
Responsible Research & Innovation (RRI) for researchers. An introduction

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Opening words

If there is one thing that characterizes much of European society today, it is that knowledge and information form an intrinsic part of people's everyday lives, and the way we interact with each other and our environment. Knowledge no longer belongs exclusively to universities and it hasn't for many years now. Many other platforms are capable of generating, processing and conveying knowledge. From museums to civic centres, hospitals or companies, it is hard to think of any setting or organization that doesn't work with and thanks to knowledge.

This is the context in which we scientists conduct our research – a context where we also have to overcome the significant social challenges that affect and hinder us all. These global challenges were summarized well in the 2030 Agenda for Sustainable Development passed by the United Nations in September 2015. It is becoming increasingly clear that we scientists and the science we work on are inherent in the society we live in. Nonetheless, some developments and innovations resulting from scientific advances have not foreseen the unintended consequences for society. These consequences could have been avoided if the other people affected by these developments had been involved right from the start, from the posing of the problem to be solved.

The concept of Responsible Research and Innovation (RRI), as defined by the European Commission, intends to do just this. It aims to act as a call to arms for researchers and research organizations to work *with and for society*. The idea is to continue to look for solutions to the problems we face, but to do so in a different way. It is not a case of different science, but the same science done differently.

The aim of this course, which we are running from the Universitat Oberta de Catalunya in collaboration with the University of Bristol and the Universitat Autònoma de Barcelona, is to enable researchers and research group support and management staff to embrace this exciting and diverse concept of RRI. The course falls within the framework of the UOC's commitment to research; the aim is to strengthen this research and to bring it closer to society and the challenges society faces. Once you complete the course, we expect you not only to have gained a clear idea of the different aspects of RRI, but also to have started to consider a different approach to how you understand and conduct the research you are immersed in from day to day.

Pastora Martínez, UOC Vice President for Globalization and Cooperation

Presentation

RRI is a new framework developed by the European Commission for its current Horizon 2020 research and innovation programme in order to make research and innovation more responsible. The course «Responsible Research & Innovation for researchers. An introduction» is a hands-on training course that fosters your understanding of the **Responsible Research and Innovation (RRI) framework**, offers practical tools and helps you gain experience in integrating the RRI framework in your research projects from the first moment on. In order to get acquainted with the theoretical background and the main concepts of RRI, we designed this first module and the document you have in your hands as a general introduction to the main challenges within our current research and innovation systems, from a perspective of responsibility, as well as a way expose you to the wider concept of RRI. This document is meant to accompany you through the whole course and guide you when analysing the more practical use of the existing tools and instruments.

Before exploring the main dimensions of RRI, we will discuss the **nature of our current research and innovation systems** as drivers behind the emergence of the *RRI movement*. We invite you to critically reflect on what kind of R+I system our society needs, what kind of changes are required to achieve it and whether the RRI concept is able to contribute to fostering this systemic transformation.

Once these basic and more philosophical questions related to the RRI framework are clear, we will present and analyse the different **RRI agendas**: gender, open access, ethics and integrity, science education and public engagement.

Finally, we will share some reflections on the **challenges and opportunities** that lie in the application of the RRI concept.

Objectives

- 1.** Invoke an understanding of the interdependencies of science and society as well as the need for addressing issues of responsibility in relation to research and innovation.
- 2.** Introduce some of the major challenges our research systems are facing and critically reflect on them.
- 3.** Understand the origins and evolution of the RRI concept and framework.
- 4.** Get to know the main dimensions of RRI and agendas and their possible applications to your research.
- 5.** Critically reflect on the RRI concept and its opportunities and challenges.

1. The research system and its challenges from a perspective of responsibility

Before exploring the RRI framework and its key issues, and reflecting on what «responsible» means when accompanied by «research and innovation», it is necessary to understand where this new framework comes from. To do that, we briefly introduce some broader reflections on the role of science and the research systems in our modern societies. Taking into consideration the duration of this course, we are unfortunately not able to discuss all these issues in detail, but we still wish to mention them in order to offer you a broader space for reflection in which to locate the emergence and development of the RRI framework.

1.1. Science and risk: questioning the model of science

Place yourself in a world where science and technology sometimes create risks for people and their environment and consequently ethical dilemmas and uncertainty. It is our current society, which was coined as the «risk society» by sociologists Ulrich Beck and Anthony Giddens during the 1980s. One of the first evidences of these risks is well-described and documented by biologist Rachel Carson in her book *Silent Spring*, published in 1962, which exposes the hazards and detrimental effects of the indiscriminate use of pesticides (particularly DDT), highlighting the risks of the chemical industry for the environment and questioning humanity's blind faith in technological progress.

Subsequently, evidence on the risks of nuclear power, biotechnology, nanotechnology and other research areas, its accidents, unanticipated consequences, potential damages or uncertainties, has called into question the model of science. Are science and technology contributing to the well-being and quality of the environment or are they increasing inequalities and generating more pollution? Furthermore, fast information channels like the Internet have contributed to increasing disinformation on scientific issues, generating more uncertainties and even scepticism about the benefits of research and innovation in our society.

1.2. Science and sustainability in times of increasing complexity

Over and above the risks of scientific and technological research, it is remarkable that we are living during a time of unprecedented changes and uncertainties at a global level: climate, food, energy, health, security—and science is expected to address all of these issues. In such an interconnected

Bibliographical references

U. Beck (1992). *Risk Society: Towards a New Modernity*. SAGE.

R. Carson (1962). *Silent Spring*. Penguin.

Note

Langdon Winner brilliantly refers to some of these risks in his book *The Whale and the Reactor* (1986), which is today more relevant than ever.

world in terms of social, technological and ecological systems, reductionist approaches that focus on a single problem without considering the broader context are insufficient.

Bridges between the biophysical sciences, social sciences, humanities and technological disciplines have been built to **unravel the complexity** of today's global challenges. Several interdisciplinary centres around the world focused on different key topics—the Internet, environment, resilience and education, among others—have proliferated in the past few years to connect and integrate different schools of thought, methodologies and technologies to solve complex problems.

Examples

The Stockholm Resilience Centre, the Cambridge University's Interdisciplinary Research Centres or the Internet Interdisciplinary Institute at UOC place transversality and interdisciplinarity in the foreground to contribute to social progress through exploring and addressing the interaction between the human and engineering sciences.

Interdisciplinary research, although necessary, is also challenging because it goes beyond traditional academic boundaries where researchers used to feel comfortable. Therefore, interdisciplinarity is not only an institutional responsibility, but an individual commitment.

1.3. Science and power: acknowledging biases

Up until the 1970s, there was a predominant idea that scientific and technological innovation should be understood as neutral and autonomous processes, marginalised from any social dynamics and that only their consequences impacted positively (or negatively) on social and cultural development. Thanks to different studies that belong to what we call today *Science and Technology Studies* (STS) that have shown the impossibility of understanding scientific and technological development without taking into consideration political, social, economic or cultural conditions, this vision has slowly been overcome and today we know that **science is not neutral**, but strongly related to society.

This close relationship makes it necessary to think about science and power in modern societies.

«The problems which are strictly linked to science and its application have become an everyday experience, not only to scientists and politicians but to citizens everywhere. From genetic engineering [...] to the fight against Ebola and HIV viruses; from the hope of eradicating hunger and poverty to the environmental catastrophes caused by our inability to forecast—it is always science, its applications and its relations with power which are at the core of debate.»

Augusto Forti (1995). «Introduction». In: F. Mayor *et al.* *Science and Power*. Unesco.

Part of this debate has been articulated around the notion of «informed consent». In the last decade many efforts have been made at individual and collective level in the fields of medicine, behavioural and social sciences, as well as in technology, to avoid irresponsible practices done in the past when researchers conducted experiments with humans without providing them with an explanation of the unknown risks and possible negative consequences of the treatment or intervention.

Example

The Code of Ethics of the International Society of Ethnobiology «acknowledges that biological and cultural harms have resulted from research undertaken without the consent of indigenous peoples, a highly vulnerable group due to its disempowerment in the modern world. The ISE code of ethics advocates for working collaboratively with them under the guiding value of mindfulness».

1.4. Science and the market: increasing competence at the expense of social impact

One of the buzzwords that has highly influenced our higher education and research systems over the last few years is «excellence». With this idea in mind, international **rankings** of higher education institutions, mainly based on the academic impact of the research they carry out and often promoted by private editorial companies, burgeoned and everyone strives to be placed under the top international institutions. While many institutions prioritise the climbing up in these international rankings, contributing to continuously increasing competitiveness among researchers, there are more and more critical voices questioning the international rankings and they are warning about the effects of an obsession with them.

This goes hand in hand with a growing **commercialisation of research**. Much of the knowledge generated in our scientific systems is not available for the common good, but is protected by patents and only contributes, in some cases, to some people's benefits and not to society in its entirety.

The downside to the growing competitiveness and pressure for excellence is the never ending pressure for researchers to publish, with very negative effects for our research systems and the advancement of knowledge. Two of the main problems are **reproducibility** and the resultant **waste of resources and funding**. «Currently, many published research findings are false or exaggerated, and an estimated 85% of research resources are wasted» (Ioannidis) and in 2010, only in the United States, \$200 billion have been wasted (*The Lancet*, 2015). Another worrying tendency is the growing of **misconduct and fraud within research practice**. The magnitude of the problem made even *The New York Times* published an editorial—«Scientist who cheat»—on this issue two years ago.

Recommended reading

Ellen Hazelkorn (2015). *Rankings and the Reshaping of higher education. The Battle for World-Class Excellence*. UK: Palgrave Macmillan.

Bibliographical reference

J. P. A. Ioannidis (2014). «How to Make More Published Research True». *PLoS Med* [11(10)]. Available at: <<https://doi.org/10.1371/journal.pmed.1001747>>

1.5. Science and democracy: the mantra of participation

The 21st century is witnessing what we can call a more «inclusive or participatory» way to do science and research. If science aspires to be democratic, then it must be built on un-dogmatic principles of re-assessment and questioning of authority. If in the past decision-making on science-related issues was influenced only by scientific experts, now public engagement in science has become a mantra. In this sense, public opinion is now more than ever a source of data for policy change. An example is the **Eurobarometer**, a set of periodic public opinion surveys conducted by the European Commission that provide a systematic and impartial picture of the climate of opinion about science and technology (S&T), showing the evolution of the public perception of science in Europe regarding the associated risks, the resulting outcomes and its contribution to its wellbeing and environmental sustainability. Back in 1995, the Eurobarometer results showed that only 17% of respondents considered S&T as a priority action for the European Parliament (EC, 1995). Ten years later, «Europeans perceived themselves as moderately well informed on science issues but slightly less interested in science issues than they were in 1995» (EC, 2005). Findings from this survey also suggested that the scientists' work was perceived as credible, but risk was perceived in some S&T activities such as nuclear energy and biotechnology. In turn, a 2010 Eurobarometer showed that Europeans were more optimistic about the image of science and technology but had less clear insight into the efficiency of scientists' work (EC, 2010).

It is believed that through engaging citizens, scientists and policy makers in a dialogue on what the benefits and the risks of a particular research could be, it will be possible to establish and maintain citizens' confidence in science and technology. To achieve such cooperation between science and society is precisely one of the main objectives of the Horizon 2020 «Science with and for Society» programme. As mentioned before, however, we must be aware that power inequalities exist in science and research, and these need to be challenged if citizens and scientists are supposed to participate in a dialogue as equal partners.

2. Research policy change in Europe: RRI and its dimensions

2.1. What does RRI mean?

Based on the need to address this evidence about Europeans' public perception on science and research policy, as well as on previous work done separately by scholars in such diverse areas about unexpected risks and outcomes of new technologies and controversial scientific achievements (e.g., research integrity and ethics in research, public engagement, interdisciplinarity for innovation, technology assessment and anticipatory governance), a new paradigm was born from academic discussions, and coined as «**Responsible Research and Innovation**» (RRI).

One of the most cited definitions of RRI is the one from Von Schomberg, which is anchored to European policy processes and values:

«A transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to 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).»

Rene Von Schomberg (2011). «Prospects for Technology Assessment in a framework of responsible research and innovation». In: M. Dusselhorp, R. Beecroft (ed.). *Technikfolgen abschätzen lehren: Bildungspotenziale transdisziplinärer Methode* (pp. 39-61). Wiesbaden: Springer VS.

In 2013, when the European Commission was building the RRI concept, a Eurobarometer was launched to explore Europeans' perceptions on the **key aspects** of the RRI framework: governance, science education, public engagement, ethics, open access and gender. One of the findings was that respondents across Europe were «concerned about the speed of change science and technology have, and their potential for negative consequences». Also, around three quarters (74%) agreed «that developments in science and technology could have unforeseen negative side-effects on health and the environment» (EC, 2013). Such evidence strongly supported the need to improve the way research and innovation dealt with risks and engaged society. With the Horizon 2020 programme for Research and Innovation (2014-2020) the EC adopted **RRI as a strategic approach to governing science and innovation through the lens of responsibility**, that is, to make research and innovation more responsible.

Bibliographical reference

R. Owen *et al.* (2012). «Responsible Research and Innovation: From science in society to science for society, with society». *Science and Public Policy* (issue 39, p. 751-760).

2.2. What does «responsible» mean when accompanied by «research and innovation»?

RRI aspires to facilitate the involvement of civic society and other stakeholders with research, technology and innovation, and to guide decision-making towards societally desirable, sustainable and ethically acceptable ends. Such values are aligned with the democratic values of the EU Treaty. However, the ambiguous and interpretively flexible concept of RRI and related values when, for instance, referring to inclusiveness, led us think about instrumental motivations to put RRI at the core of the research and innovation policy in Europe. From a critical point of view, we can think about the different meaning that the questions «responsible for whom» and «responsible of what» would have when asked to different stakeholders such as private companies and civil society organisations.

The Rome Declaration of Responsible Research and Innovation in Europe (November 2014) seems to turn a blind eye to these conflicting nuances and adopt a conciliatory approach with an emphasis on the benefits instead of the challenges:

«The **benefits** of RRI go beyond alignment with society: it ensures that research and innovation deliver on the promise of **smart, inclusive and sustainable solutions** to our societal challenges; it **engages new perspectives, new innovators and new talent** from across our diverse European society, allowing to identify solutions which would otherwise go unnoticed; it builds trust between citizens, and public and private institutions in supporting research and innovation; and it reassures society about embracing innovative products and services; it **assesses the risks** and the way these risks should be managed.»

European Community (2014). *The Rome Declaration of Responsible Research and Innovation in Europe*.

Under this conceptual understanding, **RRI entails four dimensions of the process of research** that try to overcome the limitations of top-down risk-based models of governance and to encapsulate the social, ethical and political stakes associated with techno-scientific advances. These dimensions are:

- Diversity and inclusion
- Openness and transparency
- Anticipation and reflection
- Responsiveness and adaptive change

In what follows we briefly describe them based on the definition of the RRI-Tools project.

Bibliographical reference

Jack Stilgoe, Richard Owen, Phil Macnaghten (2013). «Developing a framework for responsible innovation». *Research Policy* (vol 42, Issue 9, p. 1568-1580).

See also

Go to the «Gender», «Public engagement» and «Science Education» sections below to find out more information and examples.

RRI is about: including all actors, and process dimensions

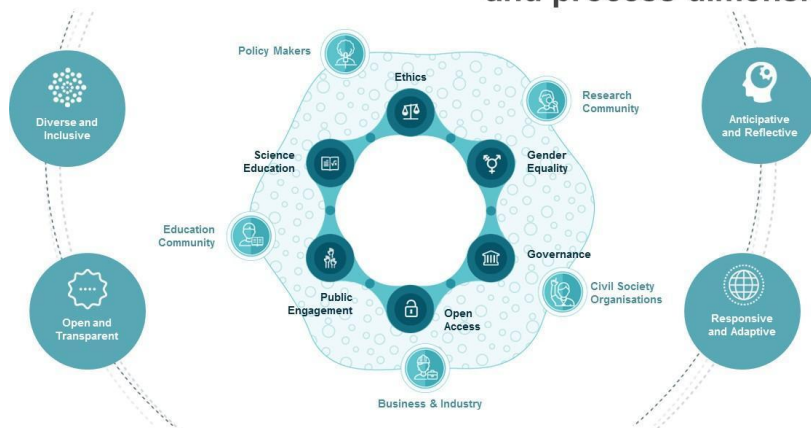


Figure from RRI-Tools project

2.2.1. Diversity and Inclusion

Diversity and inclusion means **early involvement** of a wide range of actors and publics in your R&I practice, deliberation, and decision-making **to yield more useful and higher quality knowledge**. Actors can include a wide range of audiences from the **research community**, **business and industry**, **policy makers**, the **education community**, and **civil society**. This is supposed to strengthen democracy in research and innovation and to broaden sources of expertise, disciplines and perspectives.

2.2.2. Openness and Transparency

Openness and transparency means **to communicate** in a balanced and meaningful way the methods, results, conclusions and implications of your research to the audience so as **to enable public scrutiny and dialogue**. This is expected to enhance the visibility and understanding of your research and innovation procedures and outcomes.

See also

Check sections below, specifically «Open access & Open Science» to find out more information in this regard.

2.2.3. Anticipation and Reflection

Anticipation and reflection means to **envision impacts** and **reflect on the underlying assumptions**, values, and purposes to better understand how your research and innovation shapes the future. Also to reflect on the consequences and outcomes impacts of your research. This can lead to valuable insights, prevent from detectable risks and increase your capacity to act on what it is known.

See also

The «Ethics & Integrity» section can be useful for you to go deeper into this topic.

2.2.4. Responsiveness and Adaptive Change

Responsiveness and adaptive change means to be able to **modify modes of thought and behaviour** while doing your research and innovation and overarching organizational structures, **in response to changing circumstances**, public values, knowledge and perspectives. This is expected to align action with the needs expressed by different actors and publics.

See also

The examples provided within the «RRI agendas» section below will guide you to follow this pathway.

3. RRI agendas

RRI has been translated into **six key aspects or policy agendas**:

- Governance
- Public engagement
- Science education
- Open access
- Gender equity
- Ethics

We consider that governance lies at the core of the concept and permeates the entire RRI paradigm, as described in the previous sections. Therefore, we will examine the other 5 key aspects of RRI in detail, but we include here an example related to governance and RRI. The Res-AGorA Responsibility Navigator was conceived as a *thinking tool* supporting the identification, development and implementation of measures and procedures that can transform research and innovation in such a way that responsibility becomes an institutionalised ambition. It is not only intended to make individuals, organisations and institutional systems more responsive towards societal needs and preferences, but also to make existing and new governance instruments and arrangements robust, and to allow, encourage and process contestation, learning and experimentation.

3.1. Gender and RRI

What has gender to do with Responsible Research and Innovation? There is little doubt that science is a fundamental part of contemporary Western societies. It is key for addressing our most pressing challenges such as climate change, renewable energy, or health issues to name just three. Therefore, decision-making as well as participation in science in general should reflect the needs and concerns of all members of society, women and men alike. **Historically, science was the exclusive domain of men and still today one can trace the reverberations of this historical exclusion of women by tracing the different forms of gender bias and gender inequality within science.**

The European Research Area (ERA) addresses these concerns through three basic objectives:

Bibliographical reference

S. Kuhlmann, J. Edler, G. Ordóñez-Matamoros, S. Randles, B. Walhout, C. Gough, R. Lindner (2016). *Responsibility Navigator*. Karlsruhe: Fraunhofer ISI. Retrieved 9 February 2017, from <<http://responsibility-navigator.eu/>>.

- Achieve gender equality in scientific careers
- Reach gender balance in decision-making bodies
- Integrate a gender dimension in research and innovation content

More information

EC webpage «Research & Innovation».

How science is *gendered* goes well beyond those three ERA priorities. However, within the specific European Policy Agenda of Responsible Research and Innovation, these three objectives are of central concern and will be explained in further detail in the following paragraphs.

3.1.1. Improving access to- and retention in scientific careers

As the latest «She Figures» show, **equal participation of women in science and research is still an issue**. Although women made up 47% of PhD graduates in the EU-28, they only constitute 33% of researchers and 21% of top-level researchers (grade A). Science is also not exempt from broader patterns of gender inequality that permeate society such as for example the pay gap: women's average hourly earning is 17.9% lower than those of men in scientific research and development.

Bibliographical reference

European Commission (2016). «She Figures». Luxembourg.

Current differences in access and participation of women in research and innovation have historical roots: until well into the 20th century, science used to be the exclusive domain of men. History is full of revealing examples of how women scientists managed to overcome bias, disbelief and rejections of their family, colleagues and the wider society in order to make their groundbreaking contributions to science.

Example

A telling example in this sense is the German mathematician Emmy Noether (1882-1935) who worked without pay and taught in the name of her colleague David Hilbert at the University of Erlangen during 15 years until she finally got a position with a reduced salary.

See GENPORT resources for similar stories abound as one can see by reading through the portraits and fictitious letters of the art project by Jennifer Mondfrans who provides interesting insights into the life stories of women scientists.

Although we have come a long way since the beginnings of the last century in terms of women's access and participation in science, there still remain important gaps to be addressed.

3.1.2. Gender balance in decision-making

A crucial cornerstone of equal participation is access to decision making positions. Only 28% of women in the EU-28 are scientific and administrative board members. As a consequence, women do not participate in the decision making process of evaluation and excellence criteria —upon which the

distribution of resources is based. This in part may explain the continued existence of the funding gap in science: success rates are higher for men in most of the EU-28 countries.

Access to funding is closely aligned with the question of how we conceive excellence in science. Unequal access to decision-making points to a much deeper problem of a gendered value system. Society usually grants higher status to men and those activities coded as masculine while those activities coded as feminine are less visible and undervalued.

A good example in this sense is innovation policy and funding: whereas regional economic development through knowledge transfer activities, innovation or research grants tend to focus on masculine, high-tech innovation that values growth-oriented profits, women and feminised types of knowledge targeting equality or community well-being in areas such as education and health are under-valued. Our very understanding of **innovation has to be conceived as gendered** in that it is often limited to technological gadgets— whereas the social fabric in which these innovations are embedded are simply taken for granted and not recognised.

Thus, **gender equality in research and innovation** is not just a «women's issue» but implies an understanding of masculinity and how masculine values and norms are inscribed in the science system in the form of excellence criteria and decision-making processes.

In practical terms, the GEAR tool includes a range of activities and instruments that can be useful to foster institutional change in research organisations and higher education institutions through a Gender Equality Plan (GEP) addressing different areas and themes. In the specific context of research organisations and higher education institutions, the European Commission considers a GEP as a set of actions aiming at:

- Conducting impact assessment of procedures and practices to identify gender bias.
- Identifying and implementing innovative strategies to correct any bias.
- Setting targets and monitoring progress via indicators.

Bibliographical references

M. K. Blake, S. Hanson (2005). «Rethinking innovation: context and gender». *Environment and Planning A* (vol. 37, issue. 4, pp. 681-701). Available at <<http://doi.org/10.1068/a3710>>.

M. Gray, A. James (2007). «Connecting gender and economic competitiveness: lessons from Cambridge's high-tech regional economy». *Environment and Planning A* (vol. 39, issue. 2, pp. 417-436). Available at <<http://doi.org/10.1068/a37406>>.

A. Parken (2010). «Gender, Knowledge Dynamics and Regional Policy». In: H. Halkier, M. Dahlström, L. James, J. Manniche, L. S. Olsen (ed.). *Knowledge Dynamics, Regional Development and Public Policy*. Aalborg Ost: Department of History, International and Social Studies, Aalborg University.

Bibliographical reference

European Institute for Gender Equality webpage.

3.1.3. The gender dimension in knowledge production

The most recent developments among gender scholars have indeed provided impressive examples that gender equality in science goes beyond equal access and participation in decision-making in order to address **the gendered bias inherent in knowledge production and research content**. The insight that a gender dimension helps improve the scientific quality and societal relevance of the produced knowledge, technology and/or innovation gets right to the heart of RRI.

Impressive evidence is available from medical research where gender bias can have fatal consequences in terms of wrong or misleading diagnostics and treatments. The clinical standards for cardiovascular diseases for example, have been based to a large degree on the male pathophysiology without considering that symptoms for women differ, leading to mis- and late-diagnosis of heart attacks in women. Gender and sex differences for cardiovascular disease have been on the forefront of investigating the impact of gender bias in medical research.

Similar, osteoporosis or eating disorders have primarily been associated with women and girls; that is, defined through female reference models again leading to an under-diagnosis of these health issues in men and boys.

The importance of the **gender dimension for research and innovation also affects research methods directly**, especially in the life sciences. A telling example comes from pain research: most research shows that women have a higher sensitivity and lower tolerance to pain than men; women also report higher pain ratings and have a greater ability to discriminate among varying levels of pain. The evidence so far suggests that sex differences in pain processing of immune cells could be the underlying cause of this.

However, the crucial point in terms of a gender dimension is that most preclinical experiments in the laboratory that involve animals—in the context of new drug developments or for understanding pain processing by the body for example—is largely performed on male rodents only. However, if there are sex differences in pain processing, the validity of the experimental results is severely limited in that they make predictions based on male reference models for the whole population when in fact important physiological differences do exist.

Gender equality in Responsible Research and Innovation here means to improve the quality as well as societal relevance of research to the entire population, women and men alike.

Further reading

For a general overview of how the gender dimension can make a difference not just in the health sector but also for engineering and the natural sciences, see the Gendered Innovations project website.

Further reading

For a good overview of the gender dimensions across the Horizon 2020 priorities see GenPORT Research Synthesis 4 «Gender in Research Content and Knowledge Production» by Elizabeth Pollitzer and co-authors. Lacking an understanding of gender- and sex differences in health can thus have severe consequences in terms of wrong diagnosis and treatments.

Bibliographical reference

J. S. Mogil (2016). «Perspective: Equality need not be painful». *Nature* (535, S7). Available at: <<http://doi.org/10.1038/535S7a>>.

Many more examples are available concerning machine learning, car safety, urban planning among others (GenPORT). What more, although RRI and previous EU policy directives directly target gender equality in science, many other faultinesses of discrimination are apparent where gender issues intersect with racial discrimination or discriminates based on age and/or class.

3.2. Open Access & Open Science

Some policy institutions have recently introduced open science initiatives and mandates. The European Commission, for instance, aims at improving knowledge circulation and innovation by requiring open access to all scientific publications funded within Horizon 2020.

3.2.1. Open Access

Most scientific publications are papers/articles published in academic journals. Those journals have traditionally been available for scientists through their university libraries, that previously pay the required subscription to the academic publishers (usually large private firms with huge revenues) that edit and sell them. With the advent of the World Wide Web, in the middle of the 90's, many scientists envisaged the possibility of making all scientific literature freely available through the Internet in digital form. Sometime later **the movement for open access** began.

The open access movement aims at having online research outputs—mostly journal articles but also other scientific publications—freely available on the Internet, without restrictions of access (paywalls) and without restrictions on use (copying, printing, and quoting them, among others).

There have been different manifestos and declarations fostering and urging for open access. One of the first and more notorious was the *Budapest Open Access Initiative* that defined open access as follows:

«By “open access” to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.»

As can be seen from this excerpt, open access can entail much more than simple free online access. In fact, there is not a single and shared definition but different interpretations of what open access is or should be.

Bibliographical references

- About machine learning:
A. Caliskan, J. J. Bryson, A. Narayanan (2017). «Semantics derived automatically from language corpora contain human-like biases». *Science* (356(6334), p. 183-186). Available at <<http://doi.org/10.1126/science.aal4230>>.
- About car safety:
D. Bose, M. Segui-Gomez, J. R. Crandall (2011). «Vulnerability of female drivers involved in motor vehicle crashes: an analysis of US population at risk». *American Journal of Public Health* (vol. 101, issue 12, p. 2368-73). Available at: <<http://doi.org/10.2105/AJPH.2011.300275>>.
- About urban planning:
I. Sánchez de Madariaga (2009). «Vivienda, movilidad y urbanismo para la igualdad en la diversidad: ciudades, género y dependencia». *Ciudad y Territorio. Estudios Territoriales* (vol. XLI, issue 161-162, p. 581-598).

There are currently two main modalities of open access:

- **Green open access.** Also known as «self-archiving», refers to the practice of placing articles, once they have been published in standard journals, in open access repositories, usually built and maintained by universities. The problem is that journal publishers often require delays or *embargos* and even forbid that practice.
- **Gold open access.** It refers to articles openly available directly by journal publishers, mostly in so-called «Open Access Journals». Quite often, the publishers ask for an extra fee to authors, which is usually paid by the research funder or by the author's institution.

There are two main drivers in the movement for open access:

- Favouring the diffusion and communication of research to those scientists working in institutions that cannot afford to pay the often expensive subscription fees to some journals.
- Allowing access to scientific research to other social actors (user or patients groups, environmental activists or even the general public) beyond the scientific community.

3.2.2. Open Science

Open access is increasingly framed within a broader movement for open science. While open access refers mainly to publications, open science advocates sharing, through digital means, other important elements of science and the research process also: data, notebooks, software tools, methods and educational resources.

Open data are particularly important since a great deal of the practice of science involves collecting and analysing data, but also reanalysing, critiquing and reusing data produced or collected by other scientists.

It can be argued that science has been an open endeavour since the so-called «scientific revolution» in the 17th century, but there are certain contemporary elements that make a difference.

- Firstly, science has increasingly turned into a collective task and most research is done today in teams—some very large; the sharing of data is an essential requirement in this context.

- Secondly, digital tools and the Internet provide, in principle, an ideal medium for sharing data.
- Thirdly, and maybe most importantly, there is a present trend towards the commodification of scientific research and the privatisation of science.

Since some research outputs have the potential to generate commercial revenues, many research institutions—including public universities—want to capitalise on these products by withholding information and data through non-disclosure agreements or patents. Many governments, in turn, boost this move when they wish to render both education and research more responsive to market incentives. Scientific knowledge is then treated as a proprietary and closed good, though, paradoxically, those same institutions—universities and governments—often ask scientists to disseminate their research through open access.

The **ambiguity of the term «Open Science»** is much higher than that of open access. Sometimes, for instance, the term is linked or even equated to «Science 2.0», stressing the need to use available Internet platforms—mostly privately managed—to disseminate research. In fact, there is a growing number of for-profit social networking sites for academics, with abusive terms of service regarding the data that scientists upload, that publicise themselves as open science champions.

The **motivations behind open science** are also diverse and not necessarily consistent. Sometimes open science is praised as a way to **speed up** research and make science **more efficient**—whatever that may mean. Sometimes open science is understood as a way to make science accessible to a wider audience—particularly to amateurs and lay people—and then facilitating public engagement. Others argue that any research product—particularly those coming out of publicly funded projects—should be freely available to the public.

3.2.3. Practical recommendations

When publishing in open access there are some basic things to take into consideration:

- **Publisher copyright policies & self-archiving.** Every journal has its specific policies on open access publication. Possibly the journal in which you wish to publish your article allows you to publish your pre- or post-print openly.
- **Predatory publishing.** While the open access movement has evolved, there has also been an increase in publishing houses that offer the publication of your article in a supposedly quality journal. Nevertheless,

Bibliographical reference

At Sherpa/Romeo you find an overview of the journal policies.

often these editorials have low or no peer review or other quality mechanisms.

It is important to check if the journal you have chosen is to be trusted.

Regarding the publication of your research data in open access we recommend:

- Include the research data management in your research from the start of the research process.
- Create and maintain up-to-date data management plans whenever possible so that you can define all the requisites (technical, legal and ethical) that you have to take into account.
- Get to know the data archiving and reuse options.

Further reading

For further information on open science and for good practices for researchers we recommend you to read:

The Working Group on Education and Skills under Open Science (2017).

«Providing researchers with the skills and competencies they need to practise Open Science».

3.3. Ethics and Integrity

«We see ethics not as an obstacle, but more as design principles for research and innovation.»

Michelle Rijnen, Athena Institute (Netherlands)

RRI explicitly acknowledges the **power of science and innovation to shape the world** that we live in, and that science should seek to shape the world in a way that is desirable to those that live in it. Ethics is a key facet of this alignment, in that societal ethical norms are one of the main ways in which the values and expectations of society are expressed. Thus, scientists working in a RRI approach have a responsibility to both understand the ethical values of society, and the ethical implications of their own research.

However, far from being a burden on scientists, RRI argues that ethics can be viewed as a useful tool with which to ensure that their innovation will be successful. If your research is aligned with the values of society, through comprehensive ethical reflection and public engagement to explore these ethical concerns, then it is more likely to be accepted by wider society.

 **Ethics in RRI means...**

<https://www.youtube.com/watch?v=ptuOvzGk7dg>

3.3.1. Realms of ethical responsibility

When we talk about ethics and integrity in RRI, we are essentially talking about three nested realms of ethical responsibility that the scientist holds.

In realm 1, we are talking about our responsibility towards our immediate surroundings, our projects and the people directly affected by the work our projects entail. This realm of ethical responsibility is commonly referred to as **research ethics**. Some researchers think that only clinical research requires such considerations, however this is not the case—any research involving humans or that impacts humans should do a thorough ethics assessment. Within the frame of research ethics, there are many different opinions on what the key issues of consideration are, however they often include respect for persons (informed consent, privacy, anonymity, confidentiality, protection of vulnerable people), justice (Who benefits? Who is included/excluded?), fidelity (trustworthiness and integrity in relation to the people involved in your research) and notions of harm and good.

These kinds of ethical considerations are commonly covered by ethical panels / ethical statements / the ethical requirements that accompany some funding, or official permission to carry out certain types of research. In many countries, research funders do not have regulations with regards to ethical research conduct, and thus the European Commission, through their research programmes, and focus on RRI, have sought to seed the concept throughout the countries and science cultures they fund.

Further reading

For further depth on these issues and how to tackle them in research, we recommend the book:
Hannah Farrimond (2013).
Doing Ethical Research.
Palgrave Macmillan.

Further reading

To get an idea of the kinds of things you might need to consider, take a look at the EC Horizon 2020 Ethics Self-Assessment Tool.

In realm 2 we are concerned with the institution, and the wider academic community. Issues here include: academic freedom, intellectual fraud and scientific integrity in the context of the scientific community. This area is sometimes referred to as **research integrity**. The human infrastructure of academic science, collaboration across institutions and geographical boundaries, relies on trust in the integrity of the conduct of our peers. The way we work, both as individuals and in community, underpins the success of the scientific enterprise.

Finally, realm 3 concerns wider society, which of course includes as well everyone we have just spoken about. We must consider the short term, and longer-term implications of the work we are doing on our environment and the society in which we live. When we talk about wider society, we must be clear that we are not just meaning our immediate communities, or even our nation states, but humanity and the environment on a broader scale.

Whilst on a basic level, the European Commission is interested in embedding basic research ethics in the research cultures of all European countries, it is through engaging with ethics on the wider and longer-term levels that the aspiration of RRI can truly be realised.

It is through considering the ethical implications of our work and engaging with the public about them that we can produce research and innovation that is properly aligned with the values and needs of society, and helps us tackle the challenges facing us in a sustainable and ethically acceptable way.

3.3.2. Practical recommendations

A few key pieces of advice on how to integrate ethics into your research:

- **Start early in the research process.** Ethical consideration should form part of the earliest stages of scoping your research topic and should entail continuous reflection.
- **Seek advice.** Speak to your colleagues about ethics in your discipline and institution. Find the people who are knowledgeable about ethics in your community and make use of their expertise.
- **Reflect with your peers.** One of the best ways of understanding the ethical implications of your work is through discussing it with others. Peers in other disciplines may have a particularly interesting perspective.
- **Be ready to change your practice.** You must be willing to change your plans if, on reflection, they are ethically problematic. Beyond merely

Further reading

The European Code of Conduct for Research Integrity gives an excellent and well-rounded view on research integrity, misconduct and suggested mechanisms for tackling these issues, as well as links to further resources.

Further reading

For further information on ethics in research, The Norwegian National Research Ethics Committees have produced a fantastic resource: The Research Ethics Library.

This website contains detailed information about a wide range of ethical issues across all subjects.

preventing harm, being flexible and responsive is the best way to ensure that your work will be relevant and useful to society.

3.4. Public Engagement

Public engagement is key to RRI as it **allows researchers to align their work with the needs and interests of the public.**

3.4.1. What is Public Engagement?

According to the National Coordinating Centre for Public Engagement (NCCPE) «public engagement describes the myriad of ways in which the activity and benefits of higher education and research can be shared with the public. Engagement is by definition a **two-way process**, involving interaction and listening, with the goal of generating **mutual benefit**».

There is not a strict recipe for good public engagement. It will depend on your research, your aims, the groups you want to work with and the resources that you have at hand. What is very important though is that there is a **genuine dialogue between researchers and society** and that researchers are open to change or to inform their practice in response to the views of the public. A good public engagement activity provides a space where different expertise is taken into account; it is not about researchers educating the public. Listening to publics' expertise can provide insights that you would not necessarily get from other researchers.

It is important to highlight that public engagement is not exclusive to research or to science. Many other fields use engagement methodologies that can be adapted to scientific research, a good example being the arts, especially in socially engaged arts. It is worth having a look at some projects for inspiration; check out for example the ones developed by Mammalian Diving Reflex or by Creative Time.

Public engagement can take place at any point during the research process; it is not about disseminating your findings. You could for example get a relevant group to help you define your research question or you could involve members of the public as co-researchers. A good example of this is Patient and Public Involvement (PPI) where patients help shape the research related to their condition.

Example

Check out this video for an example:

Further reading

In the National Coordinating Centre for Public Engagement website you will find lots of information and publications on different aspects of public engagement as well as case studies. They also coordinate the open access journal *Research for all*.



<https://www.youtube.com/watch?v=q6G1DUQI3WQ>

There are many other projects and resources that you could look at to see examples of public engagement. Take a look at the University of Bristol Engagement Awards where you can access a playlist of videos on some of the best engagement taking place at the University of Bristol, and INVOLVE where you will find lots of resources on how to involve the public in research.

3.4.2. How do you go about developing a public engagement activity that is based on your research?

Now that you know a little bit about public engagement, there are a few questions that you can ask yourself to help you develop your activity:

- **Why do you want to engage people with your research?** Consider the level of involvement that you want from the public. You may want to have a **conversation** with them, you may want to **consult** them to get their views or you may actually want to actively involve them (**collaborate**).
- **Who do you want to engage?** People tend to talk about the general public, but there is no such thing as the general public. People can be grouped in different ways such as where they live, what they are interested in, age group, etc. You need to think about which groups may be interested (or have a say) in your research and also who you are keen on hearing from. Being specific in choosing your audience helps you to design an activity that is more suited to them and the results will be more useful for you. It also makes it easier to recruit participants.
- **How might you engage them?** Once you know your aims and your audience you can think about your activity. Where would you find the audience? How may you interest them? What format of interaction is appropriate? A way to find out the answers to these questions may be to talk with them or work with an institution that works with them already (e.g. charity, museum, etc). Working with these institutions will make it easier for you to access your audience and to know them better. It is important that you put yourself in their shoes and that you get creative to design your activity.

Further reading

A good way to think about it is to have a look at «A Ladder Of Citizen Participation» and see what would be the most useful approach for your particular research. It is important to have a clear idea of what your specific objectives for public engagement are as this will help you see later if you have achieved them.

Sherry R. Arnstein (1969). «A Ladder Of Citizen Participation». *Journal of the American Planning Association* (vol. 35, issue 4, p. 216-224).

Example

There are many great examples that you can take inspiration from and you can experiment with different approaches. Explore the NCCPE website for a range of examples.

- **What do you need?** It is important to have a clear idea of the resources you have and need to do your activity, including time, money and people. You also need to think of any training you may need or support from other teams in your research centre (e.g., events, public engagement, marketing, etc.). Remember that you do not always need to plan everything on your own, you can collaborate with others or consider tagging into events already happening in your area.
- **Has it worked?** As mentioned before: **there is not a recipe for good public engagement.** Therefore it is important to check that what you are doing is actually achieving your aims. This is where **evaluation** comes in. You want to get the views of everyone involved (public, researchers, partners) in order to improve your activity for the next time and measure its impact. You can get creative with evaluation and integrate it into your activity. Try to measure change in the participants if you can and use the evaluation to share your experience with other people.

Further reading

The «Public Engagement Evaluation Guide» from the Manchester Beacon provides guidance on how to plan your evaluation.



This video of Invincible project shows an interesting example of Public Engagement in the field of synthetic biology research. <https://www.youtube.com/watch?v=71K6h3wg1i8>

Getting started in Public Engagement takes some planning but remember that there are lots of resources that you can use and that most Higher Education institutions will have some kind of support that they can offer you. Try to make the most of it and enjoy the process. Public engagement can definitely enrich your research if you work with the appropriate audience.

3.5. Science education

As mentioned above, and according to RRI, citizenship participation is crucial to better align social values, needs and expectations with the outcomes of scientific research. This requires the preparation not only of future scientists, but also of non-scientists. That is why science education is a key RRI agenda.

Indeed, education has the power to shape minds and culture. However, as environmental educator David Orr remarked, «it is not education that will save us, but rather education of a certain kind». In other words, if we want to transform science and societies into more democratic and transparent ones, we need as well an education that fosters critical, engaged citizens and a culture of cooperation and respect.

In this line, according to the report «Science education for responsible citizenship», under the lenses of RRI, science education should contribute to equip students with the necessary knowledge, resources and skills to participate as active citizens in democratic societies and to better face current complex societal challenges.



In this video from RRI-Tools you can find a brief framing of RRI in science education
<https://www.youtube.com/watch?v=3kDGaNNC6PE>

3.5.1. Science education within the RRI framework

Broadly speaking, such an educational paradigm implies a shift in the focus of science education from learning by rote discrete scientific facts to also understanding how to apply science learning to different and new situations, and to stimulate curiosity, scientific thinking and the understanding of the nature of science. This, obviously, affects **science pedagogy** and requires **creative and innovative approaches** to science education.

Bibliographical reference

David Orr (1991). «What is education for? Six myths about the foundations of modern education, and six new principles to replace them». *Context* (issue 27, p. 51). Retrieved June 15, 2010 from <<http://www.context.org/ICLIB/IC27/Orr.htm>>.

Bibliographical reference

E. Hazelkorn *et al.* (2015). «Science Education for Responsible Citizenship».

Bibliographical reference

E. Hazelkorn *et al.* (2015). «Science Education for Responsible Citizenship».

In this sense, RRI represents an umbrella term that both agglutinates and extends aspects from different educational trends and approaches that gained momentum in science education in the last few decades, such as those based on student-centred, active pedagogies. Inquiry-based learning, 21st century skills or life-long learning are examples of these emerging approaches that fit within the RRI paradigm, due to their emphasis on developing students' critical thinking and reflexivity, creativity, cooperative skills, learning autonomy and other key competences (as defined by the EC). This includes as well paying attention to the emotional dimensions of learning, such as students' experiences while learning, and their motivations and interests to learn.

If you are designing and implementing a science education activity, **RRI can be translated into several principles** to think about and follow. In this sense, an educational process under the lenses of RRI should try its best to:

- **Be diverse and inclusive.** That is, being sensitive to the profile of the learners (age, special needs, implementation context, etc.) and a critical approach to gender issues.
- Foster students' critical thinking and reflexivity about the scientific issues approached and their potential impacts (and not only contents to memorise).
- **Reflect about ethical and political aspects of science and research,** including values, interests and conflicting perspectives, as well as issues of uncertainty in science and research practice.
- **Be contextualised** within real-life challenges and **cover a wide range of disciplines** (transdisciplinarity!), so as to connect students' learning in the classroom with their societal contexts and further applications.

If the pedagogies are to change, we should also change the ways we evaluate and assess students' learning.

In this sense, RRI is in line with formative approaches that monitor learning as it occurs, actively involving the students, so as to foster their responsibility for their own learning and their empowerment through the educational process.

3.5.2. An example of RRI in motion: Socio-Scientific Inquiry-Based Learning

The approach of Socio-Scientific Inquiry-Based Learning (SSIBL) is a good example of the integration of RRI principles in science education. SSIBL is an innovative educational approach developed by the EU PARRISE project, integrating the approaches of inquiry based science education, socio-scientific issues and citizen education. As such, it actively engages learners in their own construction of knowledge through active inquiry about societal problems with a scientific or technological component.



Video from PARRISE that further explains the concept of SSIBL
<https://www.youtube.com/watch?v=fhQ8ZrklAQc>

3.5.3. RRI in science education: resources and platforms

Introducing RRI in science education requires that we critically ask ourselves what it means to be responsible in science and reflective about research and what we need to achieve it. These questions are crucial to set a meaningful roadmap from which we can move on to the next step: how can we translate it into a specific educational process?

Depending on the educational context (formal/informal, primary/secondary/university, etc.), the contents approached and the specific learning goals, different RRI dimensions will be emphasised to address specific needs. Thus, **rather than a recipe to follow, RRI gives us an opportunity to rethink and re-feel how and what we need to learn** when approaching science as more human and aligned with societal needs. In this search, the following platforms can inspire you... Enjoy the trip!

Further reading

You can find an assessment framework proposed for RRI-based science education in these two items from the PERFORM research project:
Maria Heras, Isabel Ruiz Mallén (2017) «Responsible research and innovation indicators for science education assessment: how to measure the impact?». *International Journal of Science Education* (pp. 1-26). Available at: www.tandfonline.com/doi/full/10.1080/09500693.2017.1392643.

Bibliographical reference

M. R. Ariza, A. M. Abril, A. Quesada, A. M. García (2014) «Bridging inquiry based learning and science education on socio scientific issues: contributions to the PARRISE european project, *INTED2014 Proceedings* (p. 2599-2607).

- The RRI-Tools platform (which you already know by now), has a wide range of contents and resources focused on RRI in science education at different levels.
- Ark of Inquiry is an educational online platform bringing together learners, parents, science educators, communicators and researchers around inquiry-based learning (IBL). It shares a collection of IBL activities, a toolbox for teachers with pedagogical instruments and assessment tools and a space to connect and discuss with other people. See this video.

Further reading

See How to Integrate RRI in Secondary Education and the Handbook RRI in Practice for Schools.



<https://www.youtube.com/watch?v=Z5SxZo9cJmE>

4. What RRI? Instrumental vs Revolutionary concept

Summarising, the RRI concept aims to align the process and outcomes of research with the needs, values and expectations of society, in order to ensure that public money is properly directed at solving the global challenges facing humanity in the 21st century. Therefore, RRI seeks to readdress the relationship between science and society in a more democratic and responsible way. That is, RRI is expected to guide research and innovation to more socially desirable, ethically acceptable and sustainable outcomes, and also, to involve more actors in research (e.g. policy-makers, businesses, educators) and make research-related institutions more responsible.

Therefore, RRI is aimed to entail a **dynamic and iterative process** by which all the stakeholders involved in the research and innovation practice become mutually responsive and share responsibility regarding both outcomes and process requirements. Such an inclusive and deliberative process is expected to align research and innovation agendas with societal needs and concerns, which are related to the societal challenges of today.

This all sounds very ambitious and glorious, but you might all now think: how to achieve RRI as researchers?

On the one hand and to start with, we can think about RRI as a set of principles we should follow to be «responsible researchers». For instance, in terms of gender, we can assume that we are meeting RRI principles if our research team includes both men and women or our research team is gender-balanced. The same thing with ethics: has your research been reviewed by an ethics committee? Does it include informed consent for participants, if any? Then tick the box on RRI ethics! Are you planning to publish your results in open access? Will you share your database with other researchers once your research is finished? You can tick the box on open access. Including an outreach activity at the end of your research to share your results with a non-academic audience and get some feedback, such as an exhibition, might be considered as public engagement. Similarly, organising some dissemination activity with children or young people to show your research and try to motivate them for science could be interpreted as science education. But you might all agree that this kind of «ticking the box» might only be a starting point of getting acquainted with the different issues to take into consideration when we want to do our research in a responsible way.

Nevertheless, and if you would like to go a step further with RRI and really transform your research practice, «ticking the box» might not be enough. First of all you need to **reflect on yourself as a researcher and on your research** in terms of RRI. What are your ethical referents as a citizen? What are your

Further information

RRI-Tools website

Bibliographical references

Arnaldi and Gorgoni 2016
R. Owen *et al.* 2012.
«Responsible Research and innovation: From science in society to science for society, with society». *Science and Public Policy* (issue 39, p. 751-760).

ethical referents as a researcher? Are they the same? How are they related to the term *responsible* in research and innovation? Is gender relevant in my research (methods, outcomes, dissemination)? Am I critically approaching gender in my research? And so on.

During the course we will exchange, reflect and discuss these questions at individual and research group levels. In what follows, we present a couple of examples of toolkits to be applied to encourage reflections on RRI at an institutional level.

5. Challenges and opportunities of applying RRI in practice

RRI is thus an umbrella that covers various aspects of the relationship between research and innovation and society's different actors, and it is precisely this multidimensional nature that makes its application a challenge in research policy and practice. The following quotations from members of the GREAT project that developed an empirically based and theoretically sound model of the role of RRI governance illustrate these challenges and opportunities related to RRI:

«RRI aims to bring the word “responsible” into science and innovation.»

«Researchers and innovators have to take into account broader views than just their own, be reflective and look holistically at science and technological development.»

«RRI is a comprehensive and adaptable framework more oriented to a very early involvement of other stakeholders who will be able to address questions and issues related to research and innovation in the process.»

«RRI became more relevant in the last years because the challenges resulting from research and innovation are completely new and the responses provided have to be new as well.»

«Stakeholder engagement is the main condition, otherwise you don't have the dialogue with society and you cannot do the other dimensions of RRI.»

GREAT project, 2015

What about yourself? Do you see similar opportunities or challenges when thinking about integrating RRI into your research or do you identify other defiances? Do you think these are the same for all areas of research or are there specific ones depending on your field of research? If so, what are the particular opportunities and challenges that you can identify in your research practice?

6. Resources

6.1. General

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Ioannidis, J. P. A. (2014). «How to Make More Published Research True». *PLoS Med* [11(10)]. Available at: <<https://doi.org/10.1371/journal.pmed.1001747>>

Note

We have outlighted the obligatory readings for the course, all the rest is optional.

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Rinze, B.; Miedema, F. (2016). «Fewer numbers, better science». *Nature* (vol. 538, p. 453-455).

RRI-Tools website

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