Implementing Responsible Research and Innovation in Science Lessons - Challenges and Benefits

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Abstract

The huge problems faced by our society call for an increasing number of researchers able to explain and find scientific solutions to them. We need a bigger number of scientists able to act and find innovative solutions to the new challenges of science and technology. The educational systems all over the world are trying to find solutions to attract an increasing number of students to the Sciences and Technology areas. A lot of financial resources were allotted during the last decades to find and promote new methods and tools in Science teaching. *Responsible Research and Innovation (RRI)* is an inclusive approach of the 'Science with and for Society' FP7 Programme meant to ensure that a big number of stakeholders think and work together to connect the problems of the present society with the new discoveries and innovative solutions provided by the research area.
Due to the presence of the RRI concept among the FP7 Programme priorities, many European projects have been financed by the EU to promote research and innovation results to the general public. ENGAGE is one of these projects ("*Equipping the Next Generation for Active Engagement in Science*" - www.engagingscience.eu).
This paper aims to present the feedback of the teachers - who participated to an on-line course organized in the framework of the ENGAGE project - concerning the ways of implementing responsible research and innovation in teaching science, in order to attract students towards finding scientific solutions to the present societal problems.

Keywords: RRI; 5E model; teachers' feedback; ENGAGE Project.

1. Introduction

We are living a time when research bonds are expanding very rapidly and our society is facing new and difficult problems caused by the present changing environment. Most of the environment balance changes have been produced by the human population and now it is essential to find solutions to stop or

minimize the effects in the near future. Under these conditions, more information about scientific topics and their contribution to people's life is needed to increase the citizens' responsibility in all their actions.

The general aim of education is to make people understand the consequences of their actions and to increase their responsibility. This aim can be achieved by attracting more and more students towards learning science and technology or towards embracing a carrier related to these areas. Thus, Science Education has become a very important issue in the development of each individual (ICSU, 2011). Moreover, in this way, mankind can attract and form more scientists able to research and find innovative solutions to the new challenges of the society. Even if Science Education has evolved a lot recently and many projects have been financed to improve the students' motivation for learning Sciences, there is still a lot of work to do in order to connect the scientific topics with the problems our society is faced with today (EU Commission, 2015). In this context, questions like "*What are the best ways to increase the number of students interested in science?*" or "*Is Responsible Research and Innovation a motivation for students to learn science?*" are on the lips of all the stakeholders interested in raising the level of Science Education. Due to these aspects, a new objective was set in the framework of *Horizon 2020* (EU Decision, 2015). The 'Science with and for Society' programme is part of this framework, being devoted to increasing the scientific experience and connecting the results in science with the problems encountered by the society.

Responsible Research and Innovation (*RRI*) is one of the priorities promoted by the 'Science with and for Society' programme meant to engage people more intensely in research and innovation activities, to increase the general public access to scientific results, to ensure gender equality in the research process, to take more into account the ethical dimensions, and to promote formal and informal science education (European Union, 2014). Consequently, a big number of projects promoting RRI in formal and/or informal Science Education have been financed by the European Union during the last years in the framework of the FP7 Programme: 'Science with and for Society'.

2. The ENGAGE Project

ENGAGE - "Equipping the Next Generation for Active Engagement in Science" is a three-year FP7 project approved by the EU Commission that started in January 2014 and has as overall aim the training of the next generation of students by changing the way of teaching and learning Science (Petrescu et al., 2015). The project partnership is formed by fourteen partners from thirteen European countries who agreed to promote interactive teaching strategies and modern tools to make Science lessons more attractive for young students. The materials designed in the framework of the project have been connected to Science news appeared in the media, promoting the investigation of reality and connecting real problems to scientific topics. Thus, they are focused on identifying and testing alternative solutions that let students think, talk and apply their knowledge and consequently make responsible decisions.

But, in order to introduce this kind of materials in everyday Science lessons, teachers need to be prepared to understand the philosophy of the RRI concept and how to emphasize the RRI dimensions in teaching a certain scientific topic. Thus, the partnership proposed a three-step transformational CPD model (*ADOPT-ADAPT-TRANSFORM*) for teacher development (to represent how teachers typically

absorb an approach like *RRI-teaching* (Dwyer et al, 1991), in order to understand and apply the ENGAGE philosophy.

According to this model, the 1st step - *ADOPT* - implies that teachers understand the way of using teaching materials designed in the framework of the ENGAGE project, which include the RRI-dimensions to teach different scientific topics. During the 2nd step - *ADAPT* - the teachers must go through a transitional stage and can teach Science by including the RRI dimensions, with less prescriptive support. The last step - *TRANSFORM* - supposes that teachers understood the RRI philosophy and changed their way of teaching, by including RRI as a usual part of their repertoire.

In this context, the ENGAGE partners had to organize different face-to-face workshops and on-line courses for the teachers in all the partnership countries to help them go through the three steps of the transformational CPD model. The face-to-face workshops were focused on the first step of the model - *ADOPT* – and the partners organized them to introduce the RRI concept and connect the RRI dimensions to ENGAGE materials. The next step was to design an on-line course content focused on the first two steps of the transformational CPD model - *ADOPT* and *ADAPT* - and help teachers understand how to adapt their activity and include the teaching strategies and materials promoted by the ENGAGE partnership. In the last year of the project, the on-line framework was designed to be at the teachers' disposal, which includes a lot of materials related to RRI, 5E-model, interactive teaching strategies and project models that include RRI dimensions in teaching Science. It is supposed that, in this step, based on their previous experience in applying ENGAGE materials and adapting their teaching strategies, teachers will design and introduce their own projects that include RRI dimensions in their regular lessons.

During the activities organized in the framework of the project, different challenges were faced not only by the ENGAGE partnership but also by the Science teachers involved in the transformational CPD model. The main challenges of implementing RRI in Science lessons were different from country to country, depending on the specific educational framework, national curriculum requests and teachers' experience and habits. Even if the challenges related to introducing RRI in Science lessons were high in some countries and teachers needed time to change their regular practices, some teachers agreed that RRI also brings benefits and agreed that the materials and presentations designed in the framework of ENGAGE helped them overpass these challenges and they have started to involve more and more RRI in their teaching process.

3. Results and discussions

Having in view the ENGAGE project context presented in the previous paragraphs, Valahia University Targoviste (VUT) was responsible for the organization of all the project activities in Romania. Thus, seven ADOPT workshops were organized so far by the VUT team in five different locations in Romania (Buzău, Târgoviște, Slobozia, Suceava and Iași), where 171 in-service Science teachers participated.

At the same time, two editions of an on-line course entitled "*Methods of promoting RRI dimensions in Science Education*" were organized in November-December 2015 and April-June 2016. The course was carried out for seven weeks and was focused on the ADOPT and ADAPT steps of the teachers'

transformational CPD model (Gorghiu et al., 2016). The on-line course content aimed to help teachers understand and learn how to implement RRI in Science lessons using as models the ENGAGE lessons and comprises different materials like presentations, videos, animations, documents, ENGAGE lessons, discussions web areas, web-links etc. The framework of the course was designed on the *edX platform*, which was used for the first time by the Romanian Science teachers and this was also one of the challenges reported by the participants. A number of 159 in-service and pre-service Science teachers were involved in both editions of the Romanian on-line course, their distribution by age and teaching experience in Science Lessons being presented in Figures 1 and 2.
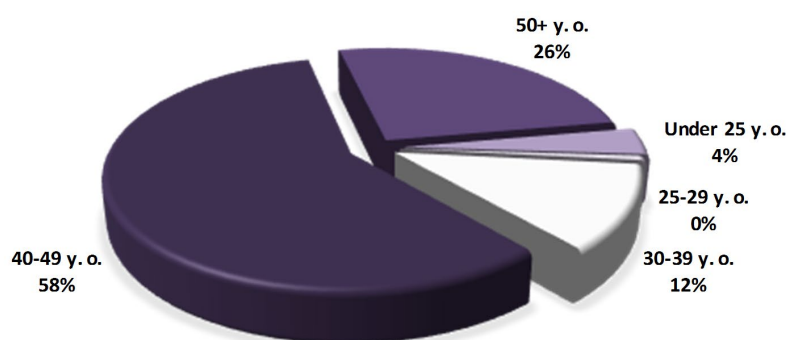
Fig. 1. Distribution of the Romanian participants to the on-line courses according to their age
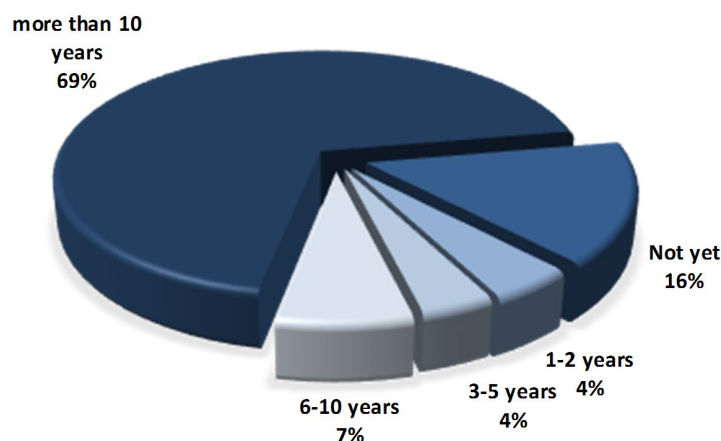
Fig. 2. Distribution of the Romanian participants to the on-line courses according to their experience in teaching Science

The percentage of participants that reported they have no experience yet in teaching Science is explained by the fact that some of the participants are pre-service teachers (students attending Bachelor / Master Study Programs related to Science and Technology areas), while some other participants are graduates but have not accumulated any teaching experience yet.

Only a part of the participants graduated the course, because not all of them achieved all the tasks in time. Figure 3 illustrates the number of the teachers who started and graduated for both editions of the on-line course. The values shown in this Figure can be explained by the challenges encountered by the participants during the on-line course activities, their experience in following a structured on-line course in a new platform, the time allocated by the participants for achieving these tasks etc.

Being interested to find out the main challenges encountered by the participants during the on-line course activities, the VUT team tried to collect the teachers' feedback related to the course content and its implications in their future activity. As research tools, specific questionnaires and reflection sheets were applied in the beginning and at the end of the on-line course "Methods of promoting RRI dimensions in Science Education" designed to help teachers understand how to apply RRI dimensions in Science teaching.
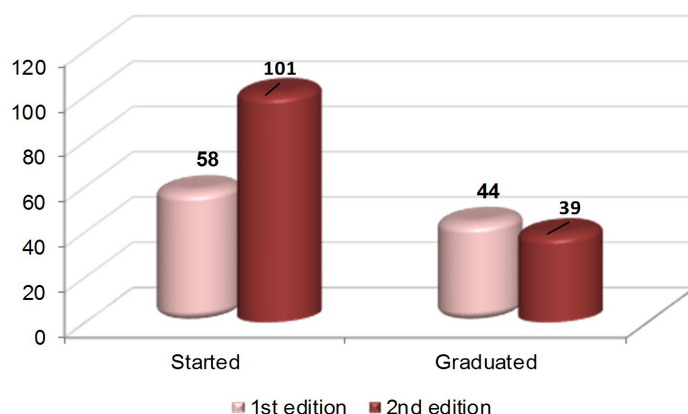

Fig. 3. The level of graduation of the on-line courses organized in Romania in the framework of the ENGAGE project

Trying to find out the teachers' previous level of knowledge related to the materials designed in the framework of the project, the participants were asked if they had already downloaded and implemented ENGAGE materials before having started the course. Their answers are shown in Figure 4 and a quick look on this figure proves that the participants were not only aware of the teaching materials produced by the ENGAGE team, but had also tried to implement them in their Science lessons.
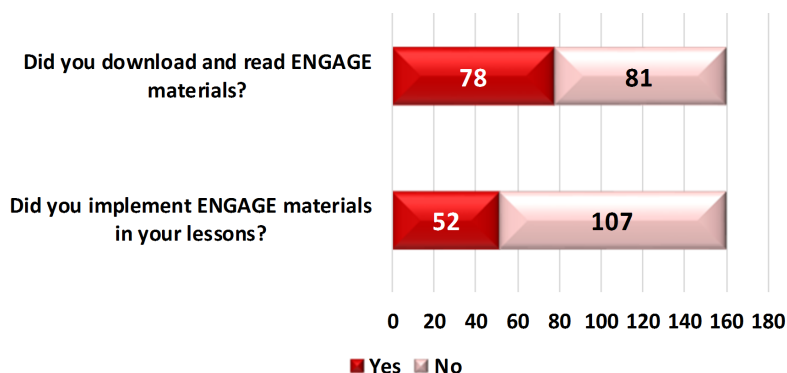

Fig. 4. Teachers' answers concerning the previous knowledge related to the materials designed in the framework of the ENGAGE project

In addition, Figure 5 shows the previous experience of the participants in the use of scientific investigation in Science lessons, while Figure 6 illustrates how often Romanian teachers use other

different teaching methods in their lessons. This proves that the most used methods in teaching Science in Romania are conversation and problem solving, while argumentation and group discussion are less used by the teachers during their regular lessons. The productive dilemma was reported by the Romanian teachers as their least used teaching method.

After the course, the VUT team tried to find out if the content designed and the materials presented and discussed during the course helped the teachers improve their experience and led to better Science lessons for the students. Thus, one of the questions in the final questionnaires was related to the extent to which the teachers had achieved some of the on-line course objectives (Fig. 7).
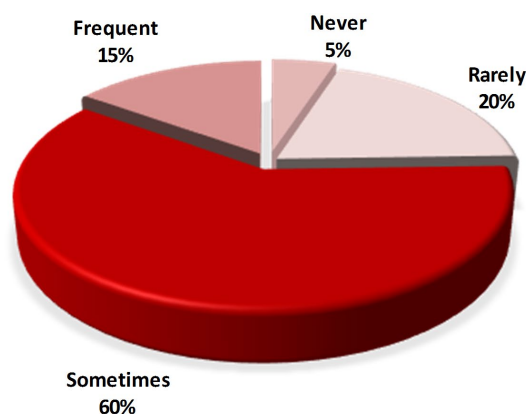

Fig. 5. Teachers' answers concerning their experience in using scientific investigation in their Science lessons
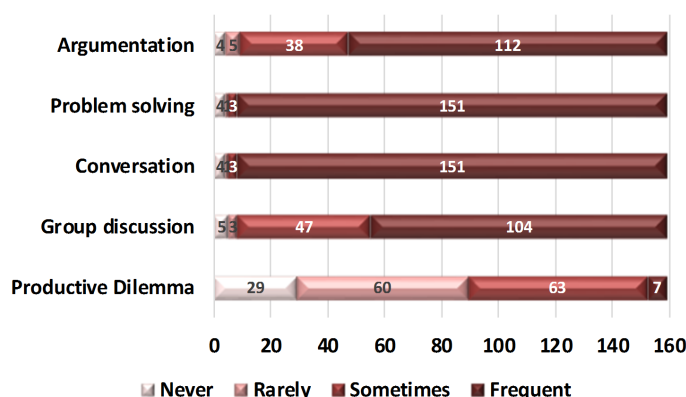

Fig. 6. Teachers' feedback related to how often they use different teaching methods in their Science lessons
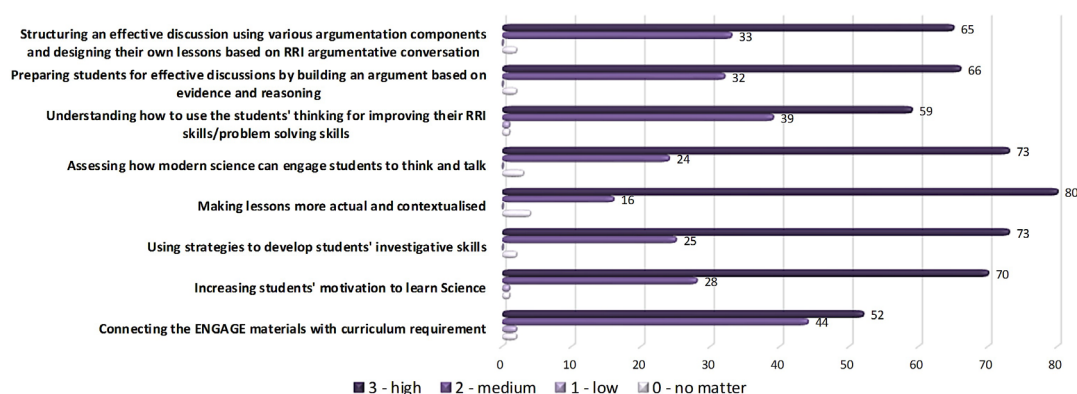

Fig. 7. Teachers' feedback related to the extent to which they achieved the specific objectives of the ENGAGE on-line course

The teachers' feedback illustrated in figure 7 demonstrates that 80% of the participants highly agreed that after this course their lessons will surely be more topical and contextualized, while 73% of them learned the proposed strategies to develop the students' investigative skills and understood the ways actual topics in modern science can engage students to think and talk. In addition, 70% of the respondents agreed that such strategies involving RRI dimensions in Science lessons increase the students' motivation for learning Science and 66% agreed that using the methods presented during the course can prepare students to participate in effective discussions and build their argumentation based on scientific evidence and reasoning. The result that 52% of teachers appreciated that ENGAGE materials are connected with the curriculum development can be explained by the fact that the Romanian curriculum is still strict and full of scientific information, teachers having very little time and not so much experience to connect theory and practice.

4. Conclusions

The paper has attempted to provide a short analysis of the teachers' feedback after two editions of the on-line course "*Methods of promoting RRI dimensions in Science Education*" organized in 2015 and 2016 by Valahia University of Targoviste, in the framework of the ENGAGE project. The study emphasized that before the participation to the on-line course, conversation and problem-solving were the most used teaching methods of the Romanian teachers, while argumentation and group discussion are less used in regular Science lessons. One of the reasons offered by the teachers for this result was the time limit for teaching a certain topic, taking into consideration the Romanian curriculum. However, the little time allocated to students to present their argumentation and effectively get involved in group discussion where to support their opinion during regular lessons are surely some of the reasons of the present lower level of understanding of scientific topics and of the lower connection between scientific knowledge and practical problems and have led to a sharp decrease of students' motivation for learning Science.

However, at the end of the on-line course, based on the course content, the ENGAGE lessons introduced in connection with the teaching strategies and discussions organized on the *edX platform*, most of the Romanian teachers agreed that interactive teaching strategies including scientific investigation and RRI dimensions can reawaken the students' interest for Science. The feed-back offered by the teachers makes us believe that introducing RRI dimensions in science teaching could bring several benefits, such as: (a) motivating students to learn science in a relaxed way; (b) improving the students' investigative skills; (c) increasing students' interest for scientific topics; (d) assessing the way modern science can engage students to think and talk.

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