



Co-creation in practice: enabling multi-stakeholder collaboration in nanotechnology research and innovation

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Executive summary

Nanotechnologies and nanomaterials have served as a test bed for governance approaches to emerging technologies for over 15 years. Induced by both anticipation of new risk profiles and public concern, approaches such as Responsible Research and Innovation (RRI) aim at redistributing responsibility among all relevant actors to align their input closer to innovation processes. Here, co-creation appears as one potential approach to the inclusion of broader publics in state-of-the-art research and innovation activities.

Co-creating nano-related products, as pursued in GoNano, may therefore be considered as a bridging activity between the societal realm, research and innovation actors, and policy. Established practices and processes for research and innovation are routinised within the innovation system, which means that from the point of view of industrial stakeholders and policy makers or regulators, integrating input from the broader society may appear challenging.

This GoNano white paper identifies opportunities and challenges for co-creation in order to provide interested parties (e.g. industrial stakeholders and research organisations) with a hands-on guidance of what to consider when thinking about implementing co-creation.

The concept of research and innovation value chain is used in the report to illustrate pre-conditions, practices and benefits to implement co-creation in research and innovation.

In this context, product suggestions emerging from the co-creation process represent condensation points of discussion, rooted in actual challenges for innovation as identified by different actors. The resulting project ideas and objects may mobilise different actor groups so that they can concretely, and together, define directions of and limitations to research and innovation.

The seven GoNano recommendations for mainstreaming and implementing a co-creation process are:

1. Identify needs and entry points for co-creation

Be clear about what your co-creation experience should be about (topic) and what you are doing it for (objective).

2. Map the innovation context

Assess the state-of-the-art of research, the stakeholders and their interests, and contextual factors (e.g. regulations) that need to be considered in the research and innovation area where co-creation takes place.

3. Showcase the benefits of co-creation

Identify good practice examples of how stakeholders have benefited from co-creation. For example, better and more accepted products, networking opportunities, improved market shares, or more socially robust decision-making.

4. Implement a structured methodology

Reflect on your own requirements for co-creation beforehand, take into account the specificity of your own research landscape and organisation culture, and the variety of engagement practices available. Selecting a structured and suitable co-creation methodology to reach your objectives will make it easier. And then: do it!

5. Balance co-creation and research and innovation objectives in scheduling

Co-creation involves two different objectives: the first one aiming to include as much ideas, values, and concerns as possible to inspire new research trajectories; the second one to distil stakeholder inputs into

concrete suggestions for product development. Both approaches are needed, but it is crucial to find the right balance between them and align their outcomes to the different stages of the research and innovation process.

6. Ensure understanding between perspectives of researchers, stakeholders and society

Finding consensus on broad societal goals is usually rather easy – no one is against responsible innovation. However, the meanings of such terms may differ between actor groups, especially when their worlds hardly meet – as may be the case for a wider public and researchers or industries. Successful co-creation has to make sure to establish a respectful and trustful relationship between different actor groups as well as shared understanding and language.

7. Restructure the environment: Create a culture of co-creation

These tall orders as outlined above can hardly be carried out by researchers on their individual shoulders: collaboration and co-creation need to become mainstream practices in research and innovation and this implies overcoming a lack of incentive structures for researchers, confidentiality or IP limitations and other obstacles. So, if a change in culture is required, this needs fundamental rethinking of research practices, research funding, and incentive structures.

Introduction

Three GoNano white papers

The present publication is part of a series of three white papers developed by the GoNano project, covering different aspects of co-creation in research and innovation, with a focus on nanotechnology.

The white papers are intended as a knowledge repository for further GoNano communication activities. As such, they provide relevant background information with condensed GoNano findings. They also form the basis for six policy briefs and two industry briefs outlining the topics with policy and industry relevance.

The three GoNano white papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnologies. Each paper addresses the question of Responsible Research and Innovation (RRI) in nanotechnology research and innovation from a different angle.¹

- **White paper 1** explores the *opportunities and drawbacks of using co-creation* as a tool to enhance the responsiveness of nanotechnology research and innovation to societal needs and values. The white paper highlights the findings from the GoNano co-creation process and suggests five rules of thumb for prospective co-creation practitioners. It is mainly targeted at researchers, engineers and other stakeholders involved in research and innovation.
- **White paper 2** provides insights on *how to implement co-creation*, considering research as well as the innovation ecosystem. It addresses industrial and business partners, research institutions, and policy makers involved in research and innovation.
- **White paper 3** provides guidance on how to realise co-creation in the light of a *gender and diversity perspective* in order to better integrate these perspectives into nano-related research and innovation. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

GoNano project and goals

This white paper explores opportunities and constraints for implementing co-creation in nanotechnology research and innovation practice. It builds on the findings of the GoNano project, which is based on the assumption that several types of knowledge and expertise are needed to support co-creation towards sustainable, acceptable, and desirable applications of nanotechnologies. GoNano explored approaches that could be put into practice in different application areas of nanotechnologies (Health, Food and Energy), combining face-to-face citizen consultations, stakeholder workshops and online consultations (see Figure 1).

There has been growing interest in co-creation in recent years. Generally speaking, co-creation is defined as the practice of collaborative product or service development, as developers and stakeholders work together; or the joint creation of value by the company and the customer; or as allowing the customer to co-construct the service experience to suit their context.²

Co-creation as a method has been applied to research and innovation to achieve very different aims and objectives. Companies have used co-creation to encourage user-led innovation. Their aim is to put the needs of users at the heart of innovation. The Creator Space initiative launched by BASF, for example, aims to foster open innovation within the company.³

1. For more information on the RRI framework by the EC please see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>) (30-06-2020). For the aspect of responsiveness please see GoNano white paper 1.

2. For further information see GoNano D2.1(2018) or, for an illustrative example, see experiences of the Fonteer project: https://www.youtube.com/watch?v=VID2EyW5W_k

3. The Creator Space initiative brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes. Originally developed as a one-time initiative to celebrate the 150th anniversary of BASF, the Creator Space now forms an integral part of the company's approach to innovation (in this YouTube video, Elise Kissling, Director of the Creator Space frontend innovation program at BASF, reports on Creator Space: <https://www.youtube.com/watch?v=Y0JuOWO0hB8> (30-06-2020).

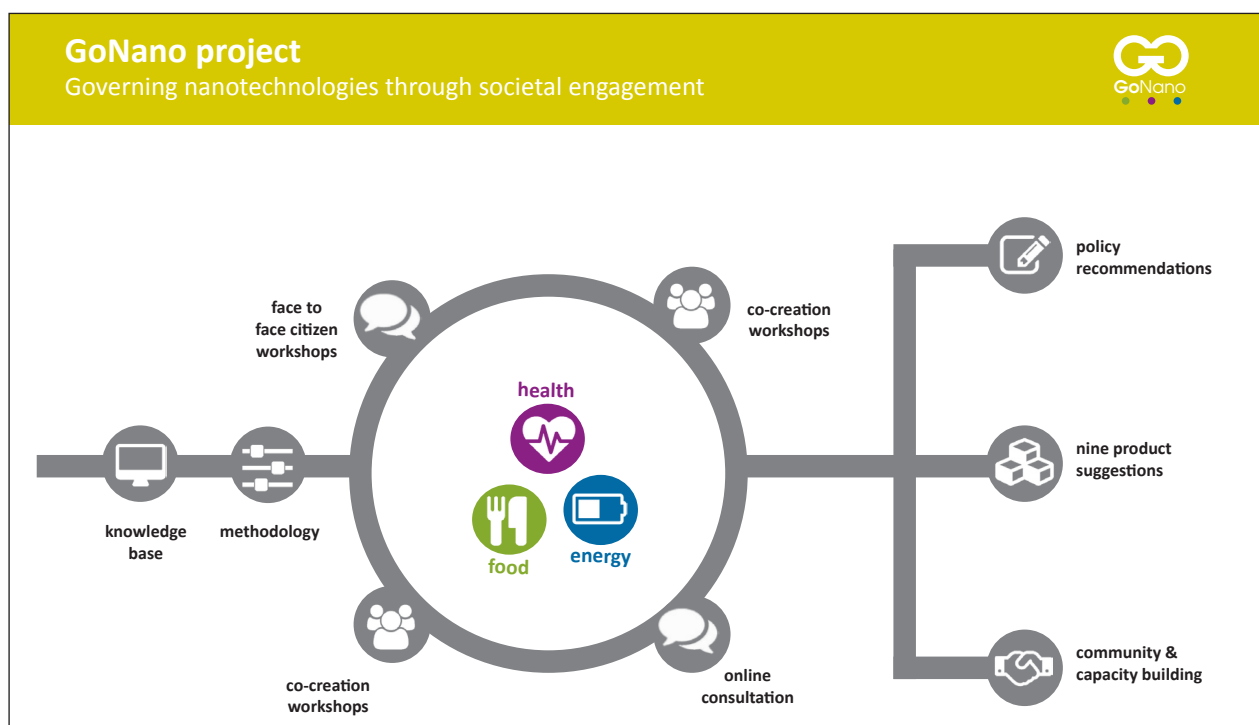


Figure 1. The GoNano co-creation process

Others have used co-creation to enable more democratic decision-making in research and innovation. The EU project Making Sense EU, for example, helped citizens to use academic technologies to make sense of their own environments.

Within the GoNano project, co-creation is applied to strengthen the ability of research and innovation processes to respond and adapt to changing demands. The underlying assumption is that research and innovation will be more socially robust if societal needs and values are considered in the early stages of innovation.⁴

GoNano defines co-creation as “activities [that] enable productive collaborations between researchers and societal stakeholders over longer timeframes, focusing on specific nanotechnology research lines, leading to tangible outcomes such as a new research avenue, proposal, product or prototype”. (GoNano D2.1, 2018)

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims to make research and innovation more socially resilient.

This requires new forms of collaboration that extend across disciplines and sectors.

GoNano established an iterative, four-step co-creation process to integrate societal considerations in nanotechnologies: the first step consisted of a series of citizen workshops (one in each of the three pilot countries: the Netherlands, the Czech Republic and Spain) where citizens expressed their wishes and concerns with respect to each of the application areas (health, food and energy, respectively).⁶ In the second step, the pilot partners organised co-creation workshops

4. Using low-cost, open-source technologies, Making Sense EU empowered citizens to discuss methodologies, devise data collection strategies for measuring air pollution, water quality or sound pollution, and interpret the results. It's a win-win project: scientists can use the datasets for their research, and citizens acquire tools to understand their environment and take appropriate action. In this YouTube video Frank Kresin, Managing Director of the Design Lab at the University of Twente, highlights Making Sense EU: <https://www.youtube.com/watch?v=au3uVptWJbU> (30-06-2020).

5. For further information, see this earlier report on the co-creation methodology for GoNano: D2.1(2018)

6. See GoNano D1.1(2018) and 2.1(2018) for knowledge base and the methodology developed in earlier stages of the project.

with stakeholders to explore ways to take the wishes and concerns of citizens into account in nanotechnology research and innovation. The results from this first stakeholder workshop were subsequently discussed in the third step of the co-creation process: an online citizen consultation to get responses from citizens from various European countries to the product suggestions of the first round of stakeholder workshops. The fourth and final step of the co-creation process consisted of a second round of stakeholder workshops organised in October and November 2019 in each of the pilot countries. These workshops explored how the product suggestions derived from the first workshops and subsequent input from the online consultation could be integrated in concrete research and innovation decisions.⁷

7. See the briefing report for further information on the outcomes of the citizen workshops. (GoNano D3.2, 2019)

Finding a place for co-creation in research and innovation processes

Nanomaterials and nano-based products have experienced a rapid development and a broad diffusion due to a huge range of applications during the last 15 years. Therefore, they provide a good example of what are known as Transformative or Enabling Technologies: technologies requiring a strong knowledge base for their development, together with intensive research and innovation and highly skilled human resources, showing a systemic relevance for all phases of product development, with the capacity to provide pervasive innovation throughout the economy and to enable new paradigms and processes, and which are strongly multidisciplinary and trans-sectoral (DG Research and Innovation, 2018).

These characteristics make the development of Enabling Technologies, such as nanomaterials and nanotechnologies, a useful opportunity to tackle grand challenges and responses to citizens' needs. At the same time, however, the rapid and large amount of disruptive applications they can enable may give rise to new (real or perceived) problems and concerns. Typical examples of this are the safety and health issues associated with the introduction of nanomaterials in products (e.g. cosmetics or food) and the governance of possible risks for the workers at manufacturing sites producing or employing nanomaterials.

Including stakeholder engagement in the research and innovation process could be a useful way to exploit the opportunities provided by new technologies while taking into account societal needs and concerns. GoNano experimented with the co-creation methodology as a way to incorporate stakeholder engagement into research and innovation processes.

Enabling technologies are characterised by a high degree of uncertainty at different levels, including scientific, technical, legal, social and market and consumer acceptability aspects. Investing in research and innovation requires a huge amount of effort, and by definition its outcomes are uncertain; this implies a degree of risk. Furthermore, effecting change in the development of a new product or solution becomes increasingly more expensive when intervening further up the Research and Development value chain, as is known from the Collingridge dilemma (Genus and Stirling, 2017; Collingridge, 1980). Looking at RRI all along the research and innovation value chain is thus fundamental, and co-creation and stakeholder engagement could play a central role to this end.

However, the challenge of co-creation is significant. All participants come to the table with their own assumptions and standard repertoires, which can compromise the willingness and thus the opportunities for mutual learning and co-creation. Such approaches provide the opportunity to broaden one's perspective beyond individual opinions by interaction. As a result, they may contribute to overcoming the widespread prejudice which perceives ethics or broader issues as hindrances to innovation processes (even if this is mistaken) (Tuncak, 2013).

As such, RRI and associated calls for responsiveness challenge the roles and responsibilities of researchers and redefines the boundary between science and society. In a sense, RRI - and the responsiveness that it purports to advance - can be viewed as a social innovation that is "gradually being articulated" (Rip, 2014). The social innovation is visible in the call for researchers to extend their roles and responsibilities to consider input from outside the research and innovation ecosystem and to actually act on this input, in order to adapt - and potentially reconsider- the direction and trajectory of the research and innovation process itself.

In order to align innovation with societal values and bring more value to people it is important to adopt a life cycle view, considering the entire research and innovation value chain, from the lab to the market and the end of life of a product (see Figure 2). Alignment to societal values calls for research and innovation processes that are able to look beyond the primary use and market and consider the entire product life cycle (GoNano D5.1, 2018; GoNano D5.2, 2019).

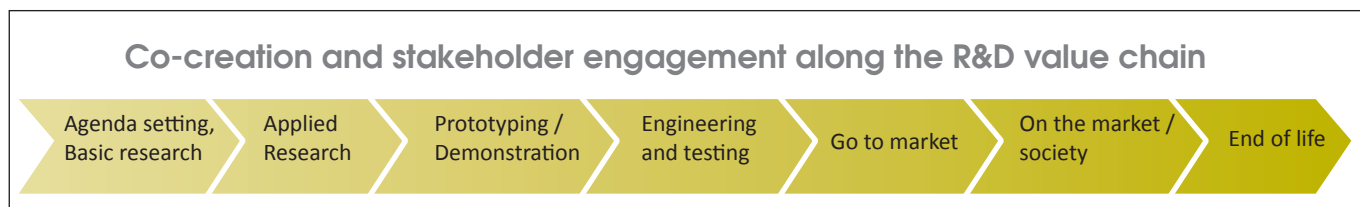


Figure 2: Research and Development value chain

Enabling technologies such as nanotechnologies are expected to have huge impacts on society, but this doesn't necessarily guarantee that the overall impact will be positive, that supposedly disruptive technologies will effectively succeed, or that companies bringing these solutions to the market will effectively reap commercial reward from it: their success will depend on their ability to provide real benefits for all. Including stakeholders' views in the development of technological innovations could be an effective method to increasing their acceptability.

In all phases of the Research and Development process, there could be positive implications to be further exploited or negative ones to be avoided from the societal, sustainability or economical point of view. Co-creation has the potential to foresee many of these implications, or at least identify them in a timely manner. Despite these added values of co-creation to connect and bring into contact multiple stakeholders, GoNano identified structural and economic issues that prevent the creation of productive connections between the stakeholders along the research and innovation value chain and impede the bridging of the gaps in the innovation process. This is a crucial point for policy and funders of research and innovation activities.⁸

This white paper proposes an overall framework to pursue the GoNano vision of co-creation (Figure 1) that identifies three levels of analysis:

- **essential elements for co-creation uptake in research and innovation**, as identified by GoNano experience
- **current conditions, barriers and challenges** in nanotechnology development that co-creation approaches could help to address
- **recommendations** to promote and perform co-creation in the research and innovation process

Objective of co-creation Aligning innovation with societal needs through more participatory and responsive approaches		
Elements for co-creation uptake in R&I	Gaps and challenges for co-creation in Nanotech R&I	Recommendations for co-creation in R&I
• Interact with the Innovation ecosystem • Enable citizens participation • Ensure awareness of participants • Provide feedback to stakeholders • Ensure responsiveness towards public and stakeholders concerns	With regard to Nanotechnologies • Safety • Transparency • Acceptability • Trust With regard to co-creation • Added value • Methodologies	• Identify needs and entry points • Map the innovation context • Showcase benefits • Implement a structured methodology • Balance co-creation and R&I objectives • Ensure understanding between different perspectives • Create a culture for co-creation

Figure 3. The framework identified in this White Paper to align nano-enabled innovation with societal needs through co-creation

8. Initiatives such as the report from the project Value4Nano (NANOfutures, European Technology Integrating and Innovation Platform on Nanotechnology, 2015) and the Re-finding Industry report have recommended the creation of clusters based on a European value chain approach (European Commission - Directorate General for Research and Innovation, 2019). Similar observations have been made by others.

Essential elements for co-creation uptake in Research and innovation

.... as identified by GoNano experience

Co-creation is a form of collaborative innovation where ideas are shared and improved together (GoNano D2.1, 2018). Essential actions/elements to obtain tangible outcomes from co-creation are:

- *multi-actor engagement*, to gather different perspectives in the Research and Development value chain and get access to the diverse range of skills needed to develop complex solutions based on enabling or disruptive technologies.
- *citizen participation*, in order to reassure citizens that their concerns matter and that their visions are important for the development of solutions.
- the consideration of the whole *innovation ecosystem*, including the stakeholders involved and their roles and relationships.
- instruments to provide *feedback* to the stakeholders involved, so they can appreciate the responsiveness of other stakeholders and the added value of the co-creation process.
- the *awareness* of the participants and their willingness to continue participating during the process.
- the *responsiveness* of innovators to the concerns, positions and perspectives of all other stakeholders.

Even when these essential elements are already present co-creation may be a challenging exercise, as shown by telling examples from the GoNano experience below.

"We knew what we wanted to do but didn't always manage to put it into practice, e.g. stakeholder workshops in Spain were attended by mostly researchers, despite seeking participation of all stakeholder groups." This, however, may also be related to the focus on trying out the method rather than starting from a pre-existing problem or opportunity.

(co-creation pilot on energy, Spain)

"It takes quite some time to understand the specific take on the development of nanotechnology in regard to expertise of the stakeholders, and the different aspects and views that these stakeholders bring to the table."

(co-creation pilot on food, Czech Republic)

"GoNano partners managed to bring stakeholders together with different backgrounds (research, industry, policymaking, CSO, and citizens) at the workshops, as they were interested in meeting other stakeholders or learning more about the co-creation process. However, it was difficult to ensure responsiveness, in a way that the suggestions that were being made during the workshops were taken up by them. Most of the stakeholders did not feel a sense of problem-ownership."

(co-creation pilot on healthcare, the Netherlands)

"Although some steps of the co-creation process at some point seem to bring less tangible results than the others, in the end all the results play similarly important role in making the process more valuable and useful for the stakeholders, citizens, and researchers behind the methodology."

(co-creation pilot on food, Czech Republic)

"During the Citizen workshop we had a first session about data management: ownership, sharing etc. We had a second loop during the first stakeholder workshop and we continued this topic a third time during the second stakeholder workshop. Then we focused more and more on data and diabetes 1. This iteration process was very effective"

(co-creation pilot on healthcare, the Netherlands)



“To discuss the topic of data management and diabetes 1, we not only have to talk with ICT technology people, but also with clients/customers, health insurance companies, doctors, and lawyers to assure that all specific elements are taken into account. Organize a co-creation workshop is complex and time consuming”

(co-creation pilot on healthcare, the Netherlands)



“The first stakeholder workshop included a number of various stakeholders from different backgrounds. It proved quite difficult to manage the expectations of all these actors. Moreover, it seemed challenging to manifest the added value of the initial input from citizens. A more focused approach, and a more sophisticated input – in the form of the results of the online consultation – seemed to be the key to manage the expectations and to bring more focused results during the second Stakeholder workshop.”

(co-creation pilot on food, Czech Republic)

Current conditions in nanotechnology development

... that co-creation approaches could help to address

Based on desk analysis and interviews with stakeholders GoNano identified some of the main challenges of nano-enabled innovation⁹ (GoNano D5.1, 2018; GoNano D5.2, 2019). Table 1 shows a selection of them, that need to be considered when designing and performing co-creation for this technology. The aspects that co-creation processes might help to address are highlighted in *italics*.

Areas	Specific challenges and potential anchor points for improvement *
Regulatory and safety aspects	• Standardisation, classification and definitions of nanomaterials • Health and environmental impacts • <i>Regulatory preparedness: discrepancy in pace between technology development and safety testing/risk assessment of nanomaterials and a resulting lack of regulation</i> • Lack of social debate on regulatory and safety aspects
<i>Ethical, social and environmental aspects</i>	• <i>Acceptability, risk perception, sociological aspects</i> • <i>Equity and justice in access to new technologies</i> • <i>Environmental and sustainability aspects</i>
Strategic and systemic aspects	• <i>Structural, cultural and economic issues preventing connection of stakeholders along the R&I value chain and impeding the connection from research to market (e.g. how to support SMEs in open innovation processes)</i> • <i>Mainstreaming of RRI (innovation eco-system)</i>
Communication aspects	• <i>Absent or misleading information on nanotechnology; fear of nanotech; considering cultural differences. How to provide balanced information to citizens on use of nanotechnology</i> • Tangibility of nanodebate: Avoidance of negative effects of a single nanomaterial could influence reputation of nanotechnology as a whole • <i>Distinction between nanomaterials and nanotechnology in public debate</i>
Institutional and policy aspects	• International harmonisation
Scientific and technological aspects	• Challenges of collecting adequate scientific data for characterisation and safety • Sharing of scientific data, including sharing and harmonisation of modelling tools
Economic and market aspects	• Cost-effectiveness of the fabrication and scale-up of nanomaterial-based technologies • Affordability of technologies and innovation

Table 1: Major issues and gaps in nanotechnology development

* marked in italic: through co-creation processes

9. With reference to the topics included in this section, it is important to underline that three large EU projects (Gov4Nano, Nanorigo and RiskGone) are now exploring a harmonised approach to these aspects with the aim of developing establishing a European Council for the Risk Governance of Nanomaterials (for further information see GoNano D5.2,2019).

Co-creation is not expected to contribute to all these areas, but this provides an idea of the innovation context for nanotechnology and of the different issues that various stakeholders may have to deal with. Co-creation could become a useful methodology to address some of these issues, for example helping to achieve regulatory preparedness by bringing together disparate fields of expertise or developing nanotechnology risk governance approaches by improving collaboration between actors along the value chain (producers, downstream users, risk researchers, regulators and civil society). A clear identification of the innovation context for nanotechnologies, together with the interaction with various stakeholders, allowed us to identify specific challenges for co-creation. As indicated in the table above not all of the areas are likely to be improved by co-creation, but they nevertheless fundamentally define the context or final outcome of research and innovation processes.

Specific challenges

...with regard to nanotechnologies

Based on the issues outlined above, nanotechnologies and nanomaterials are considered differently across industrial sectors and by different stakeholders. Therefore, a common understanding needs to be established in terms of:

- how to deal with uncertainties, mainly related to technical and scientific aspects, normative issues, ethical, social and environmental implications, and strategic and systemic aspects of research and innovation that all stakeholders along the research and innovation value chain face to some extent
- the state of the art of research activities and debate around the safety of nanomaterials and a normative framework for nanotechnologies
- the ambiguity of the debate around nanotechnologies, which is probably due to gaps in sharing of information among the different actors of the research and innovation value chain and to a shortage of reliable and acknowledged sources of information in the field (transparency)
- the difficulties in expressing, understanding and considering the needs, concerns and expectations (and perception of risks) of stakeholders (in particular citizens) in the course of nanotechnology development. This holds especially true for materials which involve radical innovations and are likely to have a significant impact on people and society (e.g. healthcare). In short, the issue of trust in nanotechnology innovation (by citizens, as well as by partners, suppliers, business operators and other stakeholders along the research and innovation value chain).

A lack of consideration of these aspects can easily polarise debate, hamper the relationships between stakeholders or cloud the dialogue with citizens. As a result, innovations can experience a slowdown or be side-lined. While there might be other reasons to be considered here (as required under RRI), the most important ones may come from the innovation stakeholder perspective.

... with regard to co-creation

The GoNano experience shows that there are challenges related to the implementation of a co-creation approach as such. In particular:

- a lack of awareness about the potential benefits of co-creation, which is associated with a lack of convincing and inspiring examples of how to include societal aspects and stakeholders' views in the development of new innovations. This then frequently results in overconfidence in one's own perspective and capacity to assess all aspects of the innovation process. The issue is therefore how to demonstrate the added value of co-creation approaches for innovation, in order to persuade research and innovation actors to use and implement such an approach.
- lack of acknowledged and good practices for co-creation. Providing good examples or finding testimonials and "ambassadors" (who have already experienced co-creation) could reduce initial scepticism and improve stakeholders' confidence, and it could also reduce the likelihood of barriers and expectations regarding co-creation being either underestimated or overestimated.

Co-creation projects are still in their infancy as a means of developing knowledge for social purposes. Most existing co-creation projects work on a local scale, seeking practical solutions that work for a specific product and service and for a specific organisation.

The following section identifies some of the existing conditions that make a case for increased efforts to introduce co-creation and stakeholder engagement approaches along the value chain on both organisational and systemic levels. These conditions are summarised in the second column of Figure 3.

To identify the areas of action for co-creation, there is a need for changes at the level of internal activities of organisations (e.g. commitment, relationships or procedures¹⁰), of cooperation throughout the innovation ecosystem (e.g. through policies or relationships involving more stakeholders or the public), and of policy actions. Suggestions from the GoNano experience are reported in the next section.

10. See also GoNano white paper 1: Rule of thumb 'Enhance potential for recognition of opportunities'.

Recommendations for actions to enable co-creation

The following recommendations have been derived from the GoNano findings. They may offer some support to those who would like to organise future co-creation processes along the research and innovation value chain, increase added value for all the stakeholders involved, and facilitate RRI-friendly conditions.

As co-creation is a complex approach requiring synergies between different functions of the organisation and stakeholders, adopting a structured management process could help to deal with it.

RECOMMENDATION

1

**Identify needs
and entry points
for co-creation**



WHY?

It is important to collect, understand and consider the needs and views of the different stakeholders who are to be involved in the co-creation from the very early stages of the process, as the goal is to provide concrete added value to each stakeholder, thus motivating them to take an active part in the co-creation process. This will also make it possible to provide a better focus for the different phases of the process.



HOW?

Each organisation along the value chain should identify the research and innovation topics and motivations that are a priority for co-creation purposes, selecting areas where the organisation could provide valuable inputs and areas where the organisation needs to receive data and information from the co-creation process.

Specific recommendations to identify needs and areas of action for co-creation are:

- Highlight the most interesting points to debate for each stakeholder (e.g. interests, needs and concerns)
- Identify criteria to prioritise topics/areas for stakeholder engagement
- Identify where in the value chain the co-creation could be most useful
- Select stakeholders to be involved in different co-creation phases
- Provide clear indications about the focus and priorities of co-creation actions

Initially, GoNano consulted selected stakeholders (interviews) about their needs and views in order to inform the co-creation process. This action explored aspects related to the most significant ethical and social issues to debate, the added value of co-creation, and the type of stakeholders to involve. Most of the results of this exercise are quite specific for the type of application and sectors considered. As an example, the needs and concerns of stakeholders identified in the case of application of nanotechnologies in the health sector are reported in the figure below.

Moving to a systemic level, this will make it possible to draw up a list of key areas or topics that are relevant for the solutions being developed and for the stakeholders involved and will help identify those most relevant for the debate. A set of criteria could serve to prioritise the topics.

Stakeholder engagement should cover the whole research and innovation value chain and may have different purposes for and involve different stakeholders. There could also be, for example, different sessions along the same co-creation process targeted to different steps of the value chain.

At a systemic level, it should always be made clear to which stage of the value chain the respective stakeholder engagement is referring, while each organisation should clearly identify the important value chain steps to select the appropriate session or initiative.

The GoNano experience with one of the stakeholder workshops (GoNano D4.2, 2019) in the Dutch pilot highlighted that in that case participants had difficulty distinguishing the prototyping session from the ideation process, while in another workshop the purpose of the session was not clear. Such confusions can be avoided. In order to move the co-creation session forward from the ideation phase to the prototyping phase, a specific problem or goal should be defined. Preparation is crucial in this regard, and interviews with stakeholders before the workshop could help to establish a framework in which stakeholders are asked to come up with suggestions for action.

(co-creation pilot on healthcare, the Netherlands)

RECOMMENDATION

2

Mapping the innovation context

! WHY?

In order to contextualise innovation, it is crucial to identify the Research and Development priorities of the sector in question. This can both provide a general idea of what innovators are considering at the present time and inspire possible future scenarios in the sector. The GoNano literature review and experience with stakeholder interviews and with citizen and stakeholder workshops confirmed that nanomaterials and nanotechnologies can contribute to providing solutions and products to address societal challenges as well as public and stakeholders' needs in the three areas considered: Food, Health and Energy.

"To map the innovation context seems to be crucial as the first step of the co-creation process – to be able to identify the application areas that seem to be most promising to be used in the near future. However, even in these specific areas, their perception may be ambivalent. On the one hand, the nutrition/novel foods application area was perceived as the most promising area connected to many expectations (citizen workshop). On the other hand, the very same application area was connected to the highest safety risks and difficult implementation in concrete products during the second stakeholder workshop."

(co-creation pilot on food, Czech Republic)

Nanotech R&D priorities Emerged from GoNano literature review, interviews and workshops		
Food • Packaging • Safety & Security • Nutrition	Health • Therapeutics: targeted and personalized drug delivery and theranostics • Diagnostic/imaging: efficient fast and site-specific monitoring • Regenerative medicine	Energy • Energy storage • Advanced photovoltaics and CPV • Wind • Renewable heating and cooling • Multi-application components

Figure 4: Nanotech Research and Development priorities (see GoNano D1.1, 2018 and 1.3, 2018)

🔧 HOW?

A context analysis of the innovation eco-system in which co-creation is taking place should be performed, to inform and inspire both the planning and the implementation phase of the co-creation process. Context analyses need to explore a series of elements, such as the ones outlined in the table below as used in the GoNano project.

Recommendations on how to analyse the innovation context are:

- Identify research and innovation priorities in the field
- Identify the research and innovation value chain
- Map the stakeholders in the innovation ecosystem (including end-users)
- Highlight type of business, market aspects, trends and consumer attitudes
- Identify relevant regulatory aspects

As a value chain approach is recommended, it is crucial to identify and map all stakeholders (including the end-users) in the respective innovation ecosystem, i.e. highlighting their interests, relations, needs and concerns. It could also be useful to consider the type of business, the specific market characteristics, the trends and the consumer attitudes. Specific attention should be paid to identifying and analysing the regulatory aspects that could influence the innovation.

The GoNano project performed an analysis of these aspects with a specific focus on the three target sectors (Food, Health, Energy), as reported in (GoNano D5.1, 2018) and (GoNano D5.2, 2019). This analysis showed that issues of safety, regulatory constraints, stakeholder attitudes are quite relevant in the development of nano-related products.

RECOMMENDATION

3

Showcase benefit of co-creation

“One of the important points to emphasize seems to be that nanotechnology in itself is connected to various fields of expertise: from biotechnology, materials science, conservation of food to circular economics. If not for anything else, the main benefit is that there is a topic which brings all these actors to one table and ensures that there is a possibility to come up with as complex solutions to current problems as possible.” In addition to this, some agreements about future collaboration were reached with the participants present at the workshop.

(co-creation pilot on food, Czech Republic)



WHY?

Our analysis suggests that individual researchers can benefit from opening up to broader perspectives. Extending partnerships beyond the usual suspects to include a broader range of stakeholders could both create new business opportunities and function as early warning for potential problems further down the line.

It also allows researchers to modulate research trajectories as they unfold, rather than after they are established (for more information see the GoNano Website).¹¹



HOW?

In order to motivate less experienced stakeholders to participate in co-creation processes, particular strategies may be deployed. However, the challenge in this process is to educate/inform the participants without undermining their values and concerns.

“Stakeholders repeatedly emphasised that the main benefit of the co-creation process is that they can meet and discuss ideas or products they work on with experts with a completely different perspective, and that these meetings and exchanges of ideas are something they lack. During one of the workshops, a representative of a state said that this was the first time they had met at one table various actors actually engaged in the development of specific products.” co-creation pilot on food, Czech Republic)

According to the developer of the artificial pancreas, for which a data-management plan was formulated, the outcomes of the workshop “improved the foundation of their product as there were some new aspects discussed they hadn’t thought of before”.¹²

The developer of the early diagnostic device for which an implementation plan was discussed evaluated the outcome as something that supported their initially somewhat vague ideas, which had since become much clearer. They thought the discussion with participants from different backgrounds was “very stimulating and motivating”.

Another example was derived from collaboration with a post-doctoral researcher at the start of their research trajectory who was focusing on the diagnosis of cancer based on specific proteins. By discussing their proposal with different stakeholders along the value chain, the researcher got new insights into how to further develop their research. These included reshaping the demand for their research by talking to other stakeholders. For the post-doc researcher, the workshop exceeded their expectations as they got a “more concrete understanding of what steps to take and what steps not to take during the rest of their research”, which helped them “to build the next three years of my research life”.¹³

Recommendations to showcase benefits of co-creation:

- Researchers should be informed as to the rationale of co-creation, that is, why they should be involved in co-creation exercises. Innovators, including researchers, may be unaware of the implications of demands for sustainable, desirable and acceptable advances in science and technology for their innovations and processes. Co-creation events offer opportunities for the articulation and deliberation of the needs and concerns of society and contribute to the development and embedding of new, more desirable advances.
- Provide examples to clarify how stakeholder engagement can enhance both the quality and the societal value of research and innovation. Additional efforts are needed to make existing experience more accessible and actionable, with respect to when and where stakeholder engagement makes sense and how it can be organised.

11. Please see: https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P_PU_m-d [2019-01-16] (30-06-2020).

12. Please see: https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P_PU_m-d [2019-01-16] (30-06-2020).

13. Please see: https://www.youtube.com/watch?v=1UbBVtbiNdM&list=PLI2-pUcVlb7Mub_FgxtwLpQZCzbHHZBOW&index=4&t=1s (30-06-2020).

RECOMMENDATION

4

Implement a structured methodology for co-creation

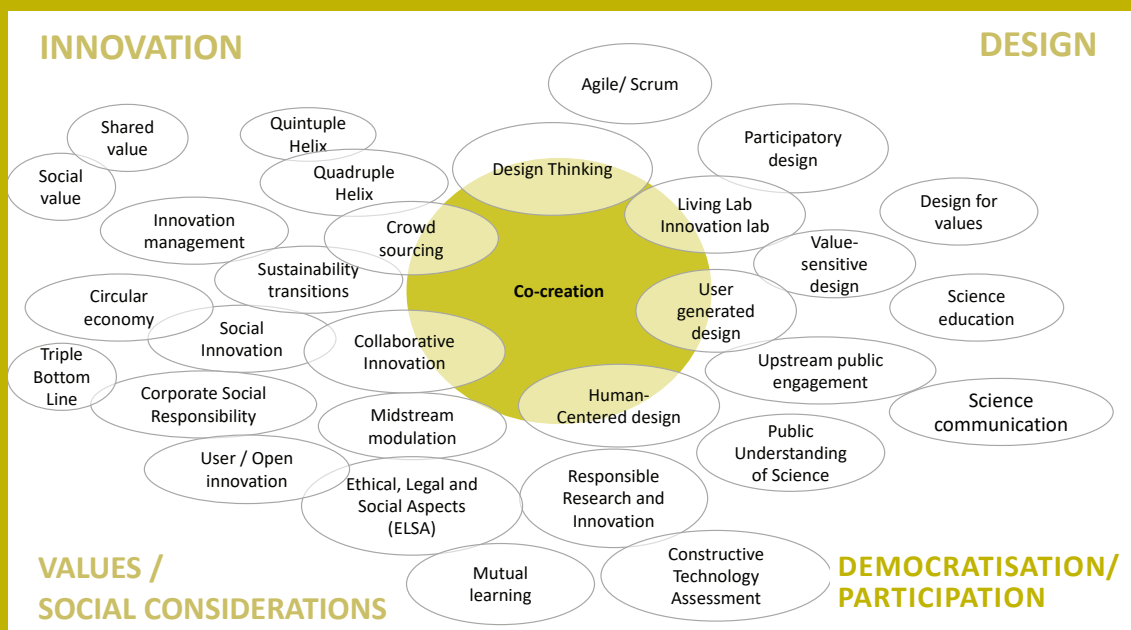


Figure 6. Positioning of the concept of co-creation between all existing methods of public and stakeholder involvement

WHY?

The objective of the co-creation process is to bring together very different views and perspectives, taking into account a variety of issues about the specific technology or innovation and considering that stakeholders often speak completely different ‘languages’. Accounting for the various perspectives, in a space where all stakeholders feel safe to express their views and where these views are heard and considered, requires deliberate consideration of obstacles and the limitations and interests of all groups involved, which, in turn, requires approaching the process with a clear sense of how to overcome these hurdles. Therefore, it is essential to have a structured and well-defined methodology in place, that will ensure a smooth and effective co-creation process.

HOW?

Although there are many methods out there (see figure 6 below), the right choice and implementation is crucial and hence needs adequate consideration. The notion of co-creation (and stakeholder engagement) is an umbrella term that groups together a wide range of activities on different levels, from formal social dialogues at the European level, to living labs at the local level and human-centred design approaches within individual organizations, just to provide some examples.

Organisations aiming to implement co-creation approaches should analyse and identify the most suitable methodologies for the specific Research and Development value chain stages and actors. GoNano explored a series of methodologies for co-creation provided in the literature used by different stakeholders and developed and tested its own specific methodology.

Recommendations about the methodology for co-creation are:

- Plan your co-creation process in advance, including timeline, type and purpose of engagement activities, recruitment strategy, guidance for participants, templates for reporting, follow-up initiatives
- Search for good practices available in literature
- Engage with experts to provide you advice and assistance in the co-creation process
- Develop Key Performance Indicators to regularly monitor and improve the efficiency and efficacy of the co-creation process

The GoNano project designed a recruitment strategy, workshop manual, and information material tailored to the needs of citizens and stakeholders (GoNano D3.2, 2019). This suggests that it is important to have a structured methodology to follow in a stakeholder engagement process. The methodology could be developed by the organisation itself, but the advice of external experts is recommended in order to focus the objectives and maximise the outputs, in particular when the number of stakeholders to be involved or their heterogeneity increases.

Experts could be, for example:

- A facilitator who understands the topic, the process and how to facilitate open and constructive discussions
- An organiser, who has a broad network and is creative in combining the very best stakeholders for this methodology
- Co-creation experts, who understand the process and know which tools are available and suitable for various steps
- Experts from other fields, such as an illustrator to make visual notes who is able to translate and visualise the various steps for final presentation, for next steps and/or for dissemination activities.

Moreover, GoNano engaged an external advisor to perform an assessment of the co-creation process, based on tailored key performance indicators. These included qualitative and quantitative indicators to measure the efficacy and efficiency of the co-creation process, monitored by surveys and interviews to partners and participants of the co-creation initiatives. Regular feedback was provided to partners by the external advisor in order to improve the impact of GoNano activities (see GoNano D8.3, 2019).

RECOMMENDATION

5

**Balance co-creation
and research
and innovation
objectives**



WHY?

The GoNano experience highlights a contrast between two different rationales for co-creation: “opening up” and “adding value”. The first rationale seeks to include heterogeneous stakeholders (including those not normally included in research and innovation), with the aim of brainstorming about possible future applications and collecting as many values and needs as possible in order to inspire new possible research trajectories. The second rationale is a convergent process involving more specific stakeholders (such as prospective users) with the aim to focus research trajectories towards concrete products and improvements (e.g. making them more efficient, cheaper or more resilient).

While ‘opening up’ is essential to collect societal inputs, ‘adding value’ is essential to translate this knowledge in products that will return value to society. Both are needed for a co-creation process that seeks to align research and innovation with societal needs and values: focusing only on “opening up” will result in a theoretical exercise, while focusing only on “adding value” would pre-empt the responsiveness of the innovation process. See also GoNano D4.4, 2020, p.20: *“Both rationales have played a role in the design of the GoNano project and the results of the workshops suggest opportunities for both. For instance, the consideration of the wishes, needs and messages from citizens during the first stakeholder workshop suggest how research trajectories can be ‘opened up’ to societal considerations. [...] However, the GoNano experience suggests that perhaps it is too much to expect both objectives to be addressed simultaneously. [...] The desire to ‘add value’ to concrete research lines may come at the cost of ‘opening up’ research and innovation, and vice versa.”*



HOW?

Recommendations on how to balance co-creation and research and innovation objectives are:

- to combine stages of ‘opening up’ and ‘adding value’ in an iterative way.
- to align the different phases with the different steps of the research and innovation process (also considering the issues to be addressed in the different phases and the stakeholders to be involved).
- to guarantee continuity of the co-creation process in parallel with the research and innovation process, for example by ensuring that the results of a previous phase are usable in the next phase (if suggestions from citizens are formulated at a high level of abstraction it is crucial to translate them in intelligible requests for developers in the prototyping phase) (see also white paper 1).
- to use adaptive approaches to the co-creation process, for example using the outcomes of an initial step to design the next steps (in terms of objectives, stakeholders, and expected outcomes).

The multi-stakeholder conversations during the first stakeholder workshops indicated that research trajectories can be effectively opened up to societal needs and values. The second stakeholder workshops suggested how societal needs could add value to the development of specific products, as for example in the case of the wireless sensor nodes for the future Internet of Things discussed in the event on energy held in Spain. Hence, both rationales have played a role in the design of the GoNano project. However, the GoNano experience suggests that perhaps it is too much to expect both objectives to be addressed *simultaneously*. Ideally, co-creation processes iteratively combine activities towards ‘opening up’ and ‘adding value’.

RECOMMENDATION

6

**Ensure understanding
between perspectives
of researchers,
stakeholders and
society**

WHY?

Translation of needs and perspectives of stakeholders within and between different stakeholder groups such as researchers, industry, and citizens are key to identifying potential social impacts of research and innovation, and translating them into research questions to address.

It is important to consider how to translate societal considerations into information that can have a bearing on concrete research decisions, as societal feedback might not fit frictionless into research scope, either because it is frequently not concrete enough or because it might lead to contradictory responses.

HOW?

From the citizens' side, insight into the individual, day-to-day decisions being taken in nanotechnology research and innovation is required (and respect for the limited room for manoeuvre at that level). From the researchers' side, an understanding of public perceptions of and attitudes towards nanotechnologies is important, as well as an understanding of the rationales underpinning them. From the industrial side, it is important to clearly communicate what information can be shared with others and what cannot be shared, e.g. due to confidentiality issues, to understand public perceptions with respect to the industrial development process and its mission and values, and also to assign the right priority to citizens' requests.

It is crucial for the process to allow participants to build a relationship and develop a shared language in which their contribution to the problems at hand can be meaningfully expressed. Similarly, the capacity to translate needs and concerns from the social realm into practical options in the technological realm in real time is essential to the success of the process.

These are tall orders indeed, but this is exactly what needs to happen to realise the policy prescriptions underlying the notion of Responsible Research and Innovation and the Science in Society movement in general: *“to encourage actors in their own disciplines and fields to participate in developing Science in Society perspectives from the very beginning of the conception of their activities.”* (European Commission, 2007)

More specific recommendations to ensure understanding between the different actors involved, and more in general to improve the efficacy and efficiency of the co-creation process, are described in GoNano white paper 1 and 3. These include suggestions on how to design co-creation processes to take into account gender, diversity and culture aspects, and how to increase motivation, recognize opportunities and build trust among participants of the co-creation process.

RECOMMENDATION

6

**Create a culture
of co-creation**

To facilitate the changes necessary to promote the consideration of ethical and social impacts, and to pursue co-creation, changes need to be made to research cultures and to the incentive structures of researchers. This point is crucial in research organisations (public or private) as well as in industry while realizing that these aspirations may still be developing in practice. Therefore, this recommendation can be considered an attempt to promote mainstreaming of co-creation practices.

WHY?

GoNano's work on taking stock and reviewing prior findings and engagement processes (GoNano D1.1, 2018), as well as integrating stakeholder perspectives (GoNano D1.3, 2018) has delivered an analysis of the current status of the RRI landscape. In the synthesis with the GoNano experiences (as outlined in (GoNano D4.4, 2020, p.32), the project *“has revealed important insights into the requirements for a more responsive research and innovation system. What is ultimately at stake in the question of enhancing responsiveness is the very way in which we understand innovation - from static, closed linear models towards responsive innovation that addresses the pressing societal challenges of our time. (...) The question is how to enable new models of innovation that integrate societal considerations earlier and more effectively in the research and innovation process. These insights align well with the findings of other European projects: they point to opportunities and preconditions for strengthening responsiveness, but they also highlight the complexities of promoting cultural change in research and innovation systems.”* (GoNano D4.4, 2020).

Among the projects identified, especially the RRI-Practice project¹⁴ has investigated the role of RRI in research funding and research performing organisations and reflected on the barriers and drivers regarding RRI in these organisations. The project found that, while responsibility norms associated with research (e.g. research ethics, integrity and open access) were, generally, established and codified in most of the organisations, the additional responsibility implied by RRI – including responsiveness – tended to be poorly articulated and codified in the organisations.

There was *“very little evidence of knowledge co-creation and co-production that accord with the EC's broader definition of and ambition for RRI”* (Owen et al., 2019, p.3). Although there was evidence of some “small scale, creative and inspiring experiments, these tend to be modest, time-limited and not routinely or systematically embedded and sustained in organisations” (Owen et al., 2019, p.3). This was due to a number of major barriers including entrenched norms, political pressures and priorities, *de facto* reward structures that do not take this kind of work into consideration, and a lack of training and infrastructure. At the same time, one sees the introduction of external forms of responsibility thinking (around integration and other similar notions) into organisations via specific organisational activities, projects or funding initiatives without significant conflict, while internal orientations rooted in the “republic of science” model remain dominant in overall practice, structures and cultures (Hennen et al., 2019). Another important finding of the RRI-Practice project concerns notion of excellence and impact that condition performance evaluation and criteria for career progression at organisational and national levels (Owen et al., 2019). The project encountered narrowly defined understandings of research quality and excellence that are at odds with calls to do RRI or to be ‘responsive’, as RRI is viewed as diverting attention and time from the pursuit of excellence.

It is important to identify and highlight the added value for each stakeholder in the innovation ecosystem. Inside the single organisation, the individual evaluation should include criteria that include the ability to integrate different perspectives and being responsive.

14. [https://www.rri-practice.eu/\(30-06-2020\)](https://www.rri-practice.eu/(30-06-2020)).



A tension exists between the de facto incentives and disincentives that form the basis of the science system and new funding mechanisms that promote efforts to address grand societal challenges through interdisciplinary and cross-sectoral research, including co-creation. While research funders continue to promote such collaborative initiatives, evaluations of researchers and research are still predominantly based on criteria of scientific excellence or the marketability or valorisation of research . Thus, funders have a key role to play in reconfiguring both the incentive structure and the corresponding evaluation mechanisms in the research system. Currently, there is no reward for engaging stakeholders in the research system . Without a clear mandate or obvious benefits, it may prove difficult to embed stakeholder engagement in the everyday practice of European research and innovation.

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