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Executive Summary

The pedagogical framework of the IRRESISTIBLE project applies a 6E-model to implement inquiry based teaching and learning and will connect these phases and activities to different RRI perspectives. The evaluation focusses on the work of the Communities of Learners transferring the framework into modules, the modules as the results of this transfer process, and again the learning outcomes on RRI perspectives as results of working with the modules.

This deliverable gives an overview about the evaluation framework and describes the module evaluation more detailed. The list of criteria used for the design and the evaluation of the modules is presented and connected to the pedagogical framework of the project.

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Glossary

Acronym/Abbreviation	Description
EC	European Commission
IRRESISTIBLE	Including Responsible Research and innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments
FP7	Seventh Framework Programme
DoW	Description of Work
PC	Project Coordinator
PSC	Project Steering Committee
WPL	Work Package Leader
WP	Work Package
IBSE	Inquiry Based Science Education
RRI	Responsible Research and Innovation
CoL	Community of Learners
UH	University of Helsinki
IPN	Leibniz Institute for Science and Mathematics Education

1. MAIN PART

1.1 Introduction

The evaluation in the IRRESISTIBLE project consists of three components: (1) Evaluation of the teacher professional development program (Communities of Learners CoL, see Deliverable D5.1), 2) evaluation of the modules, and 3) final project evaluation. This framework paper (D5.2) describes the methodological framework for the second component. The teaching-learning modules developed in the CoL's are one main outcome of the project and the measure for generating an impact on students' views on RRI. Therefore, evaluation of the modules is an integral part of the project.

Since all three evaluation components are in mutual interaction, all instruments are presented as an overview in Table 1. The table has been updated according to the discussions and decisions in the IRRESISTIBLE annual meeting in Jyväskylä, July 2014. The most significant change in comparison to former reports is the addition of case studies to evaluate the process of exhibition development.

During the first phase of the IRRESISTIBLE project, the evaluation instruments are developed and validated. In the second phase the validated instruments will be employed to measure effects of the project with regard to the three different evaluation foci.

*Table 1: Overview about evaluation instruments, their target group and when they are implemented. **NB:** In order to deliver an overall picture, the table includes all evaluation instruments used in IRRESISTIBLE. The instruments directly related to module evaluation and presented in this framework paper.*

Instrument	For whom?	When?	Analysis
Online questionnaire, incl. <ul style="list-style-type: none"> States of Concern IBSE Exhibit Design Social aspects of science education 	All CoL members: <ul style="list-style-type: none"> teachers scientists science education experts museum staff 	2 (optionally 3) times during both rounds of CoLs: <ul style="list-style-type: none"> * pre: during early CoL meetings * (intermediate: after the initial design of the module) * post: after testing with students 	Descriptive results (means) for the first round; statistical analyses (SPSS) for the second round

RRI questionnaire for CoL members	All CoL members: <ul style="list-style-type: none"> • teachers • scientists • science education experts • museum staff (+ 10 teachers outside the CoL in the first round) 	Once during round 1 Twice during round 2 (pre: during early CoL meetings; post: during the last meeting)	Descriptive results (means) for the first round; statistical analyses (SPSS) for the second round
Criteria for modules checklist	One representative of each partner (country)	At the end of the module development (round 1) and during module implementation (round 2)	Qualitative content analysis
Student questionnaires <ul style="list-style-type: none"> • RRI • Exhibit design • Social aspects of science education 	School students participating in the module (separate questionnaires for primary/secondary school)	Twice (pre-post) during module implementation in both rounds	Statistical analyses (SPSS)
Case study on exhibition development, incl. <ul style="list-style-type: none"> • interview with at least one teacher • focus group interview with students 	A teacher and a group of students	At the end of exhibition development in both rounds (and possibly using observations and interviews during the exhibit development phase, for those who are interested in the systematic analysis option)	Simple analysis & formative report Optionally: Systematic analysis leading to a research report
Project evaluation questionnaire	One representative of each partner (country)	In 2016	Simple statistical analysis

1.2 Design of the IRRESISTIBLE modules

1.2.1 Pedagogical framework

The pedagogical approaches of IRRESISTIBLE are based on Inquiry Based Science Education as well as informal learning. One example of inquiry based learning is the 5E-model which first Engages the students and then lets them Explore, Explain, Elaborate and Evaluate the subject (Abel & Lederman, 2007, pp. 424-427).

Project IRRESISTIBLE uses a slightly modified version of the 5E model which adds Exchange between Elaborate and Evaluate, hence the name 6E-model (IRRESISTIBLE

Description of Work, 2013). This addition emphasizes the collaboration between small groups and the communication of results during a learning process.

Another important approach in IRRESISTIBLE is the blend of formal and informal learning environments. Coordination of these two is very effective in IRRESISTIBLE because the teacher is in charge of the class as well as part of the module development.

1.2.2 Structure of the modules

Ten teaching modules are developed in IRRESISTIBLE in collaboration between schools, science museums and universities. The modules integrate learning in school and out-of-school settings and contain cutting edge science content (Table 2). The activities of the modules are inquiry based and involve the use of e.g. web 2.0 applications and touchscreens. School students also get to design their own science exhibit.

Table 2. Themes of the modules in the project IRRESISTIBLE (IRRESISTIBLE Description of Work, 2013).

	Theme of the module	Faculties
Finland	Climate change What are the factors affecting it and how does it affect the environment and the society?	<ul style="list-style-type: none"> • University of Helsinki • University of Jyväskylä • Jyväskylä University Museum
Germany	Oceanography and climate change An interdisciplinary view on the topic.	<ul style="list-style-type: none"> • IPN - Leibniz Institute for Science and Mathematics Education • Deutsches Museum
Greece	Nanoscience applications Development of nanomaterials in e.g. sensor, optical, photovoltaic, optoelectronic, electronic, photo catalytic and biomedical applications.	<ul style="list-style-type: none"> • University of Crete • Eugenides Foundation
Israel	Renewable energy sustainability The rising challenges of the increasing global energy demand.	<ul style="list-style-type: none"> • Weizmann Institute of Science • The Clore Garden of Science

Italy	Nanoscience and Nanotechnology Applications and ethical problems related to nanoscience and the theoretical background of the physics of it.	<ul style="list-style-type: none"> • University of Bologna • University of Palermo • Museum of Bari
Netherlands	Healthy ageing An interdisciplinary examination on healthier food.	<ul style="list-style-type: none"> • University of Groningen • Science LinX
Poland	Nanotechnology The catalytic properties of nanomaterials	<ul style="list-style-type: none"> • Jagiellonian University • Jagiellonian University Museum
Portugal	Genomics and Oceanography Ethical issues related to the possible juridical growth of the Portugese sea area.	<ul style="list-style-type: none"> • Universidade de Lisboa • Pavilhão do Conhecimento and Ciência Viva
Romania	Nanomaterials Development of nanomaterials in nanobiotechnology, food processing, food safety and biosecurity.	<ul style="list-style-type: none"> • Valahia University Targoviste • Prahova Natural Science Museum • History Museum Targoviste
Turkey	Nanoscience applications Nanoscience in health sciences. Applications and social and ethical aspects.	<ul style="list-style-type: none"> • Bogazici University • Şişli Municipality Science Center

All themes of the modules, including nanoscience, nanotechnology, climate change, oceanography, food production and genomics, deal with contemporary ethical issues, are interdisciplinary and are highly relevant to societal development.

1.2.3 Incorporation of Responsible Research and Innovation

All of the modules will incorporate elements of Responsible Research and Innovation (RRI). RRI is a framework formulated by the EU “for unlocking society’s full potential”

(Sutcliffe, 2011). The RRI key points include:

- Engagement: joint participation of researchers, industry and civil society in the research and innovation process
- Gender equality: unlocking the full potential of society
- Science education: creative education to foster the future needs of society
- Ethics: including societal relevance and acceptability of research and innovation outcomes
- Open access: free, online access to the results of publicly funded research
- Governance: the responsibility of policy makers to develop harmonious models for RRI

IRRESISTIBLE modules will incorporate these key points into the modules using a variety of approaches. A workshop during the project meeting in Jyväskylä in July 2014 offered perspectives for all RRI aspects mentioned above; these had been discussed with regard to the units developed by the partners and commented by the external evaluator, Peter Mahaffy.

One idea was to combine certain RRI perspectives with again certain elements of the 6E-model to support the teachers by working with only one framework. Such connections will be discussed and tried out in modules developed by the CoLs. Table 3 shows possible links that can be used as a starting point for further adaptations in the different modules.

Table 3. Exemplary links between 6E-phases and RRI perspectives

6E Phases	RRI Perspectives
Engage	Engagement, Equality, Education, Open Access, Ethics, Governance: How are these aspects linked to the chosen topic?
Explore	Open Access, Education: Which information is available, what education is needed to be able to use it? Equality: Who is involved in R&I projects in the area?
Explain	Education: Which knowledge is needed to understand the R&I scientifically?

Elaborate	Ethics, Governance: How are the R&I activities controlled, which ethical issues might appear?
Exchange	Engagement, Equality, Education, Open Access, Ethics, Governance: How can the different RRI perspectives been communicated to a broader audience to highlight their importance in RRI projects?
Evaluate	Engagement, Equality, Education, Open Access, Ethics, Governance: How have these aspects been considered in the project? Did new perspectives come up?

As the implementation of both criteria will be realized by the Communities of Learners including the teachers testing the approaches, one important step is to discuss the connections described exemplarily above within the CoLs and the project's pedagogical framework.

1.2.4 Communities of Learners

Teachers are engaged in IRRESISTIBLE via long term professional development training. Teachers (and in some countries teacher students) form groups that develop the modules in collaboration with research scientists, museum representatives and science education experts. These groups in which each participant has a crucial role are called Communities of Learners (CoL).

According to research findings, professional learning communities benefit teachers and students in various ways. Reported outcomes include better understanding of the interaction between different actors (Akerson et al., 2008; Fazio, 2009), better student knowledge integration (O. L. Liu, Lee, & Linn, 2010), positive impact on teacher self-efficacy (Lakshmanan, Heath, Perlmutter, & Elder, 2011) and positive effect on teaching practices as well as student achievements (Vescio, Ross, & Adams, 2008).

Research scientists provide insight into the scientific content. They participate mainly in the planning of the module. Museum representatives provide help in utilizing out-of-school learning environments and in finding appropriate presentation techniques for exhibit development. Science education experts organize the CoL meetings and the whole project, and also bring in their expertise in educational research which complements teachers' pedagogical expertise. The teachers are in the most important role since they will be in the major role in the module development, bring in their students and later even start their own CoLs with new teachers.

Hence, one important step is to discuss links between the content area chosen by each CoL and the realization of the RRI perspective within the steps of the 6E models and the related activities in each phase.

To scaffold and ensure this process to be carried out systematically, a checklist with criteria to discuss before the design and as two rounds of evaluation after the design and the testing in class has been developed.

These criteria for modules have been designed to address all the key features discussed above: aspects of Responsible Research and Innovation, elements of Inquiry-Based Science Education, as well as the utilisation of a variety of learning environments. The criteria were formulated as questions in order to facilitate self-evaluation. After a few rounds of commenting from all partners, the final version of the Criteria for Modules was released to all CoLs in February, 2014, see Table 4.

However, we are well aware of the fact that the design of a module reflects an ideal framework; the actual teaching will be different in every class. Due to resources we will not be able to observe all classes and analyse the changes that might occur during the teaching processes. Following the scheme of curriculum adaptations, described by van den Akker (1998) and applied by several development projects like those in context-based learning (e.g. Parchmann et al., 2006), we will only be able to collect data by the CoLs on their ideal framework before the school testing, and by the CoLs after the testing referring to the perceived curriculum. The questionnaire for the students and teachers on their RRI understanding offers additional insights into the attained curriculum, showing changes from pre to post.

1.3 Design of module evaluation

The modules developed in the CoLs will be evaluated with a threefold approach:

1. The modules will first be evaluated in comparison with the set of criteria specifically developed for this purpose. The criteria for the modules address the incorporation of RRI elements in the modules, the use of inquiry-based methods (the 6E model), as well as the integration of formal, informal and virtual (incl. Web 2.0 applications) learning environments in the module. The checklist will be used as a planning scaffold and used for the evaluation after the testing by the CoL; and again by another CoL employing the module in the second phase of the project.
2. The impact of the modules will be evaluated by measuring students' conceptions of and attitudes towards RRI with a pre-post questionnaire design. This quantitative data will be complemented by some qualitative content analysis of student work.
3. Student-curated exhibitions as a working method will be evaluated by carrying out case studies, including teacher interviews and focus group interviews with students.

For each module, these assessments will be carried out in at least two countries where each module is implemented. The effectiveness and impact of different modules and methods will be compared.

1.4 Instruments

1.4.1 Self-evaluation of the modules

A set of criteria of the modules has been developed in order to provide the CoLs with guidelines for module development. These criteria are used as a checklist during module development in every CoL: it is presented and discussed in early CoL meetings and then repeatedly returned to, in order to have the objectives in mind throughout the process. When the module has been developed, all partners are supposed to self-evaluate their module by writing short answers to all questions in the Criteria for Modules document. This process will be organised by the CoL; every CoL is responsible for sending a single sheet of answers in English to the WP leaders. The answers will be used to evaluate IF and HOW specific elements were incorporated in the modules. Furthermore, when each module is implemented in another country during round 2, the partners in those countries will assess the module again against the same set of criteria. WP5 leaders are responsible for reporting these results in Evaluation report 2: Modules (Deliverable 5.6). The analysis will be carried out in an inductive way, deriving approaches for linking phases of the 6E model with RRI aspects, for realizing RRI perspectives in class by certain

methods and activities, for involving students and experts in the different phases, and for perceived effects of those activities on the students' interest, perceptions and understanding.

Table 3: Criteria for the modules

IRRESISTIBLE

CRITERIA FOR THE MODULES

1. How does the module integrate the components of the 6E method?

[Engage]

- How does the module introduce the concepts through a context that is relevant to the students?
- How does the module raise interest and engage students in the subject?

[Explore]

- How does the module support students' exploration of the subject?
- How does the module help students formulate relevant questions?

[Explain]

- How do students collect data and knowledge to answer the questions?
- How do the students analyze the data?
- How do students draw conclusions from the data to answer the questions?

[Elaborate]

- How does the module support students' elaboration of their findings?
- How does the module connect the scientific content to RRI and other societal issues?

[Exchange]

- How do students exchange and communicate the findings with each other and

with a wider audience?

- How does the module support students in designing their exhibits?

[Evaluate]

- How is students' learning evaluated in the module?
- How does the module support students' own evaluation of the process?

2. How does the module address the six keys of Responsible Research and Innovation?

[Engagement]

- How does the module address the role of all societal actors (researchers, industry, policymakers and civil society) in the RRI process?

[Gender Equality]

- How does the module address the gender equality and the under-representation of women in research and innovation?

[Science Education]

- How does the module equip both future citizens and researchers with the necessary knowledge and tools to fully participate and take responsibility in the research and innovation process?

[Open Access]

- How does the module address the transparency and accessibility of research and innovation?

[Ethics]

- How does the module address ethical aspects of research and innovation?

[Governance]

- How does the module address the governance of research and innovation?

3. What platforms, ICT environments and materials does the module use/provide?

- How does the module integrate Web 2.0 activities?
- How does the module connect learning in classroom and learning in out-of-school settings?
- Does the module include at least these two documents?
 1. instructions on students' activities
 2. a teaching guide (with guidelines for assessment)
- What additional reading material on the content does the module provide for teachers and students?

4. How does the module integrate formal and informal science education?

- How are the exhibits used to enhance learning and instruction in classroom?
- How do the module and the student-curated exhibits add value to the museum/science centre?

To what extent is the activity conducted in school connected to what is done in the science centre?

1.4.2 Evaluation of the impact of the modules

The methods for evaluating the impact of CoL work (module development) on teachers' conceptions and attitudes, an important outcome of the IRRESISTIBLE project, was described in an earlier deliverable (D5.1, Framework paper for CoL evaluation). Here the focus is on the evaluation of the impact of modules themselves – when implemented, how do they affect students' views?

The main instrument of assessing the modules' impact on students will be a pre-post-questionnaire on students' attitudes to RRI. This instrument will be developed on the basis of the RRI questionnaire for teachers, used in CoL evaluation (see deliverable 5.1), by adapting it to students' level. Since the students participating in the IRRESISTIBLE modules are from various age groups, different versions of the instrument have to be developed for different age groups. First versions of these instruments will be developed until September 2014, after which the instruments will be iteratively developed

according to the feedback from the first tryouts. The instruments will be finalized until the second round of IRRESISTIBLE, and the main data for module evaluation will be collected during the second round. During that round, each module will be evaluated using the student questionnaire in at least two countries where the module is implemented.

In addition to questions on RRI, the student questionnaire will include questions on exhibit development and social aspects of science education (e.g. questions that investigate how much teachers encourage the students to take an active role in society later in their lives). These items are related to similar questions in the teachers' online questionnaire (Deliverable 5.1) in order to make comparisons possible between teachers' and students' views.

This quantitative data will be complemented by qualitative content analysis of student work. WP leaders will provide further instructions for this analysis after the first trials of the modules and the first evaluation based on the checklist answers.

1.4.3 Evaluation of the “student-curated exhibitions” method

In order to evaluate the process of students' exhibitions planning and construction, each partner is responsible for developing two case studies (one in each phase of the project) whose participants correspond to: (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 comprises three steps, the first of which corresponds 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.

Individual and focus group interviews analysis will follow a qualitative approach. Detailed instructions for the data analysis and structure of case studies will be presented in a separate document by the WP3 leaders. All partners will have two options: either to

participate in the making full-scale research report, or then just make a normative report without real scientific analysis.

1.5 Ethical issues

The evaluation will be carried out according to the ethical issues and precautions described in the IRRESISTIBLE Description of Work (2013). To ensure anonymous analysis of the research data, each surveyed student will be marked with a personal code which cannot be tracked back to the respondents' identity but can be used to connect an individuals' responses between pre- and post-tests.

According to EU regulations, participating schools, students and parents will return a consent form, also containing information about the research (IRRESISTIBLE Description of Work, 2013).

3. CONCLUSIONS

The evaluation framework offers insights into different steps of implementation with regard to the RRI perspectives that can be linked to phases of curriculum development described by van den Akker (1998). The CoLs will design an ideal framework with intended goals from their perspectives, using the checklist as a scaffold for the design of the modules. The evaluation after the school trials will report the perceived curriculum, both from the authors of the module and from at least one other CoL. The questionnaires will finally show results of the attained curriculum, reflecting learning processes with regard to the RRI perspectives.

An additional focus will be set on the exhibitions as one central and innovative part of the project.

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