



Innovative teaching for  
Responsible citizenship  
**policy report**

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Funded by



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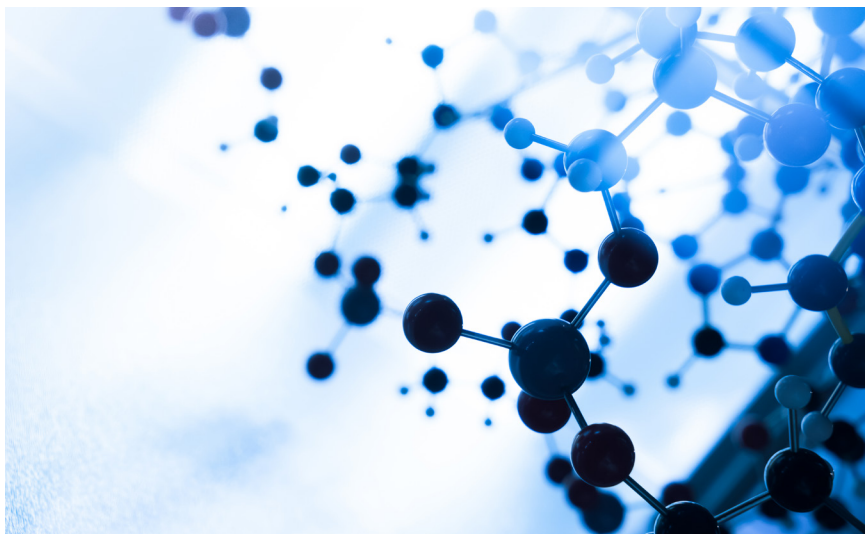
2016.



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# 1. EXECUTIVE SUMMARY

Responsible Research and Innovation (RRI) encourages the societal players (researchers, citizens, policy makers, business and third sector organisations) to work together during the research and innovation process in order to align scientific advances with the values, needs and expectations of society.

The three year ENGAGE project focused on how responsible citizenship can be promoted through inquiry based learning in science education. Its approach was to consider school environments as the priority for equipping students with the necessary skills and embed scientific knowledge, so that in the future the population has skills to evaluate and judge scientific innovations.

ENGAGE reviewed the curricula in European countries to assess the degree to which RRI is already being carried out and the potential to expand this approach. Working with experts in RRI and inquiry based learning, ENGAGE studied the best ways to extend their use, barriers to the process and teacher training requirements.

ENGAGE has also created an extensive range of contemporary materials on a website for teachers to reflect on RRI in their lessons. In order to support teachers' CPD, ENGAGE has been deploying open online courses for fostering RRI teaching with RRI experts facilitators. Working with teachers, educators, researchers and policy makers, ENGAGE has had positive results in the classroom and is now in a position to expand its impact and learn the best way to promote RRI at scale.

The aim of this policy report is to influence policy makers and establish new partnerships with current and new projects to support science education for responsible research and innovation. Its content presents key recommendations for RRI curriculum design, RRI science teaching and RRI policy on science education.

The current activities must continue and expand. **Science educators and teachers mentors** should

- Be encouraged to include RRI in their lessons.
- Share best practice through social networks, website forum, as well as through events.

**RRI experts, science communicators and education researchers** should also promote knowledge exchange for teachers to implement RRI in the most successful way, it is therefore recommended that they:

- Share information between EC and national initiatives on science education and RRI.
- Publicise the benefits of RRI and ENGAGE for policy makers, researchers as well as other professionals.
- Widen access to formal and informal science education for RRI through open educational resources, MOOCs, expert networks and communities of educators.
- Give more publicity to the freely available and editable online materials including reports and research papers.

In order to have a more comprehensive, long lasting and wider impact on science education, it is recommended that **policy makers** need to:

- Build consensus about the value of RRI with various societal actors.
- Encourage the inclusion of RRI in the curriculum ensure that teacher training, both initial and CPD, includes RRI.
- Work with the examination boards to assess competences, not just knowledge.



## 2. INTRODUCTION

**RRI** - Responsible Research and Innovation - has been part of several European Framework Programmes. It is a transparent interactive approach that anticipates and assesses impacts of new scientific and technology developments that are, or might be, positive and negative for the environment and society.

The 21st century is marked by the pace of scientific advancement. Discoveries related to various emerging fields such as nanotechnology, artificial intelligence, neuroscience and biotechnology are frequently announced to citizens through the news and media. These daily innovations often highlight issues closely connected to people's lives, for instance, food security, enhanced health, energy and environment.

However the impact of scientific innovation is unpredictable and requires scientific knowledge and skills for reflecting on social and ethical implications. This requires societies to be able to understand the uncertainties and reflect on potential benefits and risks.

Educators need to equip students for making sense of technology and science and how it may affect our lives, and ensure scientific research is carried out in a responsible way. Teachers have a crucial role in developing pedagogical know-how, questioning ability and a wider perspective to help learners to integrate science knowledge with ethical values for evidence-based thinking.

The European Commission is keen for all citizens to have a better understanding of science and technology so they can participate actively and responsibly in science-informed decision-making and knowledge-based innovation.

Science Education plays an important role for responsible citizenship so that citizens are equipped at an early age to discuss socio-scientific issues, including consequences for people, environment and economy by applying science knowledge, ethical values and inquiry skills.

Shifting science education in schools towards an RRI approach will give the next generation of young citizens the knowledge, skills and attitudes to deal with socio-scientific issues in their lives, and develop informed opinions on emerging science and technology.

Project ENGAGE's goal is to embed RRI within the science curriculum and change the way science is taught. Through a set of innovative strategies, the ENGAGE aims to shift the emphasis from transmitting a body of scientific knowledge towards applying science to issues that matter to students. ENGAGE focuses on a more inquiry-based methodology, which gives students opportunity for self-expression and responsibility for coming to informed decisions.

ENGAGE aims to:

- Help teachers address contemporary science issues and applications relevant to students
- Develop teachers' beliefs, knowledge and classroom practice for RRI
- Provide students a strong foundation to engage in science issues they will meet during their lives

ENGAGE uses real examples to simulate how citizens conduct inquiries, to help embed those methodology.

This interim report covers the work done in the first two years of the three year ENGAGE project to understand how science education has being carried out in Europe and to learn from best practice on RRI and inquiry based learning. A website was set up, workshops run and feedback collected from teachers using RRI via inquiry based learning to put this information into practice. The success of the project is detailed and the plans for further work outlined. Recommendations for education policy makers, teacher trainers, teachers, exam boards and scientists are highlighted.



### 3. RRI CURRICULA ANALYSIS

The predominant method to integrate RRI into classrooms is inquiry based learning, which uses discussions, argumentative discourse and scientific reasoning. These strategies are considered most appropriate for promoting learners' critical thinking, problem solving skills and questioning abilities – which are important for pursuing RRI aims.

In order to propose a strategy for how RRI via inquiry based learning can be incorporated it is useful to understand the scientific curricula in the different countries in Europe. Project ENGAGE surveyed eleven European countries to find out the extent to which RRI is already being used – whether that is in name or just the principles; how many teachers are using it, and whether it is embedded in the curricula.

The results of the survey carried out under project ENGAGE highlighted five challenges that have been linked to recommendations for curriculum design.

**Challenge:** Several countries (e.g. France, Romania, Israel, Spain, Switzerland and Lithuania) have recently been engaged in educational reforms focused on science education. A common element is that STEM disciplines have gained high importance within education. However, educational reforms across the countries seem to remain at the policy level and have yet to be put into practice in the classrooms.

**Recommendation A1:** Science or STEM education reforms must include the RRI principles, and proven approaches need to be implemented into the classroom.



Challenge: In various countries (e.g. UK, Germany, and Greece) the curricula prioritises acquisition of content above the development of competences. This, in turn, means that the assessment focuses on content knowledge rather than competence.

Recommendation A2: There should be better alignment between curriculum objectives and assessment systems, ensuring that assessment includes the development of competences.

Challenge: In countries where science is taught in a multidisciplinary or interdisciplinary way (e.g. Greece, France, Israel, Spain, Norway, Switzerland, Lithuania, and Cyprus) rather than by subject (physics, biology, chemistry) there are more opportunities for linking science with other subjects, and incorporating RRI.

Recommendation A3: Opportunities to integrate science education with other subjects and disciplines can aid an RRI approach.

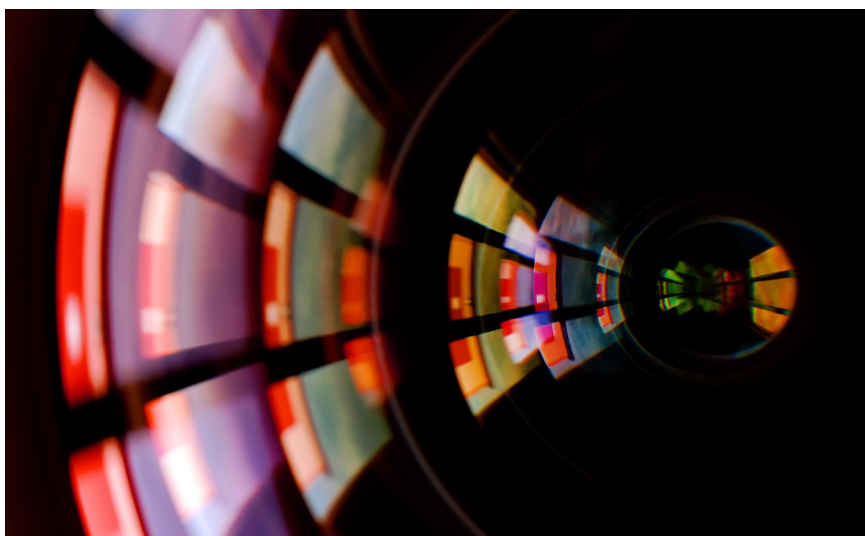
Challenge: The education policy agenda does not focus on pre-service or in-service teacher training. It is vital to bridge the gap between what is envisioned in theory, the curriculum and what is implemented in practice.

Recommendation A4: Coherence is required between policy objectives, the curriculum and teacher education in order to embed RRI.

Challenge: In all countries there are important teachers and policy makers that are implementing and promoting RRI initiatives. However there is little collaboration or connection between informal settings and formal schooling, or between general and vocational education. There is also a lack of opportunities to promote knowledge exchange.

Recommendation A5: Professional networks developed during EU funded projects should be promoted by national policy makers, in order to foster collaboration between teachers and with researchers on new methods, materials and topics.

In conclusion, there is an on-going policy discourse on the role of science education for promoting and realising RRI processes and outcomes, which are not always clearly or consistently understood. Although aspects of RRI via inquiry based learning are being used successfully by teachers all over Europe, these efforts are fragmented, with a lack of a comprehensive and coherent approach. In order to promote science education on RRI, it needs to be included in the curriculum, time devoted to teaching it effectively and the impact on the pupils needs to be assessed. Teacher' CPD is needed to enable this, and a network of experience and knowledge would help support the teachers.



## 4. EXPERT VIEWS ON RRI AND INQUIRY BASED LEARNING

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. In order to understand how RRI can be incorporated with inquiry based learning ENGAGE ran a seminar, and followed up with further research, to learn from the current experts and practitioners in the field. Barriers to progress were identified, teacher training required and resource levels were all covered to understand how science education can be adapted within current and future curricula.

There are two key elements to RRI. Firstly that science is a contemporary and constantly evolving practice, rather than a solid set of previously established facts and knowledge, and secondly that scientific knowledge is strongly intertwined in the wider social fabric. Exploration of these concepts can be effectively done through inquiry based learning. It is important that they are put in context by involving scientists and researchers in education, and examining the role of the media in setting science within a social context.

Analysis of the expert debate in the seminar highlighted that in order to embed RRI in science education, science teachers/educators will need to meet three key challenges. These challenges are connected to the following recommendations and examples from case studies.

Challenge: RRI requires a clear dialogue between scientists and citizens to better align the results of research with societal needs.

This challenges teachers to prepare students to discuss and develop evidence based opinions.

Recommendation B1: Inquiry based learning with topical science materials should be designed to help teachers foster students' socio-scientific skills including evidence-based thinking.

In order to implement this recommendation the following suggestions emerged from the expert debate:

- **b1.1:** Provide easy-to-use and topical resources explicitly linked to current curriculums with clear objectives.
- **b1.2:** Clarify why and how topical materials and tools can help teachers engage students and improve their outcomes.
- **b1.3:** Demonstrate ways to assess knowledge and skills for RRI (e.g. interrogate media, examine consequences, estimate risks, critique claims, use ethics).
- **b1.4:** Connect methodologies and structure from formal learning with context and real problems from informal learning.
- **b1.5:** Establish connections with various disciplines (STEAM - Science, Technology, Engineering and Math) for considering different perspectives.

Comments: Inquiry based science education is considered the basis for helping learners develop scientific skills, responsible values and lifelong learning. It is based on a cycle of steps: questioning, planning method, obtaining and analysing data, drawing conclusions, reviewing outcomes and communicating results. There are various frameworks that educators can use with students covering how to plan and develop their inquiry projects collaboratively. Inquiry based learning should be used to equip students acting as responsible active citizens to represent society's view and respond to new scientific developments. They also need to be able to act as qualified professionals and be responsible for innovation that is desirable, acceptable and sustainable.

Challenge: RRI requires engaging society with scientific advances for them to consider the risks and benefits of innovations together. Teachers must then equip students with knowledge, skills and attitude to act as responsible citizens with and for society.

Recommendation B2: Authentic scenarios on RRI for formal and informal learning from science-in-the news, open resources and scientists' networks should be used by teachers to help students link science with and for society.

In order to implement this recommendation the following suggestions emerged from the expert debate:

- **b2.1:** Use / identify controversial issues from science media which might be interesting for students and relevant for the curriculum, including issues related to environment, economy and society (e.g. gender, culture,...)
- **b2.2:** Promote ways to activate students' interests and curiosity through emotional engagement
- **b2.3:** Establish partnerships with science museums and science centers for RRI learning
- **b2.4:** Organise open exhibitions, fair, symposiums for students, teachers and scientists to develop projects and share best practices
- **b2.5:** Create opportunities through co-inquiry projects (beyond school environment; e.g. through open schooling, science shops,...) for students to engage with experts, scientists, parents, families and communities to discuss new issues and show outcomes.

Comments: Integrating informal and formal education might help teachers enrich lessons and provoke discussion. Topical science from the news and open resources available in science centres or museums will help students to link science to contexts. Collaborative learning with peers, educators and experts will foster meaningful science learning, which is connected to students' lives.

Challenge: RRI requires understanding and a practical approach to know how to anticipate and examine the outcomes during and after scientific innovations. Teachers need to use principles and practice to embed authentic socio-scientific issues and inquiry projects in the classrooms.

Recommendation B3: Effective professional development is required to support teachers in improving their knowledge and skills for RRI teaching.

In order to implement this recommendation the following suggestions emerged from the expert debate:

- **b3.1:** Offer flexible opportunities for teachers learning in and out-of-schools as reflective practitioners.
- **b3.2:** Clarify the value of integrating RRI into their teaching practices during the CPD activities.
- **b3.4:** Promote teachers' network for knowledge exchange and best practices.
- **b3.5:** Provide feedback on teachers' practices and outcomes by RRI experts or mentors.
- **b3.6:** Offer an integrated overview among the various EU projects on RRI for continuity.

Comments: The teachers need to be and 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 knowledge and experience to help students integrate conceptual and practical knowledge with ethical values for developing evidence-based thinking. This also includes supporting students to interact with scientists and local communities. The teachers will need continual professional development to be able to do this on an ongoing basis.

In conclusion, educators, scientists and science communicators have a collaborative role to facilitate citizen's understanding on how education, science and media interact in the real world for Human development towards a better future for all. This approach strongly relates to the notion of post-academic science introduced by physicist John Ziman more than a decade ago: Key decisions affecting the development of scientific research are no longer taken within specific body with explicit mandates, rather by complex interactions among a multitude of actors which includes research institutions, politics, the media, popular culture, art, religion, the commercial world and global society. If scientific progress is strongly socially embedded, science teaching should be even more so.



## 5. RECOMMENDATIONS FROM THE ENGAGE PROJECT

Project ENGAGE found that using RRI via inquiry based learning was effective in promoting debate, interest and excitement with pupils. It is an effective way of changing the way students think about science in society. The material and training provided through the ENGAGE website was effective in allowing teachers to introduce RRI into their existing lessons and curriculum, and the lessons were thoroughly enjoyed by the teachers and pupils. The website should expand the range of material available and develop the networking element, so that teachers can share experiences and best practice. The online training is a great resource for teachers who are new to RRI and inquiry based learning.

However this piecemeal approach, while welcome, will not transform science education. Extensive structural change will be required to have widespread changes. Education policy makers, exam boards and teacher trainers all have a role to play to facilitate wider use of RRI.

Project ENGAGE has had an overwhelmingly positive impact on the teachers and young students using its materials. It is recommended the current activities are continued and expanded.

C1. Teachers should be encouraged to include RRI in their lessons

C2. All educators should share best practice through the website forum, as well as through events

RRI coordinators (project leaders, researchers, managers and partner members) have a role in sharing best practices and mentoring teachers to implement RRI in the most successful way.

C3. Project leaders share information between EC and national initiatives on science education and RRI

C4. Principal investigators publicise the benefits of RRI and ENGAGE for policy makers, researchers as well as other professionals

C5. Project legacy managers widen access to formal and informal science education for RRI through open educational resources, MOOCs, expert networks and communities of educators

C6. Partner members give more publicity to the freely available and editable online materials including reports and research papers

In order to have a more comprehensive, long lasting and wider impact on science education, all stakeholders involved with policy should contribute to increase awareness of RRI on science education.

C7. Policy makers with society need to build consensus about the value of RRI

C8. Policy makers should encourage the inclusion of RRI in the curriculum ensure that teacher training, both initial and CPD, includes RRI

C9. Policy makers should encourage the partnership between RRI projects with the examination boards to assess competences, not just knowledge





## 6. THE ENGAGE PROJECT, OUTCOMES AND IMPACT

The ENGAGE project is part of the EU Science in society agenda to promote more Responsible Research and Innovation' (RRI) through inquiry based learning.

ENGAGE has been producing a wide range of learning and teaching resources, available on its website in 10 different languages:

- Sixty two lesson materials for students and teaching guide linked to the curriculum.
- Each lesson includes a dilemma presented through a story with a game based activity for the students to talk, think and develop informed-based opinion.
- Suggested questioning routes and extra resources such as video clips and science-in-the-news weblinks
- Three open online courses and various workshops
- Collaborative area for sharing questions, reviews and outcomes for each lesson material
- A course book and two reports on RRI and Policy
- A brokering partnership system for interacting with scientists and science communicators, available in 2016

Each lesson is focused on a particular topical scientific issue



through an engaging dilemma such as Three parent families (why is it deemed so controversial?), Fracking (should it be supported or not?), Banning coke (should the amount of sugary drinks be limited with children?) and GM crops (would you buy GM cereal?).

Country based workshops were run for teachers to understand the practical implementation of RRI via inquiry based learning. These took slightly different formats in different countries depending on their curricula, the range of experience the teachers had.

In additions, success stories about RRI were also collated and the lessons that could be learnt drawn out, these covered different aspects of ENGAGE and also looked at an example in Brazil. The UK example covers the experiences working with an examination board to update not only the curriculum but also the assessment. The French example covers the experience they had with encouraging interaction between scientists and the teachers and students. These success stories are summarised through nine cases by different countries.

The methodology developed by ENGAGE is based on a three-stage process to help teachers to become expert in RRI using inquiry based learning: adopt, adapt and transform.

**engage** wins the Open Education awards for Excellence 2017 on Topical Science Education for Responsible Research and Innovation

**OPEN EDUCATION CONSORTIUM**  
The Global Network for Open Education

**CREATIVE INNOVATION FOR EXCELLENCE 2017**

Welcome back **Ale Okada**.

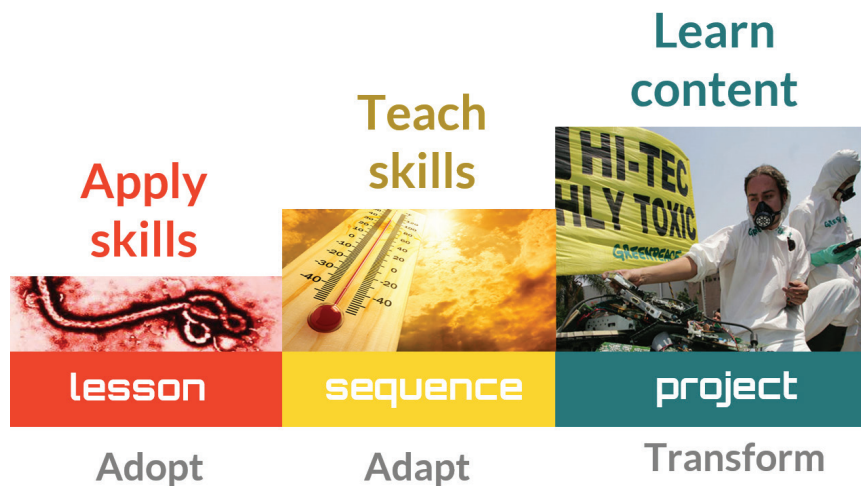
We are glad you have become an **Advanced User**.

**Vitamin D**  
Skill: Analyse patterns | Topic: Digestion  
This activity is designed to engage a wider range of students. Using the principles of 'science capital', it makes the issue of Vitamin D deficiency highly ...

**Exterminate**  
Skill: Multiple | Topic: Ecosystem  
Mosquitoes are the world's most dangerous killer. The diseases they transmit, malaria, Zika and dengue fever, cause more than a million deaths per year. Some scientists have ...

**Eco-phone**  
Skill: Multiple | Topic: Earth resources  
As the number of smartphone users worldwide exceeds 2 billion, and as users update their devices with ever-increasing frequency, there are growing concerns about the impacts ...

**Big Stuff Blog:**  
An inspiring conference, say science educators...  
The ENGAGE project conference, at the Open University on March 11th, was a unique event designed to launch a community of innovative science teachers. Funded by the European Commission (EC), this event brought together more than 80 Science teachers from right across England, as well as Russia and Brazil.



**1. Adopt** This stage helps teachers to get students engaged in socio-scientific issues related to RRI. Students are encouraged to apply inquiry skills to develop informed based opinion, which is essential for RRI. It combines exciting learning materials based on two pedagogical tools: dilemma and group discussion, and there are online courses and workshops for teachers' coaching and feedback.

**2. Adapt** This stage offers a toolkit of examples from experts, along with explanations, strategies and activities to help students learn effectively skills for RRI. A problem solving tool shows how 10 inquiry skills help learners understand the responsible decision making process on research and innovation. A conversation tool shows that how the classroom is modelling how citizens should be involved in the process of RRI.

**3. Transform** This stage provides open-ended projects to put teachers and students into partnership with practising scientists and learn about RRI directly. A scenario tool provides the relevant guidance for establishing meaningful projects and a performance assessment tool will help participants to co-evaluate the process.

There are four key areas which are relevant for ENGAGE materials and learning activities :

**1. Technology impact:** Technological and scientific developments are the basis for a better future but must

be planned carefully in order to maximise the benefits and reduce risks, particularly any harmful impact for society. Various issues must be considered, such as open access, data privacy, environment protection, wellness, economy and security.

**2.Big science:** Science is no longer an individual search for knowledge, but a collaborative and complex enterprise, done in teams. Funded largely by corporations and governments and politically determined, it favours practical applications and key areas in society. This means responsible innovations must address societal needs in accordance with societal values such as inclusion, diversity, equality and gender.

**3.Values thinking:** In emerging science and technology, there are often uncertain issues with unclear implications that require socio-ethical thinking. Decisions should be made by taking into account the views and concerns of actors in societies through anticipatory and transparent ways.

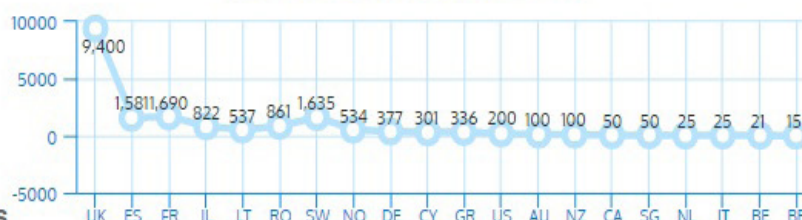
**4.Science-media:** Much of the scientific information is interpreted by the media, which has an important role in placing science news within the wider social framework, but may give an unbalanced, biased, black and white or sensationalised account. The source of information needs to be assessed in terms of its purpose, scientific credentials and currency. This includes critically read media reports about science, identify data, evidence and values thinking used to back up the claims, as well as evaluate its strength in terms of repeatability and reproducibility. This allows to contextualize and evaluate the relevance of research achievements.

## **Scope of ENGAGE and Future plans**

## USERS

154,186 Visitors  
18,043 Members  
129,674 downloads  
674,638 page views  
2,500 new visitors  
85 countries users

## TEACHERS REGISTERED 2014-2017



## Open Gaming Resources based on topical science & teaching tools

### Augmented Science for



Deal with socio-scientific issues in life for developing evidence-based opinions on emerging science & technology

### Inquiry based learning



Shift science education towards RRI approach will give the next generation knowledge, skills and attitude

### Engaging Dilemma



Activate students curiosity and interests to discuss application and implications of scientific innovations

### Group discussion



Give students opportunity for self expression and responsibility for informed decisions

### Problem-solving



Teach inquiry processes such as INQUIRY, ANALYSE, SOLVE and COMMUNICATE

### Conversation



Engage whole-class conversation to developing argumentation

### Interactive storytelling



Frame whole science topic in the form of inquiry-based projects

### Performance



Engage students to assess knowledge, skills and attitude



### LEARNING OUTCOMES

- Arguing about a dilemma
- Analysing issues and applying knowledge
- Evaluating the strength of the evidence
- Developing an evidence-based opinion

## Inquiry Skills for RRI



**INQUIRY**  
Devise questions



**ANALYSE**  
Interrogate sources  
Analyse patterns  
Draw conclusions



**SOLVE**  
Examine consequences  
Estimate risks  
Use ethics



**COMMUNICATE**  
Justify opinions  
Critique claims  
Communicate ideas



In March 2017, the ENGAGE consortium reached 18,043 teachers registered in the portal. Qualitative data from teachers revealed that ENGAGE materials cause a significant shift in teacher practice towards more realistic, open science teaching which emphasises the applications and implications of science, in line with RRI concepts.

“What is so good about this topic is that research is ongoing and new applications are being found all the time so the resource can be used to teach about each new exciting discovery!” ”Excellent activity with follow up! This is perfect for combining hsw (how science works) with real-life applications! 2016-09-17 11:31:34”,

ENGAGE materials will remain in WordPress portal (<http://www.engagingscience.eu/>) and be disseminated through Scientix to other European countries. ENGAGE online courses (<http://engage3.exactls.com/courses/>) will be available in a self-service form for teachers to take advantage of for years to come.

### **Outcomes of ENGAGE**

The ENGAGE website was launched in June 2015, and has had nearly a million visitors. It has two types of resources:

- **Single lessons** for using as a taster for introducing socio-scientific issues
- **Innovative sequences** - two lesson - so teachers can explicitly teach the ten skills in the RRI curriculum

ENGAGE has published 62 materials for students and teachers which have been translated into ten languages with 129,674 downloads and 674,638 views. These materials are based on multimedia presentations and introduce dilemmas through an interactive storytelling and gaming activity for students to talk and think on socio-scientific issues. In addition, extra resources such as science-in-the-news and videoclips were also accessed to engage students' curiosity and interests.

“changed their mind. The material is very inspiring. A strategy to provoke their curiosity would be starting the lesson cooking insects, in order to make the context more fun. The science-in-the-news links were very useful. It was possible to connect the lesson with natural resources, ecosystems, sustainable actions and societal values. When they were able to include their knowledge, information analysed in the materials and evidence found in the multimedia references ( news and TED video) they improved their writing significantly“2016-02-16 11:34:33



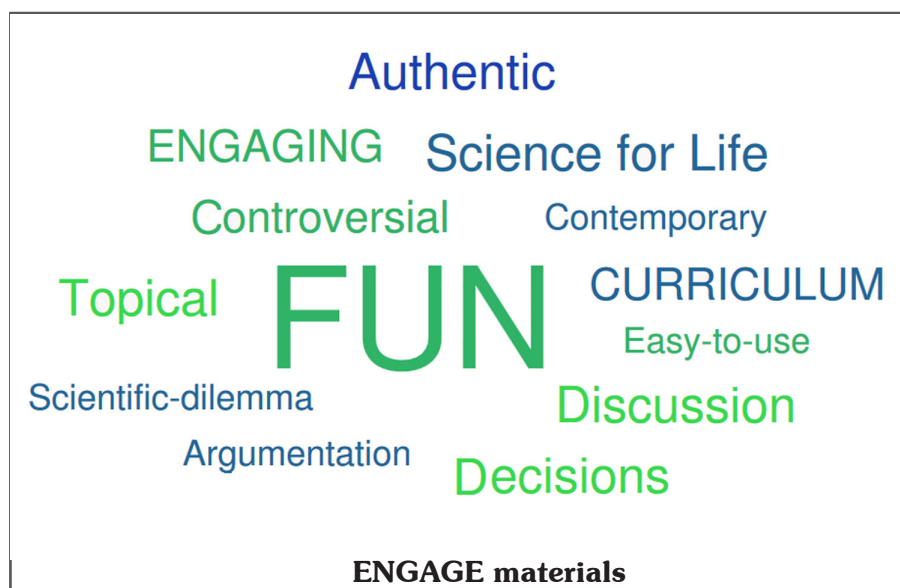
### Scientific inquiry skills for RRI

To equip students for active engagement in contemporary science for responsible citizenship, ENGAGE focuses on ten specific inquiry skills:

- 1. Devise questions:** be able to define a clear scientific question which investigates cause or correlation relationships between different factors.
- 2. Interrogate sources:** be able to question different sources and assess their validity and trustworthiness by judging the reliability of the source, check for bias and evaluate evidence for claim.
- 3. Analyse patterns:** be able to interpret observations and data in a variety of forms to identify patterns and trends by making inferences and drawing conclusions.
- 4. Draw conclusions:** be able to decide whether the claim made by a piece of research is supported by sufficient data.
- 5. Use ethics:** be able to understand and use three kinds

of ethical thinking: utilitarianism, rights and duties, and virtues in order to make informed decisions and explain why different people may have different viewpoints about an issue.

- 6. Estimate risks:** be able to measure risks and benefits by assessing its probability, weighing up and combining its probability and the scale of its impact as well as balancing against the benefits to the individuals or groups affected.
- 7. Examine consequences:** be able to evaluate the merit of a solution or competing solutions to a real-world problem, based on scientific ideas, principles and empirical evidence, by identifying and reflecting on consequences and/or logical arguments regarding relevant economic, societal, and environmental considerations.
- 8. Justify opinions:** be able to synthesise scientific knowledge, implications, and value perspectives into an informed opinion by describing key arguments supported by empirical evidence and scientific reasoning and identifying values based thinking, to support or refute a viewpoint on an issue or a solution to a problem.
- 9. Critique claims:** be able to check strength (quality, accuracy and sufficiency) of evidence provided and identify lack of clarity of justification, by commenting on whether the reasoning follows logically from the evidence and provides strong support to the claim.
- 10. Communicate ideas:** be able to effectively describe opinions and accomplishments with text and illustrations, both orally and in writing, in a range of formats, using the major features of scientific writing and speaking.



Teachers who shared review comments in the website indicated various reasons to use the ENGAGE resources in their classroom:

- materials with attractive socio-scientific dilemma are engaging and fun for students.
- content is very topical with authentic context linked to a contemporary curriculum.
- activities support argumentative discussions and evidence-based decisions.
- guidelines are easy-to-use and support teachers to plan interesting lesson.

There are more than 3,500 comments from teachers about the materials on the [engagingscience.eu](http://engagingscience.eu) (Portal in Wordpress and Online Course Open EdX). The top 3 popular resources downloaded per country are:

- Ban cola, 5711 downloads in the UK;
- Three parents, 1282 downloads in Greece.
- Appliance science, 1239 downloads in Spain.

Students really got on board as most drink Cola and the topic interested them. resources provided were good and gave them food for thought.(UK teacher)

Thanks for preparing these fantastic resources, this one was particularly topical having just had a large article in local newspaper- students enjoyed task and really got them thinking — looking forward to more of the same. (Greece Teacher)



This activity was very well designed linked to curriculum. It is related to student's life. It really encourages them to move, investigate and get them involved with the topic. It raises awareness about problems and potential solutions about energy consumption. (Spain teacher)

The most popular resources in the other countries with the average of 600 downloads are: Two degrees in France; Text neck in Cyprus; Big bag ban in Romania; What does the fox say in Lithuania and Ebola in Germany, Norway and Israel.

43% of teachers who replied the evaluation survey related to teaching practices, reported that they had never used inquiry-based teaching before. While 57% teachers who use inquiry activities more frequently described, however, they were not used to apply it with all students together, only with small groups working simultaneously.

Teacher's views about the materials posted online show that ENGAGE helped them create positive experience and outcomes.

The reaction of my students was very positive. The innovation in the classroom was to analyse a real and current scientific problem, which has no single answer. They learned to listen and understood that everyone can hold different opinions. (Science teacher, Spain)

Teachers found that the ENGAGE materials were particularly effective at helping pupils "come to an informed opinion on life, community or society decision by taking into account scientific and ethical perspectives" and "argue for his/her opinion on a socio-scientific issue".

ENGAGE activity helped students understand the difference between opinions and facts. As a department we discussed how the lesson could be extended. The students were fascinated by the topic and came up with loads of ideas (Science teacher UK)

#### General comments about teachers' requests and suggestions

- More physics materials to make it more engaging - Physics teacher UK
- More activities about healthy habits - Biology teacher, Spain
- More topics related to DNA – Biology teacher, Lithuania



### Evaluation of ENGAGE teachers' CPD

During the Adopt and Adapt phases the ENGAGE consortium has deployed innovative workshops and online courses for teachers to explain how to use the available materials efficiently to enrich their teaching strategies.

During the Adopt, first year, approximately 330 teachers have participated in the workshops in 10 partner countries. Most of the participants were in 40-49 age group and had 6-10 years' experience as science teachers (biology 37%, physics 29%, chemistry 15%, earth sciences 1% and the other subject 18%). Before the workshop, 84% of the teachers had not used the ENGAGE materials, and many mentioned that they do not often use socio-scientific dilemmas in their lessons.

Data collected on the initial workshops indicated that the majority of the participants has not used ENGAGE resources before. They mentioned that the workshop was a good strategy for increasing their awareness of topical and engaging science materials and for their CPD. Teachers explored dilemma lessons and practiced strategies for group discussion such as consequences wheel and conscience alleyway

We understood the rationale behind the adopt material "Big Bag Ban" which will help us to plan an engaging lesson (Spain Teacher).

Teachers who completed the SWOT analysis on ENGAGE highlight that its strength is engaging students; an opportunity is fostering real life skills; weakness is dealing with rigid curriculum and threat is finding time for CPD (UK facilitator)

The online courses enabled teachers to learn principles and tools for RRI teaching which are highly practical. Teachers applied the ideas by teaching RRI-based lessons and getting feedback from peers and experts. Based on the evaluation reports developed in the consortium approximately 80% found the course highly valuable. 75% found it very useful for applying ENGAGE strategies and tools to promote science content and meet the curricular goals. 71% mentioned that it was helpful for applying ENGAGE strategies and tools to develop inquiry skills.

The MOOC brought clarification of the materials presented: what, how and why to use it (Lithuania teacher)

The MOOC helps teachers plan an interesting lesson for students (Romania Teacher).

Everything was useful during the online course including the ENGAGE materials and the videoconference. (Spain Teacher)

During the Adapt, data from evaluation, particularly from teachers who attended MOOC and provided review comments in the Portal about resources confirmed that they were able to:

- help teachers address contemporary science issues and applications relevant to students. They enjoyed discussing different views and being aware of the uncertainties of innovation and its relevance of responsible research.

“Chose this as it is current in Yorkshire news where we live. Students enjoyed both sides of the argument and were thrilled to do some research into a hot topic”  
Material Fracking used on 3 July 2016 by Science teacher in York UK

- to develop teachers’ beliefs, knowledge and classroom practice for ‘RRI’. Teachers appreciated their students’ engagement with the discussion, particularly with contemporary topics. They also mentioned that the activities were easy-to-use to foster knowledge, skills and classroom practice for ‘RRI’.

“Excellent for my area of the world. Great information for my students in my subtropical climate (we have just declared a Zika emergency).

I love the discussion the lesson promotes. We have something called Argument Driven Instruction here, but I find the format more time consuming than these activities for my 12 year olds. Very well done and super teacher friendly.” Material ZIKA used on 6 July 2016 by Science teacher USA

- to provide students a strong foundation to engage in science issues they will meet during their lives It was possible to identify that students also appreciated to reflect on science issues they will meet during their lives. They considered important to be able to make sense of scientific innovations and being able to make decisions.

“ ENGAGE car wars game help us think about advantages and disadvantages of electric cars which are very popular in our town. We discussed benefits and risks of various types of cars for the environment and in terms of costs for our families. Group of 4 girls, 14 years old who used the activity CAR WARS in March 2015 UK

“ We did not know the risk of exterminating mosquito for the ecosystem. Zika is a serious problem in our community, initially we thought that Aedes should be exterminated, and now we think that scientists should find new solutions to exterminate the virus without exterminate the mosquitos” Group of 5 students - 16 years old – who developed Exterminate project in December 2016 Brazil.

#### MOOC reached teachers from countries beyond Europe

Resource very useful, it requires students to reflect on the progress of biology techniques and evaluate the pros and cons of its use.” Material: GM Decision used on 16 March 2016 in Portugal

“My students have enjoyed this activity over 2 lessons. They have combined this with PSHE lessons to make a huge impact on their making decisions skills. Thank you for this thought provoking activity.”Material: E cigarettes used on 10 December 2016 in China,

“Your resources are extremely useful! I think they are very appropriate to cause some responsible thinking!”Material: Breaking News: 3 Parents used on 10 December 2016 in India, Mumbai

“Before becoming a teacher, I worked in biomedical research at my local medical university. I worked on Salmonella typhi or Typhoid Fever. We were working on a new vaccine. I support this kind of animal testing 100%”Material: Animal Testing used on 14 December 2016 in South Africa Cape Town

The ENGAGE Transform phase offered resources and guidelines for teachers on why and how actively involving scientists and the media in their educational projects is beneficial. Why work with scientists:

- For students: understand how knowledge is produced in the real world and how scientists think and approach a problem in real contexts.
- For teachers: Motivate students through a real world scenarios and innovate their practice with topical science and expert network
- For scientists: identify public concerns and interests and interact with societal players to discuss innovations

Why work with the media and science communicators

- For students: Link school science with real world scenarios and learn how to critically use the media
- For teachers: Link science teaching to pressing social issues and ILearn storytelling (in particular digital storytelling) techniques

Successful examples of the implementation of Transform are described in the ENGAGE evaluation report showing interactions between teachers and scientists.

Working with scientists allows students understand different approaches for reducing the number of Aedes mosquitos and minimize Zika problem (Brazil teacher's educator)

An enagaging project that teaches pupils to use sources and to understand interdependence in an eco-system. My class loved this project, they asked me to leave a comment and feedback to let you know. They really enjoyed the lessons, we spent 5 lessons in total as we spent a whole lesson on the game of life task. The class is mixed ability Year 7, (11-12 years old) Exterminate (UK teacher)



## I. CASE UNITED KINGDOM

**Goal:** Influencing policy makers on assessment through a National Exam Board

**Description:** Syllabuses in science are not known for being interesting. They are typically shopping lists, itemising every fact and concept. The problem is, with all those items to check off, teachers can spend most of the time drilling pupils in the facts, instead of filling them with enthusiasm.

The new KS3 Science Syllabus from AQA in the United Kingdom is different. Jointly developed by Sheffield Hallam University and the Open University (KMi)'s ENGAGE project for the European Commission, it's a blueprint for a different kind of science teaching. Students have time to explore real-life controversial issues that affect their lives now, from genetics to climate change.

ENGAGE breakthrough design has two special ingredients, which reduce the content teachers need to cover, and show them how to put science in context.

First are Big Ideas. Instead of presenting science as a list of facts and concept, the syllabus sets out a set of principles and theories which have changed society's view of the universe. By reorganising the content in the National Curriculum around these 10 big ideas, the content was reduced by a half and teachers were able to see clearly what their students really need to know.

The second ingredient is a new section in each topic - Apply. Syllabuses usually just define knowledge, which is strange, because we really want students to be able to apply the knowledge in new situations. The KS3 Science Syllabus sets out clearly the ways students should be able to use their knowledge – including the real-life science students want to learn about.

And this is where ENGAGE fits in - making it easy for teachers to introduce science-in-news issues into the classroom. So Instead of just studying learning equations about combustion for instance, the Syllabus asks students to think about the applications and ENGAGE provides a lesson on the Diesel scandal. Students learn the chemistry by studying a diesel engine and wondering whether it's a good idea to buy diesel or not.

**Outcomes:** 9411 teachers are registered in the UK portal . Science teachers who used ENGAGE mentioned that they want to turn a conventional lesson into a provocative dilemma for students to solve. Now that these case studies are on the syllabus, it is hoped that these will become a regular part of students' work, and help to make learning science the exciting experience it should be.

**Recommendations addressed:**

- A2. Curriculum assessment competences is aligned and supported by national board.
- B1. Inquiry based learning with topical science materials helps teachers foster students' socio-scientific skills including evidence-based thinking.
- C4. Benefits of RRI and ENGAGE was publicised for policy makers, researchers as well as other professionals.
- C9. Work with the examination boards was successful to integrate scientific competences, not just science knowledge.





## II. CASE SWITZERLAND

**Goal:** Disseminating the ENGAGE project in national and global events for policy makers.

**Description:** To mark the end of the UN Decade of Education for Sustainable Development, the National Swiss Congress HORIZONS21 invited various representatives of departments of education, extracurricular partners and policy makers to take an interim review, to share experiences and to develop new opportunities for collaboration. The UN document highlights “four thrusts of education for sustainable development: improving access to quality basic education; reorienting existing education programmes; developing public understanding and awareness and providing training”.

The swiss position on a framework for sustainable development post-2015 highlights “the universal nature of the new goal framework and the growing importance of non-governmental actors, who are, in fact, already contributing substantially to sustainable development. Various actors advance sustainable development through innovative products and services and by providing employment, education and training. Large sections of the scientific community also play a key role in sustainable development through education, research and innovation”.



The ENGAGE project was proposed and accepted as one of the sixteen workshops for this event. Its aim focused on the sustainable development through a commitment for science education through inquiry based learning and responsible research and innovation. Participants educators from various areas were distributed into four groups and had time to discover and discuss a different topic connected to education for sustainable development (sinking islands, eat insects, invasion and big bag ban). The workshop offered a reflective and practical approach for participants to be aware of the curriculum materials and teaching tools, which foster a rich variety of skills that structure the inquiry process.

**Outcomes:** There were about three hundred participants from all over Switzerland in the congress. Eighteen people joined the ENGAGE workshop and found the project very relevant, topical and engaging.

The congress has helped to enlarge the network of educators that are aware of the benefits of ENGAGE educational tools. ENGAGE materials have been used in various areas: Fribourg, Valais, Bienne and Lausanne, there are also plans for collaboration with teacher educators in Bern and Ticino.

**Recommendations addressed:**

- A3: Opportunities to integrate science education with other subjects and multi disciplines can aid an RRI approach.
- B3: Effective CPD through relevant workshops and open events helped teachers acquire and improve their know-how on RRI teaching.
- C2. Best practice was disseminated through the website forum as well as through events.
- C7. Educators and policy need to build consensus about the value of RRI.



### III. CASE CYPRUS

**Goal:** Establishing partnership with scientists and the science media through ENGAGE projects

**Description:** The main aim of this project was for the students to discuss issues related to selecting the characteristics of the plants, through specific examples of products that are planted and produced in their area.

The target group were 23 students, 13 female and 10 male, 9th grade, 14-15 year old from an area in Cyprus that is depended financially on agricultural, and especially on tomato and watermelon crops. The subject was proposed and designed by the teacher who participated in all aspects of the mooc training. The teacher collaborated with an agronomist who works in the area and has expertise in tomato and watermelon crops. The importance of this Transform lesson lies in the fact that the issue is relevant to students' lives as most of their families depend on agricultural, and is a science topic that can be linked to the local curricula. The lesson took place in January and February 2017

**Outcomes:** The evaluation of this project showed that students were extremely satisfied because they tackled personally meaningful questions; teachers appreciated the motivation of the students, and could cover topics which they were not necessarily comfortable.

The students:engaged in discussions about the process of selecting plant characteristics to create new varieties,

- explored products that are planted in their area and how these are reproduced and whether there is any kind of GM in those products (e.g. tomato varieties with specific characteristics, seedless watermelons)
- discussed the positive and negative of the creation of new varieties having in mind the various aspects of the issue (environmental, social, financial)
- collaborated with an agronomist to explore more information about the issue and what is actually happening with the crops in their area.

**Comments:**

- All students were engaged in the process, even students that previously did not show any motivation to work during their biology lesson. Students were interested in the topic, and often asked advice or comments from their parents, most of which are farmers and have personal knowledge of the issue
- Obstacles were related to managing groups that focused on GMO and did not discuss other aspects. Teacher mentioned that wouldn't be able to implement the same lesson again without the help of the agronomist

**Recommendations addressed:**

- A5: Professional networks developed during EU funded projects should be promoted by national policy makers, in order to foster collaboration between teachers and with researchers on new methods, materials and topics.
- B2: Authentic scenarios on RRI for formal and informal learning from science-in-the news, open resources and scientists network support teachers help students link science with and for society.
- C5 Widening access to formal and informal science education for RRI through open educational resources, MOOCs, expert networks and communities of educators.
- C3. Information is shared between EC and national initiatives on science education and RRI.



## IV. CASE LITHUANIA

**Goal:** Online Courses for Teachers' CPD successful completion and accreditation

**Description:** MOOC for science teachers were carried out for six weeks (19th of October - 30th of November, 2015) in Lithuania, comprising both Adopt and Adapt stages. Preparatory work was done by the Lithuanian team before the beginning of the course: advertisement about the courses was created on the ENGAGE website (Lithuanian version) a month before the MOOC.

The Lithuanian guide for the courses was prepared to provide teachers all the necessary information regarding registration to the course. The course was advertised on the official webpage of Lithuanian University of Educational Sciences and the guide was downloaded 458 times, so attracted many Lithuanian science teachers. Information also reached science teachers with a help of Education Development Centre, an affiliate to the Ministry of Education and Science of the Republic of Lithuania and the Lithuanian Centre of Non-formal Youth Education. It was also distributed by regional teacher qualification centres and advertised by the Association of Lithuanian Biology Teachers.

**Outcomes:** 102 Lithuanian science teachers registered and started the MOOC. Teachers were introduced with theoretical material regarding four engaging pedagogical tools. They also were actively involved in discussions in the forum regarding different pedagogical tools and their usage (approximately 600 messages were written in the discussion forum).

Participating teachers had to do some tasks every week of the course (e.g. to choose a dilemma and to use it during a lesson and to prepare a reflection, or to organise a lesson using 5E model and to describe its success, etc).. 47 teachers successfully reached the end of the course, prepared all the required tasks and were awarded with certificates. The level of commitment required could have been the reason why part of teachers did not finish the course

Teachers were asked to provide feedback on the MOOC page: 84 % of teachers gave the highest scores (4 and 5 scores) for engaging student interest (21 out of 25 votes), 83 % for applying science content (20 out of 24 votes), and 71 % for developing inquiry skills (17 out of 24 votes). Teachers also wrote 46 comments on the advertising page of the MOOC all of which were positive.

#### **Comments**

- *“There are many useful materials for the improvement of education curriculum and teaching contents, as well for the education of students creativity. We talk about integration nowadays, so material of different themes is a good example of integration and I am happy using it.”*
- *“I used the teaching material presented on the ENGAGE site before the MOOC. Therefore, the MOOC brought clarification of the materials presented: what, where and why it is presented.”*
- *“Thank you for the interesting MOOC. It was very interesting and useful. Teaching material was well prepared. I will wait for the continuation of the courses.”*

#### **Recommendations addressed:**

- B3: Effective CPD through relevant courses, where teachers can acquire and improve their know-how on RRI teaching.
- C5: Widen access to formal and informal science education for RRI through open educational resources, MOOCs, expert networks and communities of educators





## ■ V. CASE ROMANIA

**Goal:** Promoting RRI dimensions in Science education through open online courses.

**Description:** The Romanian On-line Course “Methods of promoting RRI dimensions in Science education” was carried out for seven weeks and comprised two stages (Adopt and Adapt) of the three-stage path, towards achieving expertise related to RRI (3 stage model: Adopt-Adapt-Transform). The course was promoted by Romanian team by advertising the course at the annual meeting of science teachers organised by School Inspectorate of Dambovit County. Then, in order to promote the course to teachers from other counties, the UVT Team sent newsletters and e-mails to in-service Science teachers involved in networks from previous projects conducted by Valahia University of Targoviste. In addition, the on-line course was advertised to university students involved in study programs related to science and who are following the Teacher Training Module to become science teachers. The course was also promoted through the [ENGAGE website in Romanian](#) and the regional website of [Physics and Chemistry Teachers](#).

The course aimed to teach the skills related to understanding and learning RRI, and also implementing ENGAGE materials in the classroom. Taking into consideration that the edX interface was in a foreign language, the UVT Team produced guidelines for registration to the on-line course in Romanian in order to assure an easier registration of participants to the edX platform. The guidelines were sent to all the selected participants and then the UVT team gave details of the registration process to all the people who asked for help.

**Outcomes:** There were 60 participants (55 in-service science teachers and 5 university students involved in chemistry/chemical engineering bachelor study programme). 58 participants registered and

started the course. Distribution of participants who started the Romanian on-line course comprised 93% female and 7% male; 91% in-service teachers and 9% pre-service teachers. They were from various areas: 50% Chemistry, 34% Physics, 9% Biology and 7% Sciences.

During the on-line course the VUT team had three tutors who kept contact with participants and gave them details of how to solve the tasks.

At the same time, due to the fact it was the first time that the edX platform was used by the tutors and participants as technical environment for on-line courses, the VUT team decided to involve a network administrator to help with the challenges raised by the technical facilities offered by edX platform. A total number of 44 participants achieved the tasks and finished the Romanian on-line course.

#### **Comments:**

- *“I’m glad I attended this course! I particularly appreciated the quality of provided materials!”*
- *“Thank you for the opportunity to participate to this course! A positive experience with appreciations for the way it was designed the work!”*
- *“Useful course, I learned something that will be helpful in my future teaching”.*
- *“It was an interesting and attractive on-line course, with multiple resources that we will use on Physics lessons I thank to the trainers and ‘virtual’ colleagues who gave me a real support to complete this online course”.*
- *“I found it new due to the way of presenting materials; interesting because the proposed topics; interdisciplinary through engaging content; attractive due to the direct application to our lives; and special because this approach form and develop argumentation and reasoning as key competences in Science learning”.*

#### **Recommendations addressed:**

- B3: Effective CPD through relevant courses, where teachers can acquire and improve their know-how on RRI teaching.
- C1: Teachers are encouraged to include RRI in their lessons.



## VI. CASE SPAIN

**Goal:** to motivate teachers to use learning materials that help them to cover the content they are requested to teach and foster reflective practitioners through ENGAGE Online Courses

**Description:** As the ENGAGE CPD model is based on reflective practice, teachers were asked to reflect on what they learnt at the end of each week, how it affected or related to their teaching practice and if they had made any decision.

Teachers could answer to these questions in any digital format of their choice, and were asked to share results with other teachers who could be interested in the project. This not only fostered teacher reflection, but also communicated these reflections to the teachers' Personal Learning Network.

The teachers could use this course as an official CPD, so that it would be useful for the future in terms of promotion. The 6-week course representing a total of 30 working hours was approved and advertised on the website of the Institute for Teacher Development (ICE) at Universitat de Barcelona, which is an official in-service teacher training provider. 68 teachers enrolled through this route, and further enquiries were also logged. The online course was also advertised at the Spanish ENGAGE site, and an email was sent to more than 1700 addresses belonging to teachers, science communicators, in-service teacher training institutions and schools.



The course was delivered from 19th of October to 30th of November 2015, and covered: Dilemma (week1), Group discussion (week2), ADOPT material in the classroom (week3), Problem-solving (week4) Conversation (week5), ADAPT material in the classroom (week6). Teachers were asked to hand in an assignment each week and course facilitators provided a synthesis of the responses, linked to the course content. The facilitators moderated and summarised the outcomes of the discussions in the course forums for each week. All this information was shared with teachers. An additional period of 10 days was given to teachers to hand in pending assignments. In order to obtain the official certificate for the course, teachers had to pass at least 5 out of the 6 assignments.

**Outcomes:** 26 teachers handed in the 6 assignments, whereas 4 teachers handed in 5 assignments. At the end, 30 teachers passed the course. A progressive decrease in assignment submission can be observed as the course progressed, although the biggest difference between expected and real submissions took place on the first week, when out of 68 enrolled participants, only 38 handed in the assignment for the first week. Most teachers who made it to the third week finished the course.

The total number of forum posts was 511. Mainly, teachers posted answers to the discussion points provided by facilitators. They shared their experience with RRI and inquiry teaching, they praised the ENGAGE approach, and they expressed their concerns about particular aspects such as assessment or how to carry out these activities with a great number of students. As part of their tasks for the online course, teachers were asked to publish comments to the materials in the Spanish Knowledge Hub. In this way, future visitors to the website can read what teachers think of the materials and how to use them in the classroom.

### **Comments**

- “Everything was useful, including The ENGAGE materials and the videoconference
- “I liked the readings about problem-solving, strategies for scientific conversation and the webinar

### **Recommendations addressed:**

- B3: Effective CPD through relevant courses, where teachers can acquire and improve their know-how on RRI teaching.
- C2. All educators should share best practice through the website forum, as well as through events.



## VII. CASE NETHERLANDS

**Goal:** to understand the influence of the ENGAGE materials on teachers' development of practical knowledge.

**Description:** This research aimed to investigate if teachers develop practical knowledge while experimenting with the RRI support materials in class. Practical knowledge is the knowledge of teachers which is principally known and produced by teachers themselves. It is highly determined by individual experiences, personality variables, personal history and subject matter knowledge (Verloop, Van Driel & Meijer, 2001). The method used was based on the generic components of the Magnusson et al. (1999) model to investigate teacher knowledge in a broad sense. It is assumed that students learn better in case their teacher possesses and enacts a stronger knowledge (cf. Park & Suh, 2012).

**Participants:** The participants of this study were six students on the Chemistry master's programme of the Science Education and Communication department at Delft University of Technology. Half of the group ( $n=3$ ) were experienced teachers (2 to 10 years) and the other half ( $n=3$ ) were non-experienced teacher candidates. Some of the teacher candidates ( $n=2$ ) had experience in the fields other than education.

**Data Analysis:** Qualitative content analysis was used during this research. The data which were gathered during 9 weeks through the PK forms, interviews, lessons plans, self-evaluation forms and reflection papers were analysed by considering the Magnusson's et al. (1999) four components of PCK.

The teachers used different materials; Big Bag Ban (plastic bags), Ban the Cola (sugar addiction) and Car Wars (fuels). They reported that they have chosen the materials according to relevance of the content to the Chemistry curriculum and to current issues in Dutch culture. For example, three teachers have chosen Big Bag Ban, because from January 2016 the free plastic bags are forbidden in the Netherlands. The activities with regard to Big Bag Ban, Ban the Cola, and Car Wars were planned in 50 minutes' Chemistry lessons in secondary education (Grades 9 to 12).

**Outcomes:** The findings showed that the teachers followed the teacher guide and used the strategies in it. The teachers did not specifically focus on soft skills but they ran the lesson according to suggestions of the material; they made students learn and exercise the soft skills. All the participants mentioned that the lessons where they used the ENGAGE materials were 'enjoyable' lessons. They all shared their appreciation of observing the increased motivation and participation of the students. In two of the four components of Magnusson et al. (1999) model, the influence of the ENGAGE materials on teachers practical knowledge were found specifically 'knowledge about goals and objectives of the materials in the curriculum' and 'knowledge about instructional strategies.

**Recommendations addressed:**

- A1: Scientific education reforms must include the RRI principles, useful approaches and the findings need to be implemented into the classroom.
- C6: More publicity was given to the freely available and editable online materials including reports and research papers
- C7: Policy makers are encouraged to include RRI in the curriculum



## VIII. CASE BRAZIL

**Goal:** To investigate how ENGAGE materials can be easily disseminated to promote inquiry skills for RRI in different areas of Brazil and promote collaborations between universities and schools

**Description:** This research focuses on schools and universities located in different states in the south and north regions of Brazil. Participants used the ENGAGE GM decisions game to develop informed based opinion about genetic modified food through “Open schooling” This means schools working in cooperation with researchers, parents and experts, and become an agent for the community well-being. Families were encouraged to become real collaborators by interacting through social media and events; biotechnologist and agrobiodiversity consultants working on GM and wider society were also involved in discussing real-life projects to the classroom.

**Participants:** 1,473 learners coordinated by 36 research educators participate in the GM food activities within 1 month.

**Data Analysis:** Data collected during the period of one-month show that the ENGAGE project “GM decisions” was used in various scenarios, disciplines, age-groups and with different learning outcomes. A large amount of data was captured through these initiatives via different technologies, such as Google (hangouts and semi-structured interviews), weSPOT (teaching-learning notes, photos, maps, and discussion), nQuire (images), LiteMap argumentative dialogue mapping, Facebook messages, Youtube videos and institutional websites where new OER related to GM food were published and co-authored collaboratively.

**Outcomes:** Findings of this study shows that six skills were identified by educators: devise questions, interrogate sources, examine consequences, justify opinions, use ethics and communicate ideas. They mentioned that “GM decisions” and the “risk” game can be easily embedded in the Brazilian curriculum but it requires proper planning. Students interacted with researchers and scientists and co-created various examples to communicate their results. Qualitative data illustrates the inquiry skills for RRI can be fostered in many Brazilian states. They use of technologies to capture the RRI group discussions, help groups organise the debate, run the game and assess informed based opinions through peer comments and rating. They will adapt the risk-analysis provided by the GM decision game to the Brazil context. They used ENGAGE through an inclusive approach by including deaf people, older citizens, primary school and local communities. They created various products: 1 exhibition, 9 games, 4 new OER, 42 illustrations, 1 webinar, 28 concept-maps, 1 sign-language activity for deaf people 2 posters, 2 workshop and 4 videoclips.

**Comments:**

- The GM decision dilemma promotes open-ended discussion by engaging participants to take initiatives to co-investigate the issue beyond the face-to-face lesson.  
- Research-coordinator from Ceara
- The GM decision activity facilitated multidisciplinary work among students and teachers from other disciplines. Participants mentioned that the lessons were very interactive and meaningful. Teacher from Paraná
- Participants mentioned that the webinar and discussion supported by technologies increased students’ participation. Researchers from Santa Catarina
- The tasks introduced helped students generate more questions and arguments resulting in very reflective interaction in the classroom, Researchers from Paraná

**Recommendations addressed:**

- B1: to promote inquiry based learning with topical science materials that help teachers foster students’ socio-scientific skills including evidence-based thinking.
- C6: More publicity is given to the freely available and editable online materials on the ENGAGE website including reports and research papers



## XIX. CASE EU TECHNOLOGIES

**Goal:** promote partnerships with current European and national projects, whose aim it to offer inquiry-based learning platforms and technologies for collaborative research on science education that might be useful for RRI.

**Description:** This work investigates three technologies FP7 weSPOT and FP7 Catalyst - LiteMap for co-inquiry based learning. It also analyses ENGAGE materials and tools relevant to the Smart City Project. This requires short inquiry activities integrated into the school's curriculum. The research question was how students use co-inquiry platform to interact and collaborate for creating scientific questions.

This qualitative study focused on three inquiries developed by two science teachers and 27 secondary students related to Responsible Research and Innovation on electric cars, energy consumption and solar panels. These key themes were also identified by the smart city in Milton Keynes.

The concept of “science shop” was also used in ENGAGE lessons, which means students participating in research in response to concerns raised by the community-based inquiry activity. Science Shops are frequently organised through universities and some initiatives have also included schools.



**Outcomes:** Findings indicate how students interact as co-investigators through online co-inquiry environments. Science shop activities gave students opportunities to do community-based research as part of their curriculum, as well as interact with scientists by presenting research outcomes in the 15th International Conference on Technology Policy and Innovation (ICTPI) focused on ‘ICT and Science in a Complex World’. It attracted a large audience interested in: Education Futures, Smart Cities, New Economy, Data Security, Energy and Enterprise Growth. They used weSPOT and nQuire to develop their investigations and interact with researchers, science educators, non-academic experts and parents. Learners created scientific questions and collected data in weSPOT. They discussed data to facilitate their analysis in nQuire, and arguments were co-constructed to support their evidence-based reports in LiteMap tool. Three posters were co-authored by participants and presented at the ICTPI conference. Educators and researchers created the activities and provided support based on pedagogical approaches: Scientific Dilemma, Group discussion, Data Inquiry and Storytelling. This study indicates clear evidence on students’ progress on creating questions mediated by social PLE. The most relevant factors that support it are: easy-to-use PLE design, conceptual knowledge and pedagogical tools such as dilemma and interactive group work, which promoted students’ interest.

**Comments:** The Catalyst project recognised and highlighted the outstanding work that the ENGAGE community has been doing using the Catalyst LiteMap tool. The team in the UK has been working with LiteMap on collective intelligence applied to three scenarios: European debate, science teaching community and Secondary school – smart cities. They have been creating various collective knowledge maps using LiteMap with innovative outcomes.

The Stantonbury School team was very excited to participate in an international conference. Young students mentioned that it was the first time they participated in an international event. *“It was a great opportunity to discuss our projects, obtain interesting feedback and increase our network”*.

**Recommendations addressed:**

- A1: to promote inquiry based learning with topical science materials that help teachers foster students’ socio-scientific skills including evidence-based thinking.
- B6. More publicity is given to the freely available and editable online materials on the ENGAGE website including reports and research papers.

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