

# Moving forward together with open science

Towards meaningful public engagement with research



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## **Cover photograph**

Participants in the National Garden Bird Count (photo: Sabine Joosten/HH)

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## Foreword

Sharing in scientific advancement and benefiting from its results is a human right, laid down in the Universal Declaration of Human Rights. When researchers involve society in their research, they are helping to fulfil this right. In addition, their research can benefit enormously from this collaboration. Citizens can help researchers by asking relevant questions, collecting data, disseminating results and putting them into practice.

The European Commission and the Dutch government have high expectations of open science in their research agendas, both for science and for society. Science conducted in an open way is more deeply embedded in society and can therefore contribute more to tackling major societal challenges. Openness can also make science faster and more efficient.

Unfortunately, open science policy is still mainly confined to making publications and data publicly accessible. This is mostly of interest to other scientists. Public engagement with science is in danger of being disregarded. Where that engagement does arise, it is by no means always meaningful. Sometimes it is done mainly for show.

The Rathenau Instituut sought to answer the question: how can open science contribute to the democratisation of science? We set out to find out what meaningful public engagement is and how it can be organised in today's open science era. We analysed the scientific debate about, and policies for, public engagement over the past few decades. We also conducted studies looking at public engagement in three scientific fields. The engagement of societal actors with science has been steadily developing. Whereas it began as a way of educating citizens about science, there is now greater scope for equal dialogue.

In this publication, the Rathenau Instituut is providing a platform for meaningful public engagement in the debate on open science. Five practical steps indicate the direction for future development.

**Dr Melanie Peters**

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# Summary

## Rationale

The European Commission and the Dutch government have high expectations of open science, both for science and for society. Open science, they believe, is better embedded in society and is more helpful in addressing major societal challenges. Openness would also make science faster and more efficient.

To make scientific research more open, scientists and policymakers are currently devoting considerable attention to promoting free access to scientific articles and research data. This pushes the openness of science to society into the background. Moreover, engaging the public in a meaningful way is no easy task in the real world. Although research funders are increasingly focusing on public engagement, this can lead to scientists involving "public groups" mainly for the sake of appearance (tokenism).<sup>1</sup> Citizens may appear to be involved, but in fact contribute little and have little influence.

In this review, we attempt to ascertain when public engagement is meaningful and how it can be organised. For this purpose, we examine the (scientific) ideas about the relationship between science and society and the European and Dutch policy developments in this respect. We also draw on three domain studies that we published previously.<sup>2</sup> We present practical steps for policymakers, researchers and the public that can be taken to make public engagement with research more meaningful.

## The scientific debate about public engagement

Since the mid-twentieth century, sociologists of science have been pointing out that science is a collective search process, in which it matters who is involved. Different types of knowledge are gradually being recognised: citizens can possess experiential knowledge, which complements the formal knowledge of scientists. It is useful to involve stakeholders in research, especially when faced with uncertain facts, major interests and conflicts over values. Similar issues are at play in technology development. Who is involved makes a difference to the way new technology is embedded in society.<sup>3</sup>

We also see a shift in science communication. Whereas this used to be mainly concerned with explaining science to the general public it is now more focused on

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1 In this review we use the term public groups to indicate that "the public" consists of groups of people with different wishes, interests and contributions.

2 In order of date: Rathenau Instituut (2019), Rathenau Instituut (2020a) and Rathenau Instituut (2020b).

3 In 1986 this led to the establishment of NOTA, the forerunner of the Rathenau Instituut. This organisation was tasked with systematically studying the social significance of technology and assisting both politicians and the public to form judgements on new technology.

dialogue. This dialogue involves not only conveying scientific knowledge, but also sharing values, interests, power and trust.

### **Public engagement policy**

The development of this line of thought on public engagement is reflected in European and Dutch science policy. The European policy framework *Responsible Research and Innovation* (RRI) promotes science as a transparent, interactive process in which societal actors and researchers are receptive to each other's perspectives and needs. Attention to dialogue and participation, and to new forms of knowledge co-creation, has grown as a result of RRI. In the Netherlands, the Dutch National Research Agenda attempts to connect science and society.

Policies at both European and national level are now focusing on open science and, in particular, on more mutual collaboration and easier data sharing to achieve better, more efficient and more reliable science. This means that the relationship amongst scientists is considered more important than the relationship between science and society. Compared to RRI, the ambitions for public engagement have been watered down. Participation is often narrowed down to citizen science, i.e. citizens helping to conduct research.

### **Public engagement in practice**

In three (separately published) case studies, we examined practical examples of public engagement in different fields: psychiatry, educational research and research into water quality. This research shows that the necessary structures and incentives that enable, promote or support public engagement are not developed well enough in the world of science. Scientists are less valued if they conduct research with public groups. In addition, the prevailing methodology and epistemology within some scientific disciplines stand in the way of public engagement.<sup>4</sup>

Individuals' need for engagement with research varies according to their immediate interests. For example, patients are easier to mobilise for psychiatric research than nature lovers are for water quality research. Another factor is the degree of organisation. Where interest groups such as patients' associations advocate for a place at the research table, public engagement is less fragmented. A low degree of organisation, as we found among teachers for example, can lead to engagement being limited to individual front-runners, with little effect on the field of practice as a whole.

### **Meaningful public engagement**

Our search culminates in the proposition that public engagement is meaningful when it contributes to the democratisation of knowledge development.

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4 One example is the use in the medical sciences of randomised controlled trials, which require a strict separation between investigator and research subjects.

Democratisation means changing the (power) relationship between knowledge producers and the various groups in society in favour of the latter. This involves:

1. Accessibility; how high are the barriers to influencing research and research agendas?
2. Inclusion; do all groups of stakeholders and interested parties get involved?
3. Participation; to what extent do external stakeholders determine the role they play and the contribution they make to public research?

There can be various reasons for public engagement: substantive (citizens contribute additional knowledge), normative (citizens have a right to be involved) and instrumental (public engagement ensures greater support and a better match with society's needs). If public engagement is to be meaningful, the reasons for it must align well with:

- who will be involved (stakeholders or interested parties);
- where it takes place;
- in which phase it takes place (agenda-setting, execution of research, or implementation of research results); and
- what form it takes (providing information, co-executing, advising, joint decisions).

### **Five steps to meaningful public engagement**

Based on the current interpretation of open science, progress towards the democratisation of science is overshadowed by a one-sided emphasis on open access and open data. And yet, organising meaningful public engagement is a challenge for everyone: researchers and policymakers at knowledge institutions and research funders, citizens, interest groups, patients and professionals. That is why we have drawn up five steps towards meaningful public engagement.

#### **1. Make research accessible and inclusive for diverse public groups**

In order to maximise the social impact of research, it is important to make research as accessible as possible. This can be done by minimising the use of research jargon and academic language and, as far as possible, translating insights from research into practical tools. The more accessible the research, the greater the diversity of the participants. More diversity can enhance both the quality and legitimacy of research. In addition, wider engagement with research promotes scientific literacy among citizens. It also strengthens the position of science in society.

#### **2. Coordinate diversity of participation and raise awareness of its added value**

Involving a variety of perspectives in the formulation of research questions can improve the research agenda and make it socially more relevant. This is not just a task for researchers. Civil-society organisations can play a part in this, for example by highlighting the role and contribution of different public groups.

#### **3. Make it attractive for researchers to engage public groups**

Knowledge institutions should encourage researchers to step outside the box. The current system of recognising and valuing (and rewarding) researchers often gets in the way of more interaction with societal actors. But changes are afoot: the ambitions expressed by the VSNU, NFOU, KNAW, NWO and ZonMw in 2019 must now be translated by the knowledge institutions into specific (policy) measures. For example, a good step would be to assess funding applications for the Dutch National Research Agenda (NWA) more closely in terms of engaging public groups.

#### **4. Make expectations explicit, evaluate and reflect on public engagement**

Involving public groups requires attention to specific aspects of the research approach and quality assurance. For example, it is important to pay attention to the quality of the data that citizens collect, the influence of the relationship between citizens and researchers on the quality of the research, and the learning experiences that citizens acquire during the process. Joint reflection on these aspects can give rise to interim adjustments to the research. Evaluation of public engagement requires a focus not only on the direct research output, but also on its wider impact: where do the results end up and how are they used?

#### **5. Give citizens a say**

It is motivating for people to get a say in the goal of the research, its execution and their own role in it. If those involved can influence the research to a certain extent and decide on their role in it, this will increase public support for research.

Public engagement with science is a human right. According to Article 27 of the Universal Declaration of Human Rights: "Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts *and to share in scientific advancement and its benefits*". Science flourishes and advances when scientists are free and autonomous, but not operate outside of society. Only when science works in tandem with society will it produce the benefits that we need: answers to the challenges we are facing together. For this reason, a practical search for meaningful public engagement with science is of fundamental importance.

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# 1 Introduction

Everyone in the world has the right to share in scientific advancement and to benefit from its results. This *right to science* is enshrined in Article 27 of the Universal Declaration of Human Rights, which requires us to organise our knowledge development in an open, transparent and democratic manner. Engaging citizens and societal actors with science contributes to this democratisation. In addition, their input helps scientists answer their questions and ask the right questions.

The engagement of societal actors in research has been steadily evolving over the years in our (scientific) thoughts about science, in Dutch and European science policy and in scientific practice. While this started out primarily as a way of educating citizens in science, it has now increasingly become a way of getting citizens' voices heard in scientific research. For example, there is now Open Science, the most recent vision of science which is supported by both the European Commission (EC) and the Dutch government (European Commission, 2016 and Dutch Ministry of General Affairs, 2017). There is no shortage of ambition. Science conducted in an open way would be more transparent and therefore more verifiable and responsive. The ambition is for science to become better embedded in society through open science, thus contributing more to tackling the major challenges facing society. Moreover, openness should make science faster and more efficient.

The elaboration of open science policy focuses mainly on science itself. Both in Europe and in the Netherlands, the introduction of open science places the emphasis on making publications and data publicly accessible (Stilgoe et al., 2013 and Jones, 2014). So far, relatively few structures, practices or institutions have been set up in the context of open science to involve society more closely in the scientific research process, even though there are opportunities to use the knowledge and insights available in society and to gear research to the questions and needs of society.

The Rathenau Instituut identified a need to showcase specific examples of public engagement with science in various disciplines, and to interpret these examples. For this reason, over the past two years the institute has carried out three domain studies into the way public engagement takes place in psychiatry, educational research and research into water quality. The findings from these case studies, and an analysis of both the scientific debate on public engagement and its manifestation in science policy, form the basis for the present review.

## 1.1 The context

The development of greater public engagement with science is not an isolated event. In the course of a few decades, many social institutions that were initially

rather autonomous have become increasingly democratised. Autonomy of institutions was a typical feature of the compartmentalised society that was the Netherlands until around the 1960s.<sup>5</sup> Autonomy was self-evident for public administration, which operated at a considerable distance from the population. The people elected their representatives once every four years, after which representative democracy operated "without charge or consultation". Authorities within other institutions, such as the central bank, courts of law, health care institutions and churches, also enjoyed a large degree of autonomy.

This has now changed, and democratic involvement is no longer limited to the ballot box. People are demanding greater transparency, more accountability for the spending of public funds and more opportunity to have their say about utility and necessity, direction and strategy. They are well informed and they speak up, even across traditional hierarchical relationships. For example, individuals can influence policy or take up public tasks themselves (Rathenau Instituut, 2015). This leads to a different interpretation of citizenship, in addition to exercising the right to vote. Citizens are involved on more occasions and have a say in individual topics of their choosing.

Science is also affected by this democratisation. For decades, science was an autonomous bastion. In exchange for public funding, universities and research institutes provided knowledge development and academic education. According to the ideal of academic freedom associated with the German scientist Alexander von Humboldt (1769-1859), scientific institutions should function independently of government interference and economic interests (Anderson, 2004). Protecting scientists from outside interference is still given a high priority, for example by UNESCO.<sup>6</sup> However, the traditional social contract between science and society is undergoing a transformation (Gibbons, 1999). The democratisation of science is keeping pace with public engagement with other institutions in our democracy. Citizens are demanding and are being given a greater say in science.<sup>7</sup>

The characteristics shown in Box 1 (see next page) reflect society's interconnection with science. In addition, society is seeking solutions to pressing collective problems such as climate change and global depletion of resources, and ways of achieving the global Sustainable Development Goals. Addressing such complex challenges benefits from engaging the public. Collaboration with various actors with their different interests turns out to be important for the success of practical solutions.

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5 "Sphere Sovereignty" was the title of Abraham Kuyper's address at the opening of the Vrije Universiteit (Free University) in Amsterdam in 1880. This organisational principle recognised the relative autonomy of different social circles (spheres), their powers and moral frameworks. (Balkenende & Tieleman, 2001).

6 In 1974 UNESCO adopted the *Recommendation on the Status of Scientific Researchers*, which stressed the independent position of scientists. This recommendation was replaced in 2017 by the *Recommendation on Science and Scientific Researchers*. The independent position of scientists is still an important element and the responsibility of scientific institutions for safeguarding this position has been given greater emphasis.

7 UNESCO is currently taking steps to issue a *Recommendation on Open Science* by the end of 2021.

## 1.2 Who are the public?

In policy discussions, the term "the public" is regularly given the undifferentiated meaning of "the general public", which means something like "society". This is a catchall term, covering all kinds of different specific public groups. The relevant public may consist of individuals with an interest or direct involvement in a study. They could also be professionals working in a particular field. Civil-society organisations may represent groups of citizens or professionals. In medical research, for example, patients themselves can play a role or patient associations can do so on their behalf. Employees of water authorities can contribute to water research and teachers to research in education. Civil-society organisations may also be involved, acting on behalf of a general public interest. In environmental research, for example, environmental organisations can represent the public interest in nature conservation. The definition of "the public" therefore varies from subject to subject and is rarely homogeneous. In this document, we always describe whom we mean as best we can, or use the term public groups to indicate that the public consists of groups of people with different desires, interests and contributions (Mohr & Raman, 2012).

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### Box 1 The right to science

The right to science as laid down by the United Nations (Article 27 of the Universal Declaration of Human Rights) is not limited to sharing in the material products of scientific progress. It also includes developing a critical mind and participating in the practice of science (United Nations Committee on Economic, Social and Cultural Rights, 2020). The UN lists five characteristics of this right.

- **Availability** of scientific advances; the conduct of science and the conservation and dissemination of scientific knowledge and its applications.
- The provision of equal **access** to knowledge and knowledge production for all, without discrimination.
- **Quality** of the scientific process; ensuring quality by following the latest scientific and ethical standards.
- **Acceptability** of science; efforts to ensure the acceptance of knowledge in different cultural and social contexts and to conduct science according to prevailing ethical codes.
- **Freedom** and independence of scientists; protecting scientists from undue influence on their findings. They should also be able to establish autonomous research institutes and determine the aims and methods of research. They should be able to openly question the ethical value of research, to withdraw if their conscience so requires, and to have the opportunity to collaborate with other scientists nationally and internationally. Where possible, they should share their scientific data and analysis with policymakers and society.

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In this review, we focus on engagement that arises from non-commercial motives. Although knowledge institutions maintain long-term and fruitful relationships with industry to promote the economic valorisation of knowledge, public-private partnerships are not a subject of study here.<sup>8</sup>

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<sup>8</sup> On the subject of the "entrepreneurial university" model and its collaborations with industry, the Rathenau Instituut published a report titled *Industry seeking university* (Rathenau Instituut, 2018).

### 1.3 What will the public be engaged in?

The term "scientific research" is a catchall name for a motley collection of activities. Scientific research can be fundamental or practice-oriented. It takes place at knowledge institutions such as universities, colleges, and public knowledge organisations. Science encompasses many disciplines and fields of study, within which often various methodologies and views on science predominate. Their relationships with society and with policymakers also differ.

Logically, the function of public engagement with research is just as diverse and multifaceted. When individuals contribute their own knowledge, expertise, perspectives and abilities which complement the knowledge of scientists, we refer to this as knowledge co-creation.<sup>9</sup> Individuals can also carry out specific research tasks, such as collecting, supplying, analysing and categorising data. This form of engagement has recently been revived under the heading of "citizen science".

Public engagement can take different forms at each stage of research. Although in reality the knowledge chain is rarely linear, public groups can be engaged in:

1. decisions concerning management, programming and financing;
2. conducting the research; and
3. disseminating and exploiting the results.

There are various ways of involving society in the development of science. For example, policymakers gather input for setting scientific agendas from public consultations, questionnaires and interviews. The Eurobarometer has been conducted since the 1970s to collect the opinions and feelings of EU citizens on issues such as science, technology and innovation. Of more recent date is the Dutch National Research Agenda, a major initiative in the Netherlands to involve society in research programming. In addition, some domain-specific research funders, such as health funds, draw up their scientific programmes in consultation with their constituencies. There are also various research networks, for example around academic collaborative centres in education, which are teaming up with civil-society partners to set up a scientific agenda.<sup>10</sup>

Individuals and civil-society organisations can also play a part in conducting scientific research. The initiative for this may come either from them or from the scientists concerned. People often participate under the supervision of professional scientists, but there are also instances of "do-it-yourself science" where citizens conduct research on their own initiative (Landrain et al., 2013). An interesting hybrid

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9 See also previous Rathenau Instituut research into knowledge co-creation: *Samenwerken aan werkzame kennis* [Working together on effective knowledge] (2012) and *Kennisco-productie voor de grote maatschappelijke vraagstukken* [Knowledge co-production for major social issues] (2013).

10 An academic collaborative centre is a partnership between a university or college and one or more practice-based institutions, with the aim of translating practice-related issues into research questions and translating research results into practice.

form is known as user research, in which citizens conduct their own research with support from a university.

When it comes to disseminating and exploiting the results of scientific research, the debate centres on making them accessible to public groups. The aim of making scientific articles available free of charge (open access) is the dominant element in this debate. However, making scientific results understandable and usable for a wider public requires more than just free access. Intermediaries, such as *NEMO Kennislink*, have been established to ensure real public engagement with the dissemination and exploitation of knowledge. Many of their activities are in the field of education. This type of science communication is not always based on an equal dialogue between scientists and public groups.

In some research fields, researchers are increasingly working on an equal footing with those who will be putting the knowledge obtained into practice. This has also been described as the "participatory turn" (Jasanoff, 2003). The idea behind this is that researchers who engage with future users during the research process can make better use of their practical knowledge and respond to their needs. This can prevent problems that would otherwise only surface at the end of the journey (Wilsdon & Willis, 2004).

## 1.4 Public engagement for the sake of appearance

Policymakers and research funders are becoming increasingly aware of the importance and added value of public engagement and are therefore increasingly focusing on it. For example, experiential experts assess some of the research proposals at ZonMW based on the criteria of relevance, feasibility and level of client participation.

Funders' focus may lead to scientists paying attention to public engagement, but not always in a meaningful way. Sometimes scientists engage public groups primarily for the sake of appearance. Civil-society partners, for example, will then only be able to participate in discussions on subjects of little or no importance to the researchers. This means they do not get an opportunity to make a meaningful contribution and, consequently, researchers fail to see the value of engaging them (Ives et al., 2013). In other cases, external stakeholders do make a clear contribution, but their input is brushed aside when it doesn't match the wishes and interests of the researchers (Abelson et al., 2003). These situations are both cases of tokenism: citizens appear to be involved but in fact contribute little. This often has a demotivating effect on all those involved because the effort expended in public engagement is of little value. Public engagement then quickly becomes a box-ticking exercise to satisfy the wishes of the research funder (Snape et al., 2014 and Felt, 2017).

Greater or more engagement is not always better, if it results in tokenism. The point is not to engage citizens more often or in greater numbers. Rather, the point is to

ensure that the way in which they are engaged (the form) aligns with the reasons for engaging them. Because not all public engagement reaches a satisfactory conclusion, in this review we are looking for *non-tokenistic*, meaningful public engagement. The results of our search are the elaboration of this concept and some practical steps towards achieving this engagement.

## 1.5 Research question and reader's guide

This review is about meaningful public engagement with research. Our main question is: what is meaningful public engagement and how do you organise it?

In order to answer this question, in the second section, we examine the (scientific) debate on public engagement with research. We delve into the academic literature on the relationship between science and public groups, and explore how the way we think about the nature and ambitions of public engagement with science has changed over time.

This evolution in the debate has affected European and Dutch policy on public engagement with science and vice versa. The development of these policy frameworks is set out in the third section of this review, focusing on Responsible Research and Innovation and Open Science.

The fourth section examines how public engagement with science plays out in practice. The key element of this section is the information we gained from three case studies examining public engagement in psychiatry, educational research and research into water quality.

The debate about, the policy for and the practice of public engagement with science influence each other, with theory, policy and practice evolving in tandem. We have decided to consider them separately because each provides its own perspective on our main question: what is meaningful public engagement and how do you organise it?

The results of our search in these three sections form the basis for the analysis in section five, in which we summarise what makes public engagement meaningful. In section six we present practical steps for policymakers, researchers and the public to (continue to) encourage meaningful public engagement with research.



## 2 The debate about public engagement

The concept of public engagement has roots in different domains that have their own terminology, concerns and thinkers. For this review, we use a very broad notion of public engagement and look at several domains, which we will briefly introduce. We go on to describe the history of the debate about public engagement. The interaction between technology and society has influenced the debate regarding the relationship between science and society. We explain that what used to be a deficit model has evolved to become a more democratic dialogue model. We conclude this section with two concepts that are currently central to the thinking about public engagement with science: responsibility and openness.

### 2.1 Conceptual origins of public engagement

The concept of public engagement has several conceptual roots. There are no less than five domains within which a discourse on public engagement has emerged, each with its own terminology, focus, strengths and pitfalls (Fransman, 2018). As we are borrowing ideas from all these domains in this review, it is useful to highlight the key points in the debate about public engagement in each one.

- **Higher education and research.** This domain has a long tradition of thinking about the way the university functions in relation to society. Much emphasis is placed on measuring and increasing the impact of science and the role of public groups in this regard. There is also a focus on practical research, in which the involvement of professionals in the development of knowledge is intended to lead to insights that can be put into practice.
- **Science and technology.** In this domain, also known as Science & Technology Studies (STS), the debate regarding science and society has undergone a transformation from a deficit model to a dialogue model.
- **Public Policy.** Ideas about the role of public groups have emerged in healthcare, social work and education. In this domain, public engagement is referred to in terms of participation. Initially, the idea was that the government should strive for an ever higher level of public engagement, from consultation via cooperation to commissioning. This ambition was subsequently reconsidered.
- **International development cooperation.** Within this domain, the focus has long been on traditional forms of knowledge and knowledge development, where the different roles in knowledge development are to be understood as reflecting power relationships. Recently, the focus has shifted to measuring the

impact of public engagement, partly under pressure from NGOs that fund research.

- **Community development.** In this domain, there is a tradition of science being performed by outsiders, such as amateur scientists, outside the existing frameworks. In addition, it has seen the emergence of action research with (disadvantaged) communities. The humanities have also raised their profile in this domain to make themselves visible and relevant in society.

As stated above, for this review we are drawing on the various conceptual sources of the debate regarding public engagement. Only where necessary and useful do we refer explicitly to the specific genesis of the concepts discussed.

## 2.2 A historical sketch of science

Our thinking on the nature of science has a long history. Whereas scientists in the eighteenth and early nineteenth centuries viewed science primarily as the activity of a specific group of people, by the mid-nineteenth century the idea emerged that it was not the practitioner but the method used that determined what science was (Oreskes, 2019). This interest in the scientific method has long dominated the way we think about science. Until the middle of the last century, scientists considered themselves as treasure hunters who systematically search for hard, incontrovertible facts and objective truths (Sismondo, 2010). This is still a common view among some scientists, especially in the natural sciences.

Halfway through the twentieth century, attention shifted back from the method to the practitioner. Science is increasingly regarded as a collective affair, with scientists in a community building on each other's ideas and thought patterns (Oreskes, 2019). This emphasis on the collaborative process lays the foundation for the current dominant idea that science is a social construct. By studying scientists from an anthropological perspective, the conclusion was that they don't *find* the truth, but collectively *construct* it (Latour & Woolgar, 1979). Scientists are therefore not treasure hunters, but architects. This implies that it matters who is engaged in science. The more diverse the community (in terms of backgrounds, views, perspectives), the more diverse are the questions asked, the methods used and the ways in which findings are interpreted.<sup>11</sup>

Diversity is not only important for people within science, but also for those who are involved from outside. In the scientific sphere, recognition of different types of knowledge is increasing and universities are losing the monopoly on true knowledge that they used to have to some extent. People realise that non-scientists

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11 This line of thinking coincided with the tail end of second-wave feminism - women philosophers of science argued that more women scientists were not only needed for emancipatory reasons but that their female input was crucial to the functioning of science and improving it (Longino, *Science as social knowledge* and Harding, *The Science Question in Feminism*).

such as teachers, patients, or nature lovers possess relevant experiential knowledge that complements the formal knowledge of scientists (Wynne, 1998). In situations where facts are uncertain, stakes high, decisions urgent and values in dispute, there is reason to engage in *Post-Normal Science* (Funtowicz & Ravetz, 1993). This is the idea that "the scientific method does not claim to be value-free, nor ethically neutral" (ibid, page 86). In *Post-Normal Science*, the closed, narrow scientific community that is normally involved in the creation and evaluation of knowledge should be expanded to include experts from different fields and lay people who have an interest in knowledge.

The term "Mode 2" science was coined at the end of the twentieth century (Nowotny, Scott & Gibbons, 2001). In Mode 2 science, knowledge is not only produced within the walls of the university, but also in multidisciplinary teams that seek to solve problems in the real world. Knowledge should not only be scientifically reliable but also socially robust (Nowotny, 2003). This means that a research result is not only valid in a sterile laboratory setting, but also outside, where social, economic, cultural and political factors exert an influence. Socially robust knowledge is created in cooperation with various actors, such as scientists from different disciplines, and the end users or intended end users of the knowledge. Society is no longer just a receiver of knowledge, but also an active partner in the production of knowledge.

Mode 2 science characterises a shift in thinking about the function of science in society. Science should not only satisfy curiosity; socially robust knowledge should also be of public value. Science should have the right impact, for example in line with the values set out in the European Convention on Human Rights (Owen et al., 2012), or by contributing to the sustainable development goals of the United Nations. In other words, the place where the knowledge agenda is determined is shifting from the scientific domain to a place where researchers, together with industry and public actors, ask scientific questions (Gibbons, 1999). This makes it increasingly important to determine who is allowed to ask these questions.

## 2.3 Public engagement with technology

In the 1960s, technological change began to play an increasingly important role in our society. At the same time, social and ethical concerns about technological developments, such as biotechnology and ICT, were growing. A new type of policy research (technology assessment) highlighted the social risks and benefits of new technologies (Wong, 2014). In the 1980s, politicians and administrators wanted to anchor social and ethical issues more systematically in science and technology policy, by institutionalising the way science and technology were treated (Rathenau Instituut, 2017). In the Netherlands, education minister Deetman set up the Netherlands Organisation for Technological Research (NOTA), which later became the Rathenau Instituut, in 1986. It was tasked with systematically studying the social significance of technology and encouraging both politicians and the public to form an opinion on new technology (Rathenau Instituut, website).

In the 1990s, there was a growing awareness that society was not just a market for technology, but that technology and society were (or should be) interconnected. There was a need for social debate, for example with regard to bioethical issues. The focus of technology assessments was also shifting. Rather than just assessing the effects of new technologies, constructive technology assessments (CTAs) broadened the focus to include the design, development and implementation processes. According to Schot and Rip "CTA can be seen as a new design practice in which impacts are anticipated, users and other impacted communities are involved from the start and in an interactive way, and which contains an element of societal learning" (Schot & Rip, 1996, p. 255). The need for integration of ethical, legal and social research with technological developments continued into the twenty-first century (Rathenau Instituut, 2017).

The development of CTA in technology has also influenced our ideas on the relationship between science and society. Societal actors can be engaged in applied science and technology development, but can also get involved earlier in the knowledge production chain, moving towards fundamental research. This engagement goes beyond merely examining the ethical, legal and social consequences of scientific developments. In fact, public engagement with science helps to democratise (medical) ethical issues, thereby changing the relationship between citizens, experts and government at a fundamental level (Jasanoff, 2011). Moreover, there is a growing awareness that scientists need to involve public groups at an earlier stage in scientific developments in order to strengthen public trust in science (van Est, 2011).

## 2.4 From deficit to dialogue

As we have seen above, the relationship between science and society is constantly changing. Until the second half of the twentieth century, the prevailing view was that science needed to be explained better. The idea was that anyone who understands how science works cannot help but appreciate it. Society was portrayed as ignorant and assumed to need to be informed and educated about science. Referred to as the "deficit model", this view emerged from the field of science communication (Wynne, 2006 and Fransman, 2018). This way of thinking can be traced back to some activities undertaken to popularise science.

However, the deficit model has been criticised on several fronts. Durant (1999) summarised the criticism into three main points. The deficit model:

1. is based on conveying undisputed facts. However, as we have indicated above, knowledge is a social construct. Partly because of this, new, socially relevant knowledge is often provisional and rarely uncontroversial.
2. tends to define the public exclusively in negative terms, as lay people who lack expert knowledge. This ignores the relevant, informal knowledge that public groups do possess.

3. places the responsibility for problems in the relationship between science and society squarely on society, which is deemed to be ignorant. Critics point to the many other factors that can disrupt the complex relationship between science and society, such as disputed knowledge claims, conflicts over values and clashes between commercial, social and political interests.

In response to this criticism of the deficit model, a more democratic view is currently in vogue. This is based on the changing ideas about the relationship between science and society, as described above. This democratic model aims to achieve an equal relationship between scientists and public groups and emphasises dialogue as a prerequisite for arriving at a satisfactory resolution of differences of opinion, even when scientists present divergent perspectives on reality. Whereas the deficit model considers only formal knowledge to be important in the relationship between scientists and lay people, the democratic model involves a wider range of factors, such as informal or implicit knowledge, values, and power and trust relationships (Durant, 1999).

## 2.5 Responsibility

In recent years, the way people think about the relationship between science and society has taken on a more concrete form. In this context, philosophers of science refer to a science that maintains a responsible relationship with society. What "responsible" means has been interpreted in different ways in the discourse on European policy on science, technology and innovation. Science is responsible when (Owen et al., 2012):

- it is focused on societal challenges and needs;
- it is responsive, prepared to be guided by society in dialogue; and
- scientists take a broad view of their social responsibility.

Responsible science is therefore science that not only engages society in research, development and innovation but is also guided by and responds to society's needs. By taking into account the following four dimensions in research and innovation processes, scientists will actually be able to take on this responsibility (Stilgoe et al., 2013):

- **Responsiveness.** Making the governance of science, technology and innovation more flexible will enable a quicker response to societal and technological developments.
- **Inclusion.** Bringing together people with different perspectives, beliefs and expertise can generate new ideas and make people sensitive to each other's point of view.
- **Anticipation.** Discussing the societal aspects of science, technology and innovation at an early stage makes it possible to adjust development paths. Ethical, social and legal dilemmas then become opportunities for innovation rather than obstacles.

- **Reflexivity.** The processes and outcomes that are considered acceptable are established through joint consultation. This requires awareness of one's own beliefs, motivations and limits.<sup>12</sup>

The ambitions of responsible science are sometimes difficult to reconcile with the prevailing mores in practice (Felt, 2017 and Owen & Pansera, 2019). According to these authors, responsible science can only be embedded in society if public engagement becomes an integral part of the practice of science. This means that researchers need to be trained to get a feel for how research links in with societal issues. However, in the dominant discourse and practices of new public management, scientists are judged by quantitative indicators, including their fund-raising abilities. This gives rise to a risk that the principles of responsible science will be pragmatically translated into a few questions on an application or report form and therefore become a box-ticking exercise, leading to tokenism. Responsible science then becomes a ploy to satisfy the research funder, rather than scientists being intrinsically motivated to engage public groups with their work in a meaningful way.

## 2.6 Openness

In recent years, in addition to the ambition to create a sense of responsibility in science, there has been a trend towards open science. This trend is partly technology-driven as new technological applications and digital technologies are providing new opportunities for information-sharing and collaboration.

Because of this focus on technological opportunities, the trend towards open science is not primarily about the democratisation of science. This has been included in the formulation of this concept, which has been dubbed "open science" in policy circles.<sup>13</sup> Open science spans several schools of thought. Fecher and Friesike (2014) describe five schools of thought from which the ideas of open science have been derived.

- **Democratic;** based on the assumption that access to knowledge is unevenly distributed. For this school, the aim of open science is to make knowledge freely available, which requires scientists, politicians and citizens.
- **Pragmatic;** knowledge development can be organised more efficiently if scientists cooperate more. The main purpose of open science for this school is to open up knowledge development so that scientists from different disciplines can contribute.

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<sup>12</sup> A self-critical attitude is a core principle of science. Yet lack of self-criticism appears to be a persistent problem in science (Stilgoe et al., 2014, Wynne 2006). In addition to self-reflection, Wynne (1993) therefore argues for "institutional reflection" through public engagement, such as in RRI.

<sup>13</sup> Initially, this new way of practising science was called Science 2.0; after a "public consultation" by the European Commission in 2015, it was decided to name it open science from then on (EC, 2015).

- **Infrastructural**; the underlying assumption is that efficient research depends on the availability of tools and applications. With open science, scientists and platform providers aim to create freely accessible platforms, tools and services for researchers.
- **Public**; open science aims to make science accessible to public groups. Citizen science is an important element of this school.
- **Bibliometric**; based on the assumption that the quality and impact of scientific output is not properly measured in the current system, this school is trying to develop an alternative system of scientific impact measurement under the banner of open science.

In Fecher and Friesike's (2014) analysis, sharing in the benefits of science is the key issue. The schools of thought they describe focus mainly on access to knowledge and the process of knowledge development. In this interpretation, involving societal actors at the front end of the scientific process, when formulating the research questions, receives less attention. Yet this is precisely the phase in which societal actors and citizens can bring in new perspectives, thereby making a meaningful contribution to science (Delgado, Kjølberg & Wickson, 2011).

## 3 Public engagement policy

It is not only scientists who search for meaningful public engagement with science: the subject has also occupied a prominent position in various European and Dutch science policy programmes. The conceptual quest described in the previous section has obviously inspired the policy for public engagement with research.

In this section, we describe the most important successive science policy frameworks in the Netherlands and Europe. We will see that each new policy programme has boosted public engagement with science. The focus on the relationship between science and society has also become increasingly wide-ranging over the years. Whereas in the mid-twentieth century informing public groups was regarded primarily as a supplementary activity to science, there is now an increasing focus on the integration of public activities into knowledge development. Under the banner of open science, European and other policymakers are now even advocating a transformation of science so that it can better serve society (European Commission, 2016).

### 3.1 New policy as sedimentary layers

The policy process that shapes the interaction between science and society can be characterised as a sedimentation process (Felt et al., 2013). New policies and new policy discourses to guide this interaction form fresh layers (sediments) on top of earlier policies, which do not disappear and are not replaced, but co-exist with new policy programmes and must relate to them. In this way, we can also consider the search for a policy to engage a broader group of social actors with research and innovation as a sedimentary layer. In successive programmes attention shifts from (one-sided) communication from science to society to dialogue and participation (ibid.).

In the late 1980s, the relationship between scientists and society began to change under the influence of national policy programmes (Durant, 1999; Gregory & Lock, 2008; Jones, 2014). A publication by the British Royal Academy in 1985 aimed at enhancing the understanding of science in society was the starting point for this trend (Bodmer et al. 1985). Initially, the deficit model was at the forefront, based on the idea that society needs to be better informed about scientific progress. Since then, large surveys, such as the EU's Eurobarometer, have been used to monitor the knowledge and attitudes of the public towards science in general and towards specific technologies.



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## Box 2 Science shops

In the 1970s, several relatively small initiatives led the way in the Netherlands. Science shops were set up in various university towns. These hubs facilitated cooperation between students and lecturers who wanted to conduct socially relevant research, and non-profit organisations or residents' groups who had a particular question. The question came from society and the science shop would then seek out interested lecturers and students to conduct the research. Although the science shops managed to combine the social, scientific and educational value of science, this concept failed to become widespread or structurally embedded in Dutch or European science policy.

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Launched by the European Commission in 1998 as part of the Fifth Framework Programme for Research and Development, the Raising Awareness Programme was largely in line with the deficit model and focused mainly on communication. Through outreach activities, policymakers and science communicators tried to raise public awareness of scientific and technological developments and their consequences for society. While the programme did not involve any research activity, the European Commission did encourage researchers and their employers to attract a more diverse group of young researchers.

The focus changed over the three subsequent framework programmes of the European Commission (FP6, FP7 and Horizon 2020).<sup>14</sup> Financial resources were made available in the research programmes to investigate and further stimulate the interaction between science and society. Increasingly, experimentation with participatory research practices and co-creation of knowledge by scientists and societal actors was subsidised. The titles of the programme components that specifically focused on interaction show this shifting perspective: Science **and** Society (FP6), Science **in** Society (FP7) and Science **with and for** Society (H2020).

Science and society were regarded less and less as separate entities in successive framework programmes. There was greater attention for a dialogue that should lead to joint knowledge production (Felt et al., 2013). Within the European Commission, it has now become a central tenet that: "societal actors (researchers, citizens, policymakers, business and third sector organisations) work together during the

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14 Funding Programme (FP) 6 ran from 2002 to 2006, followed by FP7 from 2007 to 2013. Horizon2020 began in 2014 and ran until 2020.

whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society" (European Commission, 2018). The basic premise, therefore, is to involve societal actors as early as possible in the development of scientific knowledge and new technologies to explore acceptable solutions to societal challenges (Burget et al., 2017; de Saille, 2015; Owen et al., 2012).

### 3.2 Responsible Research and Innovation

European research and innovation policy has long regarded the promotion of science and technological development as an end in itself. This is in contrast to almost all other policy efforts by the European Commission, which are aimed at achieving specific normative, political objectives, such as a high level of security, sustainable development or a competitive social market economy. For a long time, the policy assumed that stimulating innovation would automatically lead to economic growth and increased employment. Market forces would ensure that innovation was focused not only on meeting society's needs, but also on addressing societal challenges. As a result, research and innovation policy did not have to worry about the direction of scientific and technological development. It could confine itself to setting criteria, for example with regard to the quality and safety of innovative products (Von Schomberg & Hankins, 2019, p.16).

This technology neutrality as a basis for research and innovation policy ended with the introduction of the European policy framework *Responsible Research and Innovation* (RRI), which from about 2012 began to emerge as a new sediment layer on top of the previous policy programmes. RRI is: "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (Von Schomberg, 2011, p.9). The Commission calls RRI a cross-cutting issue, a focus that applies to all parts of Horizon 2020 (European Commission, 2018). Therefore, stated much more forcefully than in previous policy initiatives, RRI is intended to be an integral part of scientific research and not an additional activity on top of mainstream research practice (Felt, 2017). In addition, RRI was the guiding framework for the above-mentioned *Science with and for Society* research programme that ran until 2020.

The focus on public engagement through dialogue and participation has grown because of RRI. Researchers and societal actors have been able to experiment and gain experience with new forms of knowledge co-creation. However, an evaluation of RRI (European Commission, 2017) shows that existing patterns of conducting science are hard to change. For example, civil-society organisations without links to commercial parties play a minor role in Horizon 2020. A very small part of the research budget (<1%) is allocated to them. In only 11% of funded projects do they play a role in setting the research agenda and its implementation.

Flink and Kaldewey (2018) also point out the persistence of existing research practices and the difficulty of changing them.

As the sediment layer of the European RRI policy was taking shape, the Dutch government also developed policies to link science and society more closely. The Dutch National Research Agenda (NWA) was the main instrument for this. The Dutch Ministry of Education, Culture and Science wanted to use the NWA to make scientific research more demand-driven and more closely aligned with the demands and needs of the Dutch people. The question is whether the NWA is succeeding in this regard (see Box 3). Minister Van Engelshoven again focused on public engagement in the 2019 science letter (Ministry of Education, Culture and Science, 2019). A new element was the request to NWO to reward researchers who enter into dialogue with society. The minister also made three million euros available for connecting the knowledge gained from the NWA to society. In line with this development, universities of applied sciences have set up "Centres of Expertise", in which they work with industry, government bodies and other public and civil-society organisations.

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### Box 3 Dutch National Research Agenda

The Dutch National Research Agenda (NWA) was launched in 2015. At the request of the Ministry of Education, Culture and Science, a knowledge coalition<sup>15</sup> conducted a national consultation to find out the questions which Dutch people believed science should be addressing.

Society ("everyone") could submit questions online during a public consultation that had been widely publicised on various media outlets, with appearances by well-known Dutch personalities and leading scientists. 11,700 questions were submitted, which were clustered into 140 questions by a jury of scientists. Scientists, businesses, citizens and civil-society organisations then discussed the content of the agenda in the course of three conferences.

Despite the open nature of these steps, some reservations can be made regarding the actual engagement of society with the development of the NWA. The reports show that mainly businesses and research organisations submitted questions during the consultation phase. Mostly scientists attended the public conferences (Dutch National Research Agenda, 2016). In addition, the public was no longer involved in the prioritisation phase of the agenda. The social perspective also appeared to be given little priority in the implementation of the NWA. For example, civil-society organisations were unable to apply for research funding.<sup>16</sup>

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## 3.3 Open science

In recent years, a new sedimentary layer has formed under the heading of open science, on top of previous initiatives to promote public engagement with scientific research. In the new European framework programme Horizon Europe (2021-2027), RRI is therefore losing momentum in favour of open science policies (Shelley-Egan et al., 2020).

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15 The knowledge coalition consists of the Association of Universities in the Netherlands (VSNU), the Netherlands Association of Universities of Applied Sciences, the Federation of Dutch applied research institutes (TO2), the Confederation of Netherlands Industry and Employers (VNO-NCW), the Royal Dutch Association of Small and Medium-Sized Enterprises (MKB Nederland), the Dutch Research Council (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW).

16 NWO, 2018, Call for proposals - Dutch National Research Agenda: Research along Routes by Consortia.

Even more than previous plans, the open science policy proposes a major transformation of scientific knowledge development, as can be read in the policy paper *Open Innovation, Open Science, Open to the World* (European Commission, 2016). At the same time, Horizon Europe no longer allows scope for a programme component that is specifically devoted to the interaction between science and society, such as SwafS from Horizon 2020 (see Box 4).

The open science policy is aimed both at the relationship between scientists and at changing the relationship between science and society. Open science is not so much about responsible science, but rather focuses on science functioning faster and more efficiently. Mutual collaboration, easier data sharing and improved replicability of research should ultimately lead to better, more efficient and more reliable science. Mutual cooperation between scientists was a less prominent part of RRI.

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#### Box 4 Science and society in Horizon Europe

The framework programme Horizon Europe does not have a component specifically dedicated to the interaction between science and society. The intention is for the focal points of the previous Science with and for Society (SwafS) programme component to be better interwoven with the entire framework programme, so as to "place citizens at the core of Horizon Europe" (European Commission, 2020).

The European Commission's framework programmes are always translated into biennial work programmes with their own (sub)objectives and budgets. The European Commission recognises that translating the focal points for science and society into these work programmes will require attention, with different contents and challenges in each field. Scientists have expressed concern that the disappearance of the specific programme component will lead to a weakening of the focus on the interaction between science and society. In June 2018, for example, a network of science sociologists launched a petition to advocate for a specific Horizon Europe programme component for science-society interaction, but this was to no avail.<sup>17</sup>

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Another difference between open science and RRI is that open science policy focuses more on institutional and technical change, whereas RRI policy focuses

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<sup>17</sup> See [https://www.sisnetwork.eu/about/news/call-for-action-horizon-europe-needs-a-programme-for-funding-science-society-and-citizens\\_initiatives](https://www.sisnetwork.eu/about/news/call-for-action-horizon-europe-needs-a-programme-for-funding-science-society-and-citizens_initiatives)

more on cultural change (van Lente et al., 2018). The Open Science Policy Platform (OSPP) has been given the task of further developing the policy agenda for open science in the EU. The OSPP has a clear focus on technical and organisational change in this assignment. One example is the European Open Science Cloud, a large online platform for sharing research data according to FAIR principles.<sup>18</sup> The OSPP is also focusing on making open access publishing the standard and adjusting the evaluation and remuneration structure for scientists. The OSPP reduces engaging public groups with science mainly to citizen science: public engagement in conducting research.

The principles of open science are also at the forefront of Dutch science policy. The Ministry of Education, Culture and Science presented the National Open Science Plan in early 2017. The priorities of this plan show the more internal scientific and institutional approach to open science in Dutch science policy namely:

- promoting open access to scientific publications;
- promoting the optimal use and reuse of research data; and
- adjusting evaluation and assessment systems to align with the aims of open science.

Citizen science is one of the themes of this plan. The Citizen Science working group presented its final report in late 2020 (National Open Science Programme, 2020). The working group defines citizen science as being more than just getting citizens to help collect data. It is any form of research in which "scientists collaborate with [...] volunteers and in which the involvement of the latter is essential to achieving good results". The working group has two specific proposals:

1. to develop a network that facilitates the sharing of knowledge and experience and encourages cooperation and innovation; and
2. to develop an assessment instrument that makes it possible to assess the form, approach and chances of success of citizen science as objectively as possible. This tool can help scientists, organisations or individuals aiming to embark on a citizen science project to think about the different components, focal points and pitfalls in advance.

All in all, the democratisation of knowledge development within the European and Dutch policy frameworks for open science is a less prominent theme than it was under RRI. Under the banner of open science, access to scientific results and data is now paramount and expectations and ambitions for public engagement with science have been lowered. Public groups are less often being invited to systematically consider the structural and long-term implications of research and innovation (Shelley-Egan et al., 2020). Citizen participation is often limited to the

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<sup>18</sup> Data that meets the FAIR principles is easy to find, accessible, interoperable and reusable.

assistance individuals can provide in collecting research data (Fecher & Friesike, 2014).

Several authors saw this prioritisation coming. For example, Jones (2014, p.29) stated that: "It would be a pity if the enthusiasm for open access and open data were to eclipse the progress that's been made in promoting the need for such public engagement". Stilgoe et al. (2013) also warned that open access could divert attention away from the bigger challenge of engaging public groups with science in a meaningful way, and that open access could come to be regarded as a substitute for meaningful public engagement. These authors highlighted the risk that, due to the current dominance and the interpretation of open science policy, the dialogue between science and the public would revert to an unequal role pattern.

## 4 Public engagement in practice

We examined examples of public engagement in three fields: psychiatry, educational research and research into water quality. This allowed us to supplement our search for meaningful public engagement with practical experiences. We have written a report on each field that details the benefits and challenges of public engagement in that field. In addition, we have drawn lessons from these case studies that are also relevant outside the specific field. Box 5 (see next page) summarises the key findings from each case study.

The case studies provide insights into public engagement in all of the fields. In the research practices we analysed, this is a quest for researchers, policymakers and the public itself (representatives of civil-society organisations, practitioners and citizens). Engaging public groups is also a dynamic process. We see new practices emerging and evolving. These practices look different in each field and in each (policy) domain. We discuss scientific, domain-specific and societal factors separately below.

### 4.1 Factors in science

Our field studies show that the necessary structures and incentives which enable, promote or support public engagement are not well enough developed in the world of science. The current academic system of recognition and reward has little regard for collaboration with external public groups. For example, in our case study on public engagement with psychiatric research, we noted that scientists who engage patients (and their representatives) with research are not recognised or rewarded for doing so. Indeed, research conducted at the request of, or in collaboration with, patients is generally less likely to be published in leading medical journals. Medical committees that advise the government and insurers on care standards and guidelines rely on articles published in these journals to determine the quality of reimbursable care. As a result, research in collaboration with patients actually has less social impact than regular research, which does get published in top journals. Moreover, these publications are important for the career of researchers.



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## Box 2 Findings from psychiatry, water quality research, and education

In psychiatry, we are witnessing a small, but growing and relevant movement towards greater patient engagement with academic psychiatric research. Patients are engaged with setting the agenda and selecting research proposals. Thanks to their input, more attention is being paid to issues such as recovery and empowerment, the perspective of relatives and the quality of care. These themes contrast with the prevailing biomedical perspective, which focuses on understanding, diagnosing and curing psychiatric disorders. These new research themes also demand different approaches to research, such as qualitative and participatory research. The engagement of patients with research coincides with trends in psychiatric care, in which the patient is given a greater say. Within psychiatry, there is some resistance to these paradigmatic changes in the profession. This shows that something fundamental is at stake in this field.

In water quality research, agenda-setting is highly institutionalised. The existing research institutions and policy organisations do devote attention to public interests and values, but there is little scope for direct citizen participation. Citizens do get involved in data collection relatively often. Sometimes these studies have a scientific purpose. However, academic researchers disagree on whether data collected by nature lovers can be of sufficient scientific quality. Moreover, not all of these projects aspire to be of scientific value. Sometimes the aim is mainly to increase citizens' water awareness (awareness that the quality of Dutch surface water is under pressure) and the support for measures to improve that quality. However, there has been little evaluation of whether these projects actually contribute to greater water awareness. In addition, a small group of researchers and citizens try to point out shortcomings to scientists and policymakers through their own research.

In educational research, public engagement takes the form of setting the agenda for, implementing and disseminating research, albeit on a modest scale at present. Individually, teachers and school leaders are involved in the agenda-setting and programming of practice-based research. There has been an increased focus on practical research, for example in academic collaborative centres. The research conducted there usually focuses on a specific practice and not on generic knowledge development. The education sector is also investing a great deal of energy in making research results accessible and in ensuring that they are applied in order to improve the quality of education. Nevertheless, the initiatives to get people involved are poorly coordinated and the involvement of education professionals is based on

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individual enthusiasm. Involving students and parents is considered "a bridge too far".

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Many researchers regard the fact that they are less appreciated for research involving public groups than for their conventional scientific work, as a barrier to the further development of public engagement. The academic system of recognition and reward is currently under review. Research funders, universities and the Association of Universities in the Netherlands (VSNU) can use this opportunity to encourage researchers to engage public groups with their research in a meaningful way.

The prevailing methodology and epistemology within a scientific discipline also determine which forms of public engagement can be fruitful. Disciplines are characterised by their own paradigm, with dominant views on which research questions are relevant and how they should be investigated. Public engagement sometimes fits in easily, but it can also be difficult to reconcile with this paradigm. In psychiatry, for example, we have seen the dominant view of research into mental illness shift over the years. Whereas in the past this research was mainly biomedically oriented, nowadays it tends to focus more on qualitative research into the psychosocial aspects of psychiatric disorders. This has implications for the role that patients can play and the value that is attached to their input. Within a large-scale biomedical study, patients traditionally have the role of anonymous participants in a randomised controlled trial. In qualitative studies into coping with an illness or into the quality of life, patients are given a say. This creates an opportunity for them to become involved in the design of the research as well.

To what extent a scientific discipline is application-orientated, also influences the form and extent of public engagement. The more application-oriented, the more obvious it is to engage professionals and users with the research process. The conditions under which application-oriented research is conducted, inevitably affects the outcomes. This makes knowledge within educational research, for example, highly context-dependent, as all children, classes, teachers and schools are different. For example, enquiry-based learning can be effective in Dalton schools where pupils are used to working independently but may be less suited to traditional education. This means that research results always have to be translated into an application context and this requires the involvement of people who are thoroughly familiar with this context. If insights from research in a particular school or classroom are to be used, teachers need to have an inquisitive attitude and possess research skills. The teachers' research interest will then encourage them to continue contributing to research.

## 4.2 Factors in society

Our case studies show that the public's need for engagement with research varies. It is different in every policy context. In water quality research, for example, a low level of public engagement is one of the reasons for involving nature lovers, the expectation being that contributing to research, for example by sampling water in their environment, will increase participants' water awareness (see Box 5). The tasks performed by these volunteers are generally simple and require little knowledge, although long-term monitoring projects do require a lot of commitment. In our case study, we found that the contribution of these volunteers does not generally exert much influence in the field. The major research topics, research methods and quality criteria of water quality research do not change substantially as a result of public groups being involved. However, this is the case in psychiatry, where patients demand to be involved, for example in putting research topics on the agenda. They try to shift the long-standing focus on the scientific value of knowledge to relevance for healthcare in practice. In psychiatry a system transition is taking place in which new research topics become important, new methods are used and new quality criteria are (or have to be) defined.

In addition, the way in which a domain is organised is essential for the way public engagement is shaped. In the education domain, teachers are not well organised and the interest representatives that do exist (trade unions and professional associations) are not very active in research and knowledge development. This creates the risk that engagement is limited to enthusiastic frontrunners who have time for it, and that this leads to division in the profession. Some schools have the time and resources to engage in educational research, while for other schools (not infrequently in disadvantaged areas or with many vulnerable pupils) this is not possible. Schools involved in research and development can become more innovative, attract teachers that are more ambitious and hence increase their lead over others. This may even increase the inequality of opportunity in education. Likewise, student and parent representatives do not engage much with the knowledge agenda of education or educational research in general. This is different in medical research, for example. Patient associations do play an important part in this area, particularly in putting certain research themes on the agenda.

Finally, external developments influence the demand for public engagement. For example, water quality in the Netherlands is under pressure. Because the Dutch public's low level of water awareness is regarded as one of the reasons for this, it is considered an attractive idea to engage citizens in research on water quality. In psychiatry, patients' engagement with research is related to their empowerment in health care; the empowered patients are vocal not only in the consulting room but also in the laboratory. These social trends and circumstances influence the need for and form of public engagement with research.

## 5 Meaningful public engagement

We have seen that the pursuit of meaningful public engagement is an ongoing quest in the debate about research, research policy and research practice. There is a wide diversity of ideas, plans and practices: from information and science communication to citizen science and knowledge co-creation. New ideas on the interaction between science and society are constantly demanding attention and policy measures are placing different emphases. Nevertheless, there is a risk that researchers are engaging public groups with their research mainly for the sake of appearance. Therefore, the question of when public engagement is meaningful is relevant: how does this engagement acquire scientific and social value?

Based on our research, we draw two conclusions about meaningful public engagement that we will elaborate on in the rest of this section.

- Public engagement that contributes to the democratisation of research is meaningful.
- For public engagement with research to be meaningful, the form (who is involved, where, when and how) must align with its goal (the why) (see also Fransman, 2018).

### 5.1 Democratic knowledge development

The more public engagement contributes to democratic knowledge development, the more meaningful it is from a societal perspective. What we mean by "democratic knowledge development" is research that is accessible and inclusive and in which societal stakeholders have a say in the part they play and the contribution they make (see also Brown & Guston, 2009).

Democratisation of knowledge development is about changing the balance of power between public knowledge producers and society, to the benefit of different groups in this society. It is about participation and co-determination. Three aspects are relevant to democratisation (Abelson et al., 2003).

1. Accessibility. How high are the thresholds for different groups of interested parties and stakeholders to influence public research agendas and public research?
2. Inclusion. Do all groups with an interest or concern get involved?
3. Ownership. To what extent do external stakeholders determine the role they play and the contribution they make to public research?

Accessibility also determines inclusion. The lower the thresholds, the more relevant groups are able to participate. This is not just about citizens in general or civil-

society involvement, but about involving groups that actually shape diversity in society (Bonney et al., 2015). Accessibility is vital if these new groups are to be involved in the research process. The European Commission states that it is important to open up a project to anyone who is interested (European Commission, 2020). However, more is needed to achieve inclusion, according to the literature (Kennedy et al., 2018). Research will become more inclusive when people who do not directly seek access to scientific research themselves are explicitly invited and barriers to their involvement are lowered. In water research, for example, it is important to reach not only nature lovers through citizen science projects, but also citizens who are not (yet) concerned about water quality.

The third aspect of democratisation is ownership. The more researchers regard external stakeholders as partners in a research project and as contributors of additional knowledge and skills, the further this will go. Ideally, together with the researchers, they will determine both the goal (why) and the form (who, where, when, how) of their involvement. This can be far-reaching, for example when patients themselves study aspects of their illness that they consider relevant. There are also nature lovers who set up their own research project to draw attention to an issue they consider important (see Box 6). In many other cases, the ownership over one's contribution does not go as far. Bird watchers may be perfectly content to collect sighting data in a survey designed by professional researchers.

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### Box 3 Public engagement to influence the agenda

In the water quality case study, we see different motives among research participants. Activism may motivate nature lovers. They want to voice their concerns through (their contribution to) research projects and put subjects on the scientific and/or political agenda. For example, they want to demonstrate that the water quality at a specific location has been insufficiently investigated. Or they argue that too is being done about (a certain aspect of) our water quality and they want to raise public and political awareness about this.

Examples of concerned citizens who measure water quality themselves are the Oostland Surface Water Quality Project Group and the *Meten=Weten* [Measurement = Knowledge] association. They want to use their results to make recommendations to the responsible authorities. Water activism also exists among larger interest groups, such as the Dutch Society for the Protection of Birds and *Natuur & Milieu* [Nature & Environment], an environmental organisation. They sometimes employ professional hydrologists and ecologists to carry out their own research.

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## 5.2 Why, who, where, when and how

For public engagement to be meaningful, it is necessary that the reason for this engagement (the why) aligns with its form (who, where, when and how) and that those involved have similar views in this regard.

### Why

There are several possible arguments for public engagement, sometimes even within a project. These arguments can be divided into three categories: substantive, normative and instrumental (Duncan & Oliver, 2017).

- The motivation for public engagement can be *substantive*, focusing on the quality of the research. Input of other forms of expertise, such as practical knowledge and experiential knowledge, can increase the quality of research. This is true for the agenda-setting of relevant research questions in psychiatry and for data collection in water quality research, which would not be possible without the involvement of volunteers.
- *Normative* reasons for engagement with research boil down to the argument that people have a right to it. This argument can refer to direct stakeholders. For example, patients have a right to participate in research into their illness, because it directly affects their body and their life. This argument can also refer

to the more indirect, general public interest. Research into good education affects not just students and teachers, but all of us, as society benefits from having a well-trained workforce. Another normative argument is that publicly funded science should be of service to taxpayers, who, after all, have paid for it. These normative arguments are often aimed at changing power relations and increasing public participation and inclusiveness. They call for a more democratic knowledge development process.

- In *instrumental* arguments, public engagement is used as a means of achieving other goals. For example, when people bring in the perspective of societal actors, they expect the research to be more in line with society's values or needs and to become better socially embedded. Other instrumental goals of public engagement include generating support for scientific research and increasing citizens' scientific literacy.

### **Who**

Different public groups can contribute to research. Public engagement can only be meaningful when the public group involved aligns with the purpose of the engagement. People can participate in research projects on the basis of their profession, for example as teachers, psychiatrists or water managers. These people are often the users of knowledge, who can put research results or innovations to use straight away. But people can also participate in research projects as citizens with or without specific interests, knowledge or concerns. In our case studies, for example, they were nature lovers, students and patients.

There are all kinds of intermediary structures for organising public groups. They may be interest groups who represent the needs and wishes of patients and pupils, or who represent the interests of biodiversity and nature conservation. There are also platforms that match interested citizens with researchers who want to engage public groups. In water quality research, for example, citizens compile their collected data on the website [waarneming.nl](http://waarneming.nl). This is an important resource for research into, and policy on, biodiversity.

### **Where**

As already discussed in Section 1.3, scientific research usually takes place within universities, universities of applied sciences and public knowledge organisations, where researchers can invite public groups to contribute to research. Of course, a lot of research takes place outside of these physical locations, such as the collection of nature data. Research is also conducted in virtual networks. Academic collaborative centres in educational research do not always have a fixed location and research therefore takes place both in schools (in classrooms) and universities.

In addition, research funding organisations can engage public groups. (Health) funders, NWO and ZonMW, can give patients a voice in decisions about the programming and funding of research. Furthermore, research results are not necessarily disseminated and implemented at knowledge institutions themselves. The public groups involved are therefore not always present at the location where the research itself takes place.

Finally, a small group of researchers and public groups conduct research outside of established structures. In the case of water quality research, for example, they are nature lovers who are doing science with an activist goal in mind. Through their own research, they want to point out shortcomings in water policy and research to scientists and policymakers (see Box 6).

### How and when

The role of public groups and the intensity of their engagement can take a variety of forms. A well-known hierarchical classification of engagement is the Ladder of Citizen Participation (Arnstein, 1969). The transfer of power is central to this concept: the higher up the ladder they are, the greater the agency public groups have. On the lowest rung, those involved are informed of research, without the opportunity to respond to it. One rung up, researchers consult them at the times and on the subjects that the researchers determine. The next rung is consultation, followed by science co-production. At the highest level of participation, public groups decide (or are included in decisions) on the research. Criticism of this model focuses on the assumption that participation always involves a transfer of power; it ignores the possibility that the input of experiential experts can also be considered a supplement to expert knowledge. There is also criticism of the hierarchical nature of the ladder, which suggests that a higher level of participation is better by definition (Tritter & McCallum, 2006).

Public engagement takes different forms in the different phases of scientific research.

- In the *agenda-setting phase* of research, stakeholders, for example patients, put forward topics that they consider important. In such instances, the social relevance of the research (knowledge for use) is given greater emphasis than the scientific motivation (knowing for the sake of knowing). Real-world insights can inspire scientific research questions, which makes it possible, for example, to better estimate the practical feasibility of a study.
- In the *implementation* phase of the research, citizens and civil-society organisations have more of a supporting role. For example, they can be entrusted with the technically simple, large-scale collection of nature conservation data. During this phase, public groups have only limited opportunities to have an equal conversation with the researchers about the direction of the research. In general, in this phase, citizens, professionals and other societal actors carry out the instructions set by the researchers.
- Public groups can also be involved in the *dissemination and implementation* of research results. Translating scientific knowledge into context-specific practice requires skills and practical experience that not everyone automatically possesses. This requires intermediaries, citizens or professionals with an inquisitive attitude.

The relationship between the research phase and the form of engagement is not set in stone. In the implementation phase, for example, patients can also advise on how to minimise the physical or mental strain on subjects during data collection.



A basic precondition for meaningful engagement is that the answers to the questions *why*, *who*, *where*, *when* and *how* are well aligned.<sup>19</sup> In psychiatry, for example, they are relatively well aligned. In water quality research, the form (*when*) and target group (*who*) of public engagement are not always well aligned with the goal (*why*). These examples are described in detail in Box 7.

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<sup>19</sup> We have borrowed these ideas from the Theory of Change Approach, which is used to evaluate social programmes or initiatives (Blamey & Mackenzie, 2007).

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#### Box 4 Coherent rationale or not?

In the psychiatry case study, we have seen that the elements of the rationale for public engagement (why, who, where, how and when) align logically. Patients and their representatives point out that the emphasis on biomedical research in recent decades has produced too little relevant improvement in care. They believe that their experiential knowledge can contribute to more relevant research, and thus present a substantive argument for more engagement. The answer to the "who" question is also clear. It is those directly affected by the research, namely the patients, who demand a place at the table. They do this where the relevant decisions are taken, such as at health funds and research funder ZonMW. Their goal also determines the "how" and "when" of their engagement. In order to be able to influence the research questions, they want to have an advisory or joint decision-making role in the agenda-setting and programming phase. In this way, they can help to improve the match between psychiatric scientific research and the needs of society.

The narrative in the water quality case study follows a different line of reasoning. In this case, mainly scientists and policymakers set up projects aimed at involving citizens in research. Sometimes the aim is to collect data on scientific quality. In other projects, the aim is to increase participants' water awareness and, with it, public support for the research. The place where public engagement takes place ties in with this. This is the place where the research takes place, often outside in the natural environment or at other places where water quality can be measured.

Our research shows that there is little evaluation of whether the form of public engagement – helping with data collection – actually contributes to participants' water awareness. Moreover, participants are often nature lovers who are already interested in the natural environment, biodiversity and water quality. It is therefore unclear whether the form aligns well with the goal. The target group is also not always well chosen, considering the goal. In other words, the elements of the narrative of public engagement in water quality do not always align well.

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## 6 Conclusion

In this report we highlighted the conceptual, policy and practical search for meaningful public engagement with science. We outlined the historical developments, opportunities and challenges faced by policymakers, scientists and the engaged public. From our analysis we concluded that science becomes more democratic if it is accessible and inclusive to societal actors, and if citizens are given a say in their own role. In addition, we concluded that public engagement is meaningful when the goal of this engagement (the why) aligns well with who is involved, where, when and how.

In this final section, we connect these conclusions to the policy debate on open science. Based on our findings, we set out practical steps that can help policymakers and researchers to make initiatives in which they engage public groups more meaningful. This review ends with an appeal to the scientific community to take these recommendations to heart.

### 6.1 Public engagement in open science

Anyone who wants to involve public groups in research, or who wants to become involved in research, will find themselves in a world where (talking about) open science predominates. Research proposals must comply with open access and FAIR data guidelines, knowledge institutions have appointed open science officers to disseminate the ideas and researchers can attend workshops to organise their research in accordance with open science principles.

The ambitions for open science are grand. Open science promises to transform science for the benefit of society. This will allow science to become more deeply embedded in our society, help to solve societal challenges and make the research process more efficient and effective. Thus, using fewer resources, research will answer the right societal questions.

In the previous sections, we have seen that this idea of open science and the associated policy framework did not appear out of thin air. Both build on a trend in the interaction between science and society that has been going on for a long time. This trend has so far been towards involving public groups at an increasingly early stage, in an increasingly equal manner. It has given rise to Responsible Research and Innovation. These democratising ambitions are also reflected in the work of UNESCO and the United Nations that articulates the right to science (United Nations Committee on Economic, Social and Cultural Rights, 2020).

However, the current interpretation of open science gives rise to a risk that the progress made in the democratisation of science will be overshadowed by a one-sided emphasis on open access and open data. The concept of public engagement is also in danger of being narrowed down to citizen science, which is usually associated with citizens collecting data. As a result, the dialogue between science and the public could lapse back into a pattern of unequal roles.

## **6.2 Five steps towards meaningful public engagement**

Public engagement should be given the consideration it deserves as an integral part of the pursuit of open science. This review calls for this consideration. In order to make this consideration concrete, we have translated our findings below into five practical steps to give shape to meaningful public engagement with research. We call not so much for more, but for better, public engagement: engagement that benefits both science and society.

We have seen that organising meaningful public engagement can be a challenge for all parties, including researchers, policymakers at knowledge institutions, research funders, citizens, interest groups, users, patients and professionals. The key to meaningful public engagement with research therefore lies in both the scientific and the social domain.

### **1. Make research accessible and inclusive for public groups**

In order to increase the social significance of research, it is important to make research as accessible as possible. The first step is to remove barriers. These barriers include the use of research jargon and academic language. Translating research findings into usable guidance and tools for use in practice can improve the accessibility of the research process.

The more accessible the research is to the public, the greater the diversity of the participants. More diversity can enhance both the quality and the legitimacy of research. Research benefits when people with widely differing perspectives and insights have a say in decisions. In medical research, for example, it makes a difference to a person's input whether they have a chronic condition or have already recovered, or whether they are medically literate or not. When a wider range of groups is involved in research, this promotes scientific literacy and strengthens the position of science in society.

### **2. Coordinate diversity of participation and raise awareness of added value**

Increasing the diversity of participants in scientific research is also related to the way a social domain is organised. Ideally, many different parties should be represented when research questions are being formulated – not just the "usual suspects". In educational research, for example, it would be good if not only enthusiastic teachers and school leaders were given a voice, but also educational professionals who are less at the forefront. Moreover, parents and pupils are

seldom involved in educational research. Both scientists and societal actors have a responsibility to maximise the diversity of the public groups involved.

In our case studies we have seen that public engagement can make research substantively better and/or more socially relevant. Public groups contribute additional forms of expertise, such as practical and experiential knowledge. This can lead to different research questions, new options for data collection, empirical research in practical situations and a better translation of research results into practice. Public groups can therefore play different roles in research. For example, nature lovers are mainly involved in data collection. In psychiatry, patients contribute experiential knowledge.

Civil-society organisations, such as nature conservation organisations, trade unions and patient associations, can continue to develop and highlight these roles in research. In this way they can increase the added value of public engagement and strengthen the support for it. If public groups see their input clearly reflected in the final result, this will encourage them to (continue to) contribute.

### **3. Make it attractive for researchers to engage public groups**

One way of encouraging public engagement with research is to make it attractive for researchers to go public. Research shows that the way researchers are currently recognised and rewarded prevents them from interacting more closely with societal actors (Felt, 2017). Meaningful public engagement must therefore take its place in the academic system of recognition and reward. To achieve this, the VSNU, NFWO, KNAW, NWO and ZonMw took the first step in 2019.<sup>20</sup> It is now up to the knowledge institutions to translate the stated ambitions into specific (policy) measures.

It is also important to develop appropriate quality standards for research involving public groups (see Box 8). This enhances the societal impact of this type of research, which can motivate researchers to involve public groups in their work.

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<sup>20</sup> These parties signed the position paper *Ruimte voor ieders talent - Naar een nieuwe balans in het erkennen en waarderen van wetenschappers* [Room for everyone's talent: towards a new balance in the recognition and reward of academics], which also includes impact as a key variable.

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### Box 5 New standards are needed

New forms of research sometimes follow new methodological paths, which requires new standards of quality and reliability.

In psychiatry, for example, it is more difficult to publish the results of research in collaboration with patients in reputable medical journals. Publication in these journals is an important quality check for the medical committees that advise the government and insurers on guidelines and reimbursable care. They have difficulty determining the reliability of research if the results do not appear in reputable journals, which means that research involving patients actually has less of an impact on society. This is exactly the opposite of what is intended.

Therefore new, socially relevant quality standards for research should be developed in consultation with the public, for example, by opening up quality control to civil-society partners.

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## 4. Make expectations explicit, reflect on and evaluate public engagement

Engaging public groups with research involves assumptions about how an activity will lead to results or outcomes. Sometimes these assumptions remain implicit. However, it is important to make these explicit, to base them on existing knowledge where possible, to reflect on them and to evaluate the result.

Assumptions are often made when the why, who, where, how and when of public engagement are being discussed (see Section 5). For example, in water quality research, it is often assumed that a higher level of water awareness is created when citizens take part in research (see Box 7). This is not always tested. The learning processes citizens go through as a result of their participation in research projects are still mostly unknown (Bonney et al., 2015; Ballard et al., 2017).

In addition to making assumptions explicit and substantiating them, it is also useful to reflect on engagement. The engagement process can be evaluated through surveys of participants, through focus groups and interviews or by making self-reflection part of the research process. There are several options for having multiple stakeholders collectively reflect on a research process (Metze et al., 2017). This makes it possible to make timely adjustments. The insights from the reflection can also help bring about effective forms of public engagement in future.

When evaluating a project, the direct output is important, as much as its societal impact. For the time being, public engagement initiatives focus mainly on efforts and activities whereas a picture of the wider impact seldom emerges (Mejlgaard et

al., 2019).<sup>21</sup> This wider impact is not properly evaluated. In educational research, for example, quality differences between schools may increase because some participate in academic collaborative centres while others do not. This unintended side effect should be part of the evaluation of the wider impact of public engagement.

### **5. Give citizens a say**

To achieve a science that is accessible to everyone, it is important that people have a say in what science investigates and how it does that. In general, the earlier the parties are involved in a research process, the better able they are to contribute. In this way, in consultation with researchers, public groups can have a say in the goal of the research, its execution and their own role in it. They can choose to be involved in formulating the research question or only contribute as a volunteer data collector. If those involved have a certain amount of influence on the research and their role in it, this will increase support for the research.

## **6.3 Scientists, engage society**

This review has shown that public engagement with science becomes more meaningful as it makes science more democratic. Meaningful engagement gives citizens or societal actors a say in the direction in which science develops. This results in new research questions and increased public support for science. Ultimately, science also produces more knowledge that is socially useful or otherwise valuable.

In our study we demonstrated that the debate regarding, and policy on, public engagement with science goes back decades. We found promising real-world initiatives where different forms of engagement are put to the test. It also became clear that engaging public groups with science is not yet standard practice. It is not always self-evident to invite public groups to the scientific table as equal partners in discussions with researchers.

In order to engage society on an equal footing and organise democratic knowledge development, it is important to encourage scientists to involve public groups in their work. It is necessary to make this collaboration attractive to scientists, citizens and societal actors alike. Scientists must be recognised and rewarded for this. For citizens, engagement must be accessible, inclusive and fruitful.

In addition, it has become clear that there is no instruction manual for organising meaningful public engagement. Public groups can make a different contribution in every field and in every type of research. The practical steps in this section are not

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<sup>21</sup> The MICS (Measuring Impact of Citizen Science) project is an EC-funded project to develop impact indicators. See <https://mics.tools/>

a recipe that anyone can use, with the right ingredients and preparation methods, to conjure up a dish of meaningful engagement. However, the steps do point in the right direction.

Our findings make it clear that the funding and other structures which organise public engagement with science need to be further developed. In the Netherlands, the Dutch National Research Agenda (NWA) is the most recent, concrete example of scientists being encouraged to engage public groups and of public groups being invited to engage with science. However, citizens and societal parties play a limited role in the selection of research proposals and the implementation of NWA research.<sup>22</sup> If this programme is continued or expanded, there will be plenty of opportunities to make the engagement of citizens and societal actors more meaningful. This will enable a larger and more diverse group of people to be involved in the programming, selection and execution of research funded by the NWA. Scientists applying for NWA funding can be encouraged to engage public groups by also assessing their proposals on the basis of this criterion and by helping them to do so in a meaningful way. Making the assumptions explicit and reflecting on the public engagement process could become part of the NWA's evaluation.

We began this review with a reference to the right to science, as expressed in the Universal Declaration of Human Rights, which states that every human being has the right to "share in scientific advancement and its benefits". For science to flourish and advance, scientists are needed who are free and autonomous, but who do not stand outside of society. Only when science actually works in tandem with society will it produce the benefits that we need: solutions to the challenges, both large and small, that we are facing together. For this reason, a practical search for meaningful public engagement with science is of fundamental importance.

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22 As explained in Box 3.



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