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DELIVERABLE

4.4

Final report on the insights and lessons from the engagement activities

GoNano Deliverable 4.4

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EXECUTIVE SUMMARY

This report provides an assessment of the co-creation process established by the European project GoNano (Governing Nanotechnologies through Societal Engagement). It aims to integrate the insights and lessons learned over the course of the project, reviewing findings from the knowledge base and methodology developed in the early stages of the project and the results of a series of engagement activities organised in the Netherlands, the Czech Republic and Spain from October 2018 to November 2019. The report considers how the various project activities have contributed to the specific objectives of the GoNano project as well as the overall aim to improve the responsiveness of research and innovation processes to public values and concerns.

GoNano sought to design and implement a co-creation process that aligns nanotechnologies with societal needs and values. The co-creation process aimed to derive concrete suggestions from a deeper understanding of the needs and values of European citizens, and to explore the potential commercial value of integrating societal considerations in nanotechnology research and innovation. To realise these ambitious objectives, the project partners have produced a wealth of information on research and innovation policy, public engagement and co-creation in nanotechnologies.

The overall co-creation process spanned a wide range of activities across Europe. All in all, the workshops have mobilized 249 participants around co-creation in nanotechnologies. Moreover, 46 interviewees from 14 countries have provided their views on nanotechnologies and engagement in the initial stages of the project, 893 respondents from across Europe have commented through an online consultation on the product suggestions resulting from the workshops, and 198 persons responded to the evaluation questionnaires and interviews.

The overall GoNano experience has elucidated opportunities and challenges of co-creation as a tool to enhance the responsiveness of research and innovation. The findings of the GoNano co-creation process confirm that with some effort and careful preparation, it is possible to demonstrate to stakeholders that it does make sense to look at the broader dimensions of research. Participants valued the general opportunities for mutual learning and networking. However, getting from constructive dialogue to practical action remains a significant bottleneck: there is a gap between the appreciation of broader issues around research and innovation and the actual integration of those issues in daily research practices.

The GoNano experience suggests that co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, 'translate' needs and concerns from the social realm to practical options in the technological realm, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

Aligning research and innovation to societal needs and values is not just a matter of deciding what sorts of future applications European citizens and stakeholders *want and need* (which is difficult enough, given widely divergent responses). It is also a matter of *practically realising* the desired change. Due to the relative autonomy of the research and innovation system, calls for responsiveness will need to identify the win-win opportunities where 'doing good' and 'doing well' coincide.

1. INTRODUCTION

This report provides an assessment of the co-creation processes established by the European project GoNano (Governing Nanotechnologies through Societal Engagement).[1] It aims to integrate the insights and lessons learned over the course of the project, reviewing findings from the knowledge base and methodology developed in the early stages of the project and the results of a series of engagement activities organised in the Netherlands, the Czech Republic and Spain from October 2018 to November 2019.

The overall objective of the GoNano project was to improve the responsiveness of research and innovation processes to public values and concerns.[2] GoNano brought together researchers, professional users, civil society organisations, industry and policy makers in a process of deliberative workshops and online consultations around three nanotechnology application areas (health, energy and food) to co-create concrete suggestions for future nanotechnologies.

The GoNano project has defined the following specific objectives for the co-creation process:[3]

1. To showcase an early-stage, state-of-the-art continuous citizen and stakeholder engagement process which takes into account gender and differences in culture and communication traditions across the EU.
2. To develop concrete product suggestions for future nanotechnologies in three nanotechnology research areas (health, food and energy) which are aligned with societal needs, values and concerns.
3. To establish a community of citizens, consumer and interest organisations, researchers, engineers, and policy makers working as change agents for Responsible Research and Innovation in nanotechnologies.

The next chapter will summarise the various project activities undertaken to implement these objectives. Chapter 3 will subsequently review how these activities have contributed to achieving the objectives of the project.

[1] See: http://gonano-project.eu/
[2] GoNano Part B, version 27-11-2018, p.5
[3] The original GoNano Grant Agreement lists 6 specific objectives; this report reviews the objectives which are directly related to the co-creation process.

2. The GoNano co-creation process: knowledge base, methodology and engagement activities.

The GoNano project started in September 2017 by developing a knowledge base, stakeholder network and co-creation methodology. Building on the knowledge base and methodology, an iterative, four-step co-creation process was developed to align research and innovation in nanotechnologies with societal needs, values and concerns. The co-creation process combined face-to-face citizen engagement, stakeholder workshops and online consultations (see Figure 1).

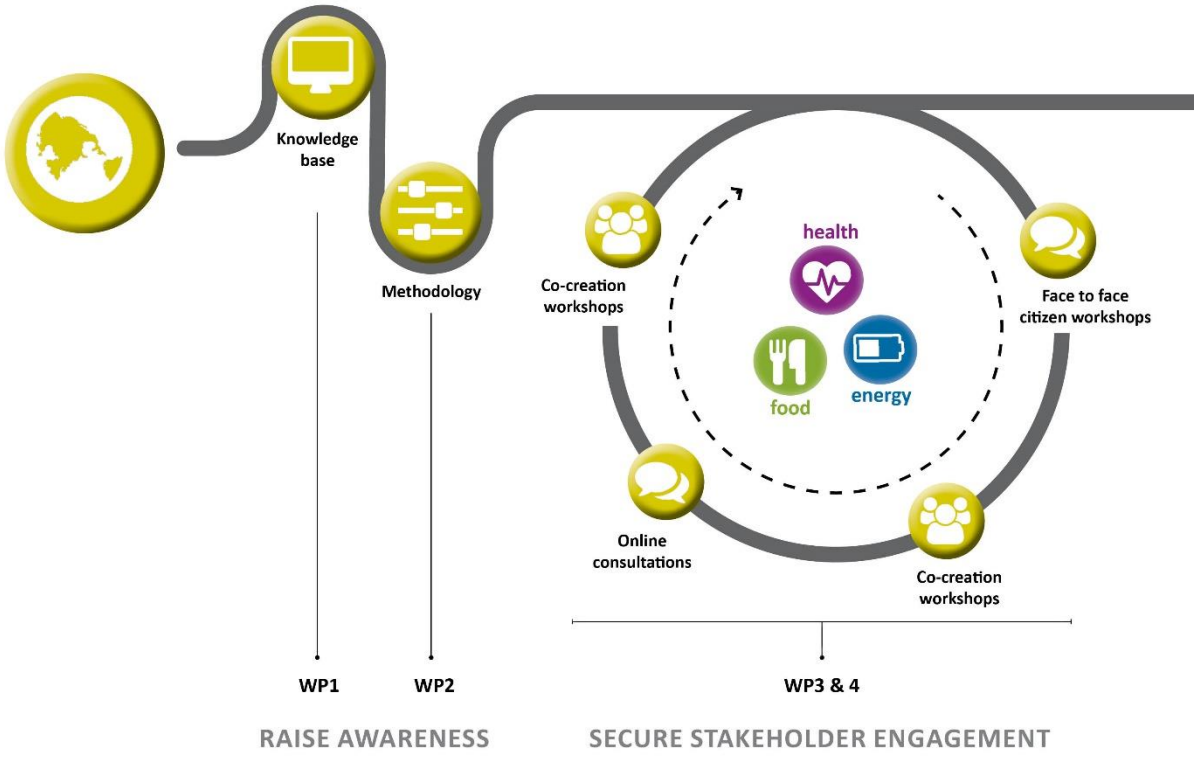


Figure 1 – Overall design of the co-creation process in GoNano

2.1 Building the knowledge base

The knowledge base was built on an extensive literature review, a review of the role of culture, gender and communication traditions and a series of expert interviews.[4]

2.1.1 Literature review

A report on the state of the art in public engagement, co-creation and mutual learning in nanotechnologies, published in April 2018, offered an overview of key findings from previous and ongoing EU and national engagement projects and relevant academic literature on how to facilitate

[4] The results from the literature review and interviews have been made available online in the GoNano Digital Knowledge Database.

and pursue a co-creation process.[5] The report noted that a shared goal, and mutual trust between participants, are key requirements to enable collaboration between stakeholders. It also suggested that the co-creation process should be designed as a protected space to nurture mutual trust and create room for experimentation, noting that collaboration should take the form of a joint enquiry in matters of common concern: all participants should have a stake in the topic at hand and should be facilitated to have a genuine influence on something that matters to them. The technology should not be pushed; rather, the co-creation process should explore the needs of citizens. On a procedural level, the report suggested that getting from constructive dialogue to practical action is a major bottleneck: design thinking is required in order to get tangible results. An iterative process is needed, encouraging creativity through the use of stories, narratives and physical materials. The report also noted that full transparency about the engagement process is required from the point of recruitment, including transparency about the roles and responsibilities of all involved, the rationale for engagement and expected impacts of the process.

2.1.2 Considering the role of culture, gender and communication traditions

GoNano also sought to understand the role of culture, gender and communication traditions and their implications for engagement methodologies, communication and dissemination. A briefing report on culture, values, communication and gender differences, published in May 2018, mapped national debates in the Czech Republic, the UK, Denmark, the Netherlands and Spain.[6] The report looked at societal issues such as gender, culture, and diversity. What motivates opinions, thoughts, needs, values and concerns - are these the same, or are there differences between or within various groups? How does gender impact the way values, needs and concerns around nanotechnology are shaped? How does demographic diversity influence such concerns?

The report found that the underrepresentation of women in science, technology, engineering, and mathematics (STEM) can be seen in the shaping of core values and assumptions by men and male norms. As a result, core values and assumptions in STEM fields, including nanotechnology, have been fundamentally shaped by men and male norms. Public surveys of attitudes to nanotechnology reveal that attitudes towards the risks and benefits associated with nanotechnology differ between men and women, with women reporting to be generally less familiar with nanotech, less enthusiastic about it, and less willing to tolerate nano-related risk. The underrepresentation of women in positions of authority over STEM resources also means that women have less influence over how resources are used, and by whom.

The results from the social data mapping exercise suggest that the level of engagement with the public on nanotechnologies is not taking place to the extent that it should, nor is there a very visible public debate about the issues surrounding nanotechnology. The report provides the following recommendations: acknowledge and highlight structural underrepresentation of women in STEM/nanotechnology, and the lack of diversity; include and incorporate gender and diversity in all aspects of nanotechnology development from the beginning; maintain awareness of how opinions are formed and what influences them; consider risk perception as a crucial point of engagement,

[5] See the report on the state of the art on public engagement, co-creation and mutual learning in nanotechnologies (deliverable D1.1): http://gonano-project.eu/deliverable-1-1/.

[6] See the report on the role of culture, gender and communication: http://gonano-project.eu/3856-2/.

both with the general public and with stakeholders; thinking strategically about engagement from the outset, deciding on the level of engagement to be achieved and how interactive the discourse should be, and adapting relevant tools in accordance (e.g. two-way communication, engage scientists in dialogue with public); target all demographic groups (e.g. gender, diversity, age) and interact "with" them, not "at" them, in engagement methodology development.

Building on the briefing report on culture, values, communication and gender differences, the project sought to illustrate and visualise gender and diversity in the information material for the citizen workshops. The information material provided short scenarios that illustrated possible future gender or diversity related implications of nanotechnologies in different everyday life settings.[7]

2.1.3 Expert interviews

Complementing the literature review on the state of the art in public engagement and co-creation, 46 stakeholders from 14 countries with different roles in nanotechnology research and innovation were interviewed to discuss the main technological developments in the health, food and energy sectors.[8] Representatives from research and innovation networks, public and private research, industry, policy makers and end users from across Europe provided their views on the opportunities and challenges of nanotechnologies and their expected impacts on society.

Several examples of applications and product scenarios to debate with stakeholders and citizens emerged from the interviews. Respondents mentioned nano-encapsulation, nanosensors and nanobiotechnologies as the most relevant developments of nanotechnology in the health area. They expected significant impacts in regenerative medicine, diagnostic and assistive medical devices, targeted drug delivery and personalized medicine. The thought key needs and concerns related to nanomedicine included scalability and affordability of new technologies and devices; the safety of nanomaterials and related risk assessment and testing activities; the adequacy of regulation to technology development (regulatory preparedness); and risk perception and communication with citizens and consumers about the impacts (risks and benefits) of nanotechnologies.

The application areas for nanotechnology in the food sector considered to be most relevant were nano-encapsulation, nanofibres, nanomembranes, nanosensors, novel foodstuffs, antimicrobial technologies and food packaging materials. Respondents indicated that there are relatively few applications exploiting nanotechnology developments in the food sector, but the products that could be available on the market in the medium or long term include smart packaging, nanofilters, novel foodstuffs and crop protection products.

The most significant developments in the energy sector emerging from the interviews were insulation, nanosensors and activators, isolated carbon nanotubes, quantum dots, nano-based

[7] See GoNano D3.1 – Background production for the pilot studies: http://gonano-project.eu/wp-content/uploads/2019/01/D3.1-RI-background-production-1.pdf.

[8] See the report on the findings of a series of expert interviews on the main technological developments in food, health and energy sectors (deliverable D1.3): http://gonano-project.eu/nanotech-in-food-energy-and-health-what-areas-and-issues-for-a-dialogue/.

silicon semiconductors (nanoelectronics), and nanostructures at material interfaces in batteries. The application of these technologies was expected to have significant impacts in the following areas: energy generation and storage, energy efficiency, and the use of Internet of Things devices to support energy production, distribution and storage.

2.2 Developing the methodology

Based on the literature review and expert interviews, the project partners developed a co-creation methodology and built a co-creation platform.

2.2.1 Method and manual for the pilot studies

The method and manual for the pilot studies developed in the first year of the GoNano project[9] defined 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" (p.5).* The manual identified the pilot studies as the unit within which co-creation takes place, suggesting that each of the four co-creation events would contribute to the co-creation process by providing specific outcomes:

> *"The citizen workshop will feed into the process a list of wishes and concerns, [...] a clear message to an actor group [...] and a list of needs and values. [...] Stakeholders will relate citizens' input (messages/wishes and concerns) to existing R&D activities. Citizens' input will help them to develop concrete research lines (or design suggestions) and recommendations regarding their implementation (boundary conditions).*
>
> *Research lines here means that the proposal of the stakeholders will be application related, however, most likely not restricted to one concrete product. Rather, it will provide a direction of possible development for a group of future products (e.g. targeted medicine) and the product suggestions will follow. Recommendations take into account the context conditions that need to be considered when implementing such research lines. Thus, this broadens the view beyond a strict product/application based focus and allows for even more embedded discussions of nanotechnology applications. Research lines and respective recommendations together make up a product case within the pilot studies" (p.12 of the method and manuals for the pilot studies).*

2.2.2 Building the co-creation platform

Project partners made use of an online co-creation platform with the aim to secure a continuous online presence to support interaction between project partners and broader audiences throughout the duration of the project and beyond. The platform was meant to support the face-to-face citizen workshops, the online citizen consultation and the two rounds of co-creation workshops with professional stakeholders and the evaluation of the workshops. The co-creation platform combined

[9] See the report on the method and manuals for the pilot studies (deliverable D2.1): http://gonano-project.eu/wp-content/uploads/2018/08/2.1.pdf.

the functionalities of the GoNano website, Facebook, Twitter and EngageSuite and other plug-ins considered necessary to fulfill the objectives of the platform.[10]

2.3 ENGAGEMENT ACTIVITIES

Building on the knowledge base and the proposed methodology, the project partners established an iterative, four-step co-creation process to integrate societal considerations in nanotechnologies: the first step consisted of a series of citizen workshops in the Netherlands, the Czech Republic and Spain organised by the pilot partners[11] where citizens expressed their wishes and concerns with respect to each of the application areas (health, food and energy, respectively). In the second step, the pilot partners organised co-creation workshops with stakeholders to explore how the wishes and concerns of citizens could be considered in nanotechnology research and innovation.[12] The third step of the co-creation process was an online citizen consultation, held in the summer of 2019. The aim of this consultation was to get responses from citizens from various European countries to the product suggestions of the first round of stakeholder workshops.[13] 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.[14]

2.3.1 Co-creation step 1: Citizen workshops

Three thematic deliberative and envisioning citizen workshops on health, food and energy formed the first step of the co-creation process. The goal of the workshops was to inform citizens on nanotechnologies and possible future application areas in order to facilitate their reflection on wishes, needs and concerns. The citizen workshops took place during the autumn of 2018 in the three pilot countries: the citizen workshop on food applications in Prague was organised by TC CAS on 20 October 2018.[15] The citizen workshop on energy took place on 26 October 2018 in Barcelona, Spain.[16] The citizen workshop on nanotechnology applications in health took place on November 24, 2018 in the Design Lab at the University of Twente in Enschede.[17]

[10] See the description of the co-creation platform in deliverable D2.2.

[11] The partners organising the workshops in the respective countries were: the University of Twente (UT) in The Netherlands, the Technology Centre of the Czech Academy of Sciences (TC CAS) in the Czech Republic and the Royal Melbourne Institute of Technology (RMIT) in Spain.

[12] See the working paper on the design and outcomes of the first round of stakeholder workshops: http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes_of_round_1.pdf.

[13] See the briefing report on the outcomes of the citizen consultation: http://gonano-project.eu/european-respondents-perceive-nanotechnology-positively-however-emphasize-the-efforts-to-make-the-possible-products-safe/.

[14] See the report on the outcomes of the second round of stakeholder workshops: http://gonano-project.eu/d4-2-b-outcomes-of-co-creation-workshops-round-2/.

[15] See also this brief workshop report on the GoNano webpage: http://gonano-project.eu/prvni-ceska-obcanska-konzultace-o-nanotechnologiich-v-potravinarstvi/.

[16] See also this brief workshop report on the GoNano website: http://gonano-project.eu/valuable-contributions-during-citizen-workshop-on-energy-at-rmit-barcelona/

[17] See also this brief workshop report on the GoNano website: http://gonano-project.eu/dutch-citizens-about-the-future-of-nanotechnology-in-health/

Table 1 – Overview of the citizen workshops

Location	Partner	Topic	Date	Participants
Prague (CZ)	TC CAS	Food	20 October 2018	50
Barcelona (ES)	RMIT	Energy	30 October 2018	21
Enschede (NL)	UT	Health	24 November 2018	48

Video impressions of the workshops are available on the project website and on YouTube[18] (see the briefing report for further information on the outcomes of the citizen workshops for further details).[19]

2.3.2 Co-creation step 2: First stakeholder workshops

The first stakeholder workshops were arranged in the three designated pilot countries in February and March 2019.[20] The University of Twente (UT) organised three workshops in the thematic area of nanotechnologies and health in the Netherlands: the first workshop on 12 February focused on diabetes, the second workshop on 5 March looked at sensors, and the third workshop on 7 March discussed health policy. The Technology Centre of the Czech Academy of Sciences (TC CAS) organised a fourth workshop on nanotechnologies and food in Prague on 28 February. A fifth workshop on nanotechnologies and energy was held in Barcelona by the European Office of the Royal Melbourne Institute of Technology (RMIT), also on 7 March.[21]

Table 2 – Overview of the first stakeholder workshops

Location	Partner	Topic	Date	Participants
Enschede (NL)	UT	Health (Diabetes)	February 12, 2019	11
Prague (CZ)	TC CAS	Food	February 28, 2019	34
Enschede (NL)	UT	Health (Sensors)	March 5, 2019	8
Enschede (NL)	UT	Health (Policy)	March 7, 2019	9
Barcelona (ES)	RMIT	Energy	March 7, 2019	27

[18] YouTube: Workshop RMIT (https://www.youtube.com/watch?v=fhvHGk1qcyM&feature=youtu.be), Workshop UT (https://www.youtube.com/watch?v=rLRYo7C069Y&feature=youtu.be), Workshop TC CAS (https://www.youtube.com/watch?v=evDJHNYD1jI&feature=youtu.be)
GoNano website: http://gonano-project.eu/ (under 'Activities')

[19] See Deliverable D3.3: Briefing report on the outcomes of the online consultation.

[20] The partners organising the workshops in the respective countries are: the University of Twente (UT) in The Netherlands, the Technology Centre of the Czech Academy of Sciences (TC CAS) in the Czech Republic, and the Royal Melbourne Institute of Technology (RMIT) in Spain. The lead partner on the coordination of the stakeholder workshops is De Proeffabriek (DPF).

[21] Brief summaries and video reports on the workshops are available on the project website:
- For the workshops on health: http://gonano-project.eu/stakeholders-insights-for-research-products-and-policy-on-nanotechnology-and-health/
- For the workshop on food: http://gonano-project.eu/setkani-odborniku-nanotechnologie-a-potraviny/
- For the workshop on energy: http://gonano-project.eu/5181-2/

All workshops followed a similar structure, featuring four interrelated co-creation sessions: an *exploration* phase, where participants got to know each other and explored the needs and values expressed by citizens as well as their own needs and interests; an *ideation* session, where participants imagined and co-created responses to the needs and values expressed by the citizens by imagining revisions of ongoing research and innovation trajectories; a *prototyping* session, where participants generated a storyboard that visualized how the resulting research lines and product suggestions could be designed in relation to the needs and values expressed by the citizens and suggested concrete actions to be taken to realise this vision; and a *concluding* reflection, where participants presented their visions and reflected on the overall workshop outcomes.

2.3.3 Co-creation step 3: Online consultation

The results from the first stakeholder workshops were discussed in an online citizen consultation. The aim of this consultation was to get a response from citizens to the product suggestions coming out of the first round of workshops with professional stakeholders, to rank the needs and values connected to the potential applications in health, food and energy, and to get an idea on how the European respondents perceive nanotechnology in general.

The data collection for the online consultation started on July 1st 2019 and ended on September 13th 2019. A questionnaire drafted by TC CAS in collaboration with all partners was translated into five languages (Czech, Dutch, Spanish, English and Danish). Standardized vignettes were used for five concrete product suggestions or research aims for each of the three themes. These were based on the outcomes from the collaboration between citizens and stakeholders in each of the pilot countries. 893 responses were received in total.

The results from the citizen consultation were in turn expected to feed into the second round of stakeholder workshops, focusing on the uptake of the responsive design suggestions of the previous round.

2.3.4 Co-creation step 4: Second round of stakeholder workshops

The second round of stakeholder workshops was organised in the pilot countries in October and November 2019 (Table 3). The aim of the workshops was to elucidate the preconditions for co-creation, building on the insights gained in the earlier stages of the project.

Table 3 – Overview of the second stakeholder workshops

Location	Partner	Topic	Date	Participants
Prague (CZ)	TC CAS	Food	22 October 2019	16
Barcelona (ES)	RMIT	Energy	30 October 2019	9
Enschede (NL)	UT	Health	7 November 2019	16

The workshops explored how input from citizens can be productively integrated in concrete research and innovation decisions, taking the product suggestions derived from the first workshops

as a starting point and discussing how the main actors identified in the product suggestions (as 'problem owners') could mobilise the considerations of citizens and other stakeholders to co-create more 'socially robust' research or product designs.

Like the first stakeholder workshops, the programme was structured around the four main pillars of co-creation: exploration, ideation, prototyping and reflection. The *exploration* session aimed to present the overall co-creation process in further detail, introduce concrete product suggestions derived from the first stakeholder workshop and input from the citizen consultations, functioning as enabling conditions for further development of the product suggestions. In the *ideation* session, participants joined subgroups where each of the product suggestions was presented in further detail. In the *prototyping* session, participants defined next steps to integrate societal considerations in the further development of the product suggestions. The concluding *reflection* session aimed to consider broader reflective questions about the feasibility of the action plan, the integration of citizen perspectives and the opportunities and barriers of the co-creation process.

3. Analysis of the engagement results: insights and lessons learned from WP 1-4

The overview of activities in the previous chapter illustrates the ambitions of the GoNano project and the extensive effort from all partners to design and implement a co-creation process that aligns nanotechnologies with societal needs and values. GoNano sought to implement theoretical insights from the Science with and for Society programme in nanotechnology research and innovation practice.[22] The co-creation process aimed to derive concrete research and product suggestions from a deeper understanding of the needs and values of European citizens and to convince researchers, producers and policy makers of the potential commercial value of integrating societal considerations in nanotechnologies.

To realise these ambitious objectives, the project partners have produced a wealth of background information on nanotechnologies, research and innovation policy, public engagement and co-creation.[23] They have also organised a wide range of activities across Europe to practically realise the co-creation process. All in all, the workshops have mobilized 249 participants around co-creation in nanotechnologies (see Table 4). Moreover, 46 interviewees from 14 countries have provided their views on nanotechnologies and engagement in the initial stages of the project, 893 respondents from across Europe have commented through an online consultation on the product suggestions resulting from the workshops, and 198 persons responded to the evaluation questionnaires and interviews.

Table 4 – Overview of participants attending the various GoNano co-creation events

	Health UT (NL)	Food TC CAS (CZ)	Energy RMIT (ES)	Total
Citizen workshops	50	48	21	**119**
1st stakeholder workshops	28	34	27	**89**
2nd stakeholder workshops	16	16	9	**41**
Total	**94**	**98**	**57**	**249**

The co-creation events provided productive spaces for engagement and mutual learning between a wide range of stakeholders: researchers, producers, policy makers, civil society and citizens. The evaluation report on the outcomes of the MML platform indicates that workshop participants appreciated these events.[24] Based on a series of questionnaires and follow-up interviews with participants, the report concludes that co-creation activities of the type developed by GoNano are fruitful ways of getting to know considerations from different types of stakeholders and listening to suggestions from citizens. Both citizens and other stakeholders agreed that bringing their

[22] See GoNano White Paper 1 on 'Responsiveness in practice' for further information on the ways in which GoNano sought to align nanotechnology research and innovation with societal needs.
[23] See the project website and Youtube channel for all the project deliverables and other outputs.
[24] See the evaluation report on the outcomes of the MML platform (D4.3).

perspectives together adds value and insights in what is important to consider when developing nanotechnology applications. Citizens appreciated the co-creation process. The stakeholders indicated that co-creation contributes to the acceptability of nanotechnology innovations and leads to an increased understanding of other stakeholders' perspectives on nanotechnology and product development. The findings from deliverable D4.3 also point out that the activities contributed to trust and mutual understanding between citizens and stakeholders: a large majority of citizens thought their knowledge and understanding of nanotechnology had increased, and they evaluated nanotechnology applications mainly as positive.

The remainder of this chapter will consider the extent to which GoNano has achieved the specific objectives identified in the introduction. The aim is to consider the opportunities and challenges of co-creation as a method to align nanotechnologies with societal needs and values, including some of the methodological trade-offs and organisational challenges encountered along the way.

3.1 Addressing the specific objectives of GoNano

The following section will first revisit the specific objectives identified in the introduction. Section 3.2 subsequently considers the value and impacts of the co-creation platform. The chapter concludes with a reflection on the progress towards the overall aim of the project: to enhance the responsiveness of research and innovation to public values and concerns.

Objective 1: Showcasing an early-stage, state-of-the-art continuous citizen and stakeholder engagement process which takes into account gender and differences in culture and communication traditions across the EU.

As the evaluation report on the co-creation workshops notes, the GoNano co-creation process facilitated engagement between stakeholders in nanotechnologies, including citizens, researchers, engineers, producers, civil society and policy makers. The activities contributed to enhanced trust and mutual understanding between citizens and stakeholders. Considering the responses to the evaluation questionnaire of the first round of stakeholders for example, those who responded to the questionnaire were very positive about the quality of the group discussion: more than 75% agreed or strongly agreed that the group discussions were of good quality, and around 65% thought the citizens' messages were relevant for the workshop. In the second round of stakeholder workshops, participants were even more positive about the quality of the group discussion, giving it a score of 4.8 on a 5-point (Likert-)scale.[25] Particularly in the Netherlands and in Spain, the majority of respondents thought it made sense to consider the needs and values of citizens and societal stakeholders in an early stage.

The overall workshop approach of enabling carefully moderated, highly focused, interest-driven discussions in a four-step process (exploration, ideation, prototyping, reflection) seems to have worked well in the stakeholder workshops. An earlier analysis of the product suggestions resulting from the co-creation process furthermore concludes that the focused, guided interactions in the stakeholder workshops can lead to innovative suggestions on how to integrate broader

[25] For further information, see the evaluation report on the outcomes of the MML platform (D4.3)

considerations in research and innovation decisions.[26] For instance, a discussion between producers, policy makers, civil society, researchers and a diabetes patient around the artificial pancreas (a monitoring device for diabetes type 1 patients that continuously measures glucose levels of the patients and adds insulin and glucagon when needed) in the first stakeholder workshop on health at the University of Twente led to data management considerations that may be relevant for future data sharing agreements between the producer and users of the device. And the discussions around the Harvestore project in the second stakeholder workshop on energy in Barcelona suggested how societal considerations can be productively integrated in the development of the wireless sensor nodes. These examples suggest that 'exposure' to use considerations further down the line can attune research design to future use contexts.

The outcomes of the overall co-creation process demonstrate how bringing stakeholders with different backgrounds together may lead to relevant discussions and insights for research and product development. The relevance of this finding should not be underestimated: the productive integration of societal considerations in research and innovation will to a large extent depend on mutual learning between stakeholders, and on the shared conviction that broader societal perspectives *matter*. The co-creation process addressed this vital precondition.

That said, the project partners also faced several challenges and trade-offs during the design and implementation of the co-creation process. The following paragraphs highlight these challenges, as they may provide relevant insights for the future development of co-creation processes.

Challenge 1: Enabling a continuous process through separate events

One of the main challenges concerns the *continuity* of the process. It sometimes proved difficult to use the outcomes of initial steps of the co-creation process as direct input for the next steps. For instance, it was hard to use the wishes and messages from citizens as direct input for the co-creation of concrete research or product suggestions. Even though the pilot partners tried to convey the meaning of the wishes, needs and messages from citizens to the participants of the stakeholder workshop (and citizens that had attended the citizen workshop were also present at the stakeholder workshop to clarify the wishes, needs and messages from citizens), participants sometimes had difficulty connecting to these suggestions.

One reason why it proved difficult to make the connection was that the suggestions from citizens were often formulated at a high level of abstraction: for instance, citizens emphasized the importance of values like sustainability, respect for nature and transparency as design considerations. While the participants of the stakeholder workshop acknowledged the importance of these social needs and values, it was not always clear to derive concrete design recommendations from these high-level considerations.

Another reason why it was difficult to connect to outcomes of the citizen workshops was that the professional stakeholders did not attend the citizen workshops. Their absence from the citizen workshops was deliberate: the idea was to prevent 'expert opinion' from dominating the discussion. As a result of this setup however, the professional stakeholders only had indirect

[26] See deliverable D4.5 on concrete product suggestions for future nanotechnologies.

evidence from the citizen workshops, making it difficult for them to assess the underlying value of the recommendations from the citizen workshops.

A similar point applies to the translation of outcomes from the first stakeholder workshop to the online consultation: it proved difficult to turn the rich and varied results from the workshop discussions into the type of brief, clear statements with multiple choice answers that an online consultation requires. And the same held for the translation of the findings from the online consultation into recommendations for the second round of stakeholder workshops, where succinct responses to multiple choice questions needed to be turned into design requirements for concrete research lines.

One way to strengthen continuity could be to involve the same participants (or possibly a 'core group' of participants) throughout the various steps of the co-creation process. This would help participants to create a shared language. As deliverable D4.2 also suggests, participants become better at exchanging the value of their contribution to the shared problem over time. This process of bartering relevant pieces of knowledge has been described as a 'Trading Zone'[27] where stakeholders develop a 'pidgin', a shared language to exchange the value of one's own contribution to a shared problem in a way that makes sense from the perspective of the other. This process takes time and commitment from all participants.

Keeping participants motivated to join several events may not be easy, however. It already proved difficult to keep participants engaged in one or two events. Attracting their continued interest will require even more attention to participants' own motivations, be it to improve the technology, increase attention to societal considerations, or to learn from others.

Challenge 2: Brainstorming versus prototyping - different logics

As the co-creation process unfolded, it became increasingly clear that the various steps of the co-creation process were less compatible than expected: creative *brainstorming* about possible future applications of nanotechnology is very different from developing concrete suggestions that can be fed into ongoing research and innovation trajectories. Both processes follow different logics. Brainstorming should be as divergent as possible: it requires creative thinking, and it can be about anything. No ideas are out of bounds, all forms of input are welcome. Brainstorming benefits from diversity and equality of the contributors. The more diverse the composition of the group and the wilder the ideas, the more productive the brainstorm session is likely to be.

In contrast, developing concrete product suggestions for ongoing research and innovation trajectories are convergent: the ideas that are brought to the table have to fit in ongoing logics. Useful contributions complement ongoing trajectories: they should be feasible and realistic. So in this case, some ideas *are* out of bounds. The need for concreteness and feasibility also puts different requirements on participants: they must have prior knowledge of the ongoing research and

[27] See: Galison, P. (2010) 'Trading with the Enemy'. In M. E. Gorman (ed.) Trading Zones and Interactional Expertise: Creating New Kinds of Collaboration. Cambridge, Mass.: MIT Press. See also: Gorman, M.E, & Schuurbiers, D. (2013). Convergence and Crossovers in Interdisciplinary Engagement with Science and Technology. In: Doorn, N., Van de Poel, I., Schuurbiers, D., and Gorman, M. E. (eds.). Opening Up the Laboratory: Approaches for Early Engagement with New Technology. Dordrecht: Springer.

innovation trajectory. They require at least 'interactional expertise' to meaningfully contribute to the problem at hand. Also, there is inevitably an asymmetry between participants, as 'enactors', or problem-owners, are distinguished from 'contributors'. The best outcome is a small number of actionable suggestions that are creative and innovative yet have a demonstrable impact on the quality of the ongoing research or innovation process.

The discrepancy between these logics can be observed both within events and between the different events. Within the stakeholder workshops, it proved difficult to shift gears from exploration and ideation to prototyping. And between the citizen and stakeholder workshops, it was not easy to move from wild project ideas to concrete suggestions for research lines or product innovations. For instance, the participants of the citizen workshop in the Czech Republic proposed the development of a 'superfood', a rectangle-shaped food having various tastes and properties. This is unmistakably a very creative solution; it is also one that could help envisage entirely new directions for research. In some ways, this proposal is reminiscent of ideas from other initiatives that aimed to envision and initiate a debate on potential future applications of nanotechnology, like the Nano Supermarket,[28] the EU project NANOPLAT or the Vision Lines 20 project.[29] From a *brainstorming* perspective, this is a highly successful outcome. But it would be hard to apply this suggestion directly to the improvement of ongoing food research projects.

This is not to say that the overall co-creation process should focus on one or the other logic. Co-creation needs to combine brainstorming and concrete, incremental reasoning. Both are valuable at different moments in the process: ideally, the co-creation process should iteratively combine divergence, brainstorming, 'opening up' with convergence, incremental reasoning, 'closing down'. Indeed, that was the thought behind the overall co-creation setup and the programme of the workshops. So perhaps the difficulty to move from reflection to action in this case was not due to the basic approach chosen in GoNano, but rather a consequence of limited time and resources. Perhaps co-creation processes should occur over much longer timeframes, if they are to deliver both creative ideas *and* concrete solutions. The overall process may need to include many more intermediate steps (and the emergence of a community of practice) if it is to transform wild ideas into concrete outcomes (indeed, BASF's Creator Space programme, which brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes based on societal challenges, does apply significantly more resources to move from wild ideas to marketable products).[30]

Challenge 3: 'opening up' versus 'adding value' – different rationales for co-creation

Another trade-off that played a role throughout the design and implementation of the GoNano co-creation process concerned the simultaneous occurrence of two rationales for co-creation. The first rationale considers co-creation as a tool to 'open up' research trajectories, inviting multiple stakeholders who would normally not be included in research decision making, and exploring how their views might be more productively integrated in research and innovation trajectories. This

[28] https://www.nanosupermarket.org/

[29] See this interview with François Jégou, Director of Strategic Design Scenarios (SDS), on the EU project NANOPLAT and the Vision Lines 20 project.

[30] See this interview with Elise Kissling, Director of the Creator Space frontend innovation program at BASF, on Creator Space.

rationale has its roots in movements for the 'democratisation' of science, seeking to explore alternative imaginations of research and innovation governance. On this view, the phrase 'alignment with societal needs and values' is to be interpreted broadly: for example, it points to the need for enhanced transparency and accountability of the research community, or the need to focus the research and innovation process towards tackling important societal challenges.

The second rationale considers co-creation as a means to 'add value' to ongoing research trajectories, by inviting feedback from specific stakeholders (prospective users for example) on particular research decisions, and seeing how this feedback might improve the research outcome (by making it more efficient, cheaper, or more acceptable, for instance). While this rationale is borne from the same origins as the democratisation movement, it argues that attempts at democratisation of research and innovation have often had merely tangential effects on the governance of research. Instead, this rationale explores the possibility and utility of 'governance from within'.[31] Acknowledging the dominant position of technology enactors, it looks at changes in research practice that may be more modest, but can be implemented in concrete decision-making processes. On this view, 'alignment with societal needs and values' is interpreted more narrowly: it might include incremental changes in product design to attune the product better to consumer needs. One this approach, some idealism is forfeited for the sake of effectiveness.

Both rationales have played a role in the design of the GoNano project. The project underlined its commitment to 'opening up' research and innovation to societal needs and values when it stated that: *"R&I governance should take into account the values, needs and concerns of society broadly, and particularly citizens. [...] To guide researchers, innovators and policy-makers in the process of developing and governing nanotechnology, it is therefore necessary for citizens' voices to be heard."* The stakeholder workshops were: *"designed so to follow-up on the workshops with citizen from task 3.2 to explore and evaluate which and how future products can align with preferences and values*." [32]

At the same time, the co-creation workshops also addressed the rationale of co-creation as 'adding value' to nanotechnology research and innovation. The stakeholder workshops were meant to: *"produce concrete 'responsive' design suggestions which can be fed back in ongoing research and innovation activities,"* and the results were expected to: *"provide input for the development of business cases on the concrete design suggestions to show the value of a collaborative and co-creative approach to integrating societal values in R&I, and as part of company portfolios."*

To be sure, both rationales are equally valid. The literature on co-creation includes the use of co-creation for both commercial and ideological purposes, as the method and manual for the pilot studies (deliverable D2.1) also notes. The results of the GoNano workshops suggest opportunities for both rationales as well. 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. And the discussions on autonomous wireless sensor nodes for the future Internet of Things which took place during the second stakeholder workshop on energy in Spain indicates how societal considerations can add value to the development of wireless sensor nodes.

[31] See Fisher, E., Mahajan, R. L., & Mitcham, C. (2006). Midstream Modulation of Technology: Governance From Within. *Bulletin of Science, Technology & Society*, *26*(6), 485–496.

[32] GoNano Part B, p.11.

However, the GoNano experience suggests that perhaps it is too much to expect both objectives to be addressed *simultaneously.* As D4.2 also noted, the desire to 'add value' to concrete research lines may come at the cost of 'opening up' research and innovation, and vice versa. The intention to 'open up' research and innovation to societal needs and values puts citizens in the driver's seat. The intention to add value puts technology enactors in the driver's seat. The wider interpretation of 'alignment' of nanotechnologies to societal needs and values is obviously much more difficult to implement: it requires changes in the dominant norms of the research culture, indeed, in the dominant economic order. The needs that lend themselves to integration are often rather more mundane, resulting in minor tweaks to existing products and research lines. Sometimes, the two interpretations align: some novel research lines or product suggestion will have both societal and individual benefits. Unfortunately, this is not automatically the case.

Conclusion: adaptive approaches needed

In retrospect, the expectation that the envisioning workshops with citizens could: *"demonstrate how continuous and ongoing co-creative deliberative processes between the range of actors directly and indirectly involved in nanotechnology innovation, can generate design suggestions which align research & innovation with the values, needs and expectations of society during early-stage product development"*,[33] may have been somewhat optimistic, given limited timeframes and resources. The product suggestions from citizens were highly creative, and their wishes, needs and messages suggested important design requirements for research and innovation – but they were not actionable or ready to apply 'as is' to concrete research and innovation trajectories. This would have required several intermediate steps (steps which the pilot partners could not possibly take with the resources at their proposal).

An adaptive approach to the co-creation process, allowing for more flexibility in terms of the engagement activities as the process unfolds, might help to produce more tangible outcomes. Ideally, the outcomes of initial steps would inform the objectives and structure of the next steps: who should attend, what the main objective should be, and what output would be expected. Indeed, an external evaluation of the GoNano project also concluded that the development of the methodology should go hand in hand with project implementation.[34] This would allow the overall approach to be tailored and adjusted as the project unfolds and would facilitate mutual learning between the project partners, who have different backgrounds, experiences and interpretations of co-creation. Realising this sort of flexibility in European projects may be tricky, as the main parameters for the project's activities are fixed from the start – but such fixed parameters may be at odds with the essential nature of co-creation as an iterative process.

[33] DoA, p.16

[34] See the external evaluation report on the GoNano project activities and impacts, deliverable D8.4.

Taking into account gender and differences in culture and communication traditions.

The project considered gender and diversity throughout the co-creation process in relation to the different participants, the content of the material provided for the workshops and the dynamics observed in the workshops.

In general, the pilot partners strove for a gender balance in the composition of participants, both for the citizen and stakeholder workshop. In the citizen workshop partners also developed recruitment criteria that aimed to collect diverse groups of citizens. Except for the Prague citizen workshop, it proved a challenge to collect a diverse group on the criteria 'level of education' (see Table 5).

Table 5 - Overview of the three citizen workshops and their main characteristics[35]

Where and when	Number of participants (m/f)	Characteristics of participants
Nanotechnologies in Food, The Academy of Sciences of the CR, Prague, Czech Republic, October 20, 2018	48 (24/24)	Balanced across gender, age, education, economic activity, and place of residence.
Nanotechnologies in Energy, Royal Melbourne Institute of Technology Europe, Barcelona, Spain, October 26, 2018	21 (6/15)	Majority female, highly educated and mostly from urban centres, wide age range.
Nanotechnologies in Health, DesignLab, University of Twente, the Netherlands, November 24, 2018	50 (27/23)	Most demographic criteria were fulfilled, except for the level of education. Citizens were mainly higher educated, a few middle-educated, but no lower-educated people participated in the citizen consultation.

In the online survey, the pilot partners explored a number of recruitment tools for reaching citizens with eduction backgrounds different to the groups reached in the citizen workshops. The effort proved to create a more balanced representation, and across the sample of citizens engaged in the online survey, 54% of respondents had a primary and secondary education, followed by 46% of respondents with tertiary education. In addition to educational background the project had focused on trying to balance across socioeconomic background and city size, and created a good balance on these criteria.

[35] See also: GoNano D3.2 – Citizen needs and values in relation to nanotechnology in food, energy and health: A report from citizen workshops in the Czech Republic, Spain and the Netherlands

In the stakeholder workshop the project also tried to organise as balanced a panel of stakeholders as possible. The moderators of all the co-creation events prepared and reflected on gender and diversity issues before the events through conversation with the European Institute of Women's Health (EIWH), a partner in GoNano. Advice included how to ask general questions on gender, and gender roles, as well as dimensions of gender and diversity in relation to ongoing research or future nano-enabled products. Following each event, partners also reflected on the influence of gender.

In practice, partners experienced that issues of gender and diversity did come up through the discussions. The GoNano White Paper on the importance of gender and diversity in nanotechnology research and innovation notes that: "*All workshops had a fairly good gender ratio, considering how male-dominated the area generally is. Because of the high intensity of discussion and fast pace of discussion, it was not possible to always keep track of exactly what role, if any, gender played between the participants. Nevertheless, the issue of diversity comes up throughout discussions in the sense that workshop participants are encouraged to think in terms of societal issues and how to solve them and to include citizens' ideas and concerns. This is crucial and shows that diversity (of gender, but also of ethnicity, education, etc.) is essential to get the co-creation process going right from the start and to get an end-product that will be beneficial and does what it sets out to do.*"

Objective 2: Developing concrete product suggestions for future nanotechnologies in three nanotechnology research areas (health, food and energy) which are aligned with societal needs, values and concerns.

The second specific objective of the GoNano project was to develop nine concrete product suggestions for future nanotechnologies in each of the nanotechnology research areas. These product suggestions were meant to demonstrate the possibility of using co-creation to align research and innovation outcomes with societal needs, values and concerns.

Over the course of the GoNano co-creation process, a wealth of creative ideas for future nanotechnologies has been produced. Some 92 product suggestions were collected across the pilot studies. These suggestions varied wildly in scope and nature. Some were optimistic, like 'Easy Paint': a paint that is permanent yet easy to remove from walls if one decides to redecorate the house. Others were very concrete, pointing to incremental innovations in medicine, like mobile diagnostic and monitoring devices for specific afflictions. Some suggestions were discarded or amalgamated during the workshops themselves through brainstorming, focussing and selection procedures. The suggestions were also categorised by GoNano partners after each step in order to use them in subsequent steps.

Given the specific objectives and limited timeframes of the project, it was impossible to follow up on every single suggestion. Still, each of the 92 ideas could in principle serve as the start of a new cycle of co-creation – provided that one of the participants sees merit in the idea. The co-creation process was not just intended to generate wild ideas, however. It was also meant to produce concrete 'responsive' design suggestions which can be fed back in ongoing research and innovation activities. This is why the product suggestions became more focused and directed towards concrete suggestions over the course of the events. Five narratives from the different pilot studies describe how several key suggestions evolved over time, maturing from an initial suggestion made in the expert interviews at the beginning of the project into a more specific proposition towards the end:

1. Developing a data management plan for the artificial pancreas.
2. Strengthening user-producer interactions in the development of new diagnostic tools for cancer detection.
3. Designing a packaging system for perishable foods.
4. Defining safety measures for the use of nanomaterials in food.
5. Capturing energy from the environment and converting it to electrical energy for clean storage and use.[36]

The co-creation workshops thus provided important clues on how broader societal considerations could enhance research and innovation outcomes. They also encouraged stakeholders to consider citizens' views more deeply. It remains to be seen to what extent those insights will lead to follow-up activities after the project lifetime. Two factors complicated the promotion of relevant insights to lasting changes in practice. First, the discrepancy between the internal logic of the GoNano project and the logic of the innovation processes it sought to change. And second, the outsider role of the project partners.

Challenge 1: project versus innovation timelines

An important observation from the stakeholder workshops is that the timelines of the suggested activities did not always correspond to the timelines of the innovation process. Considering the question of data management for the artificial pancreas for instance, the developer of the artificial pancreas did acknowledge that a data management plan may become relevant at some point in the innovation process, but the company was at the time engaged in important market approval procedures. As a small business, it had to prioritize and the question of data management therefore had to be put on hold.

This discrepancy between the timelines of the project and the innovation it seeks to address is to some extent inevitable. EU projects necessarily have a given start and end date and a structured work plan: it would have been extremely fortunate if that timeline would have run exactly in parallel with any of the ongoing innovation processes identified. Still, some more flexibility in the detailed work programme might have helped. For instance, by allowing for a degree of flexibility in the timing of the co-creation events (see also the point about alignment of methodology development and project implementation in section 3.1.1 above). Future co-creation processes could benefit from a flexible approach that aligns its activities to the targeted innovation process.

Challenge 2: the outsider role of the pilot partners

The second observation is that the pilot partners were 'outsiders' to the research projects at hand. This meant that they could not rely on the commitment of a predefined group of stakeholders. Instead, they had to identify professional stakeholders who satisfied all criteria for participation in the co-creation process: being focused on the right topic area, being at the right stage of innovation (concrete enough to be discussed, but malleable enough to be redesigned), and in the right country. They needed to convince these stakeholders to voluntarily commit to the co-creation process. They

[36] For a more detailed description of these narratives, see the report: concrete product suggestions for future nanotechnologies (D4.5).

also had to determine relevant inroads for societal considerations based on discussions with these contacts. Then, they had to identify the 'right' societal stakeholders (citizens and civil society representatives), again ticking the right boxes – and all on a voluntary basis. And then the pilot partners had to determine which sorts of conversations would lead the stakeholders to discuss relevant societal considerations, while at the same time integrating the perspectives of citizens expressed in earlier stages of the project. And finally, these discussions not only had to lead to enhanced mutual understanding, but also generate concrete product suggestions that somehow addressed the needs and values of citizens. None of this is self-evident. Given all these boundary requirements, the mere fact that all participants have rated the workshops so positively can be considered a major achievement.

Despite these challenges, the varied collection of product suggestions and co-creation narratives suggest that focused, guided interactions between different stakeholders can in principle lead to novel suggestions on how to integrate broader considerations in research and innovation decisions. Each pilot study offers suggestions in its own way. In the case of the artificial pancreas, the discussion led to data management considerations that may be relevant for future data sharing agreements between the producer and users of the device. For the post-doc researcher working on a biosensor for cancer diagnostics, interactions with prospective users helped shape future research directions. The proposal for a packaging system for perishable foods can be seen as a concrete suggestion for demand-driven innovation. The suggested safety measures for the use of nanomaterials in food are an example of how multi-stakeholder interactions can serve to provide advice to policy makers on the governance of nanotechnologies. And the discussions on energy storage and capture suggested how societal considerations can be productively integrated in the development of the wireless sensor nodes.

Objective 3: Establishing a community of citizens, consumer and interest organisations, researchers, engineers, and policy makers working as change agents for Responsible Research and Innovation in nanotechnologies.

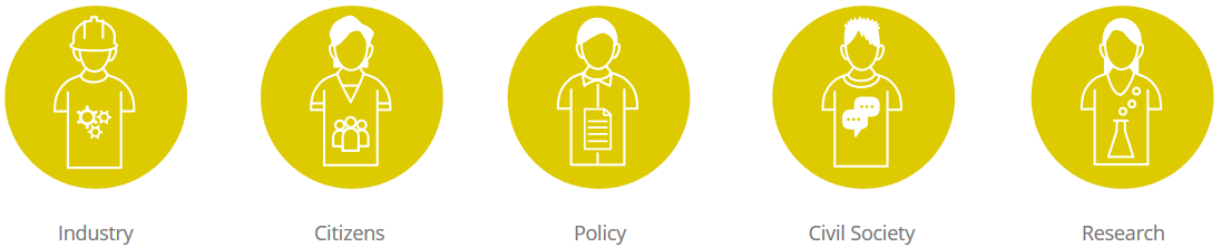
The co-creation process itself established communities of citizens, civil society representatives, researchers, engineers and policy makers. Multi-stakeholder networks emerged on the back of the co-creation events organised in the three pilot countries (although it remains to be seen to what extent these networks will remain active after the project has ended). Stakeholders valued the networking opportunities and learning from each other's perspectives. In particular, they appreciated getting new insights and making new contacts. This is in fact a recurring finding in EU projects that target multi-stakeholder collaboration: participants greatly value the networking itself. Perhaps this could be reflected in future EU call topics: instead of focusing on a primary goal and seeing the networking as a fortunate by-product, perhaps calls could focus more specifically on networking. Indeed, 'soft skills' like communication abilities, creative thinking and networking skills are vital preconditions for productive multi-stakeholder collaborations.

The brief videos and surveys with responses from workshop participants at the various events confirm these findings. They suggest how the different participants involved in the co-creation process each had something specific to contribute to the process, and how each took something

away from it.[37] This does not necessarily mean that they will immediately be encouraged to work as change agents for the development of Responsible Research and Innovation in nanotechnologies, but at the very least their responses add to the examples that are needed to convince technology enactors of the potential value of co-creation.

Considering the specific target groups that GoNano sought to reach out to (citizens, researchers, policy makers, industry and civil society, see figure 3),[38] the stakeholders have been reached to varying degrees:

Figure 3: Target groups of the GoNano project.



Researchers

The majority of the participating researchers responded positively to the co-creation process. Some were absolutely convinced of the potential added value of co-creation. The developer of the early diagnostic tool in the stakeholder workshop on health in the Netherlands confirmed that the discussions with different stakeholders along the value chain provided new research insights. She gained a *"more concrete understanding in what steps to take and what steps not to take during the rest of their research"*, which helped *"to build the next three years of my research life"*.[39]

Despite these inspiring stories, the sobering reality is that most researchers remain sceptical about the need to include wider societal considerations in research and innovation. The laboratory is in many ways still a protected space, in which (especially young) researchers are effectively shielded from outside influences by their lab directors. As the careers of young researchers still largely depend on publications in traditional – mostly monodisciplinary – journals, they often see broader societal considerations of their work as a digression from their demanding scientific curricula. They may well feel a responsibility to explore the broader societal impacts of their work, but they do not consider it to be their core business. Enabling a more open attitude towards the integration of wider societal considerations will require a sustained effort.

[37] See the interviews with workshop participants on the Youtube channel.

[38] See also the GoNano Communication Plan 2019-2020, with the communication strategy and activities for the final year of the project.

[39] Feedback from participants on the GoNano Winter School, which was held on 4-7 February 2020 in Barcelona, confirms the positive reception of the GoNano approach among (young) researchers. Participants indicated that their experience was both enlightening and beneficial, with their expectations met or surpassed and most aims and objectives achieved. Many participants left with the desire to adapt their research approaches to be more aware of and responsive to societal inputs. See also the report from the Winter School (deliverable D6.3). To encourage researchers to apply co-creation as a source of creativity in research, GoNano also developed a toolkit for research and engineers.

Feedback from participants and the project Advisory Board suggests that the co-creation process may need to focus more on technological content if it is to produce convincing examples for researchers. In other words, it is not necessarily the conceptual foundations or methodological soundness that convinces technology enactors: they will be persuaded by the practical usefulness of the outcomes.

Citizens

The citizens who participated in the co-creation process appreciated the events (see also D4.3), but it was not easy to involve citizens in the co-creation process. It also proved difficult to maintain contact with them throughout the process. To engage citizens, the process has to speak to the intrinsic motivation of participants:

1) Some people may be interested in the technologies used, and the science behind them;
2) Some people may want to act on their concern, and expect their participation to lead to better technological, societal or environmental outcomes.
3) Some people may be motivated by the participation process: they may want to become involved in the political or deliberative process, or even just to get to know people in their city better.

The need to speak to the intrinsic motivation of participants however implies that co-creation processes like the one developed in GoNano attracts specific subsections of the population, i.e. those with an interest in technology and participation.[40]

Industry

Industry proved difficult to reach. Again, those companies who joined the stakeholder workshops appreciated the initiative but other companies may not yet be convinced of the added value of co-creation. To convince companies to include co-creation and stakeholder engagement as part of their innovation processes, more compelling examples are required that clearly demonstrate the added value for companies. This will also likely require a more focused proposition: what exactly will the co-creation look like? Who will be involved, and to what end? Which of the business factors above does it seek to address? Will it save costs, spur innovation or enhance their reputation? What is the expected result, and what do they stand to gain from it? (These points will be explored in further detail in deliverable D5.4, which focuses on the 'business case' for co-creation and will be published later in 2020).

[40] The GoNano project recently reviewed existing opportunities for citizens and stakeholders to engage with nanotechnologies. A key finding of this review is that concrete opportunities for citizens and CSOs to actively engage with nanotechnologies are relatively scarce, despite a plethora of public engagement initiatives. For those citizens and stakeholders interested in engaging with nanotechnology, suitable engagement opportunities can be hard to find. The report concludes that more engagement initiatives are needed that focus on the 'empowerment' of citizens and stakeholders rather than on passive engagement. The responsive capacity of research and innovation needs to be enhanced in order to align research and innovation with the values, needs and expectations of society. See also the report from Subtask 6.2 – Information and guides for citizens and CSOs.

Civil society

Civil society organisations seem logical candidates for co-creation, being focused on representing specific societal interests. These organisations however must focus their attention on those initiatives where these interests are best represented, given their limited resources. This made it difficult to involve them in the explorative GoNano co-creation sessions. Their limited interest suggest that nanotechnologies, despite continuing policy calls for public engagement, are not considered to be among the most urgent societal problems of today. Still, the civil society representatives that did attend the co-creation events generally appreciated the process.

3.2 THE VALUE AND IMPACTS OF THE CO-CREATION PLATFORM

The GoNano project planned to combine an iterative cycle of citizen and stakeholder engagement with online engagement and information sharing. The co-creation platform was designed to supported these activities. Table 6 below shows the objectives and tasks relating to the co-creation platform, and how they were achieved.

Table 6 – GoNano objectives for the co-creation platform and how they were achieved

GoNano objective for the co-creation platform	GoNano result for the co-creation platform
Provide a space for background information for the pilot studies.	Background information was shared on the GoNano website and with participants at the workshops. Vignettes from the background material were also shared on social media, used in theme weeks of the project and for other communication e.g. at the final event.
Provide a space for visualizing and sharing results of deliberations.	Results were shared on the GoNano website
Secure a continuous online presence to support interaction between project partners and broader audiences throughout the project and beyond.	The combination of the website, Twitter account and Facebook pages created space for continuous online presence of the project, allowing interaction between project partners and broader audiences.
Include a space for shared deliberations, note taking, chat and voting.	EngageSuite provided a space for live online note-taking, chat and voting during face-to-face workshops. Outside of the workshop environments, open deliberations were possible through Facebook groups (both the general and national specific groups).
Support face-to-face workshops in 3.2 and 4.2	EngageSuite supported note-taking and presentation of questions in the face-to-face workshops.
Support the online survey in T3.3.	The online survey was supported through Qualtrics. Recruiting agencies Pollfish and STEM

	were used to involve hard-to-reach demographics.
Support the evaluation and measurement of learning in T4.3.	The surveys were distributed on paper, and the interviews were conducted face-to-face or via skype. Evaluation questions were also added to the online survey.

The GoNano project was ambitious in its aim to combine face-to-face meetings and an online survey in an iterative cycle, and to support this with an online co-creation platform. While GoNano managed to design a co-creation platform that could be used in the ways imagined in the design phase of the project, it was a challenge to coordinate face-to-face and online presence. Within the face-to-face meetings, EngageSuite worked well for the purpose of note collection, but facilitators found it difficult to maintain free-flowing and open discussions that often moved faster than the note-taker could write down discussion points in the online note-taking tool. For the online survey, the project partners opted for using Qualtrics instead of EngageSuite.

GoNano social media accounts were set up with the aim of engaging with audiences throughout the co-creation process; however, having a forum for online engagement does not ensure it will be used, or that the participants one engages with are familiar with or willing to use online engagement. Furthermore, the online engagement space is complemented, and in some cases superceded, by more personal interactions like emails and telephone calls between meetings.

Learning through the project cycle, Facebook and Twitter proved to be the most suitable tools for information sharing. Information sharing designed around themes and presenting results of the project had a better reach than information on an event. The GoNano experience shows that people will engage in deliberation on specific results, e.g. in the online survey, but that a continued and sustained deliberation online is hard to achieve. For future projects, one should consider these aims carefully, as well as the effort required to fulfill them.

3.3 Progress towards the overall aims of the project

Having reviewed progress towards the specific objectives of the GoNano project, this concluding section reflects on the overall aim to improve the responsiveness of research and innovation processes to public values and concerns. Clearly, GoNano 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. It is about trust in the direction of innovation: for what purpose? Addressing which needs? Who gets to have a say? Who benefits? The question is how to enable new models that integrate societal considerations earlier and more effectively in the research and innovation process.

GoNano has also explored co-creation as a tool to strengthen responsiveness in nanotechnologies. All partners have made a significant effort to design and implement a co-creation process that met the ambitious objectives of the project. This combined effort has brought opportunities and challenges of co-creation into view.

Co-creation comes in many shapes and sizes

The GoNano experience suggests that co-creation is a *method* that can be applied to reach many different goals. Each type of co-creation involves different types of actors, with different expected outputs in different stages of innovation. The *purpose* of the event prescribes the actors that should be involved, and the ways in which they contribute. Different possible functions of co-creation were observed as the GoNano project unfolded:

- Co-creation as *envisioning*, as in the GoNano citizen workshops, considering potential applications of nanotechnology that would respond to the values, needs and concerns of citizens. Examples from other areas are the NANOPLAT project, or Vision Lines 2020.[41]
- Co-creation as *user-led innovation:* the way data is visualised in the user interface for the artificial pancreas at UT, and the review of technological design of the biosensor for cancer detection are examples within the GoNano project. User-led innovation has been used widely in the commercial sector to improve consumer goods and services.
- Co-creation as the *creation of shared value through product development*: an example from GoNano is the integration of societal considerations in the Harvestore project. BASF's Creator Space offers another example.

Co-creation can offer contributions on different Technology Readiness Levels

Co-creation could help to enhance creativity at different Technology Readiness Levels (TRLs).[42]

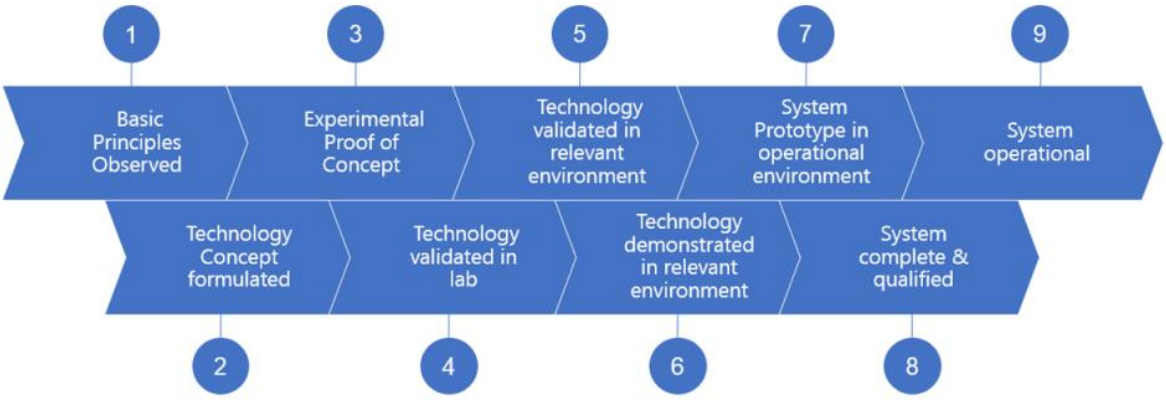


Figure 4 – Description of Technology Readiness Levels from the European Commission

[41] See this interview with François Jégou, Director of Strategic Design Scenarios (SDS), for further information about the EU project NANOPLAT and the Vision Lines 20 project.

[42] Annex G of the General Annexes of the Horizon 2020 Work Programme provides the European Commission's definition of TRLs.

GoNano originally targeted TRL 2-5 as the level at which feedback from citizens could generate design suggestions to align research and innovation with the values, needs and expectations of society. Indeed, the suggestion made at the stakeholder workshop in food in the Czech Republic to design a packaging system for perishable foods could be situated at TRL 2 (formulating a technology concept). The wireless sensor nodes developed in the Harvestore are also at TRL 2, and the sensor for cancer detection developed at UT is at TRL 2-3. However, the artificial pancreas is closer to TRL 7 (prototype is demonstrated in an operational environment), and in this case the suggestions raised in the workshops proved also to be potentially relevant. Societal inputs can therefore be sought at different TRLs but one should remain conscious that the malleability of a technology proposal will tend to decrease as the TRL increases.

Co-creation is not a panacea

To be sure, co-creation presents opportunities *and* drawbacks. Working together with different types of stakeholders increases the 'transaction costs' of the collaboration. Developing a shared language takes time. In fact, many 'ordinary', straightforward, technical problems may best be solved by traditional, monodisciplinary teams. It's especially the 'wicked problems' (problems that are impossible to solve and have no single solution because of incomplete, contradictory and changing requirements that are often difficult to recognize) that require collaboration between stakeholders.[43] Co-creation can be an especially effective tool to tackle these types of problems. Nanotechnology governance is such a wicked problem: the challenges do not only reside in the development of the technology itself, but also in the required alignment between working practices, responsibilities, knowledge levels, expectations and concerns across widely divergent fields of expertise. As Rittel and Webber (1973) note: *"in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first."*

The opportunities and challenges identified in the GoNano project are not limited to nanotechnologies only, but apply to the governance of emerging technologies more generally. Overarching questions of responsiveness, participation and sustainability equally apply to biotechnology, robotics and information technologies.

Working within the margins of enhanced responsiveness

The findings of the GoNano co-creation process, then, reconfirm earlier findings: with some effort and careful preparation, it is possible to demonstrate to stakeholders that it does make sense to look at the broader dimensions of research. Indeed, the GoNano co-creation process has offered insight into the potential value of co-creation initiatives. Participants valued the general opportunities for mutual learning and networking opportunities offered by the stakeholder workshops. However, as has been shown previously, getting from constructive dialogue to practice action is a significant bottleneck. The gap between appreciation of broader issues around research

[43] Rittel, H.W. J. & M.M. Webber (1973). Dilemmas in a General Theory of Planning. Policy Sciences 4: 155–169.

and innovation and the actual integration of those issues in daily research practices and priorities remains significant.

The implementation of a co-creation process that identifies *and* realises concrete steps towards more socially robust research and innovation requires considerable resources. Co-creation processes need to identify the concrete interests and address the motivations of all participants, maintain continuity of thought, and drill down to the level where the discussion topics and identified courses of action are specific enough to affect the decisions of the actors involved.

Moreover, the challenge of aligning research and innovation to societal needs and values lies not only in deciding what sorts of future applications European citizens and stakeholders *want and need* (which is difficult enough, given the multitude of answers to the question of what contributions research and innovation are expected to make to economic, societal and environmental challenges). The challenge also lies in *practically realising* the desired change.

Given the relative autonomy of technology enactors in deciding on the directions of research and innovation, a focus on the value that co-creation can add to existing practices is the price one has to pay to call attention to societal considerations in individual research and innovation projects. If there is nothing 'in it' for the innovator, change is unlikely. Calls for responsiveness will need to identify the 'win-win' opportunities where 'doing good' and 'doing well' coincide.