressing the concept of Responsible Research and Innovation on students' competences and teachers' personal and professional development.

All the results presented in this report allow the conclusion that the IRRESISTIBLE project had several levels of strong impact in the countries involved: a) a first level is connected with the knowledge developed by teachers, students, families and communities that research and innovation must be driven by responsibility; b) a second level is related with all the expertise developed by science educators, science centres experts, teachers and scientists about how to address Responsible Research and Innovation (related with cutting edge scientific and technological issues) in formal and non-formal educational contexts.

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1. WP3 Description of Work

As part of the teaching module produced, groups of teachers and students were involved (and supported by the local scientists, science centre experts and partners) in the development of exhibitions addressing the concept of Responsible Research and Innovation. Through this process, teachers and students had the opportunity to understand that uncertainty and risk are inherent to scientific and technological enterprises, and so, research and innovation must be driven by responsibility. Teachers developed their expertise on how to address Responsible Research and Innovation (related to cutting edge scientific and technological issues) through the construction of exhibitions centred on such issues. These exhibits took place in schools, universities, and science centres or museums.

This work package was triggered, for example, by a visit to a science centre, a museum or an exploratory. Teachers and students considered not only the content of the exhibition but also its production values. In some cases, by prior arrangement, the museum or science centre included an empty space. The task for teachers and students was to present within that space interactive exhibits which relate to issues of Responsible Research and Innovation. An interactive exhibition incorporates social networking and urban computing (the use of technology in public environments, increasing the interaction between humans and such environments and allowing access to complementary information, educational materials (for example, quizzes) and communication tools. This sort of exhibition fosters the expansion of knowledge through a process that dilutes the boundaries between teacher and student roles.

The construction and presentation of exhibits functioned as a pretext and a context to study the impact of this process on teachers' personal and professional development and students' competences.

Each partner was responsible for finding teachers and groups of their students willing to participate in this process. The partners, the scientists and the science centre experts were responsible for following and supporting the work of each group and studying the impact of this process on teachers and students.

2. WP3 Objectives

Work Package 3 had four important objectives during the three years of the Project:

- a) To involve groups of teachers and students (with the support of the communities of learners) in the construction of exhibits addressing the concept of Responsible Research and Innovation (**O3.1**)
- b) To help teachers and students to understand that uncertainty and risk are inherent to scientific and technological enterprises and so, research and innovation must be driven by responsibility (**O3.2**)
- c) To develop teachers' expertise about how to address Responsible Research and Innovation (related with cutting edge scientific and technological issues) through the construction of exhibitions centred on such issues (**O3.3**)
- d) To produce knowledge about the educational potentialities of exhibit construction regarding the concept of Responsible Research and Innovation (**O3.4**)

In order to accomplish these objectives, several activities were developed – either by the WP3 coordination team (**table 1**), either by all IRRESISTIBLE partners (**table 2**).

Table 1 - Activities implemented within WP3 by the coordination team

YEAR 1	A literature review on: (a) the educational potential of building exhibitions by students; and (b) the concepts of interactivity and interactive exhibition. Part of this review was integrated in the “Development Guide for an IRRESISTIBLE Exhibition” prototype and submitted to the partners’ analysis and feedback.	
	The definition of a strategy for the implementation of the exhibitions by each partner’s Community of Learners (CoL) during the project implementation. This strategy was defined during two workshops realized at Groningen and Jyväskylä meetings.	
	The construction of a “Development Guide for an IRRESISTIBLE Exhibition” aimed at supporting each partner’s Community of Learning (CoL) during the process of planning, implementing and evaluating exhibitions addressing the concept of Responsible Research and Innovation. This guide prototype addresses the following themes: a) the potential of student planned and designed exhibits about responsible research and innovation; b) different phases for creating and implementing an exhibition; c) how to develop interactive exhibitions; d) different possible scenarios for exhibits; e) general guidelines for all scenarios; f) how to use text in exhibitions; g) how to evaluate exhibitions. This guide was improved with partners’ analysis and feedback.	
	The realization of an extra workshop in Lisbon, on the 17th and the 18th of October, with the aim of developing CoL members’ expertise on how to address different aspects of Responsible Research and Innovation (related to cutting edge scientific and technological issues) through the construction of interactive exhibitions centred on these issues. During this workshop, science educators, school teachers and science centre specialists from different countries discussed: a) ways of involving students and teachers in planning and developing exhibitions addressing the concept of Responsible Research and Innovation; b) several examples of Responsible Research and Innovation exhibits developed specially for the workshop; c) instruments and methodologies for evaluating the impact of this process on teachers’ and students’ competences. The workshop was also used to discuss and validate the content of the “Development Guide for an IRRESISTIBLE Exhibition” prototype.	
	The construction and validation of items to be included in the students’ questionnaire (developed within WP5) to evaluate the impact of exhibitions’ planning and development on students’ perceptions regarding their competences.	
YEAR 2		The construction of guidelines for the development of the case-studies, which included: a) the methods to be used for the data collection; b) the case-study general structure; c) teachers’ items guide; d) students’ items guide; e) experts’ items guide. The case studies will allow us to know the impact of exhibitions’ development and construction, addressing the concept of Responsible Research and Innovation, on teachers’ personal and professional development and to understand how students experience these exhibitions and their effects on students’ competences.
		The construction of two case-studies regarding the process of exhibit development in two of the Portuguese schools that tested the Portuguese IRRESISTIBLE teaching modules (CoL1). For the case-studies construction several interviews were conducted – to both teachers and students. The case-studies were shared with the IRRESISTIBLE partners with the purpose of exemplify what was intended with the task of case-study construction.
		Data collection from all IRRESISTIBLE partners regarding the exhibits developed within CoL1. Analysis of the data in order to conclude about the characterization of the diverse exhibitions, the potentialities and limitations, and ways of improvement.
		The preliminary analysis of the case-studies developed by the IRRESISTIBLE partners (concerning the exhibitions developed within CoL1). The case-studies will allow us to know the impact of exhibitions’ development and construction, addressing the concept of Responsible Research and Innovation, on teachers’ personal and professional development and to understand how students experience these exhibitions and their effects on students’ competences.
	YEAR 3	The construction of several vodcasts focusing on Exhibits on Responsible Research and Innovation, and on the exhibits that were developed within the IRRESISTIBLE Project during CoL1. The vodcasts, illustrating what can be done by students and teachers within exhibit development focusing on cutting-edge scientific topics, can be used by teachers in schools as continuing professional development.
		Several presentations at schools by the different partners with the purpose of clarifying teachers and students on how to develop interactive scientific exhibitions.
		Development of a new version of the IRRESISTIBLE Exhibitions Development Guide (available in .pdf and in digital magazine formats) including photographs from all the exhibitions developed within CoL1, and improvements in the Evaluation section.
YEAR 3		Data collection from all IRRESISTIBLE partners – through questionnaire and focus group – regarding the exhibits developed within CoL2, and the integration of RRI in the exhibitions. Analysis of the data in order to conclude about the characterization of the diverse exhibitions, the potentialities and limitations, and ways of improvement.
		The construction of two case-studies regarding the process of exhibit development in two of the Portuguese schools that tested IRRESISTIBLE teaching modules (CoL2). For the case-studies construction several interviews were conducted – to both teachers and students.
		The meta-analysis of the case-studies developed by the IRRESISTIBLE partners (concerning the exhibitions developed within CoL1 and CoL2). The case-studies allowed us to know the impact of exhibitions’ development and construction, addressing the concept of Responsible Research and Innovation, on teachers’ personal and professional development and to understand how students experience these exhibitions and their effects on students’ competences.
		Analysis of students answers to the pre and post-questionnaire to evaluate the impact of exhibitions’ planning and development on students’ perceptions regarding their competences.

Table 2 - Activities implemented within WP3 by all partners

<div>YEAR 1</div> <div>YEAR 2</div> <div>YEAR 3</div>	Feedback on the prototype of the guide for the development of case-studies focused on the perceptions of students, teachers and researchers enrolled in the process of exhibition development.	
		Feedback on and/or contributions to the prototype of the Irresistible Exhibitions Development Guide in order to produce an improved version of it.
		Presentations at schools/CoL1 and CoL2 teachers with the purpose of clarifying teachers and students on how to develop interactive scientific exhibitions.
		Data collection of teachers' and students' perceptions regarding the process of exhibition development – through interviews and questionnaires –, in order to build case-studies that allowed for the understanding of the impact of such activities on both students and teachers.
		Development of 26 case studies in order to evaluate the impact of student-curated exhibitions – addressing the concept of Responsible Research and Innovation – on teachers' personal and professional development and on students' perspectives and competences.
		Description of the exhibitions developed within their 1 st and 2 nd CoLs.
		Share of images for the vodcasts' development.
		Feedback on the usefulness of the vodcasts.
		Reflections on the positive and negative aspects, and ways of improvement, of all the exhibitions developed within their 1 st and 2 nd CoLs.
		Development of several exhibitions on cutting-edge scientific topics addressing Responsible Research and Innovation.
		Reflections on the potentialities and limitations of integrating RRI in the process of exhibition development.

Such activities allowed for the development of very important knowledge, which was used for the development of the four WP3 Deliverables (**table 3**).

Table 3 – WP3 Deliverables.

Number	Title	Description
D3.1	Different exhibitions	Interactive exhibitions on Responsible Research and Innovation (related with cutting edge scientific and technological issues), written in each partners language
D3.2	Reports on exhibitions	Vodcasts, podcasts and films, deliverable through the internet, of exhibitions on Responsible Research and Innovation which could be used by teachers in schools as continuing professional development or as an activity to be used with students
D3.3	Case studies	Case studies about the impact of the process on teachers' personal and professional development and students' competences
D3.4	Final report	Final report on teaching Responsible Research and Innovation in science education through the construction of exhibitions

Next we will focus on the Deliverables, describe the activities that generated the necessary knowledge for their development and reflect on the achieved results.

3. WP3 Deliverables

D3.1 “Different exhibitions – Interactive exhibitions on Responsible Research and Innovation (related with cutting edge scientific and technological issues), written in each partners language”

The purpose of this Deliverable was to (a) describe the process of the IRRESISTIBLE Exhibitions Guide development, (b) present and reflect on the final results from the evaluation made by all partners in what concerns the usefulness of the Guide, its potentialities and limitations, and, from there, suggestions of improvement, (c) present the Guide, on its latest version, (d) describe and characterize, globally, the set of exhibitions developed within the first phase of the Project, (e) present and reflect on the evaluation made by all partners regarding the positive and negative aspects of their exhibitions and also the integration of RRI in them, and (f) present improvement suggestions regarding the process of exhibition development.

In order to develop D3.1, several activities were implemented during Year 1 and Year 2 (table 4).

Table 4 – Activities implemented, within WP3, by the coordination team and by all partners. These activities allowed for the development of D3.1.

Activities implemented by WP3 coordination team	Year
A literature review on: (a) the educational potential of building exhibitions by students; and (b) the concepts of interactivity and interactive exhibition. Part of this review was integrated in the “Development Guide for an IRRESISTIBLE Exhibition” prototype and submitted to the partners’ analysis and feedback.	1
The construction of a “Development Guide for an IRRESISTIBLE Exhibition” aimed at supporting each partner’s Community of Learning (CoL) during the process of planning, implementing and evaluating exhibitions addressing the concept of Responsible Research and Innovation. This guide prototype addresses the following themes: a) the potential of student planned and designed exhibits about responsible research and innovation; b) different phases for creating and implementing an exhibition; c) how to develop interactive exhibitions; d) different possible scenarios for exhibits; e) general guidelines for all scenarios; f) how to use text in exhibitions; g) how to evaluate exhibitions. This guide was improved with partners’ analysis and feedback.	1,2
The realization of an extra workshop in Lisbon, on the 17th and the 18th of October, with the aim of developing CoL members’ expertise on how to address different aspects of Responsible Research and Innovation (related to cutting edge scientific and technological issues) through the construction of interactive exhibitions centred on these issues. During this workshop, science educators, school teachers and science centre specialists from different countries discussed: a) ways of involving students and teachers in planning and developing exhibitions addressing the concept of Responsible Research and Innovation; b) several examples of Responsible Research and Innovation exhibits developed specially for the workshop; c) instruments and methodologies for evaluating the impact of this process	1

on teachers' and students' competences. The workshop was also used to discuss and validate the content of the "Development Guide for an IRRESISTIBLE Exhibition" prototype.	
Data collection from all IRRESISTIBLE partners regarding the exhibits developed within CoL1. Analysis of the data in order to conclude about the characterization of the diverse exhibitions, the potentialities and limitations, and ways of improvement.	2
Activities implemented by all partners	
Feedback on and/or contributions to the prototype of the Irresistible Exhibitions Development Guide in order to produce an improved version.	1,2
Presentations at schools/CoL1 and CoL2 teachers with the purpose of clarifying teachers and students on how to develop interactive scientific exhibitions.	1,2
Development of several exhibitions on cutting-edge scientific topics addressing Responsible Research and Innovation.	2
Description of the exhibitions developed within the 1 st CoL.	2
Reflections on the positive and negative aspects, and ways of improvement, of all the exhibitions developed within their 1 st CoL.	2

The activities featured on **table 4** allowed for:

(a) The development of knowledge in what concerns:

- 1) The potentialities of having students developing interactive exhibitions on RRI in the context of Science Education;
- 2) The concept of *interactivity* and *interactive exhibition* – elementary concepts that needed to be clarified to all partners in order to give the IRRESISTIBLE exhibitions their identity;
- 3) The possibilities of *interactivity scenarios* in order to operationalize the concepts of interactivity and interactive exhibition;
- 4) The strategies for assessing the impact of exhibitions' development in students, teachers and visitors.

(b) The development of the *IRRESISTIBLE Exhibitions Development Guide* with the purpose of developing a tool that could support CoL members – specially teachers – in the process of exhibition development.

(c) The evaluation of the *IRRESISTIBLE Exhibitions Development Guide* in order to reflect on its usefulness, potentialities and constraints with the purpose of develop an improved version.

(d) The description and evaluation of the IRRESISTIBLE exhibitions developed within the first year of module testing.

(e) The presentation of suggestions for improving the process of exhibition development within the 2nd CoL, especially in what concerns the integration of RRI.

The development of the *IRRESISTIBLE Exhibitions Development Guide*

Having in mind the novelty of exhibition development for the majority of CoLs, we developed a Guide with the purpose of giving all partners a basis, within a theoretical framework, for working with each CoL the process of exhibition development. The effort to make available a prototype of the Guide as soon as May 2014 was to allow each partner to integrate its content in the first CoL phase, starting, for the majority, in September 2014.

For the Guide development – a process that started in January 2014 – first we revised on the potential of having students developing scientific exhibitions on cutting-edge topics; next, the concept of interactivity within museums and science centres was revised in order to clarify the characteristics of an interactive exhibition and, also, of an interactive object. Next, we focused on how to achieve, within the context of an exhibition, a satisfactory level of interactivity (i.e., interaction between visitors and between visitors and objects), giving the reader some suggestions on how to design interactive objects. Next, our major concern was to give examples or scenarios of interactivity for partners and their CoL teachers to get inspired on; at the same time the scenarios allowed the demystification of what was intended with "an interactive exhibition" within the framework of IRRESISTIBLE. Finally, we addressed the importance of evaluating the impact of exhibition development – on students, teachers and visitors – and suggested assessment tools to be used by teachers and students.

Within the task of developing the Guide, we followed a Design-Based Research approach given the fact that we used a methodology aimed at developing a tool that could, itself, help at improving educational practices, through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings (Wang & Hannafin, 2005). Along this process there were several iterations, which conducted, from a prototype, to the final version of the Guide (**figure 1**).

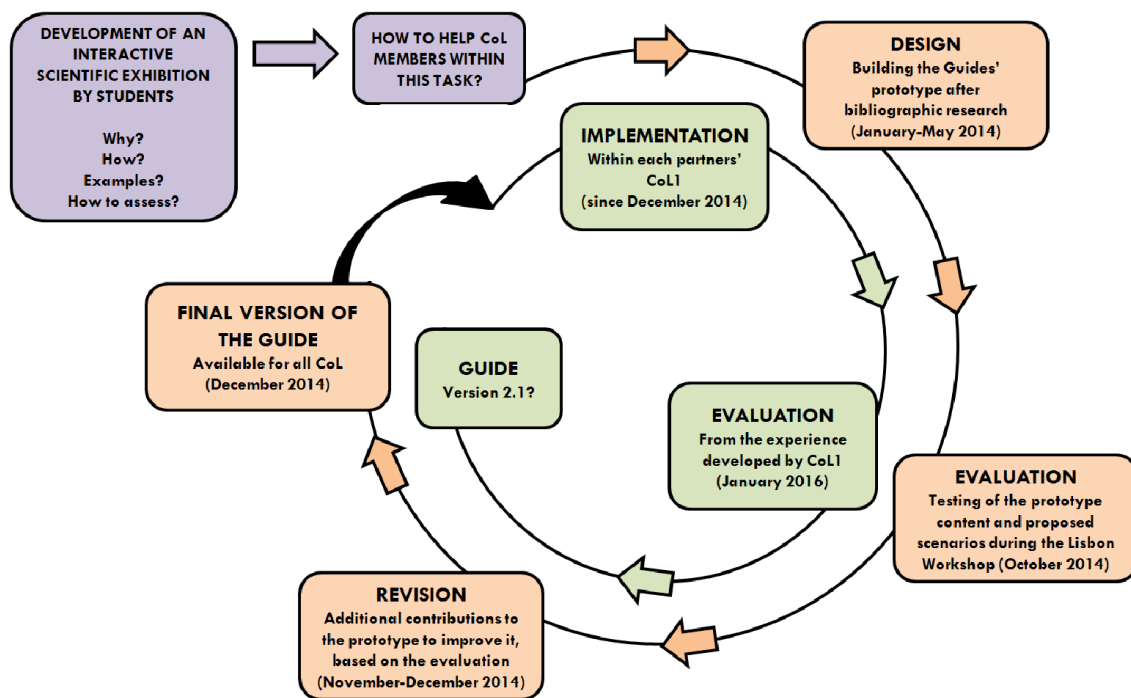


Figure 1 – The Design-Based Research approach in the process of Guide development.

Bibliographic research

When planning the Guides' content, it was clear to us that there should be two distinct parts: a) one, more theoretical, aimed at framing the concept of interactivity and interactive exhibition, and the potentialities of its development by students; b) and a second one, more practical, showing some different scenarios as a way to materialize the so desired "interactivity".

From January 2014 until March 2014 we dedicated at revising several publications from authors that develop their research in the field of informal science education, communication of science, museology and development of scientific exhibits in the context of science centres. The goal was to clarify the concept of *interactivity*, which we considered essential in the context of the development of IRRESISTIBLE exhibitions, and also the concept of *interactive exhibition*. The research brought to light a concept of interactivity that does not, necessarily, require the presence of technology, but, instead, does necessarily require the interaction between the visitors within the exhibit and between them and the objects that are being exposed. Neither this interaction requires any physical movement – we can be in the presence of an interaction between the visitor and the object, even if the visitor is *only* thinking and reflecting on the stimulus from the object.


Along with the chapters on interactivity and interactive exhibitions, we added a chapter that already had served as framework for WP3, dedicated to explore and discuss the potentialities of having students planning and developing scientific exhibits on RRI topics. To us, this is also crucial information that has the purpose of providing science teachers with the necessary support to carry on a project of this nature.

Along with the research, we started to write down the first version of the Guide – in its prototype format, which we finalized in May 2014. At that time, after uploading to the IRRESISTIBLE Dropbox folder, we shared with all IRRESISTIBLE partners – through an e-mail – in order to get their feedback and suggestions of improvement. After gathering all the feedback, we proceed to some changes of the initial Guide, adding to it a section on how to create an exhibition “Creating an Exhibit”, focused on the three phases (D’Acquisto, 2006) of exhibit development.

The Lisbon Workshop: testing and evaluation of the Guides’ prototype

The Lisbon Workshop “Planning and Developing an IRRESISTIBLE Exhibition” was hold in the Education Institute of Lisbon University, in the 17th and 18th of October 2014. This event had the purpose of gathering science educators, science teachers and experts from science museums and presenting and discussing some ideas about how to plan, develop and evaluate an IRRESISTIBLE exhibition on Responsible Research and Innovation (**figure 2**). It also had the purpose of testing the content of the Guide, since the planning and concretization of the workshop was, also, based on it.

When planning this event it was clear to us that it was necessary to let the participants experience the interactive scenarios proposed in the Guide. Therefore, we prepared different objects and, for the physical ones, placed them on the room of the Workshop, allowing the participants to place themselves both in the role of visitors and critics (**figures 3-4**). There were also digital versions of some of the objects that were tested by the participants. At the end of this testing session there was a moment of discussion on the positive and negative aspects of each object/scenario, and also on its potentialities and limitations. The feedback from the participants was very positive, which indicated that the Guide was on the right path.



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Engaging the Young with
Responsible Research and Innovation

Workshop program: Planning and Developing an IRRESISTIBLE Exhibition
October 17 and 18, 2014, Lisbon/Portugal

Friday, October 17.
Instituto de Educação da Universidade de Lisboa; Alameda da Universidade, 1649-013 Lisboa

13h00 Welcome, organizational aspects.
Visiting an IRRESISTIBLE Exhibition on RRI with several examples of exhibits (different scenarios).
Presenting the concept of interactivity and discussing different strategies to promote interactivity.

14h00 Analysing and discussing the different dimensions (RRI, Web 2.0 tools and 7E model) of each exhibit.

16h00 Coffee break.

16h30 Miniature museum exhibition and how to write and organize the text for an exhibition.

18h00 How to evaluate the impact of IRRESISTIBLE Exhibitions on teachers, students and visitors.

19h00 End of the session.

Saturday, October 18.
Pavilhão do Conhecimento – Ciência Viva; Alameda dos Oceanos, Lote 2.10.01, 1990-223 Lisboa

9h00 Welcome.

9h15 Brief presentation of the Pavilion of Knowledge – Ciência Viva.
Overview of the planned activities.

9h30 Group 1 – How to build a robot.
Group 2 – Interactive or not? | Exploring littlebits.

10h30 Coffee break.


10h45 Group 1 – Interactive or not? | Exploring littlebits.
Group 2 – How to build a robot.

11h45 Tour to the backstage of the science centre.

12h15 Discussion.

13h30 Wrap-up of the day and evaluation.

14h00 Closing.



The IRRESISTIBLE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101019719. The project has also received funding from the Portuguese Government through the National Institute of Education (IEP) and the National Institute of Scientific and Technological Development (INCTE).




Figure 2 – The official program of the Lisbon workshop.



Figure 3 – The Lisbon Workshop participants at the Education Institute – Lisbon University.



Figure 4 – Testing of the interactivity scenarios at the workshop.

IRRESISTIBLE Exhibitions Guide: from prototype to a final version to be used by CoL teachers

After the Lisbon Workshop, and following the feedback given by the participants, and also following the contributions of some of the IRRESISTIBLE partners, the Guide grew up. And its final 46 pages pdf English version was official shared with every partner, and uploaded in the IRRESISTIBLE Dropbox folder (**figure 5**). This was the version intended to be shared within each CoL and used by its science teachers when testing the IRRESISTIBLE teaching modules in Phase1 of the Project.



Figure 5 – Cover and first page of the final version of the Guide “IRRESISTIBLE Exhibitions: a Development Guide”.

Guides' evaluation by IRRESISTIBLE partners

After the first phase of the Project, it was time to reflect on the usefulness of the Guide. In order to obtain the necessary data to perform that reflection, we created a non-anonymous online questionnaire composed of five questions: one in a multiple choice-type format, another in a Likert Scale-type format, and three open-ended questions. We delivered the questionnaire in January 2016 and asked all partners to fill in.

With the developed questionnaire we aimed at getting feedback from partners concerning:

- a) The use that each partner made of the Guide (multiple choice question);
- b) The appreciation of the distinct parts of the Guide and its usefulness (Likert-type scale question);
- c) The most positive aspects of the Guide (open-ended question);
- d) The most negative aspects of the Guide (open-ended question);
- e) Improvement suggestions (open-ended question);

The data collected from the questionnaire was analysed. The answers to the open-ended questions' underwent content analysis, followed by a quantitative analysis (calculus of absolute and relative frequencies). The answers to multiple-choice and Likert-type-scale questions were subjected to a quantitative analysis (calculus of absolute and relative frequencies). After the analysis of partners' answers, important conclusions were achieved regarding the main **uses that partners' made of the Guide**: a) the Guide served as framework for the work with CoL teachers, especially during the workshops with teachers, b) the Guide was shared with CoL teachers, and c) parts of the Guide were included in the developed teaching modules.

In what concerns **Guides' usefulness**, all partners considered the Guide useful, revealing also that it add something to their knowledge about Interactive Exhibition Development. For the majority, the Guide clarified the concept of Interactive Exhibition, and allowed for a greater awareness on (a) the potentialities of having students planning and developing exhibitions on cutting-edge scientific topics, and (b) the possibilities of scenarios for the IRRESISTIBLE exhibitions.

The *Scenarios of Interactivity* presented in the Guide were the main aspect highlighted by the partners as a **positive aspect**, since they were especially useful for teachers and students, illustrating and clarifying the possibilities of interactive exhibitions and supporting teachers in the process of students' guidance. For us, the presence of the scenarios in the Guide was a priority, given the fact that the development of an interactive exhibition in a school context poses some challenges regarding the novelty of the task, both for students and teachers. Hence, the scenarios were created as examples of what is intended. Our concern was, at the same time, to create scenarios with both a physical and a digital formats, in order to deal with the constraints that are present at several schools regarding the use of ICT. Having that in mind, we tried to include options that could be achieved without a permanent availability of computers.

In what concerns the main **negative aspects** of the Guide, there wasn't a consensus – some partners considered that some sections were too extended and detailed; for others the level of development of some scenarios wasn't appropriate for younger students, as it may be quite demanding for them.

Following partners' **suggestions of Guides' improvement**, a new version of the Guide was developed, which included (a) examples of exhibits developed within the IRRESISTIBLE Project, (b) suggestions of rubrics for evaluating the exhibitions. After the suggestions made by the partners, the second version of the Guide was improved to a 2.1 version. This version was disseminated on a pdf format but also in the format of an electronic magazine¹ (published at ISSUU) and an e-book, published by the Instituto de Educação – Universidade de Lisboa (**figure 6**).

¹ http://issuu.com/institutodeeducacao-universidadedel/docs/development_guide_-_v2.2_web



Figure 6 – The improved version of the Guide.

Description and evaluation of the 32 IRRESISTIBLE exhibitions developed within the first year of module testing

In order to receive feedback from all partners concerning the exhibitions developed within the first phase of the project, we developed a questionnaire asking for each partner to characterize each exhibition regarding: a) the scientific topic, b) the group of students involved (total number, age and grade), c) the place where the exhibition was held, and d) the type of exhibition. We also asked them to include any special remarks

concerning each exhibition. After this characterization, we requested for an overall balance regarding the positive and negative aspects of the set of developed exhibitions and the integration of the Responsible Research and Innovation aspect in them. This questionnaire was sent in October 2015. This analysis followed both a quantitative and qualitative approach.

Characterization of the exhibitions

Within the first phase of the Project, more precisely during the school year 2014/2015, and following the implementation of the several teaching modules, a total of 32 exhibitions were developed. **Table 5** presents a synthesis of their global characterization.

Table 5 – The 32 exhibitions: a synthesis.

Partner	Total of exhibitions	Theme (number of exhibitions per theme)	Total number of students involved	Place of exhibition (number of exhibitions per place)
The Netherlands	4	Carbohydrates in breastmilk	139	School
Finland	1	Adaptation to climate change	87	Museum
Germany (IPN)	2	Plastic – Bane of the Ocean	39	School
Germany (DM)	1	Oceanography	60	School
Portugal	4	Polar Science (3)	169	School
		Climate Geonegineering (1)	43	School
Romania	1	The World of Nanomaterials and Solar Energy	1000	Museum
Turkey	4	Nanotechnology Applications in Health Sciences	97	School (3) University (1)
Poland	6	Nanotechnology	134	School (5) Conference room (1)
Greece	2	Nanoscience and Nanotechnology applications	108	Eugenides Foundation (1) Museum (1)
Italy (UNIBO)	2	Nanotechnology and solar energy	55	School
Italy (UNIPA)	1	Nanoscience for solar energy conversion	73	University
Israel	4	Perovskite-based photovoltaic cells	65	School (3)
				Science Museum (1)
	32		2069	

Regarding the type of exhibition, and taking into account also the interactivity scenarios presented in the IRRESISTIBLE Exhibition Development Guide used by all partners, a great variety of artefacts were produced. Some exhibitions were more homogeneous concerning the type of artefacts; others more eclectic. **Table 6** presents the results with respect to the type of artefacts produced within the 32 developed exhibitions.

Table 6 – Occurrences of types of artefacts within the 32 exhibitions.

Type of Artifact		Number of exhibitions with this type of artifact
Game	Physical (e.g., cardboard, soccertable)	17
	Digital (e.g., quizzes)	3
Poster	Physical	16
	Digital	3
Multimedia presentations (e.g., videos, audio)		10
Cartoons (digital or printed)		6
Models		6
Experiments/demonstrations		5
Digital application		3
Newspaper		1
Book		1
IKEA bookshelf (EXPOneer system)		8

As we can see from **table 6**, it is clear the prevalence of games, posters and multimedia presentations as the main types of artefacts presented within the exhibitions. The option for developing **games**, either physical or digital, was taken into account for the majority of students and teachers involved in the development of the interactive exhibitions. Indeed, games (**figures 7-8**) can be a very powerful strategy for stimulating the participation of visitors, allowing for their interaction and creating an atmosphere where the discussion and reflection about important issues can be accomplished in a more playful manner.

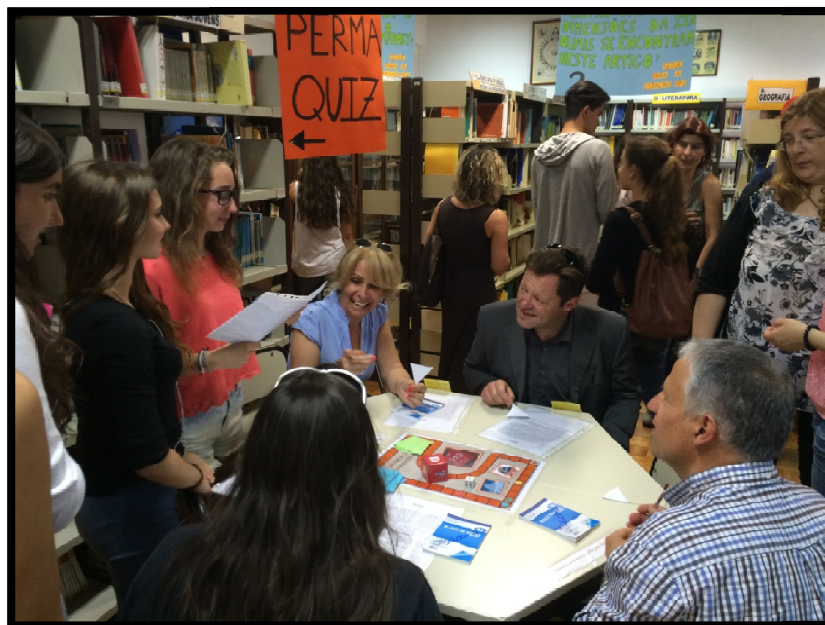
**Figure 7** - The cardboard game about RRI in Polar Science developed by Portuguese students.



Figure 8 – A Turkish student explaining his game to the audience.

The second most frequent type of artefact produced within the IRRESISTIBLE exhibitions was the **poster** (figures 9-10). Having in mind the goal of interactivity, a poster can assume several formats and require from the visitor different responses.



Figure 9 – Posters hanging from the wings of an albatross model, developed by Portuguese students.

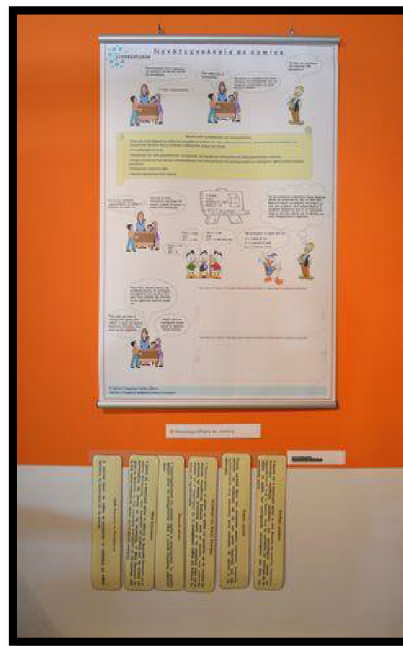


Figure 10 – A poster developed by Greek students; the bottom panels can be placed in the poster by the visitor, allowing him to co-construct the artefact.

In what concerns multimedia presentations (**figure 11**), although this type of artefacts require for a dispositive (PC screen, tablet or other) for their visualization (which may not be a valid option for some schools), their development is normally felt by students as a very enjoyable task, contributing for their motivation towards the exhibition production.

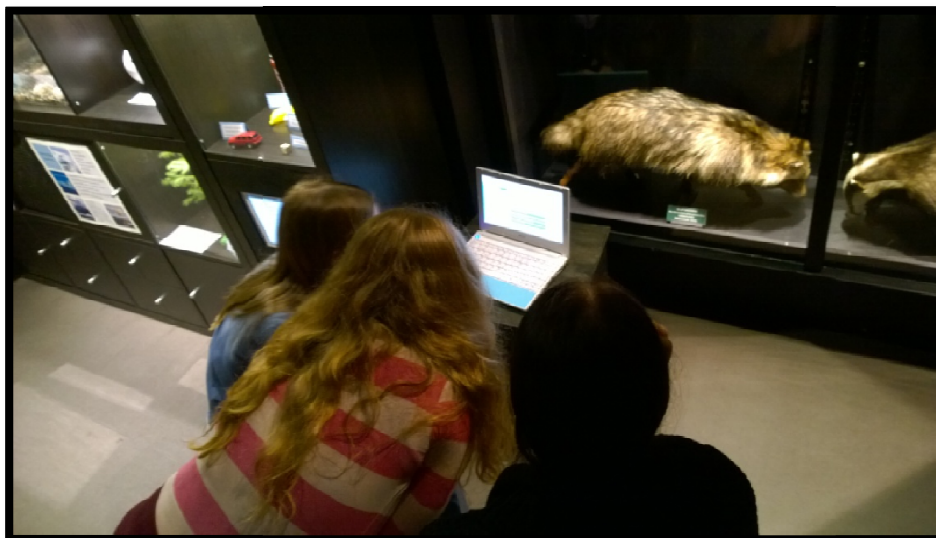


Figure 11 – Finnish students developed videos with the purpose of creating awareness on climate change.

The development of **cartoons** was another option taken into account. Indeed, whether in a printed or digital format, six exhibitions presented this type of artefact as a way to engage visitors with the scientific theme researched by students (**figure 12**).



Figure 12 – Printed cartoons, arranged in a book format, developed by Portuguese students.

The development of **models** was another interesting option for some students and teachers especially when their exhibitions supports on physical and chemical concepts and phenomena (**figures 13-14**).

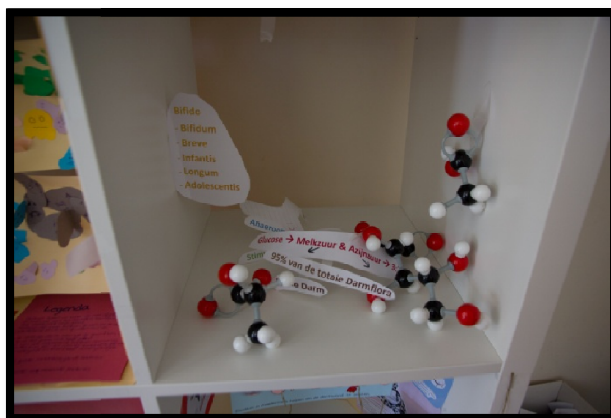


Figure 13 – A model related to the module of Carbohydrates in breast milk, developed by Dutch students. This artefact was an integral part of the IKEA bookshelf system chosen by the Dutch CoL to support their exhibitions.



Figure 14 – A model for the adsorption phenomenon developed by Polish students.

Another artefact, chosen for some IRRESISTIBLE exhibitions, capable of stimulating the interaction between visitors and the exhibition was the **experiment/demonstration** (figure 15).



Figure 15 – An experiment, developed by Italian students.

A special remark must be done to the EXPOneer system that was chosen to support 8 exhibitions. It is a modular exhibition system, based on the furniture of the Expedit/Kallax-

series of IKEA. Each case of the shelf can allocate different types of artefacts, depending on the desire of students and teachers developing the exhibition (figure 16).

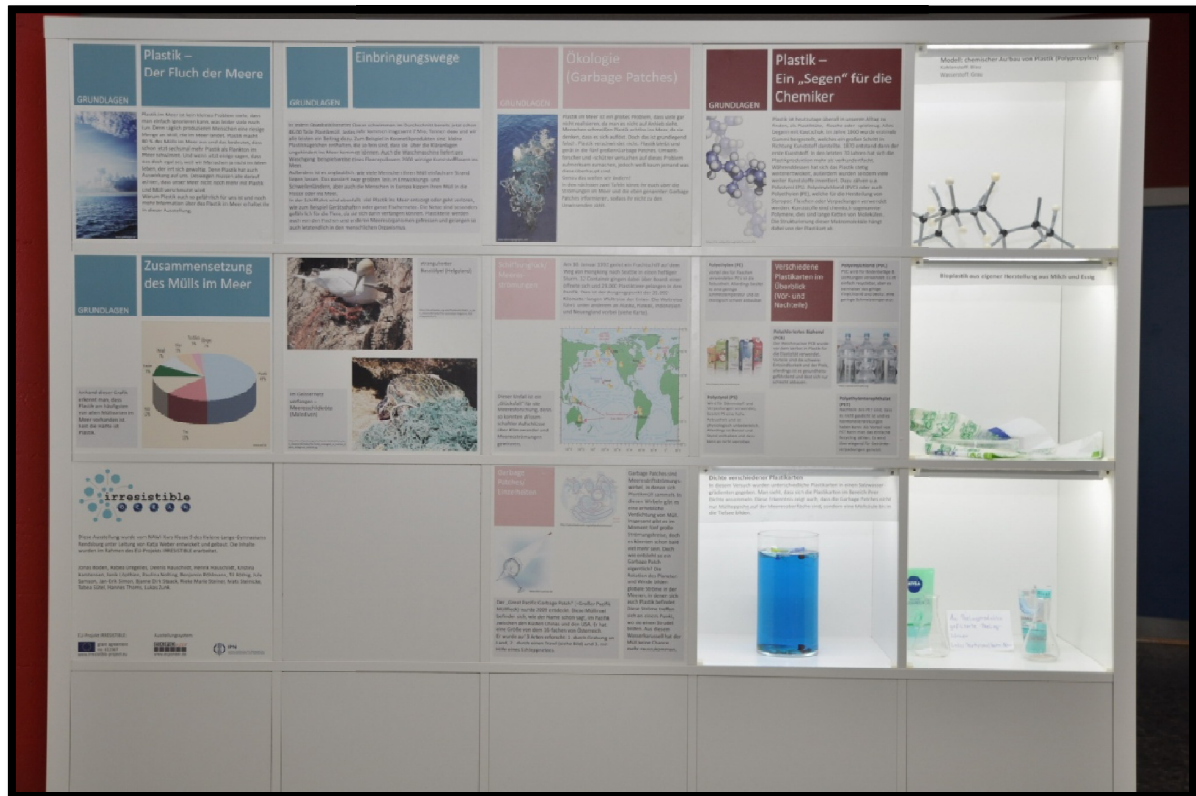


Figure 16 – The EXPOneer system supported exhibition developed by German students; as artefacts, this exhibition held posters, demonstration and models.

Evaluation of the exhibitions

The questionnaire sent to partners in October 2015 asked for a global evaluation of all exhibitions developed within their CoL and their integration of RRI dimensions. The answers underwent a content analysis process, through which categories of both positive and negative aspects emerged.

As what concerns the **most positive aspects**, partners have highlighted that (a) the exhibitions have allowed for students to *develop their learning on the scientific topics and RRI*, (b) students developed a more meaningful learning by the fact that they needed to develop an exhibition for the public, hence, more than having to know something just for the sake of it, they *needed to know something because of the important task of having to explain it to others*, (c) students developed important skills, namely communication, collaboration and teamwork, accountability for results,

problem solving, organization and planning, and information search, (d) students engaged more in their science classes, (e) students were able to express their creativity in a not so (frequent) creative context, (f) the integration of RRI in the scientific topics was facilitated, and (g) it created the opportunity for students to *exchange knowledge* by interacting with the visitors.

As for the more **negative aspects** of the exhibitions developed within the first CoL, partners have highlighted that (a) RRI integration in the exhibition was difficult and, in some cases, poorly achieved, (b) the tasks of developing the exhibition were time consuming, (c) the limitation of resources posed a challenge, (d) the moment of the school year (at the end) chosen for the exhibitions was a bad choice due to the several factors (exams, tests, other activities).

Improvement suggestions

By analyzing and reflecting on the positive and negative aspects of the exhibitions, we elaborated a few improvement suggestions to be taken in consideration by all partners in what concerns the development of the exhibitions in CoL2:

- a) RRI integration: given the results, and taking into account the importance of developing an exhibition that can truly address the RRI issues of the scientific cutting-edge topic studied by students, one might suggest the need to address more frequently and in a more intricate manner the RRI issue during the whole module implementation, and not only during the Extend/Elaborate phase. It might be important to introduce the RRI aspects of the topic at the very beginning of its exploration. That implies from the teacher an effort to previously identify the *loose ends* on the topic that might relate to RRI and bring them to frequent discussions with students.
- b) Time management and moment of school year: having in mind that the majority of partners mentioned as a constrain the time available for the exhibition development, one might suggest that this process should be considered since the beginning of the module implementation. In fact, students must be aware, since the Engage phase, that all their work and effort will result in the development of one exhibition. So it is important to allocate time to think about it during the several weeks/months of Project implementation, not just at the end of it (on the Exchange phase). Also, students and teachers must understand that, although the importance of this Project and of the task of exhibition development, they have other commitments at school (other classes

to attend to, tests, exams, other schoolwork). So they need to focus on developing good, simple and effective ideas. It is also important to choose the best moment of school-year to develop the exhibition, specially the construction phase, preferably a moment when students don't get overload with exams or tests.

- c) Students' engagement and contribution to the task of exhibition development: we cannot forget that students must play a central role in the planning and development of exhibitions, hence their active participation is crucial. If they're not motivated to collaborate or if they don't see the purpose of developing the exhibition, their commitment to this task will decrease. Here the role of the teacher in motivating them and helping them to see how important their work is in order to alert the community for the scientific issues is very important. Students must feel and understand that they play a very important role in society, and they can contribute to solving some of its problems. Presenting an exhibition, based on their own research, with the purpose of inform and alert to important scientific issues that concern us all is a very valid way to play an active citizenship.

What can we conclude from D3.1?

The analysis of the different exhibitions developed in the first phase of the Project allowed us to conclude that **all partners, despite the various novelties within the IRRESISTIBLE (cutting-edge scientific issues linked to RRI, interactive exhibitions and interactive artefacts), made an excellent effort of developing interactive exhibitions**, creating several artefacts capable of promoting the interaction between visitors and between them and the objects.

The **IRRESISTIBLE Exhibition Development** Guide has contributed to these results. Indeed, according to the data gathered from the questionnaire applied to all partners after Phase 1 of the Project, concerning the usability of the Guide, and also their opinion regarding the positive and negative aspects, as well as improvement suggestions, we can conclude that **this tool has great potential in supporting teachers (and, consequently, their students) in the process of exhibit development**. We can also conclude that this tool can be used in the **context of teacher professional development**. In fact, we've developed a tool that allowed, for each partners' CoL, the construction of very important pedagogical knowledge concerning the implementation of interactive exhibition development as a mean of students Exchange, with visitors, their knowledge and concerns regarding cutting-edge scientific themes with a focus on

RRI. Indeed, the developed tool not only allowed for the clarification of the concepts of interactivity and interactive exhibitions – foundational concepts within the abovementioned pedagogical strategy – but also allowed for the enlightening on the more practical aspects related to exhibition development. Aspects such as the three phases (and sub-phases) of exhibition construction, the care that must be taken into account when elaborating texts for exhibitions, and the importance of assessing (and how to assess) the impact of the exhibition on teachers, students and visitors. Finally, the given set of interactivity scenarios contributed to exemplify and operationalize the concepts of interactivity and interactive exhibitions.

The analysis of the partners' feedback regarding the positive and negative aspects of the exhibitions developed by their CoLs, allowed us to perform important learning that was intended to be taken into account by all during the Phase 2 of the Project. Although the novelty of the tasks implied in this Project, one cannot forget its main purpose: to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI). And for that, the phase of exhibition development plays an important role, since the exhibition acts as a platform for students to reach the public and speak out their own thoughts on important social issues, as RRI is. The developed exhibitions have proven to be able to fulfil the Exchange phase of the 6E model (and, for other partners, also the Empowerment phase of the 7E model), acting as a platform for students to share their learning and concerns about the scientific topic, and by doing that, promoting their contribution to help solving some problems related to science-technology-society-environment.

D3.2 “Reports on exhibitions – Vodcasts, podcasts and films, deliverable through the internet, of exhibitions on Responsible Research and Innovation which could be used by teachers in schools as continuing professional development or as an activity to be used with students”

Having in mind the objectives of WP3, more precisely: a) **O3.1** (promoting the involvement of teachers and students in the construction of exhibits addressing the concept of RRI), b) **O3.2** (help teachers and students to understand that uncertainty and risk are inherent to scientific and technological enterprises and so, research and innovation must be driven by responsibility) and, b) **O3.3** (develop teachers’ expertise about how to address Responsible Research and Innovation, related with cutting edge scientific and technological issues, through the construction of exhibitions centred on such issues), it was necessary to develop digital products – vodcasts – deliverable through the Internet, able to disseminate the project and its first results, which could be used by teachers and students in order to support the process of exhibition development. The vodcasts were seen as a tool that could be used by teachers in schools as on-going professional development or with students.

The purpose of D3.2 was to (a) release the final version of the vodcasts, (b) describe the process of vodcasts development, (c) present, and justify, the topics selected for dissemination through the vodcasts, and (d) present, and reflect on, the evaluation made by all partners in what concerns vodcasts’ potentialities, limitations and usefulness.

In order to develop D3.2, several activities were implemented during Year 2 and Year 3 (table 7).

Table 7 – Activities implemented, within WP3, by the coordination team and by all partners. These activities allowed for the development of D3.2.

Activities implemented by WP3 coordination team		Year
The construction of several vodcasts focusing on Exhibits on Responsible Research and Innovation, and on the exhibits that were developed within the IRRESISTIBLE Project during CoL1. The vodcasts, illustrating what can be done by students and teachers within exhibit development focusing on cutting-edge scientific topics, can be used by teachers in schools as continuing professional development. The sources for developing the vodcasts were: a) Project official documents, b) images of CoL1 exhibitions, c) the IRRESISTIBLE exhibition development guide, and d) the case-studies developed by all partners ^a . They were analyzed in order to decide on the content of the vodcasts.		2,3
Activities implemented by all partners		
Share of materials for the vodcasts development (images and case-studies ^a)		2,3
Feedback on the usefulness of the vodcasts		2,3

^aThe activities implemented within WP3 in order to develop the case-studies will be presented in the D3.3 section, which is dedicated exclusively to this matter.

Vodcasts' development

Four vodcasts were designed and produced under the IRRESISTIBLE Project with the aim of: 1) disseminating the project, 2) presenting practical ways of introducing RRI in an educational context, and 3) highlighting the potentialities of interactive scientific exhibitions as an educational strategy to promote scientific literacy and active citizenship, in order to raise the awareness of the community on Responsible Research and Innovation.

The content of the vodcasts resulted from the analysis of several documents and materials: a) project dissemination documents (website, brochure and presentations), b) images and videos from the several exhibitions developed within Col1, c) the IRRESISTIBLE exhibitions development guide, and d) the case-studies developed by all partners, focusing on the evaluation of the process of exhibition development. The iMovie was the editor used for constructing the vodcasts. **Figure 17** presents some screenshots of the vodcasts.



Figure 17 – Screenshots of the vodcasts.

Vodcast content

The contents to be included in the vodcasts were selected taking into account that the audience could be quite diverse and constituted by different age groups and educational levels. It was intended to address the concept of Responsible Research and Innovation, and also the process of developing interactive exhibitions – two main aspects of the Project. **Table 8** lists the vodcasts.

Table 8 – The four vodcasts produced within WP3 and the .url for their access through the YouTube IRRESISTIBLE Project channel.

Vodcast 1	IRRESISTIBLE Project: Engaging the Young with Responsible Research and Innovation https://www.youtube.com/watch?v=vptpl_Sy-80&index=2&list=PLu37haOPMIkoxTxKI9GPu42UH5AMMDsXQ
Vodcast 2	Responsible Research and Innovation in an Educational Context https://www.youtube.com/watch?v=gpcwbkDHjwQ&index=3&list=PLu37haOPMIkoxTxKI9GPu42UH5AMMDsXQ
Vodcast 3	Interactive scientific exhibitions developed by students on Responsible Research and Innovation https://www.youtube.com/watch?v=ifjmbRfP0_8&index=1&list=PLu37haOPMIkoxTxKI9GPu42UH5AMMDsXQ
Vodcast 4	IRRESISTIBLE Project: Exhibitions on cutting-edge scientific topics https://www.youtube.com/watch?v=zIBDtXQvEvU&index=4&list=PLu37haOPMIkoxTxKI9GPu42UH5AMMDsXQ

Vodcast 1 aims to present the project and its context (**figure 18**). It includes the project goals and purpose, the project partners, the definition of RRI and their dimensions, the IBSE approach adopted by the project, the project phases, as well as the expected products and future expectations.

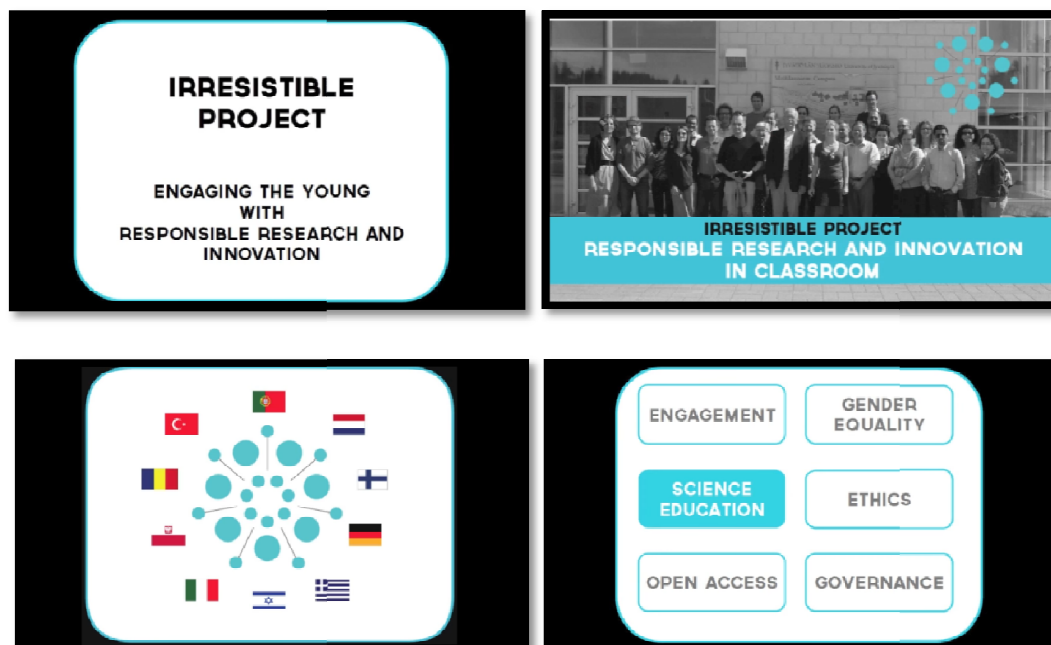


Figure 18 – Screenshots of Vodcast 1.

Vodcast 2 intends to highlight the importance of Responsible Research and Innovation nowadays and show how RRI could be explored in an educational context (**figure 19**). As such, the concept of RRI is presented and exploited, including its six dimensions. It is also justified the importance of RRI and demonstrated why all citizens should be concerned and aware of the need of a Responsible Research and Innovation. Finally, the IRRESISTIBLE teaching modules are presented, indicating the different scientific topics explored, introducing its structure and the final common task to all of them – the exhibition development.

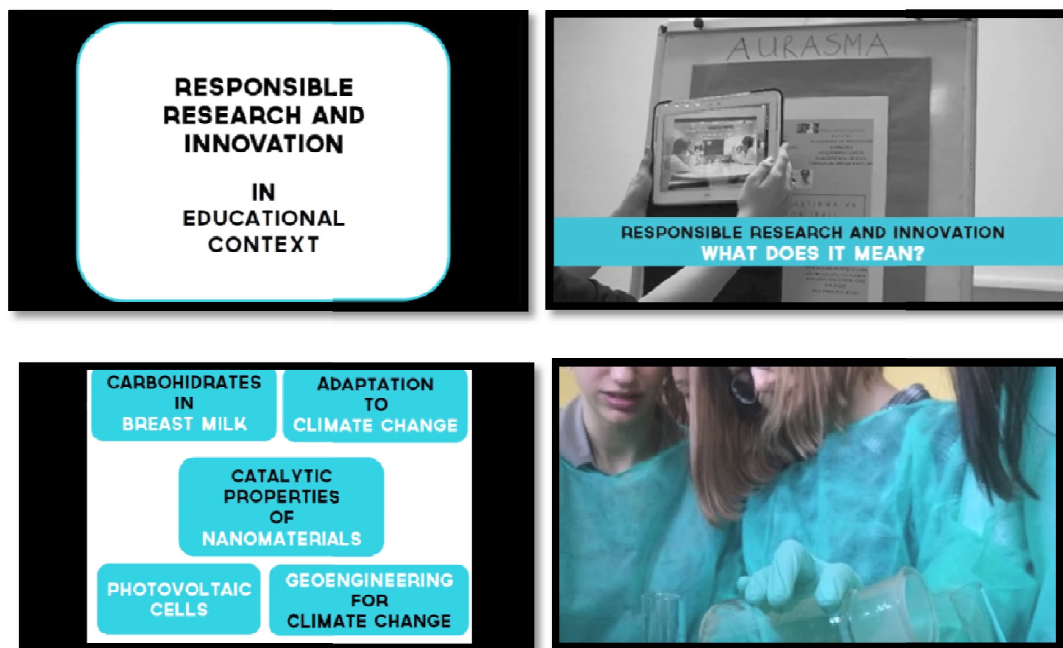


Figure 19 – Screenshots of Vodcast 2.

Vodcast 3 has the purpose of presenting interactive scientific exhibitions as a strategy for activism in school context, in order to raise the awareness of the community on Responsible Research and Innovation (**figure 20**). It is emphasized the potential of the design and construction of the interactive scientific exhibitions in the learning process, both for students and teachers. It is also provided information about the process of exhibition development and how to promote interactivity in exhibitions. The different stages of the process of creating an exhibition are presented and explained, highlighting the most important aspects to take into account either in planning or constructing the exhibitions. In addition, there are presented different interactive scenarios that could be used to create interactive exhibitions, in order to exemplify what is intended.



Figure 20 – Screenshots of Vodcast 3.

Finally, **vodcast 4** intends to give an overview of the several exhibitions developed by Col1 students from all IRRESISTIBLE partners (**figure 21**). This vodcast also presents students' and teachers' perceptions about the process of exhibition development, namely the learning achievements. The development of this vodcasts was supported in the analysis of Col1 case-studies.

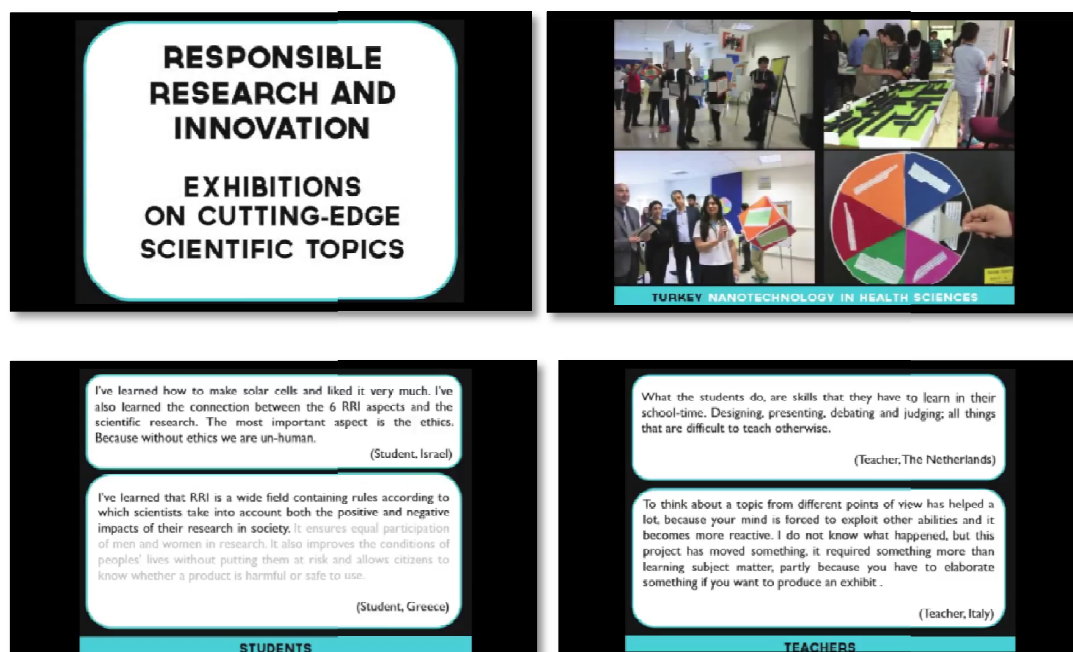


Figure 21 – Screenshots of vodcasts 4.

Justification of the selected topics

The two main topics highlighted in the four vodcasts are: a) RRI in educational context, and b) the process of development of interactive exhibitions addressing the concept of RRI.

The selection of the *RRI in a education context* topic was based in the assumption that the school community – students, teachers and others involved – is, potentially, one of the most important public groups that could practice and disseminate RRI by the fact that it includes young people, adults and educators. The school community has also connections with several Governance components. So, it is essential to develop an appropriate strategy of innovative school community involvement. The development of teaching modules about a cutting-edge scientific topic, addressing the different aspects of RRI – such as social and environmental impact and ethical aspects – promotes positive attitudes towards RRI among students and teachers.

The presentation of the module's topic, methodological suggestions for teachers concerning the implementation in the classroom, and additional sources of information on the subject, allows other interested parties to use the modules in external contexts to the project.

The component of interactive exhibition development is also highlighted since it enables the spread of RRI and the awareness of its importance by the school community, allowing for students to develop their active citizenship skills in what regards their power in participating in collective action for solving problems related with science-technology-society-environment.

As for the topic *the process of development of interactive exhibitions addressing the concept of RRI*, its selection was based on the fact that all IRRESISTIBLE modules foresee the development and construction of interactive exhibits on cutting-edge scientific topics addressing concept of RRI. This process is new for most teachers and students participating in the project, and probably for many other teachers and students.

Through the construction and presentation of exhibits on RRI, both teachers and students are introduced to a different type of science from the one that is usually presented in science classes. Most formal science education focuses on conventional, non-controversial, established and reliable science. On the contrary, cutting-edge scientific and technological matters highlight a “borderline science”, that is controversial, preliminary, uncertain and under debate. In producing an exhibition pupils can re-present scientific facts as speculative questions, transmissive teaching can be transformed, and the audience at the exhibit can construct their own learning.

The construction of exhibits invokes inquiry-based approaches to address the concept of RRI. In the process of creating an exhibit the emphasis is on eliciting personal reflection by those engaging in the exhibit. The discussion inherent to exhibits' preparation can be particularly useful both in terms of learning about the contents, the processes and the nature of science and technology, and in terms of the students' cognitive, social, political, moral and ethical development (Hammerich, 2000; Kolstø, 2001b; Millar, 1997; Sadler, 2004), as is showed by teachers' and students' perceptions about the process of development and construction of exhibitions presented in vodcasts 4.

It is important and necessary to support teachers and students in the process of exhibition development, highlighting the educational potentialities inherent to this process, not only for those that are involved in the exhibition design and construction but also for all visitors. Give them technical knowledge about the development and construction of the exhibits and share possible interactive scenarios is also crucial to develop expertise about how to address RRI (related with cutting edge scientific and technological issues) through the construction of exhibitions centred on such issues.

Vodcasts' evaluation

The usefulness of the vodcasts developed by WP3 coordination team was evaluated through a questionnaire filled by all partners. In order to obtain the necessary data to perform a reflection about the vodcasts, we created a non-anonymous online questionnaire (**figure 22**) composed of five questions: two multiple choice and three open-ended questions. All partners were asked to answer.

With the questionnaire we aimed at getting feedback concerning:

- a) The most positive aspects of the vodcasts (open-ended question);
- b) The most negative aspects of the vodcasts (open-ended question);
- c) The purpose of the vodcasts (multiple choice question);
- d) The means of vodcasts sharing and dissemination (multiple choice question);
- e) Suggestions for improvement (open-ended question).

Feedback on the Irresistible vodcasts

As the WP3 leader we developed 4 vodcasts* focused on the Irresistible project and on the Development of Exhibitions. In these vodcasts we present the Irresistible project, discuss the importance of RRI and its exploration in an educational context, give insights on the potentialities of having students developing scientific exhibitions on RRI and present the developed exhibitions by CoL1 partner countries as well as the perceptions of some of the teachers and students involved in its planning and construction.

In order to get feedback from you regarding the evaluation and use of these vodcasts, we would like you to answer the following questions.

That information is crucial for the reflection aspect of the D3.2.

Many thanks for your cooperation!

The IE-UL partner

*The Vodcasts can be accessed via the following youtube Link:

[VODCAST 1](#)

[VODCAST 2](#)

[VODCAST 3](#)

[VODCAST 4](#)

1. Name of the person who filled this questionnaire | Partner (Country/Organisation)

2. In your opinion, what are the most positive aspects of the vodcasts?

3. In your opinion, what are the most negative aspects of the vodcasts?

4. With that purpose you could use the vodcasts?

☐ Irresistible project dissemination

☐ Irresistible project results dissemination

☐ Continuing professional development of teachers

☐ Activity development with students

☐ Other (please, specify)

5. What kind of vodcast sharing you intend to do?

☐ Institutional websites

☐ Irresistible project partner countries social networks

☐ Personal social networks

☐ Workshops

☐ Other (please, specify)

6. Finally, how could we improve the vodcasts? Please, give us some suggestions.

Concluído

Figure 22 - Screenshot of the questionnaire (<https://pt.surveymonkey.com/r/SLCDD2J>)

The partners indicated as most *positive aspects* the **quality, information, organization and dynamics** of the vodcasts. They considered that the vodcasts have a good design and the sequence of the selected images is well connected with the audio, giving a good visualization of the Project. It is mentioned that the contents are well organized, providing a clear message and good insights into the project, thereby facilitating the understanding of the shared information and displaying a good summary of the whole Project.

As for the *negative aspects*, it was mentioned the **fast switch of some images, the length of some vodcasts** and a **few technical aspects** as the cut of still images, background music and the use of computer generating voices that do not convey emotion.

In what concerns the *purpose of vodcasts' utilization*, partners stated that they will use them to **disseminate the IRRESISTIBLE Project** and also its **results**, for **continuing professional development of teachers** and as an **activity development with students**. The results demonstrate that vodcasts will be used mainly to disseminate the project and its results. Nevertheless, they could be very useful for teachers and students, especially for those that are taking part in CoL2. The vodcasts could give them a clear notion about the purpose of the project, as well as, illustrate and clarify the process of development and construction of interactive exhibitions.

Related to *sharing and dissemination of vodcasts*, partners reported that the means by which they intend to share and disseminate the vodcasts are: the **partners' Institutional websites**, the **social networks** and **workshops**. The dissemination made through Institutional websites and social networks will achieve not only the public who know or are already taking part in the project, but also the audience unaware of the project. That will allow for the dissemination of the project's objectives, the approach taken by the project, and also its results. Dissemination through workshops will also enable the dissemination of the project and its results and also be a tool for teachers' professional development.

As for *improvement suggestions*, partners' suggested a) some technical adjustments (in the presentation of still images, in the background music and in the use of the narration in order to show more emotion), b) placing in all vodcasts information about the project (i.e., objectives) in order to be possible to show the vodcasts separately. One of the partners also suggested adding slides that allow navigating between videos and also with links to the project website.

What can we conclude from D3.2?

According to the results gathered from the questionnaire applied to all partners, concerning the evaluation and usefulness of the vodcasts, their opinion regarding the positive and negative aspects, as well as improvement suggestions, we can conclude that the vodcasts have great potential in the dissemination of the project and its results. We can also conclude that the vodcasts can be a great tool to support teachers and students in the process of exhibition development and in the context of teacher professional development.

D3.3 “Case studies – Case studies about the impact of the process on teachers’ personal and professional development and students’ competences”

Within the three years of the Project, a total of 172 exhibitions on RRI – involving 7295 students – were developed. In order to understand the process of exhibition development and also the impact of this process on both teachers and students in each of the two CoL phases, each partner developed (at least) one case study focusing one particular exhibition. The development of the cases, and its subsequent analysis by WP3 leader, is in close relation with the last of the WP3 objectives: to produce knowledge about the educational potentialities of exhibit construction regarding the concept of Responsible Research and Innovation (**O3.4**).

The purpose of this D3.3 was to (a) discuss on the potentialities of having students planning and developing exhibitions on RRI; (b) describe the process of case-study development; (c) present, and reflect on, the results from the meta-analysis of the case studies in order to better understand the impact of exhibition development on both teachers and students; (d) present the potentialities and limitations of integrating RRI in the process of exhibition development; (e) present and discuss on the impact of students’ participation in IRRESISTIBLE in what concerns their perceptions of the process of exhibition development.

In order to develop D3.3, several activities were implemented during the three years of the Project (**table 9**).

Table 9 – Activities implemented, within WP3, by the coordination team and by all partners. These activities allowed for the development of D3.3.

Activities implemented by WP3 coordination team	Year
The construction and validation of items to be included in the students’ questionnaire (developed within WP5) to evaluate the impact of exhibitions’ planning and development on students’ perceptions regarding their competences.	1
The construction of guidelines for the development of the case-studies, which included: a) the methods to be used for the data collection; b) the case-study general structure; c) teachers’ items guide; d) students’ items guide; e) experts’ items guide. The case studies will allow us to know the impact of exhibitions’ development and construction, addressing the concept of Responsible Research and Innovation, on teachers’ personal and professional development and to understand how students experience these exhibitions and their effects on students’ competences.	1,2
The construction of two case-studies regarding the process of exhibit development in two of the Portuguese schools that tested the Portuguese IRRESISTIBLE teaching modules (CoL1). For the case-studies construction several interviews were conducted – to both teachers and students. The case-studies were shared with the IRRESISTIBLE partners with the purpose of exemplify what was intended with the task of case-study construction.	2
The analysis of the case-studies developed by the IRRESISTIBLE partners (concerning the exhibitions	2,3

developed within CoL1 and CoL2). The case-studies allowed us to know the impact of exhibitions' development and construction, addressing the concept of Responsible Research and Innovation, on teachers' personal and professional development and to understand how students experience these exhibitions and their effects on students' competences.	
Data collection from all IRRESISTIBLE partners – through questionnaire and focus group – regarding the exhibits developed within CoL2, and the integration of RRI in the exhibitions. Analysis of the data in order to conclude about the characterization of the diverse exhibitions, the potentialities and limitations, and ways of improvement.	3
Analysis of students answers to the pre and post-questionnaire to evaluate the impact of exhibitions' planning and development on students' perceptions regarding their competences.	3
Activities implemented by all partners	
Feedback on the prototype of the guide for the development of case-studies focused on the perceptions of students, teachers and researchers enrolled in the process of exhibition development.	1
Data collection of teachers' and students' perceptions regarding the process of exhibition development – through interviews and questionnaires –, in order to build case-studies that allowed for the understanding of the impact of such activities on both students and teachers.	2,3
Development of (at least) one case-study for CoL1 and one for CoL2 in order to evaluate the impact of student-curated exhibitions – addressing the concept of Responsible Research and Innovation – on teachers' personal and professional development and on students' perspectives and competences.	2,3
Description of the exhibitions developed within 2 nd CoL	2,3
Reflections on the positive and negative aspects, and ways of improvement, of all the exhibitions developed within their 2 nd CoL	2,3
Reflections on the potentialities and limitations of integrating RRI in the process of exhibition development.	3

The activities featured on **table 9** allowed for:

- (a) The construction of one tool to be used by all partners in the process of collecting teachers', students' and experts' perceptions regarding the process of exhibition development. With this tool – a Guide, indicating all the procedures to be taken, and also the goals, structure and sections of the case-study – it was guaranteed that the data featured in all partners' cases were comparable. It was also assured that the evaluation of the process of exhibition development to be made by all partners would take into account important aspects for the Project, which should not be kept aside.
- (b) Providing a framework for the development of the case-studies. By developing the efforts of building and sharing with all partners, two case-studies (focusing the development of two Portuguese CoL1 exhibitions) we intended to help those partners that revealed having more difficulties in conceptualizing how should the case-study be. Our two case-studies served as models for the development of the other cases.
- (c) The development of knowledge in what concerns the impact of exhibitions' development and construction, addressing the concept of Responsible Research and Innovation, on teachers' personal and professional development and to understand how students experience these exhibitions and their effects on students' competences.

- (d) The development of knowledge in what concerns the characteristics and diversity of exhibitions developed within CoL2.
- (e) The development of knowledge in what concerns the potentialities, difficulties and ways of improving RRI integration in the process of exhibition development.

Case-study Guidelines: from its development to its application

In order to guide the process of case-study development, we developed a prototype version of case-study guidelines and asked partners to give feedback in order to improve them (May 2014). The final version of the guidelines was made available and shared, via e-mail and Dropbox, with all partners. These guidelines were clarified during the Scopia meeting of 15th April 2015.

The guidelines included: a) Objectives, b) Procedures (regarding participants and data collection), c) Case-study structure and, d) Teachers', Students' and Experts' items guide (**figures 23-27**).

A. Important information

- Each partner has to develop at least one case study per CoL phase;
- The 1st case study has to be delivered, in English, until the end of October 2015;
- The 2nd case study has to be delivered, in English, until the end of June 2016 (preferably) or, at maximum, until the 15th of July 2016;
- Whenever the science-museum expert is, at the same time, the person in charge of collecting the data, he/she will make a self-reflection having in mind the Experts' Guide items;
- The data collection must happen at the end of the process (example: if there is an exhibit at school, and after, one at the university, you need to collect the data after the university exhibition takes place, and you can enrich the case-study adding the perceptions of students and teachers regarding the dimension "school exhibit vs university exhibit").

B. Objectives

In order to know the impact of exhibitions development and construction, addressing the concept of Responsible Research and Innovation, on teachers' personal and professional development and to understand how students experience these exhibitions and their effects on students' competences, WP3 will develop several case studies.

C. Procedures

During the first year of the CoL, each partner is responsible for developing one case study. The case study corresponds to an exhibition on Responsible Research and Innovation, implemented at school, university, science center or museum.

C.1. Participants

The participants of the case study correspond to the target population of the exhibition.

- Teacher(s) who coordinated the exhibition
- Students involved in the exhibition
- Experts from universities, science centers, museums or exploratory and researchers from the thematic field.

C.2. Data collection

In order to collect data for constructing the case study, several methods should be used.

- At the end of the construction and development of exhibitions at schools, universities, and science centers or museums, each partner has to collect data from the teachers, using an individual interview or an open questionnaire, with the goals of understanding: difficulties with the construction and development of exhibits; professional learning; impact on students learning; and evaluating the construction and development of exhibits (Annex A).
- Focus group interview with the students (each group constituted by six to ten students), with the goal of understanding: difficulties in the construction and development of exhibits; competencies developed; and evaluating the construction and development of exhibits (Annex B).
- At the end of development of the exhibition, each partner has to collect data from the scientists and the experts of science centers/museums, using an individual interview or an open questionnaire, with the goal of understanding: perspectives about the process of construction and development of exhibitions; and evaluating the construction and development of exhibits (Annex C).

Figure 23 – Front page of the Case-study Guidelines.

D. Case Study Structure

Exhibition name	
Topics addressed (General topic and RRI topics)	
Teacher(s)	
Student group and grade	
Links to materials	

- 1) Description of the process of construction and development of the exhibition
- 2) Evidences of teachers' perceptions
- 3) Evidences of students' perceptions
- 4) Evidences of the experts' perceptions
- 5) Overall balance
- 6) Partner evaluation

Figure 24 – Case-study structure.

Annex A

TEACHERS' ITEMS GUIDE

Dimensions	Objectives	Questions/Topics
Teacher's characterization	To identify the teacher	<ul style="list-style-type: none"> Gender and age Professional experience Academic education
Students' characterization	To identify the students	<ul style="list-style-type: none"> Gender and age Grade Number of students involved
Topics addressed	To identify the general topic and RRI topics addressed in the exhibition	<ul style="list-style-type: none"> Selected topics Reasons to select the topics
Exhibition' selection	To identify the exhibition	<ul style="list-style-type: none"> Type of exhibition selected Reasons to select the exhibition
Exhibition' construction and development	To understand teachers perspectives about the processes of construction and development of the exhibition	<ul style="list-style-type: none"> How was the exhibition constructed and developed? How much timing was spent? How were the students organized? What difficulties have you experienced in the construction and development of the exhibition? What have you learned in the construction and development of the exhibition? What were the main difficulties that your students faced? What were the main learning goals achieved? Do you consider that the exhibition had any effect on students? Why? Please give us some details.
Evaluation	To reflect on the experience	<ul style="list-style-type: none"> Positive and negative aspects. What would you do differently?

Figure 25 – Teachers' items guide.

Annex B STUDENTS' FOCUS GROUP INTERVIEW GUIDE		
Dimensions	Objectives	Questions/Topics
Students' characterization	To identify the students	<ul style="list-style-type: none"> Gender and age Grade
Topics addressed	To know what students learned about the topic	<ul style="list-style-type: none"> What have you learned about the general topic and the RRI topics? Do you consider these topics important in our daily life? Why?
Exhibitions' construction and development	To understand students perspectives about the process of construction and development of the exhibitions	<ul style="list-style-type: none"> How was the exhibition constructed and developed? What difficulties have you experienced during the construction and development of the exhibition? What have you learned during the construction and development of the exhibition?
Evaluation	To reflect on the experience	<ul style="list-style-type: none"> Positive and negative aspects. What would you do differently?

Figure 26 – Students' focus group interview guide.

Annex C EXPERTS' ITEMS GUIDE		
Dimensions	Objectives	Questions/Topics
Experts' characterization	To identify the experts	<ul style="list-style-type: none"> Gender and age Professional experience Academic education
RRI Topic	To understand the experts' perspectives about the general topic and the RRI topics addressed in the exhibition	<ul style="list-style-type: none"> Do you consider these topics important? Why? What was your influence on the decision about these topics? If it were now, you still had the same opinion. Why?
Exhibitions' construction and development	To understand the experts perspectives about the process of construction and development of the exhibitions	<ul style="list-style-type: none"> What was your contribution to the construction and development of the exhibition? How was the exhibition constructed and developed? What have you learned with teachers and students during the construction and development of exhibition? What were the main difficulties that teachers and students felt? What were the main learning goals achieved by students and teachers? Do you consider that the exhibition had any effect on teachers and students? Why? Please give us some details.
Evaluation	To reflect on the experience	<ul style="list-style-type: none"> Positive and negative aspects What would you do differently?

Figure 27 – Experts' items guide.

Case-study analysis

In order to evaluate the process of students' exhibitions development, each partner was responsible for developing at least two case studies (one in each phase of the project) comprising **information** from: (1) teacher(s) who coordinated the exhibition, (2) students involved in the planning and construction of the exhibition, and (3) experts from universities, science centres/museums and researchers from the thematic field of the exhibition.

Data collection comprised three steps, the first of which corresponded to (1) an interview with the teacher(s) or an open questionnaire, focusing on their *difficulties* with the construction and development of exhibitions, their *professional learning*, their thoughts on the *impact on students learning* and their *overall evaluation* of the process

of construction and development of the exhibition; (2) a focus group interview with a group of students who planned and developed the exhibition, focusing on their *difficulties* in the construction and development of the exhibition, the *skills developed*, and their *overall evaluation* of the process of construction and development of the exhibition; and (3) an interview with the scientist and the experts of science centre/museums or an open questionnaire, focusing on their perspectives regarding the process of construction and development of the exhibition, and their *overall evaluation* of that process.

Each case study had to follow the same **structure**, which comprised (a) the exhibition name, (b) the covered RRI topics, (c) teacher(s) name, (d) student group and grade, and (e) links to materials. Each case study had to address the following questions: (1) description of the process of construction and development of the exhibition; (2) evidences of teachers' perceptions (data collected from the interview or open questionnaire); (3) evidences of students' perceptions (data collected from the focus group interview); (4) evidences of the experts' perceptions (data collected from the interview or open questionnaire); (5) overall balance (regarding teacher, students and experts perceptions), and finally, (6) partner evaluation.

Individual and focus group interviews were transcribed and subjected to a qualitative content **analysis**. Transcription facilitated further analysis and established a permanent written record of the group discussion that could be shared with the project partners. Once the transcript was finished, it served as the basis for the qualitative analysis through content analysis. **Figure 28** synthesizes the process of case-study development and analysis.

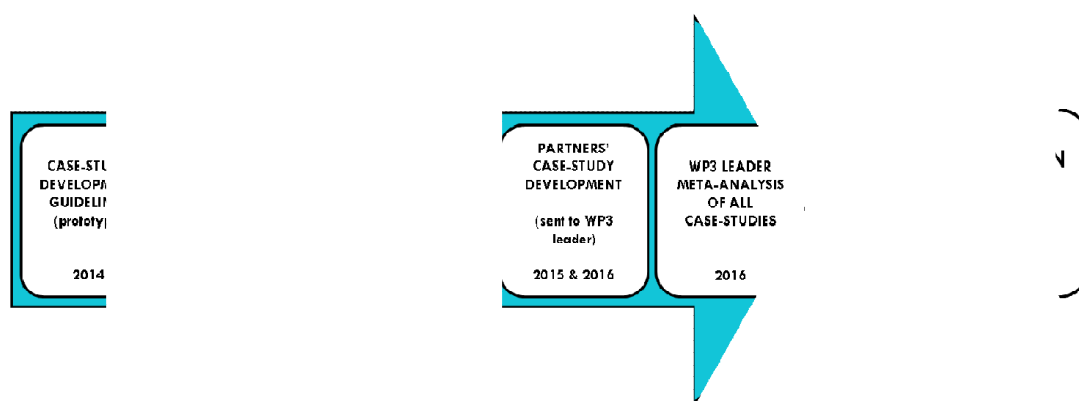


Figure 28 – The process of case-study development started in 2014, with the development of the Guidelines made available to all partners. In each of the two CoLs each partner produced at least one case-study. The whole group of cases was then analyzed by the WP3 leader.

Portuguese case-studies: two examples for guiding partners on the development of their cases

Aiming at helping partners with the construction of the cases, we elaborated two cases-studies concerning the development process of two Portuguese exhibitions and shared them with all partners in late August 2015 (**figure 29**).



Figure 29 - Front page of one of the two CoL1 Portuguese case-study and table of characterization of the exhibition, participants and links to materials.

Case-studies' cross-analysis

For the 1st CoL round, there were produced 14 case-studies and for the 2nd round, 12 case studies (**table 10**). The 26 case-studies were analyzed as a whole group of case-studies.

Table 10 – Total of case-studies analyzed (Col1 + Col2)

	Partner	Exhibition topic	Teachers	Students	Classes	Grade	Experts
Col1 (2014/2015)	Finland	Climate Change	4+16=20	86	4	6 th	3
	Germany - IPN	Ocean Plastic Pollution	1	22	1	9 th	1
	Germany - DM	Oceanography	4	60	2	9 th	3
	Greece	Nanotechnology	1	16	1	8 th	*
	Israel	Nanotechnology	1	16	1	9 th	*
	Italy - UniBO	Nanotechnology	1	23	1	12 th	*
	Italy - UniPa	Nanotechnology	3	73	4	8 th & 11 th	*
	Poland	Nanotechnology	1	35	1	10 th	5
	Portugal	Climate Geoengineering	2	21	1	8 th	2
		Polar Science	1	46	2	10 th	2
	The Netherlands	Carbohydrates in Breast Milk	2	81	3	11 th	1
		Carbohydrates in Breast Milk	2	18	1	11 th	1
	Romania	Nanotechnology	1	210	7	10-12 th	1
	Turkey	Nanotechnology	1	20	1	5-9 th	3
Col2 (2015/2016)	Finland	Climate Change & Geoengineering	1+2=3	30	4	6 th	3
	Germany - IPN	Ocean Plastic Pollution	1	27	1	11 th	2
	Greece	Nanotechnology	1	21	1	10 th	*
	Israel	Carbohydrates in Breast Milk	1	32	1	11 th	*
	Italy - UniBo	Nanotechnology	1	136	6	4-9 th / 1-10 th / 1-11 th	6
	Italy - UniPa	Nanotechnology	4	61	4	10 th & 11 th	*
	Poland	Nanotechnology	1	35	1	8 th	9
	Portugal	Climate Geoengineering	1	27	1	10 th	1
		Polar Science	1	27	1	10 th	1
	The Netherlands	Carbohydrates in Breast Milk	2	55	2	11 th	1
	Romania	Nanotechnology	1	25	1	7 th & 8 th	1
	Turkey	Climate Change	15	154	6	5 th -10 th	5
			72	1357	59		51

*information not provided

After gathering all case-studies we proceeded to their cross-analysis concerning the following items:

- The process of exhibition development: 1) who were the participants?; 2) what sort of activities and tasks were implemented before the actual planning of the exhibition took place?; 3) what happened during the phases of planning and construction of the exhibition?; 4) what were the places chosen to display the exhibitions?
- Students and teachers' difficulties;
- Students and teachers learning achievements;
- The importance of the topics for students' lives;
- Overall balance: positive and negative aspects; improvement suggestions.

Participants

Regarding the Col1 and Col2 members, there were involved in the development and construction of scientific interactive exhibitions 72 science teachers, 1357 students distributed over 59 classes from 5th to 12th grade, supported by 51 science educators and experts from museums and science centres.

Activities and tasks subsidiary for the exhibition planning

The development and construction of an interactive exhibition was the final task common to all modules. The exhibition should emphasize the scientific subject explored in the module and make explicit the dimensions of RRI in order to elucidate the visitors, whether on the scientific subject or the RRI concept, giving insights into current research and stimulate visitors' thoughts and opinions on controversial subjects through information.

The modules include several previous tasks and activities designed to engage students in the scientific theme and in the RRI dimensions. These activities were all conducted with a focus on generating content and input to the exhibition in both areas. The activities with higher implementation were: a) lectures/talks from experts, b) brainstorming/debates, c) hands-on activities/experiments, d) and visits to University labs, Museums and science centres. It is a consensus among the diverse CoL1 and CoL2 members that the tasks and activities that led up to the exhibition design were crucial for students to build knowledge that would allow them to develop ideas on the approach to be followed regarding the exhibit objects planning and construction. In fact, the construction of the interactive exhibition as a final task turned out to guide and give direction to the development of the previous tasks with a goal to meet from the beginning.

Planning and construction of the exhibitions

The planning and construction of the exhibition – the final task common to all modules – was taken into account from the onset of the module implementation. The exhibitions should be planned with the aim of highlight the scientific cutting-edge topics and also the concept of RRI and their dimensions and having in mind that they must be interactive. All the exhibitions were planned and constructed by students. The Finnish case was the only exception – being developed by student-teachers. In the majority of the exhibitions, the process was initiated by a group brainstorming or debate about the topics to include in the exhibition. In other the topics were defined from the beginning of the module implementation. The selection of the topics to include in the exhibition was followed by the organization of the students in small groups and the topic assignment by each working group, as well as, the design and construction of the objects related to the topic. Students were free to choose the type of object to conceive, having in mind the interactive character that the exhibition should have and using accessible materials that could be bought easily or recycled. The objects were built into the majority of the cases out of the classroom due to the time needed for the building process. Concerning to the interactive scenarios selected and the type of objects built by students, some exhibitions were more homogeneous and

others more eclectic: **games, models, experiments/demonstrations** and **posters** were the main types of objects presented within the exhibitions.

Where the exhibitions did took place?

Regarding the place of display of the exhibitions, schools were the favourite spot. Twenty one of the twenty six exhibitions were displayed at the schools. The Finnish exhibition was displayed in the Natural History Museum of Central Finland. The Italian RRI and Solar Energy exhibition was displayed as a boost at the EsperienzaInsegna, a general science fair held in Palermo. The Portuguese Climate Geoengineering CoL1 exhibition was displayed on the Web. The Greek CoL2 exhibition was displayed at The Natural History Museum of Crete in Heraklion. The Portuguese Climate Geoengineering CoL2 exhibition was displayed on the City Sports Park, as an event of the Children's Day event. In addition to being shown in school, the Polish exhibition was also displayed at the 43 CIMUSET CONFERENCE and at the SPIN DAY in the courtyard of the Jagiellonian University Museum. Also, the Romanian exhibition was displayed at the "Simeza Hall" of the History Museum of Dâmbovița County, the Turkish exhibition was displayed at Bogazici University, the Italian UNIBO exhibition in Museo del Balithe, the CoL2 Polish exhibition in the Jagiellonian University Museum, and Carbohydrates in Breast Milk exhibition from The Netherlands was displayed in the Night of Arts, a science event at a large church in the centre of Groningen. The amount of time that the exhibits were on display was quite varied. Some exhibits were on display one day and some a month.

Students' and teachers difficulties along the process of exhibition development

The process of exhibition development posed some difficulties for both students and teachers. After the analysis of the 26 case-studies, the difficulties were categorized having in attention the ones that respect students' difficulties (either mentioned by them and/or by their teachers) and the ones that respect teachers' difficulties (mentioned by teachers themselves).

The main challenges that **students** faced were: a) organization and management of group work; b) novelty of the scientific topic and RRI; c) planning the exhibition; d) time management; and e) constructing the exhibition. As for the main difficulties for **teachers**, those included: a) time management; b) novelty of scientific topic and RRI; c) project and group work management; and d) exhibition planning and construction.

Students' and teachers learning achievements along the process of exhibition development

The main learning achievements for **students** were: a) the scientific topic and RRI; b) project management and group work; c) development of interactive exhibits; and d) selection and organization of relevant information. Regarding **teachers**, the major learning achievements concerns: a) the didactic strategy and its potentialities; b) the scientific topics and RRI; c) organizational and project management skills; and d) interpersonal skills.

The importance of the topics for students' lives

Throughout the process of exhibition development – and in the previous tasks of the modules – students developed their learning about the scientific theme and the RRI in close relation to it. We wanted to know if students attributed importance to what they have learned, and if they considered that learning important for their everyday lives. That could show us if they attributed personal meaning and a sense of relatedness to the scientific topics and also to the theme of Responsible Research and Innovation.

The majority of the interviewed students have mentioned that the topics worked throughout the module and during the process of exhibition development were **important for their present lives**. Some have only mentioned the importance attributed to the scientific topic, others, to both that and RRI, which indicates that for some students RRI was also meaningful – apart from the scientific topic itself. A lesser number of students considered the topics more important to their **future** than to their present lives. Finally, some students found the topics only partly important to their lives.

Overall balance

Both students and teachers that were involved in the process of exhibition development focused by the case-studies have indicated positive and negative aspects associated with their experience. For students, the main positive aspects were: a) the development of an active learning; b) the learning off new scientific topics and RRI. For teachers, the main positive aspects were: a) students' active learning; b) satisfaction by achieving such a new project; c) the development knowledge about cutting-edge science topics and RRI.

As for the negative aspects, the main ones pointed by students were: a) the planning of the exhibition; and b) the building of the exhibition. Concerning teachers, the main negative aspects were: a) time management; and b) group work management.

Both students and teachers indicated improvement suggestions of their performance in order to overcome difficulties. For students it could be important to improve the

design of their exhibitions in order to achieve more interactive exhibitions, and a better integration of the RRI domain. Teachers would have liked to manage better the tasks implied in the development of the exhibition – this first experience allowed them to build knowledge regarding a better planning and time allocation for the different tasks.

The cross-analysis of the 26 case-studies allowed us to conclude that:

- a) Students did appreciate the new didactic strategy of IRRESISTIBLE Exhibitions Development, felt more motivated to learn and engaged more in their learning process;
- b) Students learned about new scientific topics and about Responsible Research and Innovation, and developed important skills;
- c) Students overcome their initial low expectations and recognized that they were capable of developing such a big and new endeavour;
- d) Students faced difficulties, especially in what concerns: a) the management of the group work and project tasks; b) the integration of RRI in the exhibition;
- e) This didactic strategy represents a great opportunity to involve (and educate) the community, allowing students to develop active citizenship skills;
- f) Teachers appreciated the experience and valued the new didactic strategy, identifying in it several potentialities in what concerns Science Education;
- g) Teachers faced difficulties, but in general were able to surpass them. Those
- h) Teachers developed as professionals.

Description and evaluation of the 186 IRRESISTIBLE exhibitions developed within the second year of module testing

Although the analysis of all exhibitions developed within the third year of the project was not the scope of D3.3 – which focuses on the case-studies – we decided that it would be important to develop an overall analysis of the IRRESISTIBLE exhibitions. Especially because we had already done that with the exhibitions developed within the second year of the Project. So, once more, we asked all partners to fill in the same questionnaire that had already been distributed during the second year of the project. This questionnaire had the purpose of collecting information concerning several aspects of the exhibitions: a) the scientific topic, b) the group of students involved (total number, age and grade), c) the place where the exhibition was held, and d) the type of exhibition. We also asked them to include any special remarks concerning each exhibition. After this characterization, we requested for an overall balance regarding the positive and negative aspects of the developed exhibitions and their integration of the Responsible Research and Innovation dimensions. This questionnaire was sent in September 2016. This analysis followed both a quantitative and qualitative approach.

Within the third year of the Project there were developed 186 exhibitions, involving 333 science teachers and 5271 students (**table 11**). Adding those numbers to the ones related to 1st CoL exhibitions, we end up the IRRESISTIBLE Project with a total of 218 exhibitions developed within its three years of duration (**table 12**).

Table 11 – Characterizations of IRRESISTIBLE exhibitions developed within the third year of the Project (second year of module testing).

Partner	Total of exhibitions	Theme (number of exhibitions per theme)	Total number of students involved	Place of exhibition (number of exhibitions per place)	Total number of teachers involved (Science and Non-Science – ST and NST)
The Netherlands	13	Carbohydrates in breastmilk (9) Polar Science (2) Nanotechnology (2)	411	School (12) Church (1)	29 ST
Finland	14	Nanotechnology (5) Climate change (6) Climate Geoengineering (3)	311	School (12) Online (2)	56 ST (41 in teacher training)
Germany (IPN)	12	Oceanography (6) Nanotechnology (4) Plastic Pollution in Oceans (2)	264	School	14 ST
Germany (DM)	2	Nanotechnology	45	School	2 ST
Portugal	15	Plastic Pollution in Oceans (5) Climate Change (3) Polar Science (2) Climate Geoengineering (2) Extension of Portuguese Continental Shelf (1)	483	School (13) City Sports Park (1) University (1)	18 ST
Romania	11	Nanotechnology	1000	Science Museum (1) School (10)	30 ST
Turkey	14	Nanotechnology (6) Plastic Pollution in Oceans (5) Climate Change (3)	596	School (9) Science Centre (5)	65 ST 1 NST
Poland	26	Nanotechnology	884	School (25) Science Museum (1)	41 ST 8 NST
Greece	46	Nanotechnology (23) + Plastic Pollution in Oceans (16) + Carbohydrates in breastmilk (7)	646	Science Centre	35 ST
Italy (UNIBO)	20	Nanotechnology	233	School (10) Science Museum (10)	22 ST 12NST
Italy (UNIPA)	3	Nanotechnology	133	School	12 ST
Israel	10	Nanotechnology (8) Carbohydrates in breastmilk (1) Plastic Pollution in Oceans (1)	265	School (8) Science Museum (2)	9 ST
	186		5271		333 ST 21 NST

* Information not provided

Table 12 – IRRESISTIBLE Exhibitions: a synthesis.

	Partner	Total of exhibitions	Theme (number of exhibitions per theme)	Total number of students involved	Place of exhibition (number of exhibitions per place)	Total number of teachers involved (Science and Non-Science – ST and NST)
Col1 (2014/2015)	The Netherlands	4	Carbohydrates in breastmilk	139	School	6 ST
	Finland	1	Climate change	87	Museum	30 ST
	Germany (IPN)	2	Plastic Pollution in Oceans	39	School	2 ST
	Germany (DM)	1	Oceanography	60	School	2 ST
	Portugal	4	Polar Science (3) Climate Geonegineering (1)	212	School (3) Online (1)	7 ST
	Romania	1	Nanotechnology	1000	Museum	30 ST
	Turkey	4	Nanotechnology	97	School (3) University (1)	10 ST
	Poland	6	Nanotechnology	134	School (5) Conference room (1)	8 ST
	Greece	2	Nanotechnology	108	Eugenides Foundation (1) Museum (1)	5ST
	Italy (UNIBO)	2	Nanotechnology	55	School	2 ST
	Italy (UNIPA)	1	Nanotechnology	73	University	4 ST
	Israel	4	Nanotechnology	65	School (3) Science Museum (1)	2 ST
Col2 (2015/2016)	The Netherlands	13	Carbohydrates in breastmilk (9) Polar Science (2) Nanotechnology (2)	411	School (12) Church (1)	29 ST
	Finland	14	Nanotechnology (5) Climate change (6) Climate Geoengineering (3)	311	School (12) Online (2)	56 ST (41 in teacher training)
	Germany (IPN)	12	Oceanography (6) Nanotechnology (4) Plastic Pollution in Oceans (2)	264	School	14 ST
	Germany (DM)	2	Nanotechnology	45	School	2 ST
	Portugal	15	Plastic Pollution in Oceans (5) Climate Change (3) Polar Science (2) Climate Geoengineering (2) Extension of Portuguese Continental Shelf (1)	483	School (13) City Sports Park (1) University (1)	18 ST
	Romania	11	Nanotechnology	1000	Science Museum (1) School (10)	30 ST
	Turkey	14	Nanotechnology (7) Plastic Pollution in Oceans (4) Climate Change (3)	596	School (9) Science Centre (5)	65 ST 1 NST
	Poland	26	Nanotechnology	884	School (25) Science Museum (1)	41 ST 8 NST
	Greece	46	Nanotechnology (23) + Plastic Pollution in Oceans (16) + Carbohydrates in breastmilk (7)	646	Science Center	35 ST
	Italy (UNIBO)	20	Nanotechnology	233	School (10) Science Museum (10)	22 ST 12NST
	Italy (UNIPA)	3	Nanotechnology	133	School	12 ST
	Israel	10	Nanotechnology (8) Carbohydrates in breastmilk (1) Plastic Pollution in Oceans (1)	265	School (8) Science Museum (2)	9 ST
		218	Nanotechnology (131) Plastic Pollution in Oceans (32) Carbohydrates in breast milk (21) Climate change (13) Oceanography (7) Polar Science (7) Climate Geoengineering (6) Extension of Portuguese Continental Shelf (1)	7340	School (139) Science Centre/Museum (70) University (3) Other (5)	439 ST 21 NST

Regarding the type of exhibition, and taking into account also the interactivity scenarios presented in the IRRESISTIBLE Exhibition Development Guide that was used by all partners, there were produced a great variety of artefacts. Some exhibitions were more homogeneous concerning the type of artefacts; others more eclectic. **Table**

13 presents the results with respect to the type of artefacts produced within the 218 developed exhibitions, and **table 14** indicates the top 5.

Table 13 – Occurrences of types of artefacts within the 218 exhibitions.

Type of Artefact		Number of exhibitions with this type of artefact	% of exhibitions with this type of artefact
Game	Physical (e.g., cardboard, soccer table)	66	38
	Digital (e.g., quizzes)	14	8
Poster	Physical	67	39
	Physical but 3D (cubes, objects...)	37	22
	Digital	13	8
Multimedia presentations (e.g., videos, audio)		37	22
Web-integrated exhibit /website/Blog		10	6
Cartoons (digital or printed)		6	3
Models		32	19
Experiments/demonstrations/simulations		32	19
Digital application		3	2
Newspaper		1	1
Book		6	3
Play		1	1
Hologram		1	1
Prototype		1	1
IKEA bookshelf (EXPOneer system)		31	18

Table 14 – The top 5 type of IRRESISTIBLE exhibitions' artefacts.

Type	% occurrence
Poster (physical)	39
Game (physical)	38
Poster (physical but 3D)	22
Multimedia presentations	22
Models	19

As we can see from **table 14**, the prevalence of posters, games, multimedia presentations and models as the main types of artefacts presented within the exhibitions is clear. The most frequent type of artefact produced within CoL2 IRRESISTIBLE exhibitions was the **poster** (on its physical format – 2D and also 3D).

When we think of a poster, what comes into our minds is something static, that does not imply the manipulation by the reader, full of text, with some images – thinking of a poster as something *interactive* is, perhaps, a hard task. Nevertheless, with the help of the IRRESISTIBLE Exhibitions Development Guide in combination with students' remarkable creativity, the posters developed within the IRRESISTIBLE exhibitions were, indeed, interactive and fulfilled the goal of actively engaging the visitors. Indeed, these posters assumed several formats and required from the visitor different responses (figure 30).

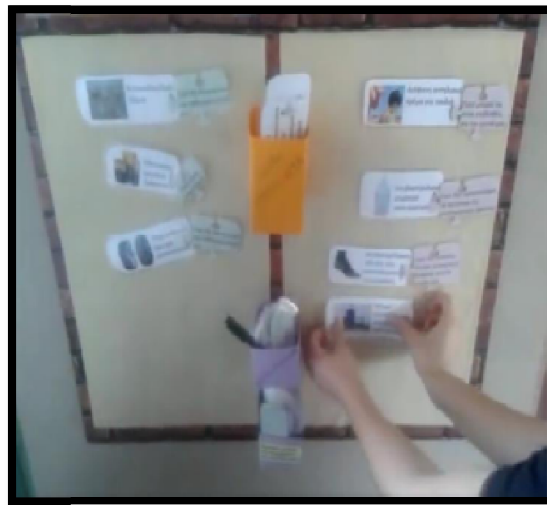


Figure 30 - Interactive poster where visitors need to decide which materials they would use and which not, sticking the corresponding images to the specific area at the poster – developed by Greek students.

The option for developing **physical games** was taken into account for many students and teachers involved in the development of the interactive exhibitions. Indeed, games can be a very powerful strategy for stimulating the participation of visitors, allowing for their interaction and creating an atmosphere where the discussion and reflection about important issues can be accomplished in a more playful manner (figures 31-32).



Figure 31 – Interactive games developed by Polish students presented in the “The Nanoscientist” exhibition.



Figure 32 – The Polar Twist game developed by Portuguese students for the *RRI in the Portuguese Polar Science* exhibition.

Multimedia presentations, such as videos or other presentations were also chosen by many students and teachers involved in the Project. Although this type of artefacts require for a dispositive (PC screen, tablet or other) for their visualization (and that may not be a valid option for some schools), their development is normally felt by students as a very enjoyable task, contributing for their motivation towards the exhibition production.

The development of **models** was another popular option for some students and teachers especially when their exhibitions focused on physical and chemical concepts and phenomena (**figure 33**).

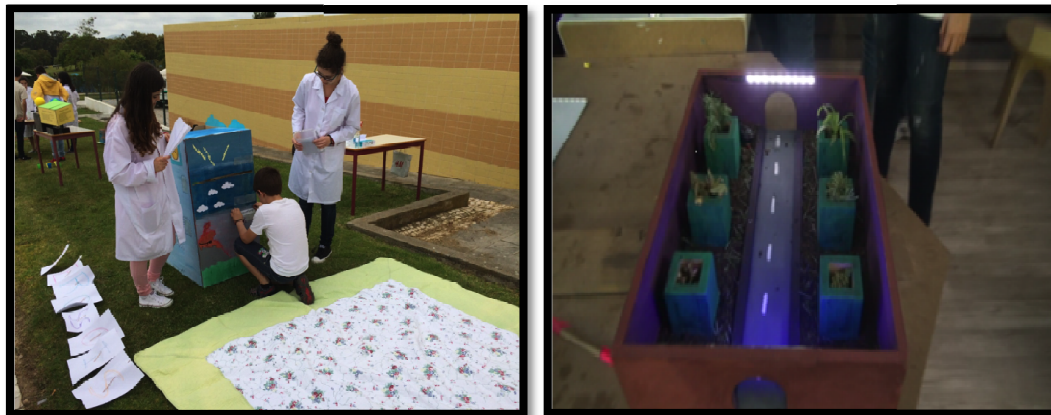


Figure 33 – Model simulating the dispersion aerosols by a miniature aircraft, Portugal (left) and Models made by Turkish students (right).

Evaluation of the exhibitions

On the questionnaire sent to partners in September 2016, we asked them, having in mind the global of exhibitions developed within their CoL and the integration of RRI in them, to indicate the most positive and negative aspects. The analysis of their answers followed a content analysis approach, through which emerged categories of both positive and negative aspects. The results are very similar to the ones achieved within the CoL1 exhibitions.

As what concerns the **most positive aspects**, partners have highlighted that (a) the exhibitions have allowed for students to *develop their learning on the scientific topics and RRI*, (b) students developed a more meaningful learning by the fact that they needed to develop an exhibition for the public, hence, more than having to know something just for the sake of it, they *needed to know something because of the important task of having to explain it to others*, (c) students developed important skills, and (d) students engaged more in their science classes.

As for the more **negative aspects** of the exhibitions developed within the second CoL, partners have highlighted that (a) RRI integration in the exhibition was, again, proved to be a difficulty – although much better achieved than the 1st round of exhibitions, (b) the tasks of developing the exhibition are very time consuming, and very often collide with other school activities, and (c) the limitation of resources posed a challenge.

Integrating RRI in the process of exhibition development

In order to produce specific knowledge in what concerns the integration of RRI in the exhibitions, in the questionnaire sent to all partners in September 2016 we also included one question aimed at this aspect. Having in mind that this was the second year of exhibitions, we all were in a better position to reflect on the potentialities and limitations of integration RRI in the exhibitions, and give specific suggestions of improvement. In order to complement these data, during the final meeting of the Project – in Kiel, Germany – we also collected partners' opinions during a focus group interview.

Potentialities

One of the goals of the IRRESISTIBLE was to involve students, teachers and the public in the process of Responsible Research and Innovation. For this to happen, the final exhibitions to be developed by students had to integrate the aspects of RRI that were more relevant to the scientific topic under students' research. Even though this integration was not an easy task, all partners found potentialities in it (**table 15**).

Table 15 - Potentialities on the integration of RRI in the process of exhibition development (N=11)

Opportunity for students and teachers to consider social and global problems not normally included in science classes	10
Promotes students' and teachers' engagement and motivation for learning about RRI	5
It allows for a better/deep understanding of RRI	5
It represents an opportunity for students to develop an active role on exchanging information about RRI to visitors	3
It represents an assessment strategy of the teaching and learning of RRI	3
Opportunity to promote the public awareness on RRI	3
It represents an opportunity for students to consider and use new methods and techniques in order to engage the public in their exhibition	2
Helps students and teachers to change their attitudes towards RRI	1
The attractiveness of themes can promote the involvement of parents in the exhibition development process	1

The majority of partners agree that the integration of RRI in the process of exhibition development creates an **opportunity for students, and also teachers, to take into account global problems that are not normally included in sciences classes**. Although the IRRESISTIBLE Project had as a premise that the themes of the teaching modules had to be featured in the science curriculums of the partner countries, by approaching them with the lenses of Responsible Research and Innovation, students and teachers are able to *rediscover* these more or less familiar topics and take another perspective, a more global and social one. And this happens because RRI forces students and teachers to think and consider other facets of the scientific problem under

investigation. By having the task of developing an exhibition that expresses the integration of RRI into the scientific topic, **students and teachers feel more willing to learn about RRI**, and this happens also because of central role that students assume (and that poses a novelty for the majority of them) related to the task of **creating something that will be shared with others as a means to create awareness on a topic that has global implications for society**.

As a result of having to integrate the Responsible Research and Innovation into the exhibition – hence, creating something that expresses the interconnections of a particular theme of science and society – **students and also teachers end up by deepen their understanding of RRI**.

Some partners highlighted the fact that the task of having to create an exhibition that integrates the RRI represented an **opportunity for the assessment of what students have learned about RRI and also the effectiveness of the teaching about RRI**.

By having to develop an interactive exhibition, students are forced to think on strategies that promote the engagement of the audience with the objects and also that stimulates visitors' interactions between themselves. For some partners, **the inclusion of RRI helps students to develop more interactive exhibitions and stimulates their creativity in order to develop something that enables the engagement of the public**.

Limitations

Although the potentialities of the integration of RRI in the process of exhibition development, partners also found limitations in this (**table 16**).

Table 16 - Difficulties on the integration of RRI in the process of exhibition development (N=11)

Integrating all RRI dimensions...	
...due to lack of knowledge about RRI	7
...due to the fact that some dimensions were more relevant for the topic/students	5
Novelty of theme and tasks makes hard for teachers to support students	8
Express the knowledge on RRI through an exhibition since it's an abstract concept	5
Novelty of the concepts makes hard to understand them	4
Understand the relevance of also exhibiting RRI, apart from the science	3
Lack of teachers' explicitly directions on the integration of RRI	1

One major aspect – understood as a difficulty when trying to integrate RRI in the exhibitions – has to do with the support that teachers can give to their students. We cannot forget that not only the RRI topic is new to students, but also the task of having to plan and develop an interactive exhibition to be presented to an audience. That is why the support of teachers is crucial – but also for them, these are novelties. Without the proper support of teachers – in highlighting the relevance of RRI in connection with

the science, and in helping the development of the exhibition – students will certainly feel lost and leave out the more demanding tasks, **creating exhibitions more centred in the science facts, and less in the RRI aspects.**

The proper support of teachers begins with the work in the classroom – if teachers don't find any potentialities or relevance in bringing RRI into their science classes, or if their approach is merely superficial and brief, students will certainly not value RRI nor will develop any efforts of trying to integrate it in their exhibition.

What changed between CoL1 and CoL2?

Taking into account the integration of RRI in the process of exhibition development, partners were asked to think about what had changed between the 1st and the 2nd CoL. The answers were quite diverse. For some, the expertise of the science educators on RRI in the 2nd round allowed (a) for more explicit instructions for teachers to insist in the integration of RRI in the exhibitions, and (b) for a better guidance on discussing the RRI topics with teachers.

Due to the fact that the 1st CoL was especially focused on developing the teaching materials, and the 2nd CoL on testing them, some partners considered that the 2nd CoL had more time to address and discuss RRI aspects. However, other partners consider that the task of module development created better opportunities to discuss on RRI, hence, for them, 1st CoL teachers were better able to guide students than 2nd CoL teachers, because they spent more time discussing its integration in the topic.

Another major distinction between rounds was the more diversity of topics/modules to be tested in the 2nd round. For some partners that made easier the integration of RRI in the exhibitions: a) the new topics were more suitable for exploring the several RRI dimensions, or b) the new modules had more clear instructions on the integration of RRI.

Finally, and considering those teachers that tested modules on both rounds, some partners expressed that these *more experienced* teachers were, on the 2nd round, more confident on the potentialities of the strategy to enhance students' knowledge and motivation to learn science and felt more confident on how to address RRI in their classes.

Ways of improvement

Taking into account the difficulties of integrating RRI into the student-curated exhibitions, we asked partners to think on ways of improving that integration.

For some, it might be important to clearly **define the target group** of the exhibition in order to help students think on the best approach to engage the audience, and also in the level of deepening of the topics to be exhibited.

Another way of facilitate the integration of RRI into the exhibition has to do with **creating a positive attitude** towards learning about it, and that might be obtained when students are helped to see placement within society as an integral part of science and science exhibits. To achieve such goals, students could visit more exhibits, or think about the kinds of everyday problems we need science in solving.

For other partners, one way to overcome the difficulties inherent to the understanding or RRI may lie in the introduction to this topic **through the all process** – and not just in the end of the module – in order for students to be able to understand and get familiar with it.

Also pointed out was the strategy of creating a **special activity** for the students, at the initial phase of exhibition development, which could consist of a brainstorming discussion about all the RRI aspects that are connected to their exhibits' content with the aim of finding ways to integrate them on their exhibition.

What can we conclude from D3.3?

All the results presented in this section show the great potentialities of student-curated exhibitions as a strategy to address in a meaningful and socially relevant way (and both in formal and non-formal educational contexts) the concept of Responsible Research and Innovation. The impact on students', teachers' and families' knowledge and engagement in activities perceived as socially relevant was very strong. All these activities contributed to strength and improve the connection between schools and communities.

4. Other Activities

Evaluation of the impact of exhibitions' development on students' perceptions regarding their competences and classroom environment

In order to evaluate the impact of exhibitions' implementation on students' perceptions regarding their competences and classroom environment we developed two sets of items that were included in the WP5 questionnaire applied to all CoL2 students that participated in the IRRESISTIBLE Project. This online pre and post-questionnaire comprised several sections. We contributed to Sections 3 and 4 with the following 16 items, to be evaluated by students through a five point Likert-scale (ranging from *totally agree* to *totally disagree*):

- a) I'm capable of planning and constructing a science exhibit about a current and relevant scientific theme
- b) Planning and constructing a science exhibit is motivating
- c) The development of a science exhibit about a given subject allows me to learn more about that subject
- d) The construction of science exhibits improves the relationships amongst students
- e) The construction of science exhibits improves the relationship between students and teacher
- f) ICTs are great tools to support the development of science exhibits
- g) I'm capable of creating science exhibits as a way to raise awareness in the community for current and relevant scientific issues
- h) Through the development of science exhibits I can influence the decisions and behaviours of other citizen's related to social issues concerning science, technology and environment
- i) In my science classes I discuss about current problems and how they affect my life
- j) In my science classes I develop competencies that allow me to have a more active role in society
- k) In my science classes I'm encouraged to ask questions
- l) In my science classes I carry out projects that I consider important and socially relevant
- m) In my science classes I learn to act in a socially responsible way
- n) In my science classes I learn to respect my colleagues' opinions
- o) In my science classes I learn about ways to influence other people's decisions about social issues related to science, technology and society

- p) In my science classes I'm responsible for initiatives that allow me to influence other people's decisions about social issues related to science, technology and society

Participants

The questionnaire was answered by a total of 3368 students on the pre-test application and 2433 on the post-test application, from a total of 10 different countries (see **table 17**). Turkey, Poland and Greece were the most represented countries, but Italy and Portugal also had more than 500 respondents each.

Table 17 - Number of questionnaires answered from each participating country.

Country	Pre-test	Post-test	Total per country
Israel	153	59	212
Netherlands	36	85	121
Finland	277	90	367
Romania	47	43	90
Portugal	269	276	545
Italy	513	185	698
Greece	617	483	1100
Turkey	623	505	1128
Germany	226	206	432
Poland	607	501	1108
Total	3368	2433	5801

Participants were distributed across all age groups as is illustrated by **table 18**, with the majority being 15 or 16 years old, but also with very large numbers from ages 11, 12, 13 and 14; and also from the 17 year old age group.

Table 18 - Participants distribution per country/age group.

Country	Age										
	-8	9	10	11	12	13	14	15	16	17	18+
Israel	0	0	0	0	0	10	2	30	118	31	0
Netherlands	0	0	0	0	0	0	23	47	14	26	5
Finland	0	0	20	121	173	34	0	0	0	2	4
Romania	0	0	0	0	0	0	0	3	39	16	28
Portugal	41	7	30	14	3	104	83	142	93	12	1
Italy	0	0	0	0	0	0	19	211	120	137	196
Greece	0	0	1	256	176	76	95	203	156	100	8
Turkey	0	0	8	116	310	217	132	150	124	64	7
Germany	0	0	0	0	0	15	67	57	110	106	75
Poland	0	0	0	0	7	88	199	183	230	234	100
Total	41	7	59	507	669	544	620	1026	1007	728	424

The instrument

The questionnaire was composed of 5 sections with a total of 33 questions. Section 1 included 3 characterization questions (country, age, gender); section 2 included 12 closed questions focused on RRI issues in education (where the participants had to rate statements on a 5 point Likert scale ranging from *totally agree* to *totally disagree*); section 3 included 3 open questions about the ethical issues tackled by the students in their projects; section 4 included 8 closed questions about the student developed exhibits (where the participants had to rate statements on a 5 point Likert scale ranging from *totally agree* to *totally disagree*); and finally section 5 included 8 closed questions about the students science classroom environments (where the participants had to rate statements on a 5 point Likert scale ranging from *totally agree* to *totally disagree*).

Here we will focus our analysis on the participants' answers to sections 4 and 5. In order to validate the developed sections, for this new population, the Cronbach's alpha index was calculated for both. The attained values for Cronbach's Alpha on these sections was respectively .853 and .876, indicating that the internal consistency of both topics was high (Cronbach's Alpha larger than .8), illustrating the reliability of the proposed topics.

Next, we calculated the overall progression of our sample. For this, in **table 19** we can observe the average mean score and standard deviation for each of the analysed questions (both pre and post-test), as well as the ANOVA results indicating if there is a significant difference between pre and post-test results. As can be illustrated by this table almost all questions (with the exception of questions number 17 and 20) showed a significant raise in their scores favouring the post-test results (considering $p < ,05$).

Table 19 - Pre and post-test results for the whole sample with ANOVA.

Questions	Pre-test			Post-test			F	Sig.
	N	Mean	Std. Deviation	N	Mean	Std. Deviation		
15. I can plan and develop a scientific exhibit about a current and relevant science topic	3117	3,41	1,128	2283	3,90	1,020	269,261	,000*
16. To plan and develop a scientific exhibit is something that motivates me	3128	3,824	1,0980	2281	3,952	1,0762	18,208	,000*
17. Developing a scientific exhibit about a given topic allows me to learn more about it	3110	4,225	,9714	2270	4,254	,9806	1,129	,282
18. Developing a scientific exhibit improves the relationships among students	3120	3,874	1,0693	2272	4,015	1,0631	23,196	,000*
19. Developing a scientific exhibit improves the relationship between students and teacher	3119	3,916	1,0428	2272	4,033	1,0560	16,464	,000*
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	3106	4,101	,9583	2268	4,116	,9508	,351	,554
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	3105	3,455	1,1143	2268	3,784	1,0510	119,516	,000*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	3112	3,545	1,0697	2267	3,732	1,0468	40,732	,000*
23. In my science classes I discuss current issues and how they impact my life	3100	3,345	1,1853	2259	3,534	1,1504	34,343	,000*
24. In my science classes I develop competencies that allow me to have a more active role in society	3106	3,496	1,1282	2264	3,652	1,0830	25,790	,000*
25. In my science classes I am encouraged to ask questions	3097	3,628	1,1600	2264	3,738	1,1238	12,059	,001*
26. In my science classes I develop important and socially relevant projects	3097	3,265	1,1768	2258	3,561	1,1281	85,368	,000*
27. In my science classes I learn how to act in a socially responsible manner	3089	3,604	1,1470	2259	3,796	1,0756	38,639	,000*
28. In my science classes I learn how to respect my colleagues' opinions	3097	3,931	1,1201	2256	4,015	1,0414	7,877	,005*
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	3093	3,405	1,1073	2261	3,632	1,0717	56,354	,000*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	3089	3,340	1,1462	2260	3,565	1,0854	52,798	,000*

* Significant difference between pre and post-test results

We have also conducted an analysis per country to identify possible differences.

Israel

In **table 20** we can observe the results concerning the participants from Israel. In this case there was a significant increase in all questions, except in the cases of questions 17, 20, and 25.

Table 19 - Israel pre and post-test results ANOVA.

Questions	F	Sig
15. I can plan and develop a scientific exhibit about a current and relevant science topic	25,582	,000*
16. To plan and develop a scientific exhibit is something that motivates me	15,458	,000*
17. Developing a scientific exhibit about a given topic allows me to learn more about it	3,567	,060
18. Developing a scientific exhibit improves the relationships among students	8,663	,004*
19. Developing a scientific exhibit improves the relationship between students and teacher	11,184	,001*
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	,966	,327
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	9,701	,002*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	9,088	,003*
23. In my science classes I discuss current issues and how they impact my life	6,670	,011*
24. In my science classes I develop competencies that allow me to have a more active role in society	24,889	,000*
25. In my science classes I am encouraged to ask questions	2,754	,099
26. In my science classes I develop important and socially relevant projects	9,387	,002*
27. In my science classes I learn how to act in a socially responsible manner	26,295	,000*
28. In my science classes I learn how to respect my colleagues' opinions	16,549	,000*
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	14,237	,000*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	15,077	,000*

* Significant difference between pre and post-test results

The Netherlands

In **table 21** we can observe the results concerning the participants from the Netherlands. In this case there was only a significant difference between pre and post-test results in question 27. It should be noted that The Netherlands was one of the countries with the least participants, including only 36 pre-test answers, making it harder to identify significant differences.

Table 21 - The Netherlands pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	2,284	,134
16. To plan and develop a scientific exhibit is something that motivates me	,333	,565
17. Developing a scientific exhibit about a given topic allows me to learn more about it	,045	,832
18. Developing a scientific exhibit improves the relationships among students	,509	,477
19. Developing a scientific exhibit improves the relationship between students and teacher	,036	,850
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	,349	,556
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	,343	,559
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	,556	,458
23. In my science classes I discuss current issues and how they impact my life	,106	,746
24. In my science classes I develop competencies that allow me to have a more active role in society	2,346	,129
25. In my science classes I am encouraged to ask questions	,980	,325
26. In my science classes I develop important and socially relevant projects	1,932	,168
27. In my science classes I learn how to act in a socially responsible manner	8,087	,005*
28. In my science classes I learn how to respect my colleagues' opinions	,041	,840
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	,909	,343
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	,075	,784

* Significant difference between pre and post-test results

Finland

In **table 22** we can observe the results concerning the participants from Finland. In this case, there was a significant increase only in questions 15, 17, 23, and 28.

Table 22 - Finland pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	11,449	,001*
16. To plan and develop a scientific exhibit is something that motivates me	,016	,900
17. Developing a scientific exhibit about a given topic allows me to learn more about it	9,348	,002*
18. Developing a scientific exhibit improves the relationships among students	,738	,391
19. Developing a scientific exhibit improves the relationship between students and teacher	,106	,745
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	,007	,933
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	,548	,460
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	,004	,947
23. In my science classes I discuss current issues and how they impact my life	6,220	,013*
24. In my science classes I develop competencies that allow me to have a more active role in society	3,530	,061
25. In my science classes I am encouraged to ask questions	,707	,401
26. In my science classes I develop important and socially relevant projects	,494	,482
27. In my science classes I learn how to act in a socially responsible manner	,120	,730
28. In my science classes I learn how to respect my colleagues' opinions	5,141	,024*
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	2,283	,132
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	,565	,453

* Significant difference between pre and post-test results

Romania

In **table 23** we can observe the results concerning the participants from Romania. In this case, there was a significant increase in every question. It should be noted that Romania was the country with the smaller number of answered questionnaires (47 + 43) making it even harder to achieve significant differences, emphasizing the relevance of the achieved progress.

Table 23 - Romania pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	81,642	,000*
16. To plan and develop a scientific exhibit is something that motivates me	58,267	,000*
17. Developing a scientific exhibit about a given topic allows me to learn more about it	23,039	,000*
18. Developing a scientific exhibit improves the relationships among students	36,166	,000*
19. Developing a scientific exhibit improves the relationship between students and teacher	9,186	,003*
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	6,408	,013*
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	41,492	,000*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	57,707	,000*
23. In my science classes I discuss current issues and how they impact my life	18,132	,000*
24. In my science classes I develop competencies that allow me to have a more active role in society	36,296	,000*
25. In my science classes I am encouraged to ask questions	18,078	,000*
26. In my science classes I develop important and socially relevant projects	51,883	,000*
27. In my science classes I learn how to act in a socially responsible manner	22,639	,000*
28. In my science classes I learn how to respect my colleagues' opinions	23,928	,000*
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	46,323	,000*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	35,649	,000*

* Significant difference between pre and post-test results

Portugal

In **table 24** we can observe the results concerning the participants from Portugal. In this case, there was a significant increase in questions 15, 17, 21, 23, 26, 29 and 30.

Table 24 - Portugal pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	10,969	,001*
16. To plan and develop a scientific exhibit is something that motivates me	,541	,462
17. Developing a scientific exhibit about a given topic allows me to learn more about it	12,739	,000*
18. Developing a scientific exhibit improves the relationships among students	,157	,692
19. Developing a scientific exhibit improves the relationship between students and teacher	,948	,331
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	,267	,605
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	4,327	,038*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	,087	,768
23. In my science classes I discuss current issues and how they impact my life	26,514	,000*
24. In my science classes I develop competencies that allow me to have a more active role in society	3,473	,063
25. In my science classes I am encouraged to ask questions	1,131	,288
26. In my science classes I develop important and socially relevant projects	9,343	,002*
27. In my science classes I learn how to act in a socially responsible manner	2,096	,148
28. In my science classes I learn how to respect my colleagues' opinions	,075	,785
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	4,335	,038*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	14,245	,000*

* Significant difference between pre and post-test results

Italy

In **table 25** we can observe the results concerning the participants from Italy. In this case, there was a significant increase only in questions 15 and 21.

Table 25 - Italy pre and post-test results ANOVA.

Questions	F	Sig
15. I can plan and develop a scientific exhibit about a current and relevant science topic	4,094	,043*
16. To plan and develop a scientific exhibit is something that motivates me	,196	,658
17. Developing a scientific exhibit about a given topic allows me to learn more about it	2,267	,133
18. Developing a scientific exhibit improves the relationships among students	1,282	,258
19. Developing a scientific exhibit improves the relationship between students and teacher	1,641	,201
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	1,299	,255
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	8,677	,003*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	,536	,465
23. In my science classes I discuss current issues and how they impact my life	,565	,453
24. In my science classes I develop competencies that allow me to have a more active role in society	,824	,364
25. In my science classes I am encouraged to ask questions	2,654	,104
26. In my science classes I develop important and socially relevant projects	1,844	,175
27. In my science classes I learn how to act in a socially responsible manner	,300	,584
28. In my science classes I learn how to respect my colleagues' opinions	,588	,444
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	1,911	,167
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	,033	,857

* Significant difference between pre and post-test results

Greece

In **table 26** we can observe the results concerning the participants from Greece. In this case, there was a significant increase in questions 15, 18, 19, 20, 21, 23, 26, 29 and 30.

Table 26 - Greece pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	32,516	,000*
16. To plan and develop a scientific exhibit is something that motivates me	,541	,462
17. Developing a scientific exhibit about a given topic allows me to learn more about it	,107	,744
18. Developing a scientific exhibit improves the relationships among students	7,132	,008*
19. Developing a scientific exhibit improves the relationship between students and teacher	16,134	,000*
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	4,671	,031*
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	6,752	,010*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	3,413	,065
23. In my science classes I discuss current issues and how they impact my life	6,797	,009*
24. In my science classes I develop competencies that allow me to have a more active role in society	,468	,494
25. In my science classes I am encouraged to ask questions	1,139	,286
26. In my science classes I develop important and socially relevant projects	9,354	,002*
27. In my science classes I learn how to act in a socially responsible manner	3,604	,058
28. In my science classes I learn how to respect my colleagues' opinions	1,178	,278
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	4,904	,027*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	5,446	,020*

* Significant difference between pre and post-test results

Turkey

In **table 27** we can observe the results concerning the participants from Turkey. In this case, there was a significant increase in every question, except in questions 17 and 20.

Table 27 - Turkey pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	51,573	,000*
16. To plan and develop a scientific exhibit is something that motivates me	19,221	,000*
17. Developing a scientific exhibit about a given topic allows me to learn more about it	,942	,332
18. Developing a scientific exhibit improves the relationships among students	15,371	,000*
19. Developing a scientific exhibit improves the relationship between students and teacher	6,384	,012*
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	1,657	,198
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	17,701	,000*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	9,395	,002*
23. In my science classes I discuss current issues and how they impact my life	14,792	,000*
24. In my science classes I develop competencies that allow me to have a more active role in society	28,686	,000*
25. In my science classes I am encouraged to ask questions	8,516	,004*
26. In my science classes I develop important and socially relevant projects	47,199	,000*
27. In my science classes I learn how to act in a socially responsible manner	32,790	,000*
28. In my science classes I learn how to respect my colleagues' opinions	14,576	,000*
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	26,029	,000*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	27,863	,000*

* Significant difference between pre and post-test results

Germany

In **table 28** we can observe the results concerning the participants from Germany. In this case, there was a significant increase in questions 15, 16, 19, 21, 22, 23, 26, and 29.

Table 28 - Germany pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	43,915	,000*
16. To plan and develop a scientific exhibit is something that motivates me	18,649	,000*
17. Developing a scientific exhibit about a given topic allows me to learn more about it	1,715	,191
18. Developing a scientific exhibit improves the relationships among students	3,064	,081
19. Developing a scientific exhibit improves the relationship between students and teacher	10,292	,001*
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	,013	,908
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	12,832	,000*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	5,619	,018*
23. In my science classes I discuss current issues and how they impact my life	4,578	,033*
24. In my science classes I develop competencies that allow me to have a more active role in society	5,737	,017*
25. In my science classes I am encouraged to ask questions	,858	,355
26. In my science classes I develop important and socially relevant projects	2,334	,127
27. In my science classes I learn how to act in a socially responsible manner	,600	,439
28. In my science classes I learn how to respect my colleagues' opinions	,366	,546
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	,379	,539
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	1,178	,278

* Significant difference between pre and post-test results

Poland

In **table 29** we can observe the results concerning the participants from Poland. In this case, there was a significant increase in questions 15, 17, 21, 23, and 24.

Table 29 - Poland pre and post-test results ANOVA.

Questions	F	Sig.
15. I can plan and develop a scientific exhibit about a current and relevant science topic	39,459	,000*
16. To plan and develop a scientific exhibit is something that motivates me	,196	,658
17. Developing a scientific exhibit about a given topic allows me to learn more about it	6,714	,010*
18. Developing a scientific exhibit improves the relationships among students	,776	,379
19. Developing a scientific exhibit improves the relationship between students and teacher	2,643	,104
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits	,984	,322
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	24,760	,000*
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	3,456	,063
23. In my science classes I discuss current issues and how they impact my life	5,375	,021*
24. In my science classes I develop competencies that allow me to have a more active role in society	,209	,648
25. In my science classes I am encouraged to ask questions	,512	,474
26. In my science classes I develop important and socially relevant projects	7,910	,005*
27. In my science classes I learn how to act in a socially responsible manner	,647	,421
28. In my science classes I learn how to respect my colleagues' opinions	,078	,780
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	10,712	,001*
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	1,687	,194

* Significant difference between pre and post-test results

It becomes clear from this analysis by country that participants' from different contexts had diverse perceptions regarding the topics covered by the questionnaire. **Table 30** summarizes the ANOVA results for every country identifying the questions where there was a significant difference between pre and post-test ($p < ,05$)

Table 30 - ANOVA significant results for all participating countries (only significant results are reported).

Questions	Israel	Netherlands	Finland	Romania	Portugal	Italy	Greece	Turkey	Germany	Poland	Total
15. I can plan and develop a scientific exhibit about a current and relevant science topic	,000*		,001*	,000*	,001*	,043*	,000*	,000*	,000*	,000*	9
16. To plan and develop a scientific exhibit is something that motivates me	,000*			,000*				,000*	,000*		4
17. Developing a scientific exhibit about a given topic allows me to learn more about it			,002*	,000*	,000*					,010*	4
18. Developing a scientific exhibit improves the relationships among students	,004*			,000*			,008*	,000*			4
19. Developing a scientific exhibit improves the relationship between students and teacher	,001*			,003*			,000*	,012*	,001*		5
20. ICT (Information and Communication Technologies) are a good tool to support the development of scientific exhibits				,013*			,031*				2
21. I am able to develop scientific exhibit that raise awareness in the community to current and relevant scientific issues	,002*			,000*	,038*	,003*	,010*	,000*	,000*	,000*	8
22. Through the development of scientific exhibits I am able to influence other citizens decisions and behaviours about issues related to science, technology and the environment	,003*			,000*				,002*	,018*		4
23. In my science classes I discuss current issues and how they impact my life	,011*	,	,013*	,000*	,000*	,	,009*	,000*	,033*	,021*	8
24. In my science classes I develop competencies that allow me to have a more active role in society	,000*			,000*	,			,000*	,017*		4
25. In my science classes I am encouraged to ask questions				,000*				,004*			2
26. In my science classes I develop important and socially relevant projects	,002*			,000*	,002*		,002*	,000*		,005*	6
27. In my science classes I learn how to act in a socially responsible manner	,000*	,005*	,	,000*				,000*			4
28. In my science classes I learn how to respect my colleagues' opinions	,000*		,024*	,000*				,000*			4
29. In my science classes I learn how to influence other citizens' decisions about social issues related to science, technology and the environment	,000*			,000*	,038*		,027*	,000*		,001*	6
30. In my science classes I am responsible for initiatives that allow me to impact other citizens' decisions about social issues related to science, technology and the environment	,000*			,000*	,000*		,020*	,000*			5
Total	14	1	4	16	7	2	9	14	7	6	

From the analysis of **table 30** the differences between countries become clear. Romania, Israel and Turkey were noticeably the ones where more significant differences were observed (16-14 out of possible 16). Greece, Portugal, Germany and Poland also had several questions with significant differences (9-6). With The Netherlands, Italy and Finland being the countries with the least significant differences (1-4).

Concerning the posed questions, from this analysis it also becomes clear that questions 15, 21 and 23 were the ones where more differences are observed (9-8 out of possible 10). Questions 19, 26, 29 and 30 were also questions where differences are important to mention (5-6 out of possible 10). With questions 20 and 25 being the ones where the least amount of differences were observed (only 2 countries each).

Attending at the results we can conclude that students improved their perceptions in what regards their competences for developing exhibitions in science classes as a way of creating awareness on topics relating science-technology-society-environment: at the end of the project, they felt capable of attaining this goal. Also they realized that this sort of project improves the relationship between students and teachers.

Concerning their classroom environments, the Project contributed to students' improved perceptions that in their science classes: a) they discuss current issues and how they impact their lives; b) they develop socially and relevant projects; and c) they learn how to influence other citizens' decisions about social issues related to science, technology and environment.

5. Final Remarks

All the results presented in this report allow the conclusion that the IRRESISTIBLE project had several levels of strong impact in the countries involved. A first level is connected with the knowledge developed by teachers, students, families and communities that research and innovation must be driven by responsibility (**Objective O3.2 of WP3**). A second level is related with all the expertise developed by science educators, science centres experts, teachers and scientists about how to address Responsible Research and Innovation (related with cutting edge scientific and technological issues) in formal and non-formal educational contexts. A strong impact is noticeable on the knowledge related with the pedagogy and the educational potentialities of student-curated exhibitions as a strategy to address the concept of Responsible Research and Innovation (**Objectives O3.1, O3.3 and O3.4 of WP3**).

The materials/tools developed during the WP3 of the IRRESISTIBLE project (Guides, Vodcasts, on-line magazines) can be extremely useful in contexts of initial and in-service teacher education regarding educational strategies (formal and non-formal) to address in a meaningful and social relevant way the topic of Responsible Research and Innovation. The potentialities of these materials/tools were already demonstrated through the different IRRESISTIBLE activities.