Responsible Research and Innovation in Science Education

Alexandra Okada

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# Table of Contents

Executive Summary .................................................................................................................. 3

Introduction ............................................................................................................................... 7

1. RRI Concept .......................................................................................................................... 11
   1.1 RRI concept ................................................................................................................... 12
   1.2 RRI practices ................................................................................................................ 12
   1.3 RRI participatory debate ............................................................................................... 13

2. Teachers’ Professional Development in RRI ................................................................. 14
   2.1 CPD requirements ......................................................................................................... 15
   2.2 CPD frameworks ......................................................................................................... 16
   2.3 CPD practices .............................................................................................................. 17

3. RRI Formal Learning in the Classroom ........................................................................... 20
   3.1 Engaging students ......................................................................................................... 21
   3.2 RRI for scientific literacy ............................................................................................ 23
   3.3 Challenges in the classroom ....................................................................................... 25

4. RRI Partnerships (Industry, Science Centers and Scientists) ........................................ 27
   4.1 Participatory citizenship ............................................................................................... 28
   4.2 RRI partnerships ......................................................................................................... 29
   4.3 RRI impact .................................................................................................................. 30

5. European Projects ............................................................................................................. 33
   5.1 Tools, Standards and Frameworks .............................................................................. 33
   5.2 Global Networks ......................................................................................................... 35
   5.3 Public Consultation – Engaging Citizens ................................................................. 36
   5.4 Specific Areas .............................................................................................................. 38
   5.5 RRI and Inquiry Based Learning ................................................................................. 43
   5.6 Inquiry Based Learning - Teachers’ CPD ................................................................. 44
   5.7 Inquiry Science Based Education - Tools & Methods ........................................... 47

References ............................................................................................................................... 53
In this report, the Engaging Science debate is analysed for bridging Responsible Research and Innovation (RRI) with Inquiry based Science Education (IBSE). This discussion started with 50 experts about RRI and IBSE, including 40 European projects.

You are invited to contribute to our discussion:

EngagingScience.eu/en/documents

FIFTY EXPERTS:
Alexandra Okada, Andy Bullough, Anna Trifonova, Antonio Costa, Aristidis Protopsaltis, Audrey Savre, Bart Van De Laar, Bernie Steill, Camille Breton, Dalius Dapkus, Dury Jacob-Bayram, Elin Aschim, Emil Eidin, Fotini Chaimala, Francine Pellaud, Gabriel Gorghiu, Gemma Young, Harald Bjar, Ignacio Monge, Ignasi L6pez Verdeguer, Jacqueline Broerse, Julie Jordan, Kathy Kikis-Papadakis, Klaus Hadwiger, Laura Gorghiu, Laura Monica, Lia Rossi, Malte Debruy, Malvina Artheau, Maria Evagorou, Marie Knippels, Mario Barajas, Marzia Mazzonetto, Matteo Merzagora, Mauro Vannucci, Meriem Fresson, Mihai Bizoï, Padraig Murphy, Palmira Peculiauskiene, Pat Morton, Patricia Jenkins, Peter Gray, Peter Van Marion, Philippa Hulme, Sanuel Heinzen, Silvia Alcaraz, Sonia Hetzner, Tony Sherborne, Vanessa Mignan, Yael Shwartz.
EXECUTIVE SUMMARY

All societal actors should be equipped to investigate sustainable ways of taking care of Earth today. All of us need to contribute to scientific innovations by discussing applications, implications, risks and benefits. This is essential for our generations to solve problems and enjoy life on our planet.

This report presents key recommendations for bridging Responsible Research and Innovation (RRI) and Science Education for a safe and sustainable world. It aims to identify potential opportunities and challenges to equip learners for responsible citizenship and scientific development through European projects. This content provides a detailed overview of the RRI debate in Science Education, developed by various experts on the field.

The purpose of this report is to promote large dissemination of RRI discussion to rethink how science education can be innovated for the 21st century. This debate might benefit various actors including: teachers’ educators, pedagogical researchers, CPD coordinators, curriculum designers, project members and policy makers interested in RRI in science education.

This work consolidates the analysis of various sets of sources using LiteMap Tool. It started with the First European seminar on RRI in Science Education held in Paris in 2014, which was organised by the ENGAGE project team. Traces and The Open University (OU UK) invited fifty experts including twenty-five leaders of European projects to share questions, challenges and recommendations for knowledge exchange between projects. Data produced during and after this event, including groups’ reports, debate maps and video clips, was then analysed by the Knowledge Media Research team - OU UK. Forty European projects, including recent references in RRI such as the new initiatives of Horizon 2020 in 2015, were integrated in this analysis to provide a global overview.
The online mapping tool LiteMap was used to categorise and map issues, ideas and the pros and cons of discussions, projects and references. A questionnaire was sent to the experts and project representatives interested in the seminar. Data mapped from the survey indicated three common themes for discussion. Three groups of experts were then organised on: (G1) Teachers’ professional development, (G2) RRI in formal learning and (G3) partnerships to integrate informal learning. The debate during the seminar was set up through six steps:

1. **Introduction**: initial information mapped from the surveys about participants and their interests was presented to the attendees by the project coordinator.

2. **Group Discussions**: three teams were organised based on common interests with the aim to map key challenges and strategies.

3. **Plenary session**: teams presented their issues and received feedback which allowed the teams to extend their ideas with new issues.

4. **In-depth conversation**: focused on mapping problems in depth with solutions.

5. **Plenary session**: teams presented their final conclusions with discussion for more feedback.

6. **Conclusions**: coordinators of the event presented key issues and next steps.

During the discussion, each group had six collaborators who provided various sets of data for this report:

1. **Facilitator**: engaged participants with the discussion.
2. **Mapper**: represented the debate through LiteMap.
3. **Rapporteur**: captured the debate through a narrative.
4. **Communicator**: shared the group’s work in the plenary.
5. **Digital Curator**: collected interesting links and references.
6. **Researcher**: analysed the group discussions.

Maps, videos and this report are available as OER under creative common license in the website Engagingscience.eu. These resources are also included in the teachers’ online course - Engaging Science: Innovative Teaching for Responsible Citizenship.
We will be discussing this content in events, workshops and courses in order to gather evidence-based practices, technologies and case-studies. Our goal is to extend this report into an e-book, which will contain teachers and students’ voices, visions and actions on Responsible Research and Innovation for Engaging Science. We hope to connect the ENGAGE project with various national and international projects, which are all relevant to support the RRI movement across the globe.

Welcome to our debate.
INTRODUCTION

The 21st century is marked by the pace of scientific advancement in all areas. Due to the open access to technologies, social networks and scientific knowledge; opportunities for innovation reach a broader audience beyond the research community. Citizens have many more opportunities to take part in the knowledge society than ever before [6][7].

21st century Education has an important mission in engaging and empowering students to become lifelong learners, competent professionals and responsible citizens in our innovation-driven-world.

This report highlights how important it is to bridge Responsible Research and Innovation (RRI) and science education to equip students with knowledge, skills and values for scientific citizenship. Our current generation of learners and future scientists must be able to face uncertainties and voice their concerns. They need to address challenges and contribute to innovations that provide needs in the workplace and society.

RRI, coined by the European Commission during this decade, refers to the transparent and interactive process by which citizens and innovators help each other. All societal actors should share informed-based opinions and ethical views about an innovative product or new method. They must discuss potential risks and benefits during the whole process of scientific development [8].

Scientist and non-scientists must reflect together on the applications and implications of innovations for society. This process should be inclusive, interactive, anticipatory and transparent. To better align the innovation outcomes it must be based on the societal needs, expectations and ethical values [9].

Science education has a crucial role of educating the next generation for scientific literacy, responsible research and public engagement in scientific processes, and decisions for innovation [10][11]. Science educators/teachers might meet various challenges:
1. to support students to discuss and develop evidence-based opinions;

2. to equip students to be responsible citizens with and for society;

3. to embed authentic socio-scientific issues and inquiry projects in the classrooms.

To overcome the first challenge, inquiry based science education is considered the basis for helping learners develop scientific skills, responsible values and lifelong learning. Inquiry based learning is a constructivist approach, which supports students in active experimentation [12]. It is based on a cycle of various steps: questioning, planning method, obtaining and analysing data, drawing conclusions, reviewing outcomes and communicating results. There are various frameworks for educators when teaching students how to plan and develop their inquiry projects. The five E’s is one example, which fosters inquiry based learning through five steps: engage, explore, explain, extend and evaluate [13][14].

Students must be prepared to act as responsible active citizens representing society in new scientific developments. They also need to be equipped to work as qualified professionals responsible for innovation that is desirable, acceptable and sustainable.

The second challenge requires integrating topical issues and authentic scenarios into the curriculum. Integrating informal and formal education can be used to enrich teachers’ lessons. Topical science from science-in-the news and open resources available in science centres or museums will help students to link science to contexts [15]. Collaborative learning with peers, educators and experts will foster meaningful science learning, which is connected to students’ lives [16].

Science educators play an important role. They need to equip students for making sense of the cutting edge technology and science that affects their lives to make better decisions collaboratively in the present and for the future.
Finally, the third challenge is that teachers will need continual professional development (CPD). They need to feel capable of using socio scientific dilemmas and topical issues related to emerging innovations to scaffold students inquiry based learning. They need to develop pedagogical know-how and experience to help students to integrate conceptual and practical knowledge with ethical values for developing evidence-based thinking [17].

Science teachers must also be equipped for supporting students to understand how scientific research is developed in a responsible way.

The global scenario of progress and uncertainties requires helping educators and learners to develop key skills for participation with and for society. This refers to the ability to develop evidence-based opinions, make judgements of current innovations and manage own continual professional achievements with societal needs in their minds. How can science education equip the next generation for scientific citizenship?
1. RRI Concept

Responsibility is essential in research and innovation for pursuing improvements in quality of life now and for future generations [18]. Scientists must be able to discuss the potential benefits and risks of their developments with society, while society must be active and responsive to communicate their needs. They must also examine the outcomes during and after scientific innovations [19].

Responsible Research and Innovation requires a dialogue between scientists and all citizens including youth to better align the results of research with societal needs.

However, establishing interaction between scientists and non-scientists during research is not easy. There are various challenges [20] [21]. Formalising the RRI procedure is not enough to assure that people will meaningfully consider scientific innovations and provide informed-based opinions. Moreover, genuine interactions between research community and society involve a considerable investment of time and energy. Effective dialogue between scientists and non-scientists requires two factors: a trusting relationship for mutual exchange of information and know-how for collaborative decision-making processes.

Trust, knowledge and skills are essential requirements for proper discussion about innovation between researchers and citizens.

There is no doubt about the increasing importance of science education in the preparation of citizens and future scientists for scientific interactions. But, how can we facilitate this role?

Experts in the RRI seminar emphasise that RRI is not a clear concept for citizens and researchers. Wide dissemination of the conceptual and practical meaning of RRI is essential. In addition, it
should be built through collective discussion among all societal actors: students, parents, teachers, teacher educators, project coordinators, scientists, entrepreneurs, science journalists, policy makers and other professionals.

Clear and practical examples of RRI from different countries will be useful for raising awareness, increasing impact and developing sustainable actions in Europe.

1.1 RRI concept

The conceptual understanding of RRI is very challenging at scale due to the diversity of societal actors involved in the process from different cultures and countries. There are various perspectives from different knowledge areas or fields to be considered as well. The RRI expert groups highlight some recommendations for facilitating the RRI awareness in Europe:

- “Multi-dimensional conceptualisation of responsibility will add value to RRI”. Shwartz, group 1.
- “Simple and multidisciplinary language will be useful for various stakeholders”. Chaimala, group 1.
- “Clear purpose with common vocabulary for a wide range of actors takes time, but it will enrich the process and allow open-ended outcomes”. Jenkins, group 3.

1.2 RRI practices

The practical meaning of RRI is also relevant for improving people’s understanding. Meaningful examples from RRI projects, developed by a variety of societal actors, will help citizens and professionals to contribute to RRI.

The expert groups emphasise the need to disseminate RRI clearly to increase public and scientific participation in Europe. For that, they suggest:
• “Authentic examples based on different perspectives might increase understanding about RRI”. Kikis-Padadaski, group 3.

• “Some case studies about how RRI were applied with multi stakeholders on both contexts: formal and informal education will attract more participants to enrich their practices”. Okada, group 2.

• “Ethical dimensions and how educators and learners work with ethics are important to understand RRI in a practical way”. Van Marion, group 1.

• “Standards for RRI, which seems to be missed, will be important for various stakeholders Verdeguer, group 3.

1.3 RRI participatory debate

Collective Sensemaking of RRI is an appropriate approach for promoting common understanding based on its own principles. Therefore, RRI dimensions inclusive, transparent, interactive and anticipatory are relevant to reach dissemination at scale. This requires not only top-down approach but also bottom up through public participation. The RRI expert groups point out the importance of connecting the various approaches of the RRI projects for widening dissemination:

• “Information about RRI for informal learning “to” and “from” the public, is not currently enough and it is essential to promote RRI”. Merzagora, group 3.

• “Top-down and bottom-up European approaches are relevant but very challenging because there a lot of differences about needs, interests and practices among European countries”. Hetzner, group 1.

• “Sustained dialogue is a key to overcome gaps and communication problems”. Barajas, group 2.

• “Collaborative interaction among industry, companies and citizens including learners, parents, and professional must be established for promoting understanding of RRI”. Protopsaltis, group 2.

• “Integrated and sustainable infrastructure to promote discussion, collaboration, and obtain a big picture (overview) would be useful to increase understanding and awareness of RRI”. Gorghiu, group 3.
2. Teachers’ Professional Development in RRI

A key challenge for teachers is to change how science is taught by moving from the content-based lessons to an approach that is focussed on equipping students with the knowledge, skills and values to use science in society [22].

Educating for Responsible Research and Innovation requires Innovative teaching.

Promoting community networks is a key driver for teachers’ innovation [23]. In communities of practice (CoP), teachers might find creative opportunities for improving professional skills, especially to address changing circumstances. They can discuss materials and tools for re-adapting and applying resources for helping students learn [24]. Innovation can be considered as a way of learning professionally [25].

Communities of practices for RRI provide teachers with resources and strategies to update their practices and enrich students’ learning.

However, innovative CoP take time to consolidate [26]. They also require digital skills. Another challenge is to build strong enough bonds among experts and apprentices to create enough energy and momentum to sustain interaction and identity [27].

Educators need the kind of professional development and resources that meet their teaching concerns and extend their knowledge to address the learners’ needs.
2.1 CPD requirements

Teachers’ needs must be considered in planning effective CPD [8][9]. This will help European projects to identify ways of inducing an uptake of “RRI culture” [10] in science teaching. Establishing common interests and objectives among all participants will strengthen the outcomes. During the phase of CPD deployment educators must be encouraged to share their experience, achievements and difficulties with other members of their learning communities for feedback and suggestions for improvement. Ultimately, the evaluation of CPD and the assessment of teachers’ knowhow will be helpful for valuing their achievements and encouraging innovation in future practice [11].

“How could teacher professional development be integrated to IBSE and Ethical dimensions in science teaching?” van Marion.

“How can CPD and online communities prepare teachers for RRI adoption?” Sherborne

- “Flexible curriculum supported by the government is essential to embed RRI issues, teachers who might be ready to enhance lessons are not allowed to due to their existing curricula”. Gorghi

- “Evidence of added value of RRI teaching. Is important for supplying evidence for educational research and science teaching”. Hetzner.

- “Assessing RRI skills is a key issue. If there are assessable outcomes then teachers are more likely to adopt it”. Van Marion.

- “Including socio-scientific issues connected RRI will enrich in service and pre-service teacher education”. Jacobs.

- “Pedagogical know-how for integrating socio-scientific issues, scientific knowledge and ethical values needs to be developed”. Van Marion.

- “Confidence to tackle ethical issues is necessary for teachers to enrich their lessons”. Jordan.
• “An education framework for CPD might be useful for teacher educators”. Knippels.

• “Teachers’ digital skills are essential for online CPD and increasing opportunities for teachers’ informal learning through communities of practices”. Shwartz.

• “Easy-to-use platforms for online teaching are essential; teachers cannot cope with all the different tools”. Gorghiu.

2.2 CPD frameworks

Effective CPD frameworks offered by European projects are essential for preparing teachers [32]. There are various factors to be taken into account when producing new or combining existing CPD approaches for RRI teaching. The principles of RRI are themselves useful in developing and deploying RRI CPD: transparency, inclusiveness, interaction and anticipation [33]. Engaging teachers with CPD developers before, during and after their training will be useful for keeping CPD actions aligned to the participants’ needs and concerns.

“What are the most interesting innovative training approaches and communities of practice that can motivate teachers and students for RRI?” Sherborne.

“What are the approaches for and experiences with teachers’ CPD for RRI, and RRI in the classroom?” Knippels.

• “Teachers like very practical approaches not only for their lessons with students, but also for their professional development as learners”. Shwartz.

• “Starting with what teachers already do will help them uncover a lot of good practice so we can show people what is already being done in some schools”. Van Marion.

• “Teachers should develop their strategies for themselves as well with guidelines to help them. A toolkit for teacher training might help them develop building blocks for their lessons”. Knippels.
“Observing and activating students’ motivation, will encourage participation, which it is frequently low in science. So we need to interest them in the classroom, which is different to how students connect with science in a museum”. Gorghiu.

“Preliminary outcomes should be shared by all participants, teachers adopt new approaches when they see the results, for example, that their students became more engaged and motivated”. Van Marion.

“Positive feedback of teachers’ lessons, that can be recorded as video clips for others to provide positive review, will encourage teachers’ learning and confidence”. Shwartz.

“Describing issues that worked and not from various settings”. Hetzner.

“Teachers’ role reflection, will be useful they ask a lot of questions, but what is their role? Just short ‘right’ answers? We need to help teachers to value longer answers, and questions without right answers, to help students face uncertainties”. Shwartz.

“Concrete achievements, showing teachers that the RRI techniques can work, but considering exam requirements and results, which are still vital”. Aschin.

“Gradual release, approaches that break down skills very explicitly to pass over responsibility to students”. Jordan.

2.3 CPD practices

CPD practices on RRI must be fostered through informal learning as well. Open Educational Resources (OER), online course and communities for teaching and learning RRI open up much more access to knowledge [34]. However digital skills are necessary for teachers. Communities for continual interaction between apprentices and experts teachers will allow them to develop strategies to continue improving their skills and implementing RRI in various settings. Online social networks
are useful for teachers seeking to expand their professional networks, establish collaboration with peers and participate in new initiatives. When teachers are more engaged with RRI by sharing challenges and strategies, they might feel able to co-investigate their own practices, mentor their peers and support changes. They might then feel confident to act in policy making and evidence-based research by promoting the best practices and supporting others to innovate [35]. Nevertheless, there are various issues to overcome.

“How are our projects connecting RRI with informal learning settings including online courses and platforms?” Savre.

“How could educators and youth be supported by RRI CPD initiatives for a more knowledgeable and critical public to voice their concerns and understand crucial developments?” Hadwiger.

• “Teachers need to be shown the value of integrating RRI into their curriculum. Most are under constraints in terms of curriculum content and time.” Young.

  - “Flexible resources and training to be implemented in different countries allow teachers to readapt or reconstruct for their own contexts and curriculum”. Debry.

  - “A document to state RRI issues prepared by teachers collaboratively will be relevant for education as whole not just science education”. Gorghiu.

• “The construction of knowledge can be done together. Teachers can choose RRI topic and they could research themselves. They learn aspect of RRI if they are provided with the opportunity and guided by driving questions. Teachers could do it with CPD facilitators and then their students with their teachers.” Shwartz.

  - “Bringing together all key aspects (knowledge, skills and values) will be useful to illustrate examples”. Hetzner.

  - “Teachers should be engaged in policy making and involved in shaping things and establish links to student voice as well”. Chaimala.
“An integrated overview of various European projects will be helpful for teachers who participate in various initiatives and might feel lost with various messages”. Shwartz.

- “Enhancing collaboration between different teachers including pre-service and in-service will facilitate interdisciplinary approaches for RRI with different perspectives”. Gorghiu.

- “Explaining the continuity from other projects is also necessary for teacher to get an overview of approaches that can be integrated”. Debry.
Various projects and case studies highlight the importance of connecting formal and informal learning in science to promote youth motivation and authentic learning [36][37]. Students become more interested in investigating questions and tackling problems when they can apply science in real life [38][39]. Engaging and enjoying science at an early age will help them develop scientific skills so as to become scientifically literate citizens or science-career professionals [40][41].

Bridging formal education with informal learning can make science more relevant and authentic for students when they are exposed to real-world scientific experiences inspired by scientists.

Partnerships among schools, science centers, science-media and science-based business [42] are useful for students developing collaborative research (co-inquiry) techniques and using science in real settings [43][44]. Exciting co-inquiry projects activate students’ engagement, inspiration and self-learning skills [45] when:

1. Scientists, science journalists and entrepreneurs inspire students’ scientific curiosity.

2. Teachers or science mentors scaffold students’ science knowledge and RRI skills.

3. Local and online communities, families and their environment provide opportunities for students to devise scientific questions and co-investigate problems.
4. Experts, both scientists and non-scientists, support by co-assessing their work through constructive feedback-review for students to improve their research and communicate their findings.

The School curriculum and educators must bring science to life and life to science in and outside the classrooms for igniting students’ curiosity and passion to acquire knowledge and scientific skills.

Co-inquiry activities with various societal actors in formal and informal scenarios open up new opportunities for lifelong learning beyond schools. Another similar approach is Open schooling whose aim is to help educators innovate their teaching practices by transforming learning into meaningful experiences in real context in and outside school.

The European Commission defines “Open schooling” as the collaborative process by which schools and other societal actors are actively involved in cooperative research. They develop together real-life projects with evidence-based research outcomes and expertise. Open schooling initiatives include families, enterprise professionals, scientists and non-scientists experts, technologists, local communities and any other interested collaborator from wider society.

Learners must experience the excitement and strength of understanding the scientific world and act as a scientifically literate person in their careers.

3.1 Engaging students

Student’s engagement in RRI should be one of the goals of Science Education. The more students are engaged and equipped with RRI skills, the better they can investigate and tackle problems, risks and concerns. They are more prepared to live in the knowledge economy. They are also more aware of their role with and for society.

They are more capable of understanding “real world science” and debating its many applications and implications. They are more confident in innovating and creating solutions to improve and enjoy life.
“How could we apply a chain management approach that addresses young talent all the way through (from primary-secondary-HE-labour market)?” van de Laar.

“What are the strategies for engaging parents when working with young people? How could we make the science more inclusive by broadening its concepts and outcomes in the general opinion?” Breton.

“RRI learning should be conceived as an ecosystem for valuing the whole network where school has a role to play but not the only part. All societal actors are important, including parents.” Sherborne.

“The scientists and policy makers must contribute to the process of engaging students with RRI, they are the ones directly involved in RRI”. Evagorou.

- “Supporting open events, fair, exhibitions organised by schools, universities or organisations where students present their best inquiry projects to the community including families, scientists and researchers”. Okada.

- “Socio-scientific issues based on society’s needs or interests must be considered for students to extend their knowledge and practice RRI skills”. Pellaud.

- “CPD initiatives must show why and how informal learning activities can help teachers engage students and facilitate their achievements in the classrooms”. Trifonova.

- “Getting students participating in debates based on their interests through voting, focus group, etc.” Broerse.
“Incorporating what students do and learn outside the classroom particularly what and how make them be interested. A lot of them read about issues and they have an idea. They play games, they interact with people and there are issues everywhere”. Aristos.

“Educators must be aware of informal learning activities out-of-schools for students: science cafes, science camp, NGO events that also include parents”. Breton.

“Resources and strategies must be planned including short, medium and long term projects for teachers to guide students to RRI learning in formal and informal settings along their education pathway: science museums, learning centres, games, field trips, outdoors experiences, community projects, companies and science events”. Okada.

“An emotional engagement with the topic students are studying will encourage their participation and motivate their further involvement.” Gardom Hulme

3.2 RRI for scientific literacy

RRI for students’ scientific literacy is essential to foster responsible citizens. Young learners have natural-born curiosity, full of questions and wonder. Science education must help learners develop scientific thinking and challenge students to build a base of knowledge and skills for solving problems with increasingly in-depth solutions with sophisticated explanations along their lives. Although schools and universities are the central institutions for national education in each country, all parts of the extended system have a responsibility for improving scientific literacy.

“What are the key issues to promote citizenship and scientific literacy through science communication/ informal learning as well as support evidence-based policy making?” Costa & Mazzonetto.

“What are the key issues for including science news and the contribution of active scientists to enrich students’ learning?” Sherborne.

“What are the best practices in other projects and other initiatives to promote RRI awareness in the formal education sector?” Debry.
• “Understanding how science is influencing our everyday life and why that influence will most likely increase in the future, so we all must know about how science and RRI will help us to make “better”/more informed decisions in our lives and therefore create a better life conditions.” Protopsaltis.

– “Policies and institutions’ initiatives must create the links between formal and informal learning for scientific literacy. While formal learning provides methodology and structure, informal learning offers context and real problems.” Eidin.

– “The science centers should create more initiatives towards presenting productive socio-scientific issues and making exciting materials for the visitors and the teachers.” Trifonova.

• “Teachers must develop skills to teach how science is built. Nobody recognizes that this philosophy of science is not the science that the teachers grew up with. A lot of teachers never have worked in science, let alone RRI. We need to change the philosophy of CPD, shifting the top down curriculum and then try to shift the teachers’ practices”. Sherborne.

– “Teachers should learn out-of-schools in science cafes, for instance, by creating materials and collaborating with informal learning in creative ways. Then they can transfer that experience to their students.” Savre

– “Teachers can participate in science summer camps, science holidays as learners or as teachers of other participants (who are not their students in formal settings). That approach might change their perspective in the classroom. Breton.

– “Teachers should participate of science events to experience science out-of-schools and then identify how the links with their learners can be establish for meaningful learning”. Okada.

• “Controversial debates presented by science-in-the-news and science-media open up exciting discussions. This provides opportunities for students using argumentation and developing RRI skills, however teachers have to learn not to dominate the discussion and give some control to the audience”. Merzagora.
“Socio-scientific issues can be complex without a definite answer. Various strategies should be used for students to discuss those issues and developing scientific skills.” Broerse.

“Listen the different beliefs and values are important for inclusive discussion, so teachers can contribute to the discussion with questions, facts and arguments to challenge students and show that beliefs are not wrong or right so students’ feelings can be respected by everybody”. Pellaud.

“Students must also reflect on why they are keeping their beliefs at the end of discussion by being able to explaining it connecting knowledge Barajas.

“The role of the family in one’s education for scientific literacy is important as well. The families should be involved with RRI debates, how science affects our lives right now and probably what is going to happen in the future”. Protopsaltis.

3.3 Challenges in the classroom

RRI for students’ challenges should be expected by teachers. RRI is considered a relatively novel concept particularly in school [55]. Despite RRI’s novelty [56], RRI learners must be aware that there is a solid grounding of support, which draws on an extensive history of methods and principles, for instance, consequences, risk and impact assessment, ethics principles, technology foresight, public participation, participatory deliberation, collective intelligence [57]. However there will be various challenges and recommendations to embed RRI in Science Education through both formal and informal settings. Although its principles (interactive, transparent, desirable, inclusive [58] might help teachers engage students with topical and relevant debates in real scenarios, participants will face problems and downsides when applying new resources or strategies [59]. Problems and benefits must be identified for developing Innovative teaching and meaningful learning related to RRI. Case studies, best practices, co-inquiry-based projects, colearning outcomes must be shared through open-access to feed back for improving the process and make it sustainable [60].
How could we foster the further development of RRI in theory and its dissemination in practice? Besides advocacy, does this also require more insights into facilitating and identifying barriers? Broerse.

- "Reaching people at scale and high levels, particularly policy makers with clear recommendations will keep put RRI ideas into actions. This is one of the most difficult challenges.” Savre.

- "The concept of social responsibility, can be examined through opportunities developed by NGOs. Barajas.

- "Parental involvement in projects is also relevant to make RRI movement more sustainable, there is the European parent association that can facilitate the link between the school, universities and the parents. Kikis-Papadakis.

- "Students should be challenged to act as young scientists by developing and publishing their research. There are some science competitions that provide awards and scholarships, e.g. Google Science Fair and Intel ISEF”. Okada.

- “Students and their co-inquiry community should communicate their finding and make it available or accessible. At the end of EC projects, students should provide information and outcomes in informal context and appropriate what is happening in the real world.” Sherborne.

- “Establishing connections among disciplines will be useful to explore multi or inter-disciplinary themes and projects”. Broerse.

- “Arts and creativity must be connected to STEM for STEAM to support RRI dissemination and further research as well In the Exploratorium in San Francisco they have an exhibition asking people where they learned. And people learn from different places, e.g. from comics, TV, conversations with friends…” Merzagora.
4. RRI Partnerships

(Industry, Science Centers and Scientists)

Today Science is increasingly framed in terms of economic growth, social impacts, environmental challenges and global needs. It is conceived by the interconnection of various actors in science-business, science-labs, science policy, science governance, science funders, science media, science centres and science education. Through RRI, science advancements can be developed based on society’s expectations and anticipation of risks in order to maximise benefits and reduce risks. This is why scientists should ensure their work is in line with people’s needs and ethical values.

Responsible Research and Innovation will be increasingly essential for providing tools and strategies to enable all societal actors contribute to innovation processes and products that are desirable, sustainable and useful for the society.

Informal science education promoted by various initiatives is shaped and has been contributing to this trend. Formal science education needs to develop ways to mainstream this vision through teaching practices and learning objectives. Links between both must be developed. That means school teachers should contribute to learning design in informal learning settings while informal educators should be also involved in and associated with the school. Building RRI partnerships will be relevant for widening participation, dissemination and impact.

Big Science, technology impact, Science-Media and Values of Thinking must be approached by formal and informal Education. Informal and formal learning needs to be connected for scientific citizenship through its curriculum and teaching practices.
4.1 Participatory citizenship

Participatory citizenship [66], open schooling and collaborative inquiry projects has increasingly become a priority in Europe to enable a collective, interactive and inclusive approach. Scientific research and innovations and Science-career studies need a societal uptake for addressing societal needs and concerns [XX]. This includes increasing the number scientists and research professionals interested in shaping desirable and sustainable futures through evidence-based practices [67].

What are the strategies for disseminating and promoting partnerships? What are the key benefits and barriers for wide recruitment of stakeholders? Verdeguer.

How could we develop two-way communication, and involve target audience in science, technology and innovation with respect to different motives and interests? van de Laar.

- “Truly share “ownership of the agenda” will help to develop the full potential of “collective impact”. Verdeguer.

  - “The inclusion of all actors of society must be reached and in a meaningful way.” This includes gender, race, ethnicity, socio-economic status, digital skills and education levels. Morton.

  - “The results of RRI initiatives must be shared widely with all societal actors. So results go back to policy makers, but rarely to science. Then what matters as an impact also plays a role: in some countries it seems only commercial impact, but numbers is worthwhile” van de Laar.

- “Clarifying RRI to scientists will be essential. Scientist usually already know about the risk of their research and think they have taken sufficient measures to take them into account. They don’t understand when citizens come with concerns, telling them that there are risks.” Verdeguer.
“RRI is more than the sum of its parts and provides a new way of thinking about research. However, it is embedded in a system which is resistant to change at all levels. Van Marrion.

Everyone must feel safe to express her/his values and opinions. RRI, to begin with, has to do with contributing to create an atmosphere of dialogue and respect. Monge.

“In informal education should be integrated in the school curriculum instead of being considered as a complement of formal education”. Kikis-Papadaski.

“Young students including children should be involved in the RRI discussion as social actors too”. Jenkins.

### 4.2 RRI partnerships

Concrete examples of RRI partnerships are crucial to develop significant cases on RRI in Science Education. RRI Best practice built through partnerships between schools, local communities and local industry will allow us to know how to foster science education for responsible citizens at scale. The outcomes of best practices might be useful for opening up opportunities for new schools, centers, museums and industries in different countries.

“How are our projects establishing strong connections between IBSE, RRI, science in society and science museology?” Verdeguer.

“How are our projects fostering collaborations between corporations, universities, local authorities and science centers?” van de Laar.

“Including examples with various stakeholders will facilitated the link with RRI and inquiry-based science teaching methods”. Van Marion.
“Understanding how initiatives are developed in the formal education sector are useful to establish partnership for RRI”. Debry.

“Supporting the movement towards a better inclusion of all actors of society, will be useful particularly parts of civil society who are still not reached”. van de Laar.

“Empowering all participants as agent for change through “social capital”, can be done by using awards”. Jeckins.

“Developing themes such as ‘gender’ and ‘open access’ can create opportunities to make them more potent as change agents”. Morton.

“Opening up the discussion and diversifying partnerships are necessary, (i.e. parents associations - see the Czech “Parents project”, or families – see Yorkshire Grand Days out)”. Kikis-Papadaski.

“Different knowledge places would benefit from more connections which are often disconnected, such as universities and science centers. (E.g. Places)”. Costa.

“Communication back to people on what was done with their opinion and making policy makers accountable for what they do with it are very important”. Mazzonetto.

4.3 RRI impact

Evidence of significant impact of RRI projects is fundamental for policy makers in order to put strategies and recommendations into action [68]. The dissemination of clear impacts will enable the transformation of practices and actors into agents of change for valuable innovations [69]. There are three desirable impacts based on the RRI partnerships in Science Education highlighted by the European Commission:

1. More scientifically interested and literate students with a better awareness of and interest in scientific careers [70].

2. More meaningful resources, tools and skills for citizens and researchers make informed decisions [71].
Increasing the numbers of scientists and researchers in Europe.

“How could we promote RRI as a radical change in the way research and innovation activities are conducted across Europe”? Gray.

“How different projects are promoting institutional transformation, children’s empowerment, trans-disciplinary working”? Jenkins.

“How could we support RRI living systems (ecosystems, human-systems etc.) function, and how they could be improved if needed”? Artheau.

“Discussing and elaborating legacy plan for the sustainability of the projects outcomes. Making Toolkits that are produced by partners sustainable at the end of projects is difficult. Knowledge Hubs and portals take time and should take over after the end of a project (see RRI tools project).” Verdeguer

“Additional post project funding would be useful. Indeed the final deliverables of projects are usually ready when the project ends, leaving little time & money to spread and support them.” Verdeguer

“Involving target audience in science, technology and innovation with respect to different motives and interest for widening dissemination and impact.” van de Laar.

“A radical change in the way research and innovation activities are conducted across Europe.” Gray

“Identifying facilitators and barriers to increase the impact of RRI and discuss the role of Science Communication.” Artheau

“Providing self-assessment tools to all partners and different groups of stakeholders was considered a good way to make some progress.” Some projects provide a few, namely the SiS-Catalyst and PERARES projects Brenton and Murphy.
“Developing a useful evaluation framework for RRI activities including learning analytics.” Mihai.

“Establishing partnerships with policymakers, particularly who keep the power, make decisions about public consultation outcomes, governance and funding.” Artheau

“Understanding better how policy makers work and value evidence of our projects’ outcomes: in order to make decisions, establishing new actions and new funding directions.” Costa
5. European Projects

5.1 Tools, Standards and Frameworks


**Aims:** to develop standards and approaches for RRI implementation within Europe, to improve respect of ethics principles and laws in research and innovation, and to make sure that they are adequately adapted to the evolution of technologies and societal concerns.

**Target:** more than four hundred stakeholders acting together on the ethical impact assessment of research and innovation. The coalition includes government agencies, standardization agencies, multinationals, academic organizations, civil society/NGO actors, and UNESCO.

**Methods:** the project includes the involvement of participants in workshops and training sessions.


**Aims:** to foster RRI for and with society through a Toolkit, which will allow users to search information, perform RRI, access a library and develop the RRI community. The all phases of the project are based on a permanent dialogue with all the stakeholders.

**Target:** all societal actors (researchers, citizens, policy makers, business) work together during the whole research and innovation (R&I) process in order to align its outcomes to the values, needs and expectations of European society.
**Methods:** the project will build a community of practice in Europe to ensure the use, evolution and enrichment of the Toolkit and 19 national centres “the RRI Hubs” responsible for opening participation to the maximum number of institutions and individuals in the field.

**3. CONSIDER (FP7: 2012 - 2015, 8 partners) Ref. 288928.**

**Aims:** to support the participation of civil society organisations (CSO) in the governance of research, by exploring the knowledge and research potential of CSOs, investigating how CSOs are involved in research processes and using this knowledge to inform policy makers on how to integrate CSOs in further research and innovation activities.

**Target:** civil society organizations that pursues a common purpose for the public interest. CSOs are responsible for articulating the opinions of various social spheres, and cover, for example, environmental groups, minority groups, consumer representatives and patient organisations.

**Methods:** the development of guidelines will involve a large number of Associates, some of whom will be policy stakeholders. The CONSIDER participants will be organised through a virtual Network of Associates.

**4. PERARES (2010 - 2014, 28 partners) Ref. 244264.**

**Aims:** to strengthen interaction in formulating research agendas between researchers and Civil Society Organisations (CSOs).

**Target:** researchers and Civil Society Organisations (CSOs).

**Methods:** a network of research bodies doing research for/with CSOs. Ten Science Shop was created for adding studies on good practices to the available knowledge base and organising workshops and two large conferences.
5.2 Global Networks


**Aims:** to develop an empirically based and theoretically sound model of the role of responsible research and innovation governance.

**Target:** the project will explore the dynamics of participation in research and innovation, and investigate the characteristics of responsible practices. It will investigate the nature of new partnerships among various stakeholders, researchers and policymakers that are developing within innovation networks and the influence that these developments have on knowledge production and policy.

**Methods:** this will be done by determining the characteristics of research and innovation, involving diverse groupings and determining the social processes involved in responsible research and innovation practices.

6. **PReGReSS (FP7 2013 - 2015, 10 partners)** Ref. 321400.

**Aims:** to link existing international networks of RRI with relevant societal actors on a global scale to focus innovation on societal desirability.

**Target:** a global network on responsible research and innovation (RRI) involving academia, SMEs, international organisations, policy advisors, research funders, NGOs and industry. It also investigates funding strategies and innovation policies in Europe, the US, China, Japan, India, Australia, and South Africa.

**Methods:** to advocate a European normative model for RRI globally, using constitutional values as a driver to inform societal desirability and develop a strategy for fostering the convergence of regional innovation systems at the global level.

**Aims:** to develop a normative and comprehensive governance framework for RRI for facilitating constructive negotiations and deliberation between diverse actors and co-construct with stakeholders the central building blocks and procedures of an overarching future governance framework for RRI.

**Target:** direct impact on RRI practices (science, industry, policy), and strategic impact in terms of the political goals (Horizon 2020) and competitiveness (Lead Market through growing acceptance of new technologies).

**Methods:** providing grounded comparative analysis of a diverse set of existing RRI governance arrangements and their theoretical/conceptual underpinnings across different scientific technological areas, a continuous monitoring of RRI trends and developments in selected countries.


**Aims:** to develop a global virtual observatory for enhancing the interaction among research outcomes and policy making, making use of the full potential of scientific achievements to be incorporated in the policy development and implementation.

**Target:** the societal, policy and research stakeholders.

**Methods:** It is based on three components: observatory, forum and networks.

5.3 **Public Consultation – Engaging Citizens**


**Aims:** to foster an alignment of research and innovation (R&I) with the needs, values and societal expectations.

**Target:** different stakeholders involved and/or affected by R&I will participate in a debate and reflection process on RRI Learning through online and offline Forum actions.
**Methods:** It will create and share an inventory that gather results of other EU funded RRI projects, good cases and practices of RRI and RRI Learning for RRI Training programs and formative materials different HEI educational levels (undergraduate, MD and PhD, summer courses and MOOC), mainly based on Problem based learning methodology, and supported by multimedia materials (videos and microvideos, 2.0 materials, etc.). All results and products will be uploaded at RRITools Platform.

**10. EnRRICH (2015 - 2017, 13 partners) [Ref. 665759]**

**Aims:** to improve the capacity of students and staff in higher education to develop knowledge, skills and attitudes to support the embedding of RRI in curricula by responding to the research needs of society as expressed by CSOs.

**Target:** Higher Education community.

**Methods:** identifying, developing, piloting, and disseminating good practice and relevant resources to embed the 5 RRI keys in academic curricula across Europe. It focus on the co-creation of research to enable students to acquire the broad range of skills, knowledge and experience needed for a knowledge economy and knowledge society to flourish.

**11. CIMULACT (2015 - 2017, 29 partners) [Ref. 665948]**

**Aims:** to engage citizens and multi-actors in co-creation of research agendas based on real and validated societal visions, needs and demands.

**Target:** The collective intelligence of society gives Europe a competitive advantage by establishing genuine dialogue between citizens, stakeholders, scientists, and policymakers visions and scenarios for the desirable futures.

**Methods:** The project will expand the outlook and debate on STI issues, increase scientific literacy in a broad sense, which includes the understanding of the societal role of Science, Technology and innovation (STI), and create shared understanding between scientific stakeholders, policy-makers and citizens.

**Aims:** to foster Public Participation in Developing a Common Framework for Assessment and Management of Sustainable Innovation related to Climate action, environment resource efficiency and raw materials.

**Target:** stakeholders in area of Climate and Environment.

**Methods:** promoting the debate on conceptual dimensions, policy boundaries, and good practices combining innovative pursuits with sustainability objectives. It makes a more thorough inquiry into the balance between the social, economic and environmental impacts of innovations, and will help determine priorities for national and EU policy making.


**Aims:** to increase the use of engagement methods and policies by spreading awareness of the opportunities amongst researchers, policy makers and other interested parties.

**Target:** all different societal actors.

**Methods:** exploring how members of society are involved today and in the future. It will investigate how, where and why members of the public, stakeholders, consumers and other groups are engaged in the research process, from early policy development to the delivery of research activity. The project will map existing policies, structures, methods, approaches, tools and instruments, as well as highlighting promising new or adapted approaches we would like to see in the future.

5.4 Specific Areas

**SYNTHETIC BIOLOGY**


**Aims:** to contribute to RRI in synthetic biology by establishing an open dialogue between stakeholders concerning synbio’s potential benefits and risks, and by exploring possibilities for its collaborative shaping on the basis of public participation.
Target: stakeholders in the area of synthetic biology.

Methods: to address its objectives, SYNENERGENE (1) has a strong orientation towards the future and its shaping (‘open futures’), (2) involves citizens as real co-creators of RRI, (3) takes scientific research and development as cultural activities crucial for RRI, (4) involves a wide range of stakeholders and various disciplines, (5) has a strong international dimension with a focus on global players and (6) makes use of online communication in many ways.

INDUSTRY


Aims: to design an Exemplar Implementation Plan of RRI in Industry to demonstrate how industry can work productively together with societal actors and integrate principles and methodologies of RRI into research and innovation processes.

Target: industry partners, established RRI experts, policy advisors and civil society organisations.

Methods: current discourses on RRI in the industrial context, practical cases, Delphi study 130 stakeholders and an international Multi-Stakeholder workshop.

NANOTECHNOLOGY


Aims: to establish a programme for outreach and dialogue throughout Europe for supporting the effective governance of nanotechnologies through 3 steps: INSPIRE: Organise engagement and dialogue at the ‘upstream’ level of research policy; CREATE: Enable processes of co-creation during research and innovation, EDUCATE: Professionalise nanotechnology education and training and ENGAGE: Establish a coherent programme for outreach and communication on nanotechnology.
**Target:** academia, industry, civil society, education and communication.

**Methods:** ‘midstream’ engagement (by organising open innovation workshops at the level of R&D) and ‘downstream’ strategies for education and communication.

**17. NANO OPINION (FP7: 2012 - 2014, 17 partners) N. 290575.**

**Aims:** to monitor public opinions on nanotechnology and engage the general public in debate on potential risks and benefits of nanotechnologies.

**Target:** It explores ways to connect nanotechnology subjects to school curricula and produce educational materials for teaching and learning about nanotechnology in secondary schools. It also considers public opinion on what we expect from innovation with nanotechnologies.

**Methods:** The project promotes informed social debate over the Internet through: 1. Website of NanOpinion with surveys, questionnaires and blogs. It offers an extensive online repository with more than 150 educational and informational resources on the subject. 2. four media channels that publish news: The Guardian (UK), El Mundo (Spain), Le Courrier (France), TiConUno.

**ENVIRONMENT - WASTE**

**18. VOICES (FP7: 2012 - 2014, 17 partners) N. 612210.**

**Aims:** to produce an innovative and replicable participatory process, orienting research, innovation and policy making more strongly towards societal needs. VOICES represents a milestone in (RRI), fostering new multi-stakeholder participatory activities in the future.

**Target:** a groundbreaking consultation, using the opinions of 1,000 people from across 27 EU countries to shape the future of European research.
**Methods:** The methodology used, 3-hour focus groups, resulted in a deep, unique understanding of citizens’ views. Citizens around Europe were delighted by the clear commitment of the European Commission to make use of their VOICES to influence research priorities. VOICES has proved to be a successful model of democratic science governance.

**FOOD SECURITY**

**19. INPROFOOD (2011 - 2014) N. 289045.**

**Aims:** to help further incorporate public concerns and providing feedback to underpin the policy debate on integrating society in science to support practical guidelines for inclusive, sustainable research designs.

**Target:** It aims to find new ways to establish dialogue and mutual learning between industry, academia and civil society in the area of food and health to tackle policy questions on food and health research.

**Methods:** an inclusive research programming for sustainable food innovations. It considers that governance of research and technological developments facilitate sustainable and inclusive solutions.

**SCIENCE COMMUNICATION**

**20. PLACES (2010 - 2014, 60 partners) N.244449.**

**Aims:** to develop Local Action Plans targeting science communication policies in European cities and regions with strategic visions.

**Target:** the City Partnerships constitute alliances of science communication institutions and local policymakers.

**Methods:** builds the European City of Scientific Culture, which is a platform of Local Authorities and Communicators Engaged in Science. Citizen consultations thus have been key steps in the development of the Local Action Plans. An extensive series of Pilot Activities have tested innovative approaches
to communicate science-based solutions in cities. Annual Conferences, Science Cities Workshops, training opportunities and Thematic Working Groups brought PLACES stakeholders together in a united effort.

**NEURO-ENHANCEMENT**

21. **NERRI (FP7 2007 - 2013, 18 partners) N. 321464.**

Aims: to contribute to the introduction of RRI in neuro-enhancement (NE) in the European Area through mobilization and mutual learning.

Target: the project will involve different stakeholders and will promote a broad societal dialogue about neuro-enhancement, including interviews and workshops engaging scientists, policy-makers, industry, civil society groups, patients and the wider public.

**CO2 EMISSIONS**

22. **CARBOSCHOOLS (2008 - 2011) N. 217551.**

Aims: to offer resources to teachers and scientists willing to encourage pupils to experience their impact on the earth system and reduce CO2-emissions.

Target: carbon science researchers and secondary school teachers invite young people to learn about local and global impacts of climate change, explore scientific research on the topic and act locally to reduce emissions of greenhouse gases.

Methods: materials developed and shared with a broad range of players in science education via the internet and a European conference and regional dissemination activities.
5.5 RRI and Inquiry Based Learning


**Aims:** to build up a scientifically literate society, which enables its citizens to participate in the research and innovation process as part of RRI.

**Target:** the project will establish a multidisciplinary team and facilitate networking activities among teachers, teacher educators and educational researchers in 11 countries.

**Methods:** It offers an integrated approach Socio-Scientific Inquiry-Based Learning (SSIBL). It collects and shares existing best practices across Europe and develop learning tools, materials and in/pre-service training courses for science teachers based on the SSIBL approach.


**Aims:** to help teachers develop the beliefs, knowledge and classroom practice for RRI teaching. It synthesises contemporary models of professional learning and curriculum development.

**Target:** educators and students.

**Methods:** going beyond training events, its three-stage path will propel teachers in their own inquiry to become expert with RRI. It combines science-in-the-news materials with strategies from informal learning. It provides: (1) an online community of practice to support teacher reflection; (2) online courses and workshops to add coaching and feedback. (3) toolkit of examples, explanations and activities to help students learn effectively and (4) open-ended projects to put teachers and students into partnership with practising scientists, to learn about RRI directly.
25. **IRRESISTIBLE (2013 - 2016, 14 partners) N. 612367.**

**Aims:** makes young people more aware about Responsible Research and Innovation issues.

**Target:** community of Learners, Researchers and people from industry.

**Methods:** It focusses on developing materials to be used both in the classroom and in the science centres as well as teacher training. Each partner will form a Community of Learners in which teachers work together with formal education experts and informal education experts. The topics they will work on are derived from cutting edge research taking place at the partners’ university. Ten modules will be published and disseminated using www.scientix.eu and through workshops at local and (inter)national conferences.


**Aims:** to foster more challenging, authentic and higher-order learning experiences and more opportunities for pupils to participate in scientific practices and tasks, using the discourse of science and working with scientific representations and tools.

**Target:** Its platform brings together inquiry-based activities, learners and supporters (teachers, university students, researchers, staff of museums and universities).

**Methods:** face-to-face training for teachers and supportive web-based materials.

5.6 Inquiry Based Learning - Teachers’ CPD

27. **TEMI (2013 - 2015, partners) N. 321403.**

**Aims:** to help transform science and mathematics teaching practice across Europe by giving teachers new skills to engage with their students, exciting new resources and the extended support needed to effectively introduce enquiry based learning into their classrooms.

**Target:** teachers and students.
**Methods:** It implements innovative training programmes called ‘enquiry labs’. These are based around the core scientific concepts and emotionally engaging activity of solving mysteries, i.e. exploring the unknown. The enquiry labs use scientists and communication professionals (e.g. actors, motivational speakers, etc.) to mentor teachers through the transition to use enquiry to teach science. TEMI helps teachers foster a deep motivation to learn, by bringing to the fore the sense of mystery, exploration and discovery that is at the core of all scientific practice.

**28. PROFILES (2010 - 2015, 24 partners) 266589.**

**Aims:** to promote IBSE through raising the self-efficacy of science teachers and in so doing aiding a better understanding of the changing purpose of teaching science in schools and the value of stakeholder networking.

**Target:** teachers.

**Methods:** the proposal innovation is in utilizing science teaching materials to support teachers, through an inspired, longitudinal training programme reflecting stakeholder views and needs, I focuses on disseminating Inquiry-Based Science Education through innovative learning environments and programmes for the enhancement of teachers’ CPD. It raises the self-efficacy of science teaching to enable educators to take ownership in more effective ways in science teaching.

**29. STENCIL (2012 - 2014, 9 partners)**

**Aims:** to offer to science teachers and practitioners in science education from all over Europe a platform to encourage joined-up thinking and European co-operation, to contribute to the improvement of science teaching.

**Target:** science teachers and practitioners in science education.

**Methods:** the European Online Catalogue of Science Education Initiatives, the Annual Reports on the State of Innovation in Science Education, presenting innovative practices at national and EU level and the Manifesto for teaching and learning science in creative ways focusing on the main issues for innovation.

**Aims:** to disseminate and facilitate the use of inquiry-based science teaching approaches with second level students (age 12-18 years) on a large scale across Europe.

**Target:** second level students and the key stakeholders in science education across the eleven European.

**Methods:** collaborative environment.


**Aims:** to engage elementary and secondary pre-service teachers in critical discussions of everyday science through socio-scientific issues (SSI) and prepare them to teach SSI.

**Target:** pre-service teachers.

**Methods:** It provides evidence of how pre-service teachers can collaborate to provide answers regarding SSI issues of concern for all partner countries.


**Aims:** to promote the effective widespread use of inquiry and problem based science teaching techniques in primary and secondary schools.

**Target:** It brings together experts in the field of science education research and teachers’ communities, scientists and researchers involved in pioneering scientific research, policy makers and curriculum developers.

**Methods:** It offers guidelines for the educational community to further explore and exploit the unique benefits of the proposed approach in science teaching. In this way the project team aims to facilitate the development of communities of practitioners of inquiry that will enable teachers to learn from each other.

**Aims:** to increase the adoption of IBSE through various forms of teacher professional development and to make inquiry an integral component of teacher education generally.

**Target:** teachers and teacher educators across Europe.

**Methods:** It focuses on disseminating inquiry-based science teaching methods (IBSE) to the widest possible range of teachers and teacher educators across Europe and associated countries.

5.7 Inquiry Science Based Education - Tools & Methods


**Aims:** offers a scientific inquiry platform for science learning and teaching in combination with today’s curricula and teaching practices.

**Target:** students and Educators from secondary and higher education.

**Methods:** It works on a meta-inquiry level in order to: (a) define a reference model for inquiry-based learning skills, (b) create a diagnostic instrument for measuring inquiry skills, and (c) implement a working environment that allows the easy linking of inquiry activities with school curricula and legacy systems. Its platform offers (1) an open source service framework for inquiry workflows, (2) tools for mobile data collection and personal experience sampling, (3) learning analytics tools for collaborative and personal reflection, and (4) a badge system for linking formal and informal learning activities via social media. These products will be customized and evaluated in at least 8 primary test-beds in a European wide approach in 8 European member states.

**Aims:** to promote a widespread use of inquiry-based science teaching (IBST) in primary and secondary schools. It offers training courses in which pre- and in-service teachers will learn about IBST supported by teachers from vocational education, representatives from industry and informal learning.

**Target:** pre- and in-service teachers.

**Methods:** they will develop inquiry tasks in vocational contexts, leading to a large European task repository. Teachers will experience IBST themselves and through iterative cycles of implementation followed by reflection integrate this into their practice. To ensure widespread participation we will use a pyramid model in which we will work with a small number of teachers first each of which will then work with further teachers. Additionally we will develop an innovative interactive e-learning platform. To profit from the international perspective offered by the project teachers will be connected with existing European networks and our own thematic network on IBST through (virtual) meetings, a forum and the task repository.


**Aims:** to bring together the experience and learning of a wide range of projects in European Science and Mathematics education.

**Target:** teachers and students.

**Methods:** It links research, practice and policy in a unique way. Its aim is to promote inquiry based teaching, to gather innovative teaching methods and to raise students’ interest in science as well as offering them careers information in STEM subjects. It also acts as an integrated provider of STEM education materials and techniques, based on the work of previous projects. It takes a critical, reflective and inclusive approach to the various strands of practice and development work carried out in projects across Europe.
37. SIS CATALYST (2011 - 2014) N. 266634.

**Aims:** to foster and support ethical, effective and sustainable engagement between children aged 7-14 years and the social, cultural, political, scientific and educational institutions which make the decisions that will shape their futures.

**Target:** children aged 7-14 years.

**Methods:** enhancing interaction will benefit both children and institutions through exchange of views and improved mutual understanding. While it seeks to empower children everywhere and influence all kinds of institutions to engage with them, the initiative has a particular focus on strengthening relationships between post-secondary education institutions and the children who, despite ability, currently appear unlikely to enter them.

38. ENGINEER (2011 - 2014, 26 partners) N. 288989.

**Aims:** to support the widespread adoption in Europe of innovative methods of science teaching and provide extensive teacher training on inquiry-based methods.

**Target:** training will be provided to 1,000 teachers, and trained teachers and school/museum activities will reach 27,000 students during outreach.

**Methods:** It will be based on the proven “Engineering is Elementary” (EiE) program developed by Boston’s Museum of Science (BMOS) and now widely used in primary schools. Incorporating engineering in science teaching, using inquiry-based pedagogic methods results in highly desirable impacts on students and teachers, raising students’ interest in science and engineering. BMOS will play an instructional and advisory role in ENGINEER. Museums will offer programs for student groups as well as for the general public.


**Aims:** to promote inquiry in mathematics and science education across Europe.
**Target:** mathematics and science teachers.

**Methods:** It focuses on a change across Europe in the teaching and learning of mathematics and science with teachers supported to develop inquiry-based learning (IBL) pedagogies so that students gain experience of IBL approaches. Ultimately, our objective is a greater number of students with more positive dispositions towards further study of these subjects and the desire to be employed in related fields.

40. **CoReflect (2008 - 2011, 8 partners)** [N.217792](#).

**Aims:** to provide Digital support for Inquiry, Collaboration, and Reflection on Socio-Scientific issues. It promotes evidence-based practice in science teaching and learning, by collaborating to iteratively design, enact, critique, and validate problem-based innovative inquiry learning environments.

**Target:** science teachers and learners.

**Methods:** these environments, which are being hosted on the STOCHASMOS web-based teaching and learning platform, data-rich scientific rigor with the flexibility and easy modifiability that is needed for widespread adoption and use by teachers.
Technologies for Science Education - RRI

GM decision

Following a EU rule change, the growing of GM crops across Europe will increase in many countries. It looks likely that GM foods such as breakfast ...

Ebola

The 2014 Ebola outbreak in West Africa was the largest in history, and killed more than 11,000 people. New cases are still appearing. Scientists have responded ...

Making Decisions

Carriers of an inherited condition have to make many difficult decisions including what to do if they want children. In this activity students are placed in ...

Take the test?

Genetic tests can be used to determine whether a person is a carrier of a genetic condition - but is having a test always the best ...

Three Parents

Babies will soon be born which have two Mums and a Dad! A new procedure which creates babies with the DNA of three people has
Approaches for RRI teaching and learning
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PARTICIPANTS AND EXPERTS

Experts who contributed to this debate and their respective projects

1. Alcaraz, Silvia: ENAGE
2. Artheau, Malvina: RRI-TOOLS
3. Aschim, Elin: TEMI, ENGAGE
4. Barajas, Mario: PATHWAY
5. Bayram-Jacobs, Dury: ENGAGE
6. Bizoi, Mihai: IRRESISTIBLE, PROFILE, ENGAGE
7. Bjar, Harald: TEMI, ENGAGE
8. Breton, Camille: SIS-CATALYST
10. Bullough, Andy: ENGAGE
11. Chaimala, Fotini: STENCIL, WESPOT, ENGAGE
12. Costa, Antonio: PLACES, ECSITE
13. Dapkus, Dalius: ENGAGE
14. Debry, Maite: NANO OPINION, RRI-TOOLS, SCIENTIX, SCHOOLNET
15. Eidin, Emil: ENGAGE
16. Evagorou, Maria: PREESEES
17. Fresson, Meriem: ENGAGE
18. Gorghiu, Gabriel: PROFILE, IRRESISTIBLE, ENGAGE
19. Gorghiu, Laura: PROFILE, IRRESISTIBLE, ENGAGE
20. Gray, Peter: S-TEAM
21. Hadwiger, Klaus: INPROFOOD
22. Heinzen, Sanuel: ENGAGE
23. Hetzner, Sonia: STENCIL, WESPOT, ENGAGE
24. Hulme, Philippa: ENGAGE, UPD8
25. Jenkins, Patricia: SIS CATALYST, INSTEM
26. Jordan, Julie: TEMI
27. Kikis-Papadakis, Kathy: EPNoSL, STENCIL, WESPOT, ENGAGE
28. Knippels, Marie: PARRISE
29. Mazzonetto, Marzia: SYNERGENE, VOICES, RRI-TOOLS, ECSITE
30. Merzagora, Matteo: TEMI, ENGAGE, SYS-CATALYST
31. Mignan, Vanessa: ENGAGE, TEMI
32. Monge, Ignacio: ENGAGE
33. Monica, Laura: IRRESISTIBLE
34. Morton, Pat: ENGAGE
35. Murphy, Padraig: PERARES, RESAGORA, SOCIAL IMPACT
36. Okada, Alexandra: URBAN INQUIRIES, WESPOT, ENGAGE
37. Peciuliauskiene, Palmira: ENGAGE
38. Pellaud, Francine: ENGAGE
39. Protopsaltis, Aristidis: WESPOT, ENGAGE
40. Rossi, Lia: ENGAGE
41. Savre, Audrey (Project manager): ENGINEER, ECSITE
42. Sherborne, Tony: ENGAGE, TEMI, UPD8
43. Shwartz, Yael: ENGAGE
44. Steill, Bernie: ENGAGE
45. Trifonova, Anna: ENGAGE
46. van de Laar, Bart: IRRESISTIBLE, CARBOSCHOOLS, PLACES,
47. van Marion, Peter: INSTEM, S-TEAM, SUN
48. Vannuci, Mauro: WESPOT, ENGAGE
49. Verdeguer, Ignasi Lopez: RRI-TOOLS
50. Young, Gemma: ENGAGE, UPD8
The ENGAGE project consortium

Associated partners and collaborators