RESPONSIBLE RESEARCH AND INNOVATION IN SCIENCE EDUCATION: THE SOLUTION OR THE EMPEROR'S NEW CLOTHES?

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ABSTRACT

The European Commission has for the past 10 years emphasised the importance of "Responsible research and innovation" (RRI). RRI is an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation. Despite efforts to support RRI projects, however, little attention has been given to RRI in science education and science education research over this period. This article problematises the concept RRI and its relation to some of the key concepts in science education, comparing and discussing it in relation to scientific literacy, nature of science and socioscientific issues. The meeting between scientists and students is emphasised as a key issue to address, if RRI is to be regarded as an important part of science education.

KEY WORDS

Responsible research and innovation (RRI), Scientific literacy, Nature of Science (NOS), Socioscientific issues (SSI), Science education.

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INVESTIGAÇÃO E INOVAÇÃO RESPONSÁVEIS EM EDUCAÇÃO EM CIÊNCIA: A SOLUÇÃO OU *A ROUPA NOVA DO IMPERADOR*

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RESUMO

A Comissão Europeia tem enfatizado nos últimos 10 anos a importância da Investigação e Inovação Responsáveis (IIR). A IIR é uma abordagem que antecipa e avalia as potenciais implicações e as expectativas societais no que diz respeito à investigação e inovação, com o objetivo de fomentar o desenvolvimento de uma investigação e inovação inclusiva e sustentável. No entanto, apesar dos esforços para apoiar os projetos de IIR, durante este período pouca atenção foi dada à IIR na educação em ciências e na investigação em educação em ciências. Este artigo problematiza o conceito de IIR e a sua relação com alguns dos conceitos-chave da educação em ciências, comparando-o e discutindo-o relativamente à literacia científica, à natureza da ciência e às questões sociocientíficas. O encontro entre cientistas e estudantes é enfatizada como uma questão-chave a abordar, se a IIR for considerada uma parte importante da educação em ciências.

PALAVRAS-CHAVE

Investigação e Inovação Responsáveis (IIR), Literacia científica, Natureza da ciência, Questões sociocientíficas (QSC), Educação em ciências.

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Responsible Research and Innovation in Science Education: The Solution or The Emperor's New Clothes?

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INTRODUCTION

The concept of *Responsible Research and Innovation* (RRI) has during the past years been emphasised in policy documents and in different kinds of project declarations, and notably those emanating from the European Union (EU) and European Commission (EC) (EC, 2017; Von Schomberg, 2013). The European Union and European Commission view Responsible research and innovation as "an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation" (EC, 2017). RRI is consequently seen as of particular importance for citizens' involvement in the development of society. In other words, the concept of RRI expresses the ambition that not only scientists, economists or politicians should engage in determining which research should be supported, and that these choices concerning our future are instead considered of vital interest for all citizens to engage in. RRI thereby becomes a highly important issue, also from an educational perspective.

EU currently supports the development of RRI through different educational activities such as teacher education programmes and other RRI activities (EU, 2017). It has been one of the highlighted goals within science education supported by the European Commission. One example is the PARRISE (Promoting Attainment of Responsible Research & Innovation in Science Education) project (grant agreement 612438), from which some examples will be offered below. RRI implies that various societal actors (researchers, citizens, policy makers, business, third sector organisations, etc.) are aware of each other's thoughts 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 society. In practice, RRI is implemented as a package that includes: multi-actor and public engagement in research and innovation; enabling easier access to scientific results; the take up of gender and ethics in the research and innovation content and process; as well as formal and informal science education (EC, 2017).

In this article, we discuss and problematise if the ambitious aims with RRI are possible to achieve. The discussion will be made mainly from an educational perspective, in view of the important role school and education play in reaching RRI. The article starts with a summary of different aspects of RRI, where definitions, history and consequences are discussed. After that, three important concepts in science education (scientific literacy (SL), nature of science (NOS) and socio-scientific issues (SSI)) will be presented and compared to RRI. All these concepts are, just like RRI, typical "boundary objects" that almost everyone can agree on, but which are given different meanings by different

individuals (Sismondo, 2009). As will be shown below, although the four concepts display many similarities, they also have differences. Some of these differences are linked to the fact that RRI is mainly a policy concept, whereas NOS and SSI are mainly used to describe a specific content and orientation of science education. SL could today be described as both a policy and a scholarly concept. However, for all the concepts there are ongoing discussions about their meaning (see further below). This article aims to contribute in particular to the discussion concerning the meaning, awareness and possible outcomes of RRI in science education, in comparison to the three other concepts. It also aims to discuss synergies and opportunities between RRI and the other three concepts.

DEFINITIONS OF RRI, HISTORY OF RRI AND SCIENCE UNDERSTANDING

RRI as a concept has a rather short history (see further below) (Owen, Macnaghten & Stilgoe, 2012). In view of the key role that research and innovation policy plays for Europe, and for different societal actors, it is not surprising that definitions of RRI are richly discussed. The most widely used definition of RRI is that it is a

> transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society). (Von Schomberg, 2013, p. 9)

With this definition, the stress on "mutual responsiveness" differs from previous ways that new knowledge connected to science and innovation have been developed and spread to citizens. Stahl (2013) discusses how research has traditionally been seen as an extension of human knowledge, and thus as a moral and public good that did not need to be questioned. Nevertheless, history demonstrates how research and innovation have been used in ways that were not for moral and public good (e.g. European Economic Area, 2001, 2013), for instance during wars and technical accidents, something Stahl thinks RRI might prevent. In other words, he describes RRI as a means to ensure desirable and acceptable research outcomes. Stahl argues that RRI should be defined as a meta-responsibility or higher-level responsibility. Also Wickson and Carew (2014) regard RRI as a reimagining of the traditional linear model between science and society, where science merely informs society about new research and innovations and the society after this information evaluate the outcomes of the research or innovation. Wickson and Carew contend that even if RRI is not the first attempt to reconceptualise relationships between environments conducting scientific development and society at large, there is still not any satisfying way to describe or evaluate such relationships. Among other factors, a lack of common standards make it hard for stakeholders, such as researchers,

project managers or research funding organisations to discuss, document and plan for RRI efforts.

To summarise, RRI is regarded as both a process and a product, where all actors (including citizens) who could be affected by current research or innovation should be aware of all processes and products of research and innovations. However, researchers and innovators carry the greatest responsibility for this to be fulfilled.

A short historical overview of how the concept RRI has emerged is made by Owen et al. (2012) and Stahl (2013). They describe how the concept has roots in discussions between researchers from different fields concerning ethical, legal and social implications of research. They mention genomics as one such field, where these discussions were intensified during the beginning of the 21st century. From 2006 onwards, public authorities such as the National Research Council and the European Commission increasingly highlighted RRI, for instance through the research framework Horizon 2020 (Owen et al., 2012; Stahl, 2013). During these years, views on RRI have developed from discourses of socio-technical integration, to also include policy approaches to managing ethical issues with science and innovation, within subjects such as genetically modified organisms, synthetic biology and geoengineering (Owen et al., 2012). Owen et al. suggest that there is an increased willingness

> to discuss challenge and rethink linear models of science and innovation policy and social contract for science. (p. 752)

In this way, RRI discourse covers both academic contributions and policy interventions (Stahl, 2013).

However, the desire to make science more understandable and available for all individuals has an even longer history. Various attempts in this direction have been made during at least the last 60 years. Under different slogans and with slightly different goals, compulsory science education has been highlighted as a key to the future. Knowledge connected to science has been regarded as a solution to many problems faced by individuals and societies (e.g. Roberts, 2007). It has also been considered essential that citizens accept and support research and innovation projects, since a great deal of public money is spent on such projects. The ambition to make science more accessible is often expressed in terms of "science for all" or citizenship, a standpoint that emphasises not only expert knowledge but also democratic engagement in decisions involving highly technical considerations. The thoughts behind science for all are multiple. Often, the purpose has been to address individual needs in various ways, for instance in decision-making. The individual's capacity to make informed decisions is frequently articulated as scientific literacy (SL). In this way, scientific knowledge is regarded as important for the individual, but also for a society and its development. It is also crucial that individuals understand how science can improve our society and how scientific knowledge is generated, validated and accepted. Questions quite similar to RRI have thus been highlighted in both society and in science education (Allchin, 2014; Driver, Leach, Millar & Scott, 1996; OECD, 2003; Roberts, 2007).

CONSEQUENCES OF RRI

One of the important factors with RRI is the focus on responsibility. Owen et al. (2012) express this as a co-responsibility, where researchers, civil society organisations, industry and policy-makers have an obligation to include all groups that may be affected by new technologies in the research and innovation processes. Through inclusive and deliberative processes, science and innovation should lead to socially desirable and socially accepted ends (Owen et al., 2012). The goal is to open up for democratic processes. However, such democratic processes are not easy to follow or measure. Wickson and Carew (2014) stress the articulation of quality criteria and indicators of RRI. They believe this is crucial if RRI should be understood and operationalised by researchers, research funders, innovators and other stakeholders. These quality criteria should, according to Wickson and Carew, focus on complex and multidimensional real-world problems and incorporate collaboration and mutual learning between researchers and stakeholders. Actors who drive and monitor innovation should also evolve a method that reflects on the problem and its contexts from a range of perspectives, and that responds on other actors' opinions. Several attempts to reach common quality standards have been made during the last decade, but no collective standards have been established to date (Jacob et al., 2013; Wickson & Carew, 2014).

Even if responses by organisations and researchers to the introduction of RRI has been mostly positive, there are some questions that have been raised within the science community. Owen at al. (2012) discuss if RRI can lead to a tension between the principle of participation and that of scientific freedom. They argue that this problem might be more noticeable for science compared to innovation, but they also give successful examples in which organisations and societies cooperate with researchers, for instance concerning diseases, such as Alzheimer's or issues as sustainable development. Furthermore, Owen et al. also bring forward another potential problem: there is a risk that RRI might be regarded as part of a competition and that a range of motivations in various parts and levels of the EC accentuate this competition, for instance by economic reasons. Owen et al. further emphasise that RRI has largely remained a political discussion that is not really established in society as a whole.

As mentioned above, Stahl (2013) sees strengths with RRI. However, he also mentions the reliance on knowledge of the future. There are fundamental epistemological limitations, which can be difficult to handle, and Stahl believes that this can lead to technological determinism. Also Von Schomberg (2013) raises certain problems with RRI, and argues that the most crucial advancement of RRI will depend on the willingness of stakeholders to work together toward socially desirable products.

The establishment of powerful agendas such as RRI will also affect educational research. It is interesting to reflect on the extent to which political policies actually should be allowed to dominate educational research or, for that matter, any kind of research. We can see some examples where political authorities to a certain extent control educational research. For instance, at a time when other funding has decreased, funding from the EU connected to Inquiry Based Science Education (IBSE) has been an important financial contributor (EU, 2017). Even if many such projects have mainly been development projects, aimed for in-service and pre-service training, they have offered a possibility for researchers to come together. During the European Science Education

Conference, ESERA, in Dublin 2017, 12 large European projects were displayed. Several presentations and posters were also the result from research projects with their origin in projects funded by EU and EC. Reported research has been made in connection with Teacher Development Programmes (TPDs) with both pre-service and in-service secondary school science teachers, such as in the previously mentioned PARRISE project. The TPDs in PARRISE were developed based on the so called SSIBL-model developed by Levinson and the PARRISE consortium (2017). The TPDs includes aspects of RRI, SSI, citizenship education, and inquiry-based science education.

On the one hand, it can be argued that such research projects would probably not have been carried out without funding from the EU; they help the research society within education to come together to develop education. On the other hand, it is clear that the kinds of projects (e.g. IRRESISTIBLE, PARRISE) that the EU finds interesting will also be those areas where much educational research will be performed. In this way, EC and EU to a certain extent decide the research agenda in education.

IS THIS SOMETHING NEW?

As mentioned above, the concept RRI was introduced at the beginning of the millennium. Other research fields and researchers have paid attention to similar questions, in which knowledge in science and about science are regarded as decisive. An example is the notion of the "risk society", put forward by Beck (1992, 1999). Beck considers that civilisation today has to face numerous risks. It therefore becomes a matter of assessing the outcomes of society's attempts to improve our lives. Changes and innovation result in both expected and unexpected consequences, so that we are constantly obliged to deal with risk. Researchers must therefore communicate their research with the public, while education needs to prepare citizens to handle these risks (Elmose & Roth, 2005). Foresight activities are key aspects in RRI, even if the future is hard to predict (Stahl, 2013). Risk analysis has to be made on several levels and by all actors. The risks will not be seen in the same way on an individual level, compared to a societal level. Nor will risks be seen in the same way by all citizens, even if they have received the same information (Lundström, 2011). RRI is built upon a model where everybody is involved in discussing both risks and positive outcomes, and it is additionally assumed that participants in such discussions will feel that they have been listened to.

So is this rethinking of a linear model possible to achieve? The ambition presupposes, among other conditions, a society where citizens in different ways keep themselves updated concerning research and innovations. It is also supposed that stakeholders feel responsibility to stir this process. This transformation of how research and innovations are negotiated can be summarised as a shift from science in society, to science for society and science with society (Owen et al., 2012). Several similar processes, based on joint discussions between actors driving scientific developments and various societal groups have appeared over the past decades (Grunwald, 2014). Science-Technology-Society studies, literacy projects and technology assessment are examples of attempts to bring together science and society. All of them aim to understand each other's agenda for a better society, as well as supporting participation from different actors.

EVALUATION OF RRI

On a practical level, it is difficult to see how RRI should be organised and evaluated (Stahl, 2013). Von Schomberg (2013) questions if it even is possible to define what should be considered desirable outcomes and impacts of research and innovation. It is not always easy to see who should be responsible for designating who can participate in or evaluate different projects or programmes. Not all individuals can take part of all projects. The question therefore remains how different actors can "participate" in research and innovation projects. Since RRI includes both processes and products, not only participation itself, but also the assessment process demands a public engagement during longer periods. The most important question concerning evaluation is according to Wickson and Carew (2014) whether preconditions, processes, or products of research and innovation (or people populating all three) should be evaluated. Stahl (2013) suggests viewing RRI as a space constituted by activities, actors and norms, whereas Von Schomberg (2013) instead regards RRI as a strategy of stakeholders. Accordingly, he points out stakeholders as responsible for RRI, similar to earlier mentioned suggestions by Stahl (2013) of meta-responsibility or higher-level responsibility. However, neither Stahl's nor Von Schomberg's models give a clear answer to the question how evaluation should be carried out in practice.

Earlier attempts with ethical councils or similar arrangements have not always been successful. Despite both laws and guidelines, the research community sometimes seems to fall short of the aim to secure ethical principles in research projects. There are recent examples where researchers and the research community have clearly failed to ensure ethical conduct. One such rather new example in a Swedish context is the so called Macchiarini scandal. Paolo Macchiarini is an Italian surgeon and researcher who was considered as a pioneer in the field of regenerative medicine. He used the patient's own stem cells together with synthetic materials as trachea transplants. Macchiarini was a visiting researcher at Karolinska Institutet in Sweden. Today, Macchiarini is no longer seen as successful. A majority of the patients who received his trachea transplants are died, and Macchiarini is accused for falsifying both his academic credentials and his results. The Macchiarini scandal is an example where a highly respected and highly ranked university failed to follow ethical guidelines in an appropriate way.

RRI IN SCIENCE EDUCATION RESEARCH

Education is naturally an important part of RRI. Thus, education is mentioned in different policy projects related to RRI (e.g. Owen et al., 2012; Stahl, 2013). Owen et al. (2012) believe that funders have a leading role to play from an educational perspective. They regard funders as responsible to meet the expectations which have been placed on RRI through programmes of education and training. By contrast, Stahl (2013) emphasises the individual researcher's engagement.

So far, RRI is an almost non-used concept within science education research, despite the efforts from the EC to bring the concept on the agenda in educational contexts.

Publications within the field have not taken this aspect on board. A search in the databases of four internationally well-known science education journals (International Journal of Science Education; Science Education; Science & Education; Research in Science Education) give no hits where "Responsible Research and Innovation" is mentioned in the title or abstract. Even if there are many other journals within science education research, this gives a hint of the relative scarcity of studies related to RRI within science education research. So why is this the case?

To be able to discuss this question, it is necessary to see which other concepts exist, which in some respect present similarities to RRI, and that have been the object for studies within science education research. This is important since the use of other similar concepts could influence the establishment of a new concept like RRI. In fact, a summary inspection reveals that several key concepts exist that present some points in common with RRI, and which have been elaborated on during many years. Among these, the most influential are probably: scientific literacy (SL), nature of science (NOS), and socio-scientific issues (SSI). These three concepts are richly described and investigated within science education research. They all in some way give attention to similar aspects as RRI, even if they are not identical.

SCIENTIFIC LITERACY

Scientific literacy (SL) is defined by Driver et al. (1996) as knowledge about science knowledge, or scientific concepts, scientific processes and situations or contexts. Roberts (2007) further opened up the concept to include more *about* science, and its role in society. Every citizen must understand how science influences society, and vice versa. As we noted earlier with respect to RRI, some criticism has been voiced concerning the goal of making every citizen able to reason about what research should be supported or allowed. Very similar criticisms and discussions have taken place with respect to SL. A number of similarities can in fact be found between an individual's scientific literacy and knowledge concerning RRI. In both cases, it is important to understand both scientific processes and products, make informed decisions and to take into account also ethical and societal aspects. One possible difference concerns how action is involved in the two concepts. In RRI this is totally clear, while implications for action in SL are somewhat blurred, although later definitions of SL do take action into account (Roberts, 2007). Roberts puts forward a *Vision II* of SL, where democratic aspects and decision-making are emphasised as part of scientific literacy. Also Levinson (2017), stresses the democratic aspects of SL. He argues that

> science education towards scientific literacy should provide the means for informed citizens to participate in democratic decision-making on contemporary techno-scientific issues. (p. 76)

Similarly, Sjöström and Eilks (2017) recently suggested a *Vision III* of SL and science education, emphasising socio-political-philosophical values and critical global citizenship.

This vision has also been described as “critical scientific literacy” (El Halwany, Zouda, Pouliot & Bencze, 2017; Sjöström, Frerichs, Zuin & Eilks, 2017), a term which was explicitly used by Hodson (2009, 2011) in his visionary books concerning the future of science education. If Vision II of SL focuses on socialization, Vision III of SL goes a step further and focuses on subjectification and emancipation. Dos Santos (2009) writes:

> beyond the purpose of humanistic science education to prepare citizens for the technological society [Vision II], it is necessary to have a clearer view of science education as having sociopolitical function. (p. 362)

Vision III includes worldview perspectives, socio-political-environmental perspectives, as well as responsible actions (Sjöström & Eilks, 2017).

NATURE OF SCIENCE

Discussions concerning the nature of science (NOS) also bears similarities to RRI, especially with respect to those aspects of NOS that concern human elements of science. For other major aspects concerning tools and products of science and science knowledge and its limits, respectively, the similarities are less obvious (McComas, 2017). Leden (2017) describes the field in the following terms:

> NOS being a field where perspectives from history, philosophy, and sociology of science meet and play roles in the interpretations of how values, believes, norms, and traditions interact with scientific knowledge and the processes connected to its development. (p. 9)

As in RRI, NOS emphasises interactions between scientific knowledge and processes (Lederman, 2007). To understand NOS means to understand how science works and how knowledge produced by researchers engaged in scientific inquiry is a part of society, and influenced by norms and values. Even if there is no complete consensus concerning how NOS should be defined or the terminology to be used, Allchin (2014) concludes that it is all about how understanding about science should help students as citizens in contemporary society to participate in decision-making and make decisions. This form of understanding about science is also an important aspect of RRI.

SOCIO-SCIENTIFIC ISSUES

Finally, the concept socio-scientific issues (SSI) underlines quite similar issues, but mainly from an educational perspective. Working with SSI gives the students a possibility to investigate a problem in society. Ratcliffe and Grace (2003) describe SSI

> to be one which has basis in science and has a potentially large impact on society. (p. 1)

SSI have attracted attention in science education in recent years and have been proposed as an appropriate means to discuss and learn about the connection between science and society. Instead of learning many concepts in the beginning of studying a discipline, SSI teaching starts with a problem or a question that can be perceived as significant and important by the students. Ratcliffe and Grace argue for the influence of our priorities, values and beliefs when taking action on a personal level. Such values and beliefs are also important in RRI.

Within science education research, extensive research about SSI has been conducted during the past decade (Zeidler, 2015). Sadler (2009) suggested to select SSI for science education, which encourages personal connections between students and the issues discussed, explicitly addresses the value of justifying claims and exposes the importance of attending to contradictory opinions. Such a version of SSI-teaching emphasises relevance (both personally and societally), ethics, civic engagement and character formation (Zeidler & Sadler, 2008).

Recently, Levinson (2017) in this journal compared SSI with other science-society education approaches like STEM (Science-Technology-Engineering-Mathematics), SAQ (Socially Acute Questions), and STEPWISE (Science & Technology Education Promoting Wellbeing for Individuals, Society & Environments). He described the educational purpose of STEM as providing human capital, that of SSI as development of scientific knowledge needed for socio-scientific reasoning, that of SAQ as developing a critical discourse, and that of STEPWISE as knowledge for action for socio-ecojustice.

On the other hand, Simonneaux (2014) has discussed a continuum of different versions of SSI, using a scale from “cold” to “hot” variants. Cold-type SSI education is quite traditional science teaching with some socio-contextualisation. It is characterised by monodisciplinarity and focus on content learning. Hot-type SSI, on the other hand, also emphasises transdisciplinarity and political citizenship, in addition to epistemic values. As mentioned in the introduction, just like the other concepts compared in this article, SSI can be understood as a “boundary object”. However, it may be debatable whether it is reasonable to include as much in the SSI concept as Simonneaux (2014) did. We would argue that it may be more appropriate to work with a somewhat narrower definition, like the one Levinson (2017) refers to, where SSI is still a “boundary object” but where there is little more consensus about what is meant with the concept. Within a narrower definition, cold-type SSI might better be termed “context-based”, while hot-type socio-ecojustice-oriented SSI could be covered by concepts such as Socially Acute Questions (SAQ). This is also the term that Simonneaux has used for “complex SSI” in most of her publications. In the rest of this article, we will use the term SSI in the narrower sense of the mainstream type outlined by Sadler and Zeidler (2009), which also Levinson (2017) referred to in this journal.

THE THREE CONCEPTS AND RRI

In this section, we will further discuss the similarities and differences between RRI and the three concepts of SL, NOS and SSI outlined above. The aim with this discussion is to scrutinise if RRI can bring something new and useable into science education, or if RRI just is the same thing, "dressed in the Emperor's new clothes". SL, NOS and SSI have all been of importance in science education research for at least the last 20 years. Especially SL has received considerable attention and has been introduced in curricula all over the world. SL is also a concept which underlies frameworks as PISA (Dillon, 2009; OECD, 2003; Sadler & Zeidler, 2009). All these three concepts describe, at least in some way, perceptions of what is desirable in certain forms of *citizenship*. The concepts rest on the shared assumption that by being scientifically literate, understanding how science works and how it is important in societal questions, the individual will be able to argue and make better founded decisions. As in RRI, these three concepts have strong democratic aspects. They all also have a contextual feature, especially SSI. Dependent on the situation, science can play different roles and different knowledge is needed in different situations. At first glance, the three concepts additionally seem to cover a large portion of what science education is supposed to cover according to different curricula. We can also observe that curricula have been revised and drafted to address these aims, expressed in various national and international policy documents.

However, there are some differences between the three concepts. NOS has strong connections to the broad field of science studies, which is an interdisciplinary research area that seeks to situate scientific expertise in broad social, historical, and philosophical contexts (Sismondo, 2009). SL is a part of the literacy movement (Norris & Phillips, 2003), which started with reading and writing, but nowadays is discussed in every school subject. Of the three concepts, SSI is the only one that is used almost only in science education. However, also this concept had its background outside science education in a field called *controversial issues education*, that started developing in the 1960s (e.g. Long & Long, 1975). Studies in science education demonstrate the difficulties with attempts to involve real-world problems (e.g. Lundström, 2011) in the science classroom. Even if science education strives to work with complex problems, it has been difficult for students to understand what science really is, how it works and the diversity within science (Lederman, 2007). These results indicate that science education today does not totally reach the goal of educating citizens who are scientifically literate.

As mentioned earlier, the RRI concept promotes societal actors to engage together in research and innovation processes in order to better align both the process and its outcomes with the values, needs and expectations of society. We think here is the major possibility to establish RRI within science education. By establishing close connections to different educational institutions, researchers might have the possibility to create situations where students, teachers, teacher educators and researchers discuss RRI. This face-to-face meeting between students and researchers might also give the possibility to raise scientific literacy among students. Our own experience from doing this is encouraging. Through inviting scientists to both teacher education programmes and to primary and secondary schools, both in-service teachers, pre-service teachers and students could discuss directly with the scientist. These encounters enable to develop issues of RRI, and possibilities to further develop these processes and different

perspectives with the students. During the PARRISE-project a Swedish scientist who worked with nano-technology development and risks, brought in important perspectives of RRI to our teacher workshops. The scientist for instance discussed the distribution between money spent on research to develop new nano-technology products (90%) compared to risk research within nano-technology (10%).

Another area where RRI could develop science education is the interpretation of data. Studies demonstrate how individuals often have problems with interpreting data (Bond, Philo & Shipton, 2011). If a collaboration is established with scientists as mentioned above, it will give an opportunity to practise to interpret data, but also to discuss with scientists how data can be interpreted in different ways. One such example could be climate data, an area that is much discussed and where debates occur concerning how to interpret and value data.

DISCUSSION

The idea of RRI builds upon a wish that people in a larger community, as for example the European Union, should share similar values, thoughts and wishes about the future. It relies on a desire that many individuals should make the same assessment when obliged to choose between economic, societal, technical or other perspectives. Is this Utopia possible to reach? Of course not, but on the other hand RRI is, just like SL, NOS and SSI, a boundary object, where the meaning of the concept is continuously under discussion and development.

Ideally, RRI relies on a unified view between different actors about the research and innovation process. The different actors must discuss and reach a decision that people can accept and see as possible. This might be hard to achieve in practice, since many questions do not have a clear straight answer and different actors will stress different questions and answers. But despite such difficulties, as mentioned earlier, Owen et al. (2012) have demonstrated how collaboration between scientists and organisations can be successful. We think this can also be the case between scientists and both formal and informal education.

If education should develop RRI skills, there are some aspects to be considered, however. Several studies point out the difficulties with transferring different types of school knowledge into other contexts outside school (e.g. Lundström, Ekborg & Ideland, 2012). Several years ago, Roth and Lee (2004) made the suggestion that science education should participate in various social activities and contexts outside school. Perhaps RRI could reconsider this suggestion and influence science education to work even more with real case studies. From our exploration and comparison between the different concepts, we have concluded that RRI does not bring in fundamentally new ideas to science education, but instead highlight parts that have been neglected. Nonetheless, the meeting between the researcher or innovator and student or teacher could offer new perspectives. The possibility to meet researchers with different perspectives in connection to inquiry based science education, we consider as a fruitful possibility to promote RRI and open the science classroom for deliberative discussions about different perspectives of research and innovation. This has of course been done to

a certain degree already. Within the PARRISE project, the combination of inquiry based science education where questions were framed by SSI-issues, in combination with encounters with researchers in the actual new-technology area, shows encouraging experiences to approach RRI within science education (Sjöström, Hasslöf & Lundström, 2017). RRI may be a top-down policy concept, embedded in interpretive challenges, but it might be a mistake to throw it away, as to blurry or complex concept, at least in relation to science education. Why? Because in a way, the challenges of RRI mirror the challenges that contemporary innovations of science and technology face. It puts science education in relation to the dynamics of societal challenges of rapid science innovations and emerge the ethical and political dimensions of science and technology. We do not have, and do not strive for any ultimate method of how to address RRI in relation to science education, but we look forward to further experiences and research in the science education field to develop the discussion of RRI further. We believe all actors have a lot to learn from such initiatives, and that arranging opportunities for face-to-face encounters of this kind would be in line with the core goals expressed by the EC with respect to RRI, namely: "multi-actor and public engagement in research and innovation, enabling easier access to scientific results, the take up of gender and ethics in the research and innovation content and process" (EC, 2017).

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