

Education and Responsible Research and Innovation (RRI): International Perspectives

Introduction by Marta Romero-Ariza (Editor)

What kind of science education is required in a world deeply influenced by science and technology? How can we contribute to Responsible Research and Innovation (RRI) through science education? Are students and teachers prepared to address current socio-scientific challenges? What kinds of pedagogies foster the skills and values required for taking a critical position in the discussion of socio-scientific problems? Which teaching and learning activities prepare students to actively contribute to the development of smart and creative solutions? These and others are some of the key questions underlying this special issue devoted to education and RRI.

In the presentation of this special issue, I will start by drawing attention to current socio-scientific issues (SSI) in order to set the stage for the introduction, justification and definition of the RRI concept. Then, I will comment on the different papers embedded in this issue providing a comprehensive overview of how any of them contributes to the discussion of RRI and its educational implications.

We are living in a fascinating age, where scientific advances are hugely expanding our capacities as human beings and the opportunities we have ever had to transform and shape the world around us. We cannot only observe galaxies but travel to the space; far from observing cells through the microscope, we are able to repair damaged cells with nanorobots; genetic engineering offers a wide range of possibilities, from the modification of organisms, to the development of highly specific gene therapies, nevertheless raising important social and ethical concerns.

Besides giving rise to exciting cutting edge advances science is transforming life in the planet at a personal, local and global scale, not only expanding opportunities but also bringing about new challenges, risks and uncertainties.

Current technological applications are significantly changing the way we live, learn, communicate and work. Nowadays we can do things that our grand parents could not even imagine. Almost anyone is carrying out a digital agenda, a photographic camera, a GPS and a set of other useful applications packed in a small mobile phone. These devices allow us to see and speak to people in other continents, buy and sell goods, order bank operations and access valuable information, among other things. But, is there any environmental and health risk associated to the production and use of mobile phones? Is everyone aware of the social and economical implications related to the use of those devices? Along with the affordances of mobile phones there is a set of negative effects. Just one of the multiple faces of the problem is that the rise in the importance of coltan,

as a mineral crucial for the fabrication of these electronic devices, is having serious consequences in Congo, one of the main suppliers. It is due to the mining conditions under which the mineral is extracted and the subsequent social and political implications (Humphreys, Sachs & Stiglitz, 2007; Mantz, 2013). Are young people aware of these issues? Does education play any role in the education of critical and informed citizens able to evaluate the benefits and risks of current technological applications?

Coming back again from a concrete example to the general scenario, scientific advances are positively influencing a wide range of domains such as medicine, transports, energy, agriculture and food. However, along with the benefits, these advances often raise ethical concerns or have detrimental side effects on other areas such as health or environment, which must be tackled. Taking this into account, research and innovation should be aligned with current societal challenges: health and wellbeing; food security; sustainable agriculture; a fair distribution of resources; secure clean and efficient energy; smart, green and integrated transports; mitigation of climate change and environmental actions and sustainability (European Commission, 2017).

According to the European Commissioner for Research, Innovation we can only find the right answers to the challenges we face by involving as many stakeholders as possible in the research and innovation process (Geoghegan-Quinn, 2012). In this line, RRI is defined as “a process where societal actors work together, via inclusive participatory approaches, during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society” (European Commission, 2015, p. 69).

Ethical acceptability, social desirability and sustainability are the three main aims of RRI (Von Schomberg, 2013). How to contribute to the accomplishment of RRI aims is an open question, which is being approached from different fields. International projects such as RRI tools, IRRESISTABLE or PARRISE are making unique contributions in this line. In the present issue we provide room for the discussion of interesting pieces of work carried out within some of those RRI international projects.

In an attempt to contextualised RRI in science education Lundström, Sjöström and Hasslöf (2017) relate the essence of RRI to some of the key concepts in science education such as scientific literacy, nature of science and SSI, emphasizing the collaboration between scientists and students as an important approach to provide a more RRI-oriented science education.

Romero-Ariza, Abril y Quesada (2017) keep on the discussion on how to best prepare citizens to address current challenges and outline the foundation of a science education model for RRI in line with the one developed within the European project PARRISE (Levinson and the PARRISE consortium, 2017). The model integrates different trends in science education and discusses the potential of authentic SSI scenarios to encourage students to map controversy and take informed and responsive actions. In addition, the quality of a set of science teaching materials designed for preparing students for RRI is evaluated according to the underlying model.

Other contributions to this special issue present research related to the development and implementation of educational interventions closely related to RRI. Zafrani and Yarden (2017) emphasise the ‘activist’ component in RRI-oriented interventions. These authors investigate the development of students' identities as activists as they participate in a high-school project aimed at resolving the problem of



global hunger. Findings indicate that the students' identities as activists were supported through participation in highly contextual and emotionally charged experiences and through the ability to fill roles that were perceived as integral and authentic to the students. In addition, they discuss the potential of a well-structured activity to assist students in deeply engaging with responsible actions.

Following a Design-Based Research Methodology within the EU-funded IRRESISTIBLE project, Dias and Reis (2017) study the impact of IBSE activities integrating Web 2.0 tools on the development of knowledge and skills necessary for an active citizenship regarding RRI. Results reveal different didactic strategies for science education in secondary school and allowed the development of new knowledge regarding the implementation of these strategies in school context.

With a focus on preparing pre-service teachers for RRI-oriented science education we can find several contributions to this special issue. Linhares and Reis (2017) present a case study involving 19 pre-service teachers, which intends to identify the potentialities and the limitations associated with the development of interactive exhibitions on socio-scientific issues as a strategy to empower future teachers for sociopolitical action. Results illustrate how "Geoengineering: Climate Control?", an interactive scientific exhibition developed within the IRRESISTIBLE project create opportunities for students to work collaboratively, take responsibility and participate in activism initiatives, promoting the development of competences important for scientific literacy and active involvement in sociopolitical action.

Romero-Ariza, Quesada y Abril (2017) emphasise the key role of teachers in promoting RRI through science education and presents the design and evaluation of a teacher professional development in this line. The training course, builds on teachers' beliefs, provides opportunities to experience the educational potential of RRI-oriented interventions, makes explicit links to the science curriculum and supports the development of specific teaching skills necessary to enact the underpinning science education model. The analysis of pre-post results shows a positive evolution of participants' beliefs in line with the science education model being promoted. Additionally, the authors present the validation of several instruments to evaluate the impact of the TPD program on teachers' beliefs.

In line with previous work and pretty aware of the importance of providing validated research instruments, Blonder, Rap, Zemler and Rosenfeld (2017) trace the development, validation and use of a questionnaire for evaluating teacher and student attitudes regarding RRI. The use of the RRI questionnaire is demonstrated through the presentation of teacher and student data taken before and after the implementation of RRI-based modules, developed in the EU-funded Irresistible Project, with a special focus on preparing teachers and students for "RRI-based thinking" regarding science and technology advances. Based on this work, the authors suggest that the RRI questionnaire can be used to assess the development of attitudes regarding RRI across diverse populations of teachers, students, scientists, consumers and other members of the general public.

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Received: October 26, 2017

Final version received: October 26, 2017

Published online: October 31, 2017

