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Responsible Research and Innovation in Science Teaching - Romanian Teachers' Reflections Expressed in an On-line Course Organized on edX Environment

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Abstract

Even the Responsible Research and Innovation (hereafter RRI) concept is not yet clarified at the scientific literature level, it is more and more frequently used, being promoted in the European Union policies (Owen et al, 2012) and programs in Science and beyond (Owen et al, 2013). At the educational level, RRI refers mainly to the idea that the future EU citizens have to possess the necessary skills to manage complex issues related to emerging technologies, and more, they are sufficiently informed about how science works. In the context of achieving of those educational goals, European Union funded - since 2014 - a big number of European projects, in order to bring closer research and innovation results to the large public. The FP7 ENGAGE Project (Equipping the Next Generation for Active Engagement in Science Equipping the Next Generation) is one of those approved projects that started in January 2014 and lasts till March 2017. This paper emphasizes our findings concerning the teachers' reflections about challenges and prospects related to implementation of RRI specific aspects in Science lessons, collected at the end of the 1st edition of the on-line course entitled "Methods of promoting RRI dimensions in Science Education". This course was organized in an on-line format, through the edX environment, by Valahia University of Targoviste, in November-December 2015.

Keywords: interactive-participative teaching strategies, on-line courses, investigation, dilemma lessons, ENGAGE project.

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1. Introduction

Starting from the general context of responsible research and innovation, it can be said that any approach and innovation research should be done in the context of researcher's ownership of social and individual responsibilities. This means that research and innovation have to meet a series of ethical, moral and social principles, to be beneficial not only for the society as a whole, but also for each individual, to take always into consideration the ratio of benefits and risks, to contribute to human progress and to be subordinated to positive purposes.

At the macro level, RRI consists of designing and implementing research and innovation policies that lead to: hiring the society in research and innovation; increasing the access to scientific results; ensuring gender equality in the research area; providing an ethics of researcher / research, and in compliance with current laws relating to ethics; promoting science education at formal and non-formal levels.

According to the Horizon 2020 initiative launched by European Commission in 2014 (Horizon 2020, 2014), RRI is the core of several European projects meant to make connection between Science and Society. It is supposed that Horizon 2020 framework "will promote a transparent engagement of citizens and civil society in research and innovation matters by promoting science education, facilitating access to scientific knowledge by developing research agendas and innovation" (Kulciński, 2012).

2. Responsible Research and Innovation and ENGAGE Project

However, trying to promote RRI at the educational level, European Union have financed since 2013 a series of FP7 projects in the Science-in-Society Programme - topic SiS.2013.2.2.1-1: *Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education*. One of those funded projects is the ENGAGE Project (*Equipping the Next Generation for Active Engagement in Science Equipping the Next Generation* - www.engagingscience.eu), a three year project started in January 2014, with a partnership consisted of 14 institutions from 13 countries (Shelbourne et al., 2014).

The main goal of the ENGAGE project is focused on the training of the next generation of students, by changing the way of teaching and learning Science. The partner institutions came with creative solutions to make Science lessons more attractive, by promoting different interactive - teaching strategies, based on investigation of reality, identifying and testing

alternative solutions for solving different problems, meant to teach students to think critically, apply their knowledge and take responsible decisions based on the acquired information. In order to achieve those goals on students' level, the partnership had first to develop continuous development programmes for teachers, in face-to-face or on-line format. The ENGAGE materials designed by the partnership have been introduced during those training programmes and the possibilities of using different interactive - participatory teaching strategies were discussed with the participants. All the ENGAGE materials start from identifying a problematic situation (*dilemma*) that students may face in their real life and based on the information sources they need to find rational solutions, by using their scientific and socio-moral knowledge. Figure 1 shows the way of including RRI dimensions in ENGAGE training units.

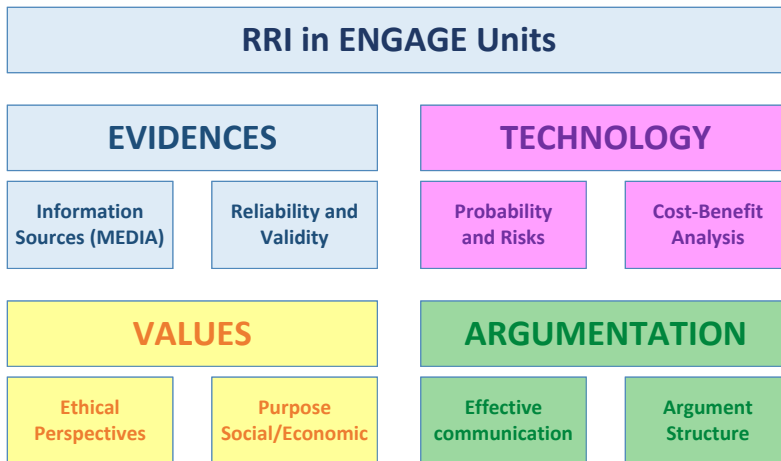


Fig. 1. Inclusion of RRI Aspects in the ENGAGE Units

In order to be very attractive for the students, the ENGAGE units have been designed starting from news appeared in the media concerning real scientific controversies. Different other scientific information was added in order to assure the reliability and validity of evidences. Concerning the technology needed for up-taking the training units, each of them invite students to make a probability and risks evaluation or a cost-benefit analysis. In terms of values, all the ENGAGE materials include aspects related to ethical perspectives or impact on social and economic environment. By inviting the students to take decisions for solving the raised problems, the units designed in the project learn students how to structure their argumentation and to participate to an effective communication related to the proposed problem.

3. Purpose of the Study

The present study was focused on obtaining the teachers' feedback before and after their participation to the 1st edition of the course entitled: "*Methods of promoting RRI dimensions in Science Education*". The course was organized by Valahia University Targoviste in an on-line format, through edX environment, during November-December 2015. The target group was formed by 58 in-service and pre-service Science teachers from Romania. To obtain the teachers' reflections about challenges and possibilities to implement the RRI aspects in ordinary Science lessons, the research methodology was a mixed-type: qualitative and quantitative. The methods and tools included questionnaire surveys and semi-structured interviews.

4. Results and discussions

For adapting the content of the course to the participants' experience in teaching Science (Biology, Chemistry, Physics, Sciences), the ENGAGE team inserted a question in the survey designed to be fulfilled in the beginning of the course. The situation concerning this aspect is illustrated in figure 2 and showed us that the group is split in two main groups - a beginning one and an experienced one. This cause a problematic situation for the organizers, who had to think about how to present the content of the course and adapt to the teaching experience of the participants. Moreover, since the ENGAGE units have as a core a problem investigation, another question related to the participants' experience was oriented on the using of *Inquiry Based Science Education (IBSE)* in their ordinary lessons. Figure 3 emphasizes that 27% of participants have not experienced the using of IBSE in Science lessons, since they never or rarely used this teaching strategy. In addition, a big part of the group (64%) have not so much experience since they used only sometimes this strategy.

The core of the units designed by the ENGAGE partnership is a "*dilemma*" connected with curricula from the Science area. Due to the fact that about 64% of participants reported - as figure 4 shows - that they did not used dilemma before (never/rarely) in their classroom, the organizers decided to introduce in the content of the course a theoretical frame related to this teaching method and the possibilities to be applied in connection with different topics present in the regular curricula of Science. Things like the criteria that must be met to create a good dilemma, with examples presented in the ENGAGE units help the participants to understand how to create a dilemma and teach a certain topic from curricula through this

teaching method. Even 35% of participants claimed they use sometimes or frequent dilemma as a teaching method, not many connected the scientific dilemma with its social impact or connected the topic with moral and ethical values. Due to this reason, the organizers decided to include in the course materials the possibilities to connect the dilemma investigation with the key aspects of RRI, and learn teachers how to create a “*socio-scientific dilemma*”, bringing students to think and treat the raised problem as a complex one.

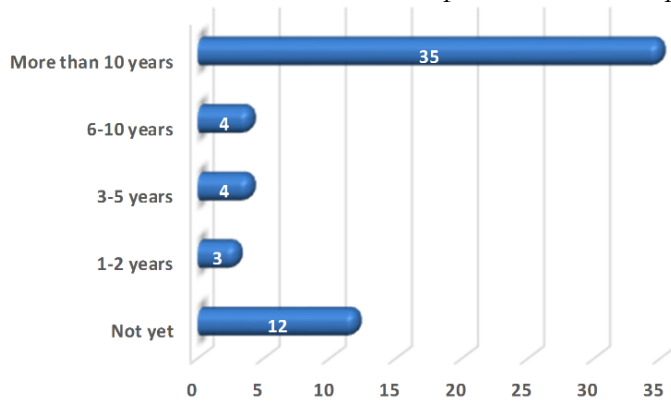


Fig. 2. Teachers' experience in Science teaching

Concerning how to introduce and solve the dilemma in the classroom, the organizers introduced also to the teachers the *5E Model* (Bybee et al., 2006), in connection with the possibilities to develop the RRI dimensions through the use of this model.

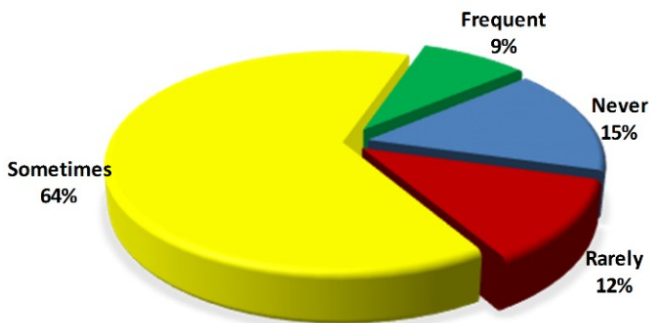


Fig. 3. Teachers' feedback concerning IBSE as teaching strategy in Science lessons

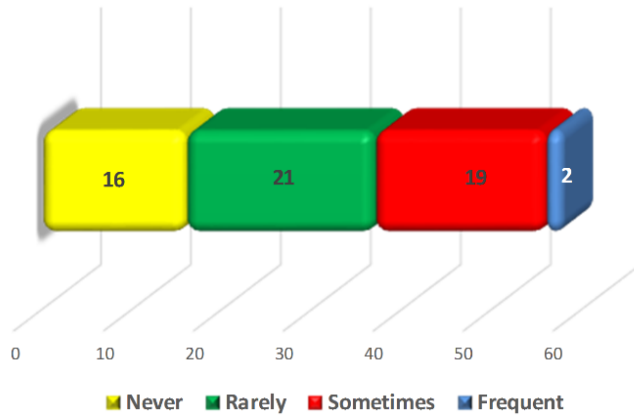


Fig. 4. Teachers' experience to use “*Dilemma Tool*” in the Science teaching process

It was also emphasized to the teachers that, if they want to increase the RRI students' skills, they can improve the 5E model with an additional 6th step, and transform it into the *6E Model* (Petrescu, 2015) that help the students to develop their structure argumentation and take a right decision based on the presented evidences (as Figure 5 illustrates).

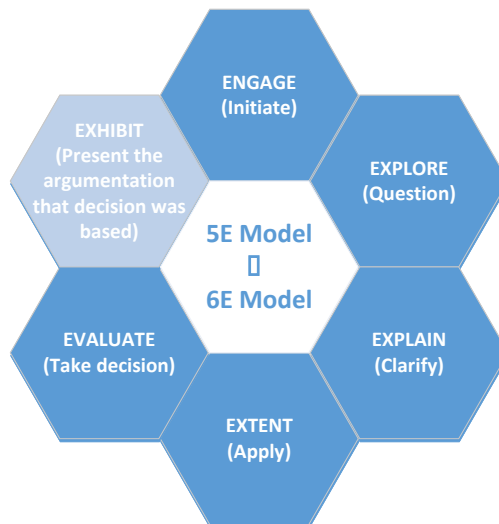


Fig. 5. The 5E and 6E Model steps that have to be followed to develop the RRI students' skills in order to solve a “socio-scientific dilemma” during Science lessons

Figure 6 shows the teachers' feedback obtained at the end of the course, concerning the benefits of using the *Dilemma Tool* in ordinary Science lessons.

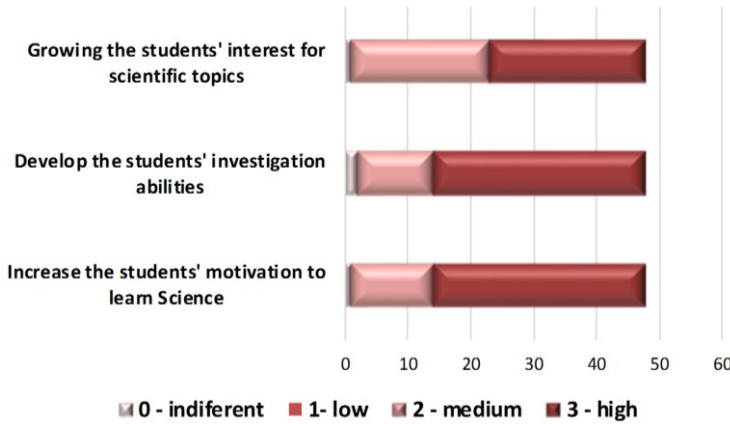


Fig. 6. Benefits of using Dilemma Tool in teaching Science

Moreover, the teachers' opinion related to the measure of using of the Dilemma Tool that contribute to increase the critical thinking, to develop and use the RRI students' skills for solving scientific problems, is emphasized in Figure 7.

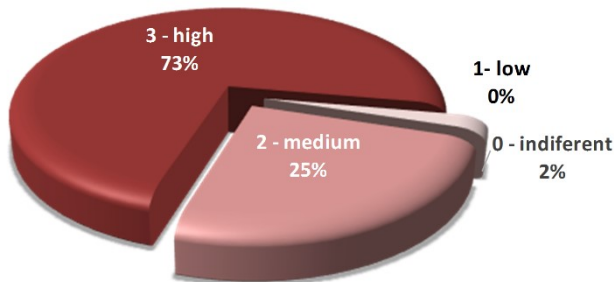


Fig. 7. Benefits of using Dilemma Tool on increasing the students' RRI skills

The RRI skills identified to be developed after implementing the ENGAGE units in Science lessons are the following: interrogate sources, critique claims, weigh-up issues (compare solutions, estimate risks), examine consequences, discuss limitations, draw conclusions, communicate ideas, argue on an opinion, use ethical principles.

5. Conclusions

Starting with the general aim and continuing with the activities organized in the partnership countries, and taking into account the curricular designed materials, the ENGAGE Project create a teachers' community who is trying to show to students that Science and contemporary technology is often based on uncertain evidences, being very important to take decisions for solving certain problems only based on enough information resources and a deep knowledge. Thus, when taking a decision, not only scientific aspect have to be weighted, but also the social impact and the ethical principles have to be taken into consideration.

The partnership of the ENGAGE Project proposes a collection of curricular materials that include RRI key elements, that invite students to think and discuss, involving them in moral, ethical and social reasoning, based on the analysis of benefits and risks of a formulated problem from Science or Technology area. Moreover, the teachers' feedback emphasized that implementation of those kind of curricular materials in ordinary Science lessons, develop the students' ability to use scientific knowledge and principles learned in the decision-making processes.

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