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Opportunities and challenges for equipping the next generation for responsible citizenship through the ENGAGE HUB.

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ABSTRACT

This paper presents the summary of a qualitative study developed during the first year of the European project ENGAGE. Our aim is to identify opportunities and challenges for equipping the next generation for responsible citizenship at scale. ENGAGE aims to spread the teaching and learning of Responsible Research and Innovation (RRI) by connecting cutting-edge Science and Technology educative materials (Sherborne et al, 2014). Our goal is to reach 12.000 teachers and 300.000 students in 14 countries within 3 years. For that, the ENGAGE Hub platform (EngagingScience.eu) combines Open Educational Resources (OER) for students, Open Online Courses (MOOC) in EdX platform and Community of Practice (CoP) for teachers. Findings show that ENGAGE reached approximately 3000 teachers in 20 countries during the first year. Various strategies were also emphasized as well as comments related to 10 RRI inquiry skills described in the ENGAGE framework.

INTRODUCTION

This paper presents the summary of a qualitative study developed during the first year of the European project ENGAGE. Our investigation focuses on identifying opportunities and challenges for equipping the next generation for responsible citizenship at scale. ENGAGE aims to spread the teaching and learning of Responsible Research and Innovation (RRI) through educative materials about socio-scientific dilemmas on cutting-edge Science and Technology (Sherborne et al, 2014). ENGAGE operates on a major scale, expecting to engage 300,000 students and their 12,000 science teachers across 11 countries: UK, Greece, Germany,

France, Romania, Israel, Spain, Norway, Switzerland, Lithuania, and Cyprus. We will spread its legacy further, to other countries around the world.

For that, the ENGAGE Hub platform (EngagingScience.eu) combines Open Educational Resources (OER) for students, Open Online Courses (MOOC) in EdX platform and Community of Practice (CoP) for teachers (figure 1). Through a set of innovative strategies, ENGAGE Hub will shift the emphasis from transmitting a body of scientific knowledge towards applying science to real life issues that matter to students. Teachers can act as reflective practitioners (Shulman, 1986), by keeping their professional development pathway updated in the CoP through self-assessment and own online portfolio of OER that they have adapted. These features aim to build a sense of community by facilitating interaction between members and rewarding committed practitioners. The platform gathers evidence on OER usage and comments or reviews posted about achievements with OER or in the MOOC environment. Through accumulated interaction with the ENGAGE Hub they can also be recognised as experts within the CoP.

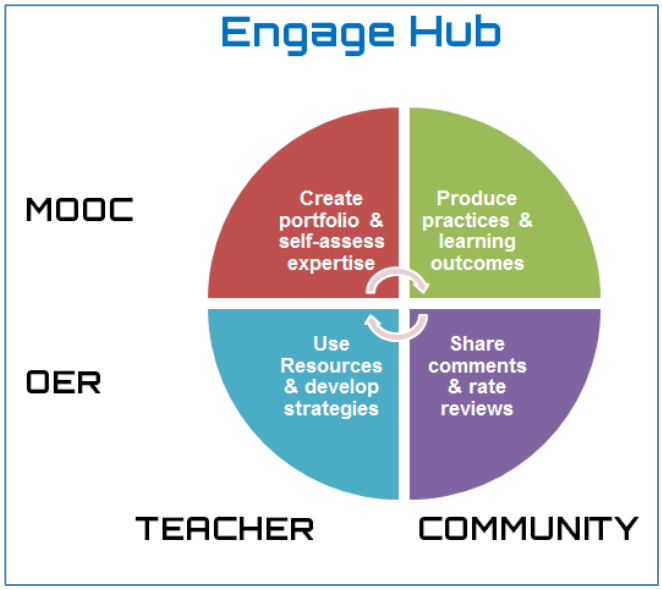

Figure 1

ENGAGE HUB (Okada, 2015)

The ENGAGE project focuses on making change easier with concrete actions and more rewarding by generating visible interest, talking and thinking in students. Teachers will develop their understanding of RRI and how to teach RRI skills to students using authentic activities to simulate how citizens conduct inquiries based on three stages: Adopt, Adapt and Transform. These three phases indicate

the degree to which science and society content is integrated with traditional science content for learning.

First, “Adopt phase” refers to minor change to embed little RRI content for motivational purposes to be applied in short lessons. ADOPT materials give practice using RRI skills in a short activity, but assume the skills and content have already been introduced.

Second, “Adapt phase” consists of significant changes through a casual infusion of more RRI content but with no explicit purpose. ADAPT materials are more ambitious. They allow teachers to teach RRI explicitly. For ADAPT we developed a novel two lesson sequence, centred around a game-like activity where students are introduced to the skill in a simple non-science content. They then reflect on this experience, before using the skill to solve the science dilemma.

Third, “Transform phase” comprises major changes based on a purposeful infusion giving even more time to RRI. We conceived the third step, called Transform, as an experiment in ‘Open Schooling’ for a small proportion of teachers who want to make RRI a major focus of a science topic. We provide the support to help them plan an issue-based project where they and their students can be mentored by practising scientists or science journalists, to learn RRI directly through experience.

ENGAGE also provides three sets of easy-to-use tools based on inquiry pedagogies for each phase. The Adopt materials help teachers to use dilemma and group discussion tools to make learning authentic. The Adapt sequences suggest problem-solving and conversation tools to build reasoning and understanding. The Transform open-ended projects indicate scenario-based learning and performance assessment tools to teach knowledge and skills.

RRI INQUIRY SKILLS

The RRI curriculum in ENGAGE (Okada, 2016) is based on 4 areas and 10 RRI inquiry skills. It targets three components: students’ interest, science knowledge and inquiry skills. The four RRI areas are technology impact, big science, values thinking and science-media. The ten RRI inquiry skills are: devise questions, interrogate media, examine consequences, estimate risks, analyse patterns, draw conclusions, critique claims, justify opinions, use ethics and communicate ideas.

Figure 3. RRI curriculum: four key areas and eight inquiry skills

The four emerging areas provide relevant background 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.
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 people, environment and economy.
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 various perspectives and actors in societies.
4. **Science-Media:** Much of our scientific information is interpreted by the media, who 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. Critically read media reports about science, identify the data, evidence and values thinking used to back up the claims, as well as evaluate its strength in terms of repeatability and reproducibility.

METHODOLOGY

One of the strategies of the ENGAGE project to integrate RRI in science education, is its' "materials strategy". Teachers learn strategies by using topical issue-based materials for classroom experimentation (Sherborne et al, 2014). All the materials are OER, which can be downloaded after registration in the ENGAGE Hub.

This quanti-qualitative study first analyses the usage of RRI-support learning materials in 10 countries: Cyprus, France, Germany, Israel, Lithuania, Norway, Romania, Spain, Switzerland, UK (Bayram-Jacobs, 2015). Second, it presents teachers' strategies for using RRI tools in their lessons and their achievements in the UK (Okada et al, 2015). All comments of the teachers on the ENGAGE Hub including the first MOOC in the UK were analysed.

In order to gather the opinions of the teachers about the ENGAGE RRI-support materials, the evaluation group developed a survey and piloted with 27 randomly selected teachers from 10 countries. After the pilot study, the revised version of the survey was replied by 197 teachers who used at least one ENGAGE material.

The quantitative analysis was developed through SPSS programme and the qualitative data related to comments of the ENGAGE Hub and MOOC were analysed using Lite Map application tool.

FINDINGS

Data from the survey showed that there are 20 countries using ENGAGE materials. Approximately 77% of the ENGAGE users are female, 59% are older than 40 years older and 38% are Biology teachers. The largest group which refers to 41% has more than 16 years of science teaching experience and used more than 1 material.

The most used material was "Ban Cola" (f=59) which invites students to "critique claims" and "examine if there is enough evidence for causal links between sugar consumption, obesity and disease". The second most popular material was "Ebola" (f=57) by which students "estimate risks", "discuss the dilemma if would you try a new Ebola vaccine", "What are the risks and benefits?", " Is it a risk worth taking?" and "Three Parents" (f=43) which aims that "students learn how it can help women with a serious inherited condition to have a healthy baby and why it is deemed so controversial" and "they use ethical arguments to decide whether they would recommend it to help a couple in need".

The RRI-support materials of the ENGAGE project were used mostly at general secondary schools (80%), with 16 year old students (23%), for example,“Ebola” (f=9) and “Three Parents”(f=7). “Ban Cola” was used mostly with 14 year-olds (f=9), Although the materials were developed for 11-16 year-olds, none of the materials were used with 11 and 12 year old students.

The teachers used the ENGAGE materials mainly because “the dilemma was interesting for the students” (33%) and “It was related to school curriculum” (27%). Therefore, the teachers like to attract attention of students by using interesting materials. However, they do not want to go out of their curriculum.

In general, the teachers have found the materials at great extent helpful in the teaching process (f=169). They think that the students found the content of the materials at high extent (f=216) and at great extent (f=80) interesting. The content of the material “Ban Cola” have found as the most interesting one for the students (f=26). Moreover, they reported that the ENGAGE materials on the “adequate” level difficult (f=231) for the students.

There are several factors influencing the acceptance of the innovative practices by teachers. How much time and effort do they need to invest are the two important factors of teachers’ decision for using or not using these practices (Guskey, 1988). The teachers who used the ENGAGE materials like to try new, innovative and interesting materials without spending extra time to prepare them, which supports Guskey’s point. For example a teacher expressed the reason of using the ENGAGE materials;

> *“To change the 'diet' of learning strategies without having to spend a lot of time producing them myself!” (More than 20 years’ experience, school leadership, UK).*

In one hand, teachers appreciated to have ready to use and complete materials. On the other hand, they like to adjust and edit it according to their aims and objectives of the lesson. For example:

> *“It was a different program than what we usually work with. Very nice with a complete package of slides and exercises*.” (Science teacher, Norway)
>
> “*Very impressed and thank you for leaving it editable*.” (Biology teacher, UK)

The great majority (92%) of the teachers mentioned that they would like to use the materials again. They think that by using the ENGAGE materials, the skill “Come to

an informed opinion on a life, community or society decision, taking into account scientific and other perspectives" of the students improved at high extent (f=368).
Data from this study show that ENGAGE materials help teachers in various aspects; introducing the subject in an interesting way, improving the certain skills of the students, enriching the way to teach science, embedding it in the curriculum and engaging students in science lessons. However, it sometimes requires preparation time, some teachers would like to make changes, add some more content and the materials needs to fit the curriculum in different countries. For example;

> *"It is difficult to find time in the school day for the use of materials*." (Earth Sciences, Germany)
>
> *"Designing courses that meet the needs of our curriculum to be used more by teachers*." (Physics teacher, Cyprus)

The ENGAGE materials aim to improve certain RRI skills of students (Sherborne et al, 2014). Mainly:

- Be able to analyse issues, apply knowledge, come to reasoned opinions, express these clearly, and consider possible actions,
- Critically evaluate the strength of the evidence for a claim about emerging science/technology, from a media report,
- Argue for his/her opinion on a socio-scientific issue related to their lifes.

Teachers mentioned that by using the ENGAGE materials, the students improved the above mentioned skills at high extent. Therefore, the RRI-support ENGAGE materials help learners improve the RRI skills which are aimed in the ENGAGE project. These teachers asked for the more materials in their teaching subject. For example: physics (UK), health (Spain) and genetics (Lithuania).

Besides, the experiences of the teachers about using the Engage materials, we also asked them about their own teaching strategies. Although 57% of the teachers reported that they have used the inquiry-based teaching strategies before, the significant amount (43%) mentioned that they did not use it before. Since the Engage and also many other European projects which work for RRI in science education use inquiry-based learning strategies (Bayram-Jacobs, 2015), this is an important point needs to be considered while designing inquiry-based RRI materials and tools.

Some teachers mentioned that they give a problem to the students and lead them to go through inquiry process to solve it. For example;

> "*Posing a problem to students through a press release or a movie and asking a little research and the development of a monograph*." (Biology teacher, Spain)

> "*With teamwork, broke part in groups and students were invited through discussion to resolve related topic of the course in the worksheet*." (Physics teacher, Cyprus)

Teachers also mentioned that they use inquiry-based teaching in laboratory, during experimentation. For example;

> "*Through laboratory experiments*." (Chemistry teacher, Romania)

> "*Practical work. Short messages in research work. Laboratory work in nature and in laboratories*." (Biology teacher, Lithuania)

> *"Investigation of properties in Laboratory."* (Chemistry teacher, Romania)

Some teachers use this approach with 5E and Problem-based learning (PBL). For example;

> *"5E and PBL."* (Science teacher, Norway & Biology teacher, UK)

The teachers also reported some specific examples of using inquiry-based teaching for different lessons. For example;

> "*In mathematics, to prove rules and / formulas arrive at rules / find context on their own."* (Maths teacher, Norway)

> *"By making use of problems to launch approached the students on topics such as photosynthesis, infectious agent or digestive system.*" (Biology teacher, Switzerland)

Most of the teachers (82%) mentioned that they use discussion during their lessons. So, the respondents of our survey use discussion more than inquiry during their teaching. When we ask them how they use it, they have given the following examples.

> *"I use discussion in the new learning moment of the lesson when I'm asking about their knowledge or opinion related by the new theme.*" (Romania, Physics).

> "*The students work in groups and they discuss the problem. After then we discuss in the class how the problem has been solved. Or at the beginning the lesson we discuss the problem and the ways it can be solved.*" (Lithuania, Physics).

> "*Mainly through question and answer sessions, use of 'What if....?'* Questions." (UK, Science).

> "*My teaching is largely dialogue-based, and allows much cooperation and discussions*." (Norway, Science).

> "*Using the rules of the debate ... to address the complexity and allow students to form opinions. using the rules of the debate ...."* (Switzerland, Biology).

> "*To bring the issue, directing students to perform a little research and gathering information and then discuss the issue."* (Israel, Chemistry).

Evidence from qualitative data shows that although teachers are open to try and use RRI-support materials, it is important to design content that can fit to the curriculum in different countries. Besides, the materials should be easy-to-use, do not need much preparation time and it is related to diverse topics and subjects of science. Qualitative analysis from teacher's comments in the ENGAGE Hub and MOOC highlights various students' achievements: applying their knowledge to increasing their understanding, willingness to spend more time studying the topics, ability to

elaborate persuasive arguments, applying numeracy, self-regulated learning, questioning other groups' beliefs and the level of concerns, practicing various inquiry skills to make their own conclusions or decisions. The ten RRI skills of the ENGAGE framework are described below with an example from teacher's comments:

1. **Devise Questions:** Define a clear scientific question which investigates cause or correlation relationships between different factors.

   "The car wars project that has started a few weeks ago really inspired students to create more questions in science. It engaged them and motivated them to learn" (Car wars) 19/06/2015.

2. **Interrogate Sources**: being 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.

   "S*tudents commented that they could have been reading different stories! At this point I (teacher) explained that they were the same "issue" but in different newspapers". OER (Giant Virus) 27/06/2014*

3. **Examine consequences:** being 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.

   "Students were stimulated to look at all the issues surrounding the dangers of this virus and vaccination pros and cons". OER (Ebola) 31/10/2014

4. **Estimate risks**: being 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.

   "A lot of pupils knew benefits but not the risks of scientific issues, e.g. they were able to explain what a tanning bed is, but none the danger linked to it. The ENGAGE activity helped them be aware of the risks". OER (Ban-the-Beds) 14/09/2014

5. **Analyse patterns:** being able to interpret observations and data in a variety of forms to identify patterns and trends by making inferences and drawing conclusions.

   "Students used real data suggested in the materials to bring questions, analyse and interpret OER" (Solar roadways) 17/12/2014

6. **Draw conclusions:** Deciding whether the claim made by a piece of research is supported by sufficient data.

   "Twenty six secondary pupils developed three urban inquiries on: Energy Consumption (Appliance Science), Electric Cars (car Wars) and Solar panels (Solar Roadways). They used ENGAGE and two platforms weSPOT and nQuire-it for creating their investigations and interacting with researchers, science educators, non-academic experts and parents. First, learners created scientific questions and collected data in weSPOT. Second, they discussed data to facilitate their analysis in nQuire-it. Third, arguments were co-constructed to support their evidence-based reports in Litemap tool. Three posters were co-authored showing their conclusions by participants and presented at the ICTPI 2015 International Conference on Technology Policy and Innovation. MOOC UK01" 09/07/2015.

7. **Justify opinions:** being 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.

   "S*tudents were able to integrate science knowledge and inquiry procedure, for instance, to elaborate the menu for the canteen by describing sourcing the insects with detailed information.*" OER (Eat Insects) 17/07/2015.

8. **Critique claims:** being 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. *"Students questioned other groups' beliefs and the level of concerns."* OER(Giant Virus)" 27/06/2014 JT1

9. ***Use ethics:*** *Being able to understand and use three kinds of ethical thinking: utilitarianism, rights and duties, virtues in order to make informed decisions*

and explain why different people may have different viewpoints about an issue.

"The series of lessons offered an extra dimension for the students to hook their knowledge and understanding scientific issues, for example: genetic inheritance onto, the issues/dilemmas of taking a test, the ignorance of some and possible prejudice of others". OER (Take test) 21/04/2014

10. **Communicate ideas:** Being 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.

    "Students questioned other groups' beliefs and the level of concerns OER" (Giant Virus) 27/06/2014.

CONCLUSION

The evidence from this study revealed challenges and opportunities for equipping teachers through the European Project ENGAGE. This work based on the RRI principles (Owen, 2015; von Schomberg, 2013) highlighted how important is to engage participants - researchers, teachers and students - to contribute to the process of innovating science education by considering their needs and expectations of society. This reflexive and participatory process allows improvements and innovation by reaching various components of a RRI inquiry ecosystem: materials for students and pedagogical tools, CPD workshops and online course for teachers. It is important to stress that the results of the current study are limited to our participants' experiences and opinions related to the first year of ENGAGE project.

Our materials attracted mostly experienced teachers. Although it is very positive that we could motivate this group of teachers to use innovative educational materials, we are aware that there is a need to develop strategies to motivate also young teachers.

We agree that the materials should fit the science curriculum. For this reason, we have done a curriculum comparison study with the partner countries of the Engage project. Although it is difficult to make the materials to fit with different curricula in different countries, it is clear that this is crucial to make them usable in different education systems.

In general, most of the teachers like to use innovative educational materials which have interesting topics for students. The teachers of this study are open to use such

innovative educational materials if they do not have to spend extra time for preparation. They appreciate to use complete pack of the ready materials.

ENGAGE HUB might contribute to innovative teaching and learning particularly when all social actors involved in the process of science education can act as reflective practitioners. This will be the focus of our next studies.

From our findings we can also point out the importance of professional learning opportunities for the teachers who do not use inquiry-based teaching, discussion or dilemma.

The questions this study raises are “How to ensure the sustainability of these resources and opportunities for teachers? and “how to ensure that teachers will change their teaching practice to teach RRI skills? ”

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