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# Citizen science and Responsible Research and Innovation

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## Highlights

- Responsible Research and Innovation (RRI) is emerging as a key approach to mediating the relationship between science and society to tackle social challenges.
- Citizen science has both overlaps with, and divergences from, RRI.
- Citizen science could learn lessons from RRI approaches and processes especially in terms of meaningful citizen participation.
- A more responsible citizen science would need to engage with issues of participation, agenda-setting (including power relations) and acting responsibly – and collectively.

## Introduction: Responsible Research and Innovation

Responsible Research and Innovation (RRI), a cross-cutting theme of the European Commission (EC) Horizon 2020 programme, is emerging as a key approach to mediating the relationship between science and society. Bringing together public engagement, open science, gender equality, science education, ethics and governance, and more, RRI aims to align the outcomes of science and innovation with the values of society to address the grand challenges ahead. As the following section will discuss, many of the objectives and outcomes of RRI also have considerable overlaps with the Ten Principles of Citizen Science (ESCA 2015).

Science and innovation are key drivers of developed economies and social change. This is clear from how the car has shaped the structure of cities and transport systems, and how the internet is changing business and social relationships. At a time of increasingly pressing challenges – such as how to feed a growing world population, take care of an ageing population or tackle climate change – many believe that science and innovation will be critical in offering answers.

However, science and innovation brings downsides as well as benefits, and the benefits are not spread evenly geographically or socially. In some instances, science and technology even challenge ways of life: The internet allows companies to produce 'stateless profit' while governments struggle to fund public services; developments in genetics raise questions about the rights of disabled people; and genetically modified (GM) crops threaten non-GM or self-sufficient farmers. It is perhaps understandable that not everyone is as enthusiastic about science as scientists themselves.

Historically, public concerns about science and innovation were seen by scientists and policymakers as 'problems' to be dealt with through more information and education – this is known as the 'deficit model' (Smallman 2014; Stilgoe, Lock & Wilsdon 2014). For example, in 1986 the UK's Royal Society published a report on 'The Public Understanding of Science' (Bodmer 1986), which claimed that improving the general level of public understanding of science was an urgent task, given the importance of science in almost every aspect of life. This soon proved to be an over-simplification of the relationship between knowledge and attitudes, however. For instance, Evans and Durant (1995) found people's attitudes becoming more polarised when they became more informed about a particular area of science or technology. Controversial topics such as embryology research were seen as more controversial by those with higher levels of knowledge (Evans & Durant 1995); while Brian Wynne (1996) highlighted the existence of 'lay expertise', describing how Cumbrian sheep farmers' predictions of how the soil would respond to Chernobyl proved to be more accurate than the 'expert' models.

In the UK, building on this insight and following public controversies around bovine spongiform encephalopathy (BSE) and GM crops, a new approach to science and society was adopted, notably outlined in the UK House of Lords report 'Science and Society' (House of Lords 2000). The report heralded in a new era of 'dialogue', which aimed to involve the public in two-way communication around science so that the public could be assured that their views were taken into account. Various activities fol-

lowed involving the public in debates about contemporary science and technology, including the UK government–led GM debate (Horlick-Jones et al. 2006; Gaskell 2004).

In Europe and North America, a practice called Participatory Technology Assessment (PTA) arose during the 1980s and 1990s (Griessler, Biegelbauer & Hansen 2011; Joss & Durant 1995). Participatory Technology Assessment is a process (or series of processes) which aimed to broaden the knowledge base of decision-making, in order to make political decisions more informed and rational (Abels, 2007). A number of European countries took up this approach during the 1980s and 1990s, most notably the Danish Board of Technology, which developed and ran a series of 'Consensus Conferences'. The Netherlands also took up the idea, organising a consensus conference on genetic modification of animals in 1993. Such ideas around participation were also taken up more widely by the European Commission's 'Science in Society' Framework 7 Programme (Owen, Macnaghten & Stilgoe 2012). Joss and Durant (1995b) argue that such participatory processes were rooted in this 'dialogue model' of the public understanding of science, in which the key activity is two-way or multi-way communication between scientists and non-scientists, with the aim of creating greater mutual understanding, which may or may not lead to greater accord between scientists and non-scientists (Joss & Durant 1995b).

For many, this move from deficit to dialogue (or public engagement as it became known) remained problematic as the objectives of science – and the assumption that science is an inherent public good – went unchallenged. Dialogue or engagement allowed the public to voice their concerns but this was often in a limited way (Macnaghten, Kearnes & Wynne 2005; Wynne 2006) and appeared to have little impact on policy (Smallman 2017). As Wynne argues, a perceived deficit in knowledge was replaced by a perceived deficit in trust, with two-way communication adopted as a new way for science to win public trust, without putting the objectives and values of the institutions themselves under scrutiny (Wynne 2006).

Drawing on lessons from public engagement, RRI takes up the challenge of listening, taking account of public perspectives and scrutinising the values of science. It aims to build a form of science and innovation that truly reflects wider social needs and values. Indeed, RRI sets out to change the purposes that science is put to – moving away from puzzle-solving and the 'Republic of Science' (Polanyi 1962) view of science as serendipitous, unpredictable and specialist, towards a co-productionist (Jasanoff 2004) perspective. Here, the visions and values of those doing

the research and development are understood to be deeply embedded in the knowledge, products and social structures produced. Opening up these visions and values to wider perspectives – and allowing the possibility that non-scientific stakeholders might occasionally take the reins away from the scientists – is key to RRI. This adds new depth to the meaning of the Ten Principles of Citizen Science. Public participation in RRI means interpreting Principle 1: 'actively involving citizens in the scientific endeavour and creating new scientific knowledge' (ECSA 2015) as much more than allowing citizens to taking part and experiencing science from the inside then – it is about citizens working with scientists, policymakers and innovators to set the agenda, anticipate the consequences and work out the best way of making use of, come to terms with or deal with science and its implications (see also Haklay; Novak et al. and Nascimento et al., all in this volume). To give a sport analogy, it is not just about inviting citizens to play in the football team, or helping them understand the rules of the game, but asking them whether they want to play football at all, or whether they would prefer to play hockey or even do some painting instead (see also Ballard, Phillips & Robinson and Gold & Ochu in this volume).

A variety of definitions of RRI have emerged (see for instance Owen, Bessant, & Heintz 2013; Owen, Macnaghten, & Stilgoe 2012; RRI Tools 2016; Sutcliffe 2011; von Schomberg 2013). Although each has a slightly different focus, they share common features: Firstly, RRI is seen as a way to focus research and innovation on societal challenges. Secondly, there is agreement that RRI will achieve this goal by:

(a) ensuring that wider perspectives shape research and innovation by involving all relevant stakeholders throughout the research and innovation process;
(b) opening up the values and visions within science and innovation to wider debate and influence;
(c) making sure that research is able to anticipate and respond to risks; and
(d) framing responsibility as a collective rather than individual activity.

RRI advocates believe that the mistakes of the past can be reduced by following these principles to ensure that technologies are 'ethically acceptable; socially desirable and sustainable'. (von Schomberg 2013, 64).

The recent EU-funded RRI tools project (www.rri-tools.eu) set out to develop this framework beyond a theory and to operationalise RRI. This involved identifying and describing case studies to bring the concept to life, and developing a set of processes and outcomes to help researchers implement this approach.

The project described RRI as 'Involving society in science and innovation "very upstream" in the processes of R&I [Research & Innovation] to align its outcomes with the values of society'. It has identified three outcomes that RRI projects should be aiming for (see box 17.1 for more detail):

1. Learning outcomes (engaged publics, responsible actors, responsible institutions);
2. Research and innovation outcomes (ethically acceptable, sustainable and socially desirable research outputs); and
3. Solutions to societal challenges.

A series of process requirements have also been developed to help researchers understand how to implement RRI and how to measure their progress in this implementation (see box 17.2). Significantly, these outcomes, processes and principles are seen to apply to across the spectrum of research – from basic to applied research. Some activities might want to emphasise some aspects more than others, but RRI is seen as a useful tool and necessary approach for all areas of research.

While these ideas might appear to be challenging, there is growing evidence that this approach offers opportunities – not just in minimising the risk of future controversies, but in opening up new business models, as the case study in box 17.3 illustrates.

Further to the outcome and process dimensions of RRI, RRI and the Ten Principles are mutually reinforcing in guiding citizen science engagement, processes and outcomes.

## Overlaps with citizen science

Responsible Research and Innovation's commitment to openness and desire to involve stakeholders in the whole of the research and innovation process demonstrates clear overlaps with the practice of citizen science. It is important to highlight, however, that there are also clear divergences between the two.

**Box 17.1. RRI outcomes**

1. Learning outcomes
   - Engaged publics
   - Responsible actors
   - Responsible institutions

   RRI leads to empowered, responsible actors across R&I systems (researchers, policymakers, businesses and innovators, CSOs, educators). Structures and organisations should create opportunities and provide support to actors to be responsible, ensuring that RRI becomes – and remains – a solid and continuous reality.
2. R&I outcomes
   - Ethically acceptable
   - Sustainable
   - Socially desirable

   Responsible Research and Innovation practices strive for ethically acceptable, sustainable and socially desirable outcomes. Solutions are found in opening up science through continuous, meaningful deliberation to incorporate societal voices in R&I, which leads to relevant applications of science.
3. Solutions to societal challenges

   Focus on seven grand challenges:
   - Health, demographic change and well-being;
   - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy;
   - Secure, clean and efficient energy;
   - Smart, green and integrated transport;
   - Climate action, environment, resource efficiency and raw materials;
   - Europe in a changing world – inclusive, innovative and reflective societies;
   - Secure societies – protecting freedom and security of Europe and its citizens.

   Our societies face several challenges, which the EU has formulated as the seven 'Grand Challenges' – one of the three main pillars of the Horizon 2020 programme. To support European policy, the EU requires R&I endeavours to contribute to finding solutions for these Grand Challenges.

Source: https://www.rri-tools.eu/about-rri

Firstly, citizen science encompasses a range of different levels of engagement, from encouraging citizens to participate in the scientific process by observing and gathering data, up to involving them in the design and implementation of scientific projects (Silvertown 2009; and see Novak et al. in this volume). Some approaches to simply involve citizen scientists in roles such as data collection – for example, classifying galaxies in the 'Galaxy Zoo' project – have been criticised for leaving citizens in passive research roles (Mroz 2011) and treating them as free labour rather than genuine partners. Questions have also been raised about the quality of their input and motivations for being involved (Editorial 2015). Moves have therefore been made to improve the support and training of citizen scientists and to encourage them to take on more active and in-depth roles (see also Nascimento et al. in this volume).

Such a participatory approach appears to be a cross-over with the ethos of RRI, but even with meaningful public participation, vital

**Box 17.2. Process dimensions of RRI**

To reach the RRI outcomes, practising a more Responsible Research and Innovation requires that processes are:

Diverse and inclusive: Involve early a wide range of actors and publics in R&I practice, deliberation and decision-making to yield more useful and higher quality knowledge. This strengthens democracy and broadens sources of expertise, disciplines and perspectives.

Anticipative and reflective: Envision impacts and reflect on the underlying assumptions, values and purposes to better understand how R&I shapes the future. This yields to valuable insights and increases capacity to act on knowledge.

Open and transparent: Communicate in a balanced, meaningful way methods, results, conclusions and implications to enable public scrutiny and dialogue. This benefits the visibility and understanding of R&I.

Responsive and adaptive to change: Be able to modify modes of thought and behaviour, and overarching organisational structures, in response to changing circumstances, knowledge and perspectives. This aligns action with the needs expressed by stakeholders and publics.

Source: https://www.rri-tools.eu/about-rri; visit site for summary and more details

### Box 17.3. RRI in practice: HAO2 – involving citizens in technology design

Hao2 (Hao means 'good' in Chinese) is a company that develops and sells 3-D virtual environments. As well as the RRI focus on outcomes that address the needs of society, its principles of diversity, inclusion and engagement, as well as responsiveness and adaptive change, form the backbone of the company.

For example, many people working in the software industry have autistic spectrum disorder, but are often expected to work in ways and environments that are challenging and uncomfortable to them. Nikki Herbertson, founder and CEO of Hao2, noticed how staff with autism working in her software company became much more sociable in online environments such as the virtual world game *Minecraft*. She therefore investigated the potential of 3-D virtual world applications to enable staff to communicate with each other. The company involved people with autistic spectrum disorder – people who are rarely involved in such a process – in developing this new product. They were so successful in their approach that that since 2010 the company has entirely focused on promoting 3-D virtual world products and services to help organisations improve services, especially for people with disabilities.

Hao2's products are now used in a range of settings, from businesses to education, and Hao2 has won numerous awards. Hao2 has built a successful company by involving more diverse groups than simply the product developers in the process of innovation, and building RRI into their DNA. Using RRI has also allowed Hao2 to build products strongly focused on solving societal problems, increasing opportunities for those with autism and other complex needs.

> It was quite clear from the outset that the only people that could really deliver the insight that we needed from a research and development point of view would be people with autism. And it was absolutely critical that they were not just a focus group, but actually that they were the citizen researchers alongside me looking at the options and then designing the solutions in a sustainable way.
>
> Hao2 Founder and CEO Nikki Herbertson

questions about power and agenda-setting can remain unanswered (see also Novak et al.; Gold & Ochu, both in this volume). Opening up such questions to wider scrutiny, debate and participation is key to the RRI agenda and is an approach that is being taken on by 'Extreme Citizen Science' (ExCiteS) (http://www.ucl.ac.uk/excites).

Unlike 'contributory' citizen science, which typically asks citizens to participate in scientific data collection and often appeals to those who have an interest in, or enthusiasm for, science, Extreme Citizen Science opens up participation in all aspects of research – including data collection, analysis and agenda-setting – to people from a wide range of backgrounds (Haklay 2013). Involving those who are not usually able to participate in such activities means that Extreme Citizen Science has the potential to open up the range of voices, values and visions directing and shaping the scientific 'project' and to include wider societal perspectives (Stevens et al. 2014). This latter point, particularly if engagement is also aimed at encouraging reflection, sharing purpose and anticipating uses and risks, offers a key way for RRI and citizen science to work together, to develop more responsible and socially relevant science and innovation.

## Developing responsible citizen science – and responsible science

Building on the foundations of Extreme Citizen Science and taking account of the ECSA Ten Principles of Citizen Science could bring RRI and citizen science closer together to develop a notion of responsible citizen science and see its realisation. Wider lessons can also be drawn from the RRI and citizen science communities. The projects in boxes 17.4 and 17.5 illustrate some of this learning.

### Box 17.4. RRI and citizen science in action 1 – the Swedish Challenge Driven Innovation programme

Challenge Driven Innovation is a research and innovation funding programme developed by Sweden's innovation agency, Vinnova, and launched in 2011. It aims to fund collaborations in research and innovation that address societal challenges and involve partners from different parts of society.

*(continued)*

To make sure the programme focused on the issues society wanted to address, stakeholders were involved from the start of the project through consultations and workshops. In this way, participants developed the three principles upon which the funding model would be based.

- Policy issues must be prioritised, and a challenge-oriented approach adopted;
- Subject areas and sectors should be intermixed, so a multidisciplinary approach rather than a traditional focus on separate disciplines was adopted;
- The user perspective must be the starting point for innovation, thus building an Extreme Citizen Science approach from the start.

With these citizen-developed principles in mind, a series of funding calls were launched. All problem-oriented, they placed no restrictions on which stakeholders, sectors, research topics or disciplines could apply. Instead, they asked for all necessary stakeholder groups to be involved – including citizens and end users – to allow the projects to address the selected challenges. Examples of funded projects include those focused on urban farming, getting more people into the labour market, making socially deprived areas more attractive and creating meeting places.

As well as funding projects that focus on real social problems, the programme appears to have had other significant impacts. Firstly, it has generated a shift in the funding organisation, away from an unspoken focus on technical innovations to a much broader concept of innovation. This led to the launch of a social innovation programme in 2015, which set out to involve civil society members to a greater extent than previous projects. Secondly, working practices at Vinnova have also changed as a result of the programme. The range of stakeholders who receive funding from Vinnova has widened, dialogue and collaboration between officers in various departments has increased and the organisation has taken up the important focus on societal challenges.

Source: www.rri-tools.eu; visit site for more details

### Box 17.5. RRI and citizen science in action 2 – Xplore Health

Xplore Health (https://www.xplorehealth.eu) is a European educational programme aiming to bridge the gap between research and secondary STEM (Science, Technology, Engineering and Mathematics) education.

Originally the project focused on building pupils' understanding of the research process through a series of online tools. The project has, however, evolved over time. Inspired by RRI and citizen science, it now focuses on empowering secondary school students to participate in R&I processes and in R&I decision-making, with a focus on making it more ethically acceptable, socially desirable and sustainable. It aims to train students to become active citizens of the knowledge society, to be able to make informed decisions and to contribute to addressing societal challenges.

With this in mind, Xplore Health combined their online activities with an innovative participatory research project, Ment Sana (Healthy Mind). Ment Sana is a Community Based Participatory Research (CBPR) project, in which educators, learners, researchers and policymakers work together to design and implement health interventions for students and with students.

The project started in 2015 with a needs assessment, where students chose the topic of stress and depression from a list of health issues and built a collective agenda of interests. Next, a number of research projects were designed and implemented in collaborations between researchers, higher education students and secondary school students. These projects culminated in a catalogue of recommendations for policymakers, which were presented in May 2016 at a final congress with more than 350 students and high-level policymakers from the Catalan Government and the NGO Federació de Salut Mental de Catalunya.

This participatory process gave students the opportunity to learn science through science, to develop scientific inquiry, critical thinking and engagement skills, but also to consider what important questions should be addressed with science – and to help address these questions (see also Edwards et al. and Harlin et al. in this volume). Participants agreed that the process strengthened both the research process and its outcomes, helping to do excellent research and find solutions adapted to the needs and expectations of end users. Most importantly, the research focus and approach was dramatically transformed by the involvement of citizen researchers.

Source: www.rri-tools.eu; visit site for more details

## Conclusions

Responsible Research and Innovation and citizen science are both emerging and developing, meaning that it is perhaps too early to set out a concrete path ahead. It is, however, clear that RRI has the potential to deepen interpretations of and contributions to the Ten Principles of Citizen Science. Over the next few years, the following issues are likely to demand attention.

### 1. Participation

How does citizen science involve citizens and reflect their contributions in all aspects of research? As well as involving participants at an early stage in establishing what science should be done and which questions it should tackle, citizens also need to be involved in anticipating possible future uses and misuses. Mechanisms exist for doing this – for example, the UK's ScienceWise programme (www.sciencewise-erc.org.uk) has developed strong methodologies for involving citizens in discussions about new and emerging science. Questions remain about how these approaches are incorporated in research.

### 2. Agenda-setting

How does citizen science involve citizens in meaningful discussions of current and future research, without their expectations being shaped by the values of scientists themselves? Public dialogue activities, for deliberate or accidental reasons, are often shaped by the aspirations and values of the scientific community such that public participation in science sees citizens co-opted into the 'world view' of science and scientists (Smallman 2016; Thorpe & Gregory 2010). For instance, the need to bring emerging technologies to life for citizens to form meaningful opinions about them means that scientists' understandings of these technologies become embedded in the minds of the participants, restricting possible futures (Smallman 2016). Questions remain about how to meaningfully engage citizens in abstract scientific ideas without limiting their thinking, in both public and private sector research.

### 3. Acting responsibly – and collectively

How does citizen science develop an idea of shared responsibility that takes account of all of the actors and implications of scientific develop-

ments? Responsibility has traditionally focused on the roles of the scientist, their responsibility for their research and the tensions between academic freedom and responsibility (see for example Douglas 2003). Questions remain about how to promote and enact shared responsibility as part of the move to involve wider voices in scientific research.

Science and innovation are arguably the biggest drivers of change in the early twenty-first century (both positive and negative). Such significant levers of power are too important to be left to a small group of researchers. For science to reach its full potential, it must be set free of its laboratories and take its rightful place – at centre stage in everyone's lives. That means developing a truly responsible approach to science, with citizens at its heart.

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