



# The importance of gender and diversity in nanotechnology Research and Innovation

Gender, diversity and culture in nanotechnology research and innovation: policy recommendations for designing engagement processes



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# Executive summary

Inequality issues of gender and diversity have been increasingly recognised within research and innovation (R&I) as both a normative challenge and a limitation to innovation. It is argued that dealing with these issues allows increased innovation capacity and provides opportunities for nanotechnology-enabled products to be better aligned to societal needs and values. Thus, balancing these inequalities has been considered a crucial challenge in the framework of Responsible Research and Innovation (RRI).

RRI claims that it will be able to foster innovation that is safe, ethically acceptable, and responsive to the needs and expectations of people; it aims at redistributing responsibility among all relevant actors to align their input closer to innovation processes in a non-discriminatory way. As a result, sensitivity towards gender and diversity and towards culture and communication require special attention. As co-creation appears as one potential approach to the inclusion of a broader public in state-of-the-art research and innovation activities, these issues need to be considered when undertaking co-creation activities so that further steps can be taken towards their mainstreaming.

In order to support mainstreaming the consideration of gender and diversity issues and of culture and communication within co-creation, this GoNano White Paper identifies opportunities and challenges related to this goal and aims to provide interested parties (e.g. organisers of such processes) with hands-on recommendations for what to consider when thinking about implementing such a co-creation process.

Recommendations and insights that emerged from GoNano pilot experiences may help in identifying necessary preconditions and ways to meet such issues when setting up co-creation.

The five GoNano recommendations for strengthening awareness of sensitivity with regard to gender, diversity, and culture and communication are:

## **1. Strengthen gender mainstreaming from the outset**

Allow for flexibility in thinking and avoid stereotypes. Individual inputs and viewpoints should be encouraged which differ from the norm and the mainstream, by informing the participants using various examples (for example diverse perceptions of risk, nano and religious beliefs) and reflecting with them on how diversity and gender play a role in the process. Taking diversity and gender into account strengthens the plasticity and lifelines of the discussion and process, but it requires some extra effort regarding the selection of stakeholders and experts and the decoding of gender aspects in the actual content of the workshop.

## **2. Include diversity from the outset**

A lack of diversity within a community (here: the nano community) disadvantages those who are in a vulnerable and 'not-normative' position in a societal or global context (historically and at the present moment), as their needs and values are not sufficiently (i.e. equally) represented in a way that would provide for equality. GoNano considers that a wide range of opinions should be included in R&I as a desirable societal norm. However, apart from humanistic ideals, encouraging diversity in science, engineering and other work contexts has been shown to create smarter and more creative teams with more output and is therefore also a profitable approach, even if deviations within groups remain small.

## **3. Adopt a strategic engagement and a two-way communication effort**

In order to adopt a strategic engagement and a two-way communication effort, it is important to have an idea of how a lay person may come to reach an opinion on nanotechnology. Once this is ensured, the next step is that the information material individuals are presented with is appropriate, respecting differing cultural and intersecting social identities. This ensures that as many opinions as possible are captured and appropriately presented, and that questions important to different demographic groups are included.

#### **4. Visualise future applications in everyday life contexts**

Especially when discussing the subject of nanotechnology, visualising future applications in everyday life contexts may enhance debates. Because nanotechnology is inherently abstract, it is often difficult for lay people to imagine some aspects of it. Concrete examples help to ensure that lay people can converse about and discuss the issues with scientists, stakeholders and other participants as equals. In GoNano, a special emphasis was put on tangibility of ethical and societal challenges with all participants in the process. In order to cope with this concern, possible scenarios were developed and provided in the workshops and also in the information leaflets.

#### **5. Challenge implicit discrimination and gender issues**

Visions of nanotechnology include subtle assumptions regarding gender and diversity implications. However, visions, prejudices and projections are highly subjective. Therefore, it is important to envisage the potential actors, their reactions, and their behaviours and to reflect and challenge existing assumptions or stereotypes. However, this policy advice is not only a specific best practice suggestion for nanotechnology processes but also a key element of best practice in science and communication in general.

# Highlights from the gonano white paper series

The GoNano White Paper series highlights the conclusions derived from the co-creation activities carried out in the project. On the basis of our GoNano experience, we recommend that the following factors should be considered when planning co-creation activities:

## Knowing and reaching the target audience

- Find ways to improve the conditions to enable responsiveness on the levels of institutions, opportunities and organisational culture
- Be cognisant of what is possible to change within the affected system
- Identify and assess issues and actors along the whole value chain for concrete scoping
- Address salient dilemmas or societal challenges to attract the attention of potential participants, using solution/opportunity-oriented framing.

## Changing perspective as a precondition or outcome of co-creation

- Foster R&I actors' appreciation of the opening up of the research process and involve perspectives not usually involved in R&I
- Challenge the ways in which (the views of) others are anticipated, simplified or ignored in relation to science/scientists, industry/industry representatives and society/citizen-consumers.

## Adopting tangible methods for co-creation

- Identify ways to empower actors to express diverse issues (enabling responsiveness)
- Balancing actors' involvement: be aware of the trade-off between specific expertise and societal inclusiveness
- Be aware of potential power differences among the participants: academics, industry representatives – and the general public.

## Increase your gain

- Share your knowledge across sectors and activities
- Improve R&I strategies and innovation trajectories
- Find new and original design and product suggestions.

# Foreword

## What are the 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 (R&I) 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 industry and policy briefs outlining the topics with greatest industry and policy relevance.

The GoNano White Papers are a core part of the GoNano project<sup>1</sup>.

The three GoNano White Papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnology. Each paper addresses the question of conditions for Responsible Research and Innovation (RRI) in nanotechnology R&I from a different angle.<sup>2</sup>

- **White Paper 1** sets out why co-creation responsiveness makes sense in nanotechnology and describes conceptual and empirical aspects of *responsiveness of researchers and engineers* in co-creation processes with a focus on nanotechnology. It mainly addresses researchers, engineers and other stakeholders involved in the research system (e.g. research funding or research institutions), including the organisational structures they are engaged with.
- **White Paper 2** provides a strategic focus regarding *how to implement co-creation*, considering research as well as the innovation eco-system. It addresses industrial and business partners, research institutions, and policy makers who are active in and are influencing R&I processes.
- **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 R&I. 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 for and constraints on implementing co-creation in nanotechnology R&I practice. It builds on the findings of the GoNano project, which is built 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.<sup>3</sup>

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 by BASF for example aims to foster open innovation within the company.

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1. For more information on the overall structure of the project and our further understanding of co-creation see <http://gonano-project.eu/>.

2. For more information on the RRI framework as set out by the EC, see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>). For the aspect of responsiveness, see GoNano White Paper 1.

3. For further information see GoNano D2.1: [http://gonano-project.eu/deliverable-2-1/\[20-02-2020\]](http://gonano-project.eu/deliverable-2-1/[20-02-2020]) or, for an illustrative example, see the experiences of the Fonteer project: [https://www.youtube.com/watch?v=VID2EyW5W\\_k](https://www.youtube.com/watch?v=VID2EyW5W_k)

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.<sup>4</sup>

Within the GoNano project, co-creation is applied to strengthen the ability of R&I processes to respond and adapt according to changing demands. The underlying assumption is that R&I will be more socially robust if societal needs and values are taken into account in the early stages of innovation.<sup>5</sup>

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.”*<sup>6</sup>  
(Bechtold et al. 2019<sup>7</sup>)

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims at anticipating contributions that can serve to make R&I more socially relevant.

To do so, co-creation approaches require new forms of collaboration that extend across different disciplines and sectors. (Figure 1)

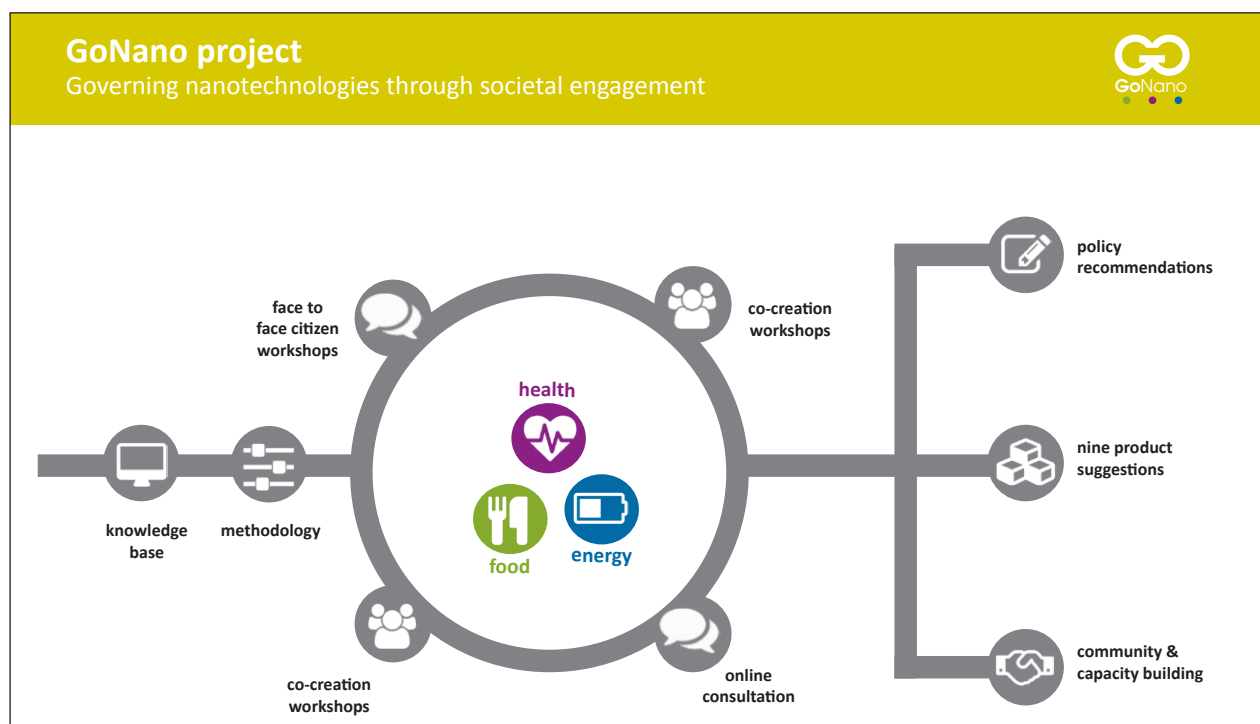


Figure 1. GoNano co-creation process

4. 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>).

5. 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 the EU project Making Sense EU: <https://www.youtube.com/watch?v=au3uVptWjBU>.

6. For further information, see this earlier report on the co-creation methodology for GoNano: <http://gonano-project.eu/deliverable-2-1/>.

7. GoNano D2.1: <http://gonano-project.eu/deliverable-2-1/> [20-02-2020]

## The process in detail

GoNano has established an iterative and interactive process through which societal considerations in the area of nanotechnologies<sup>8</sup> can be integrated into R&I. In a series of citizen workshops, citizens expressed their wishes and concerns with respect to each of the application areas. In a series of stakeholder workshops, stakeholders subsequently explored ways to take these wishes and concerns into account in nanotechnology R&I.

At the start of the iterative and interactive process, the three pilot partners (the University of Twente in the Netherlands, the Technology Centre of the Czech Academy of Sciences in the Czech Republic, and the European Office of the Royal Melbourne Institute of Technology in Spain) organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018.<sup>9</sup> The aim of the first round of stakeholder workshops was to come up with concrete responsive design suggestions that could be fed back into ongoing R&I activities, building on the outcomes of the citizen workshops. The design suggestions were to feed into a next round of citizen consultations, which would again feed into a second round of stakeholder workshops serving to evaluate the uptake of the responsive design suggestions of the previous round. The primary aim was to identify product suggestions which are better aligned with societal needs and values. Taken together, these iterative tasks explore the potential of co-creation in integrating societal values into R&I and provide more insight into the more actively-oriented responsiveness of business and industry.

Thus, the main findings of the GoNano process in the four steps of co-creation were:

### • Citizen workshop

Citizens appreciate the promise of nanotechnologies and connect the applications to current global issues concerning sustainable development, the environment, and health and wellbeing, but they also realise that the benefits might not follow automatically: In all pilot countries, citizens seem to put a strong emphasis on the role of scientists in the process of development and implementation of nanotechnologies, expecting that they will ensure that especially food and health related applications are safe to use – that they do not harm the environment or the human body. Citizens can provide a fresh and somehow ‘untainted’ picture of what the technology might look like.

... for more details, see Hebáková et al (2019)<sup>10</sup>

### • Stakeholder workshop 1

As it is far from self-evident how broader societal consideration can be applied meaningfully to R&I practice, the workshops succeeded in raising and fostering awareness with stakeholders that an early consideration of the needs and values of citizens and societal stakeholders can add value to innovation in nanotechnologies; however, it proved difficult to connect the general input from citizens to the research agenda and concerns of the professional stakeholders. So, connecting the ideas of citizens to the stakeholders and their agenda was the main challenge of all the activities.

... for more details, see Schuubiers et al. (2019)<sup>11</sup>

8. See GoNano Del. 1.1 (online: <http://gonano-project.eu/wp-content/uploads/2018/08/1.1.pdf> [2020-03-23]) and 2.1 (online: <http://gonano-project.eu/wp-content/uploads/2018/08/2.1.pdf> [2020-03-23]) for knowledge base and the methodology developed in earlier stages of the project.

9. See the briefing report for further information on the outcomes of the citizen workshops.

10. GoNano D3.2. Online: <http://gonano-project.eu/wp-content/uploads/2019/06/D3.2-Briefing-report-from-the-citizen-workshops.pdf> [2020-01-21]

11. GoNano D4.2. Online: [http://gonano-project.eu/wp-content/uploads/2019/07/GoNano\\_D4.2\\_Working\\_paper\\_on\\_the\\_designs\\_and\\_outcomes\\_of\\_round\\_1.pdf](http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes_of_round_1.pdf) [2020-01-21]

- **Online Consultation**

Results of the online consultation showed that product suggestions beneficial for the whole society gain most popularity. These products would be mostly related to health application area – specifically to diagnosis of cancer and diabetes. The online consultation again proved that for health and food, the safety is the most important main need and value for the future nanotechnology applications. However, results also show that citizens can have concerns also about the solutions for the issues they raise - preferences of the wide audiences can be easily malleable and therefore unpredictable.

... for more details, see Pour et al. (2019)<sup>12</sup>

- **Stakeholder Workshop 2**

The second stakeholder workshop – as the final step of the co-creation process – resulted in the most sophisticated exchange of ideas and feedback on the co-creation process so far. In comparison to the first stakeholder workshop, the second workshop provided important insights into the requirements for co-creation in nanotechnologies, highlighting both opportunities for and constraints on co-creation.

... for more details, see Schuurbiers et al. (forthcoming)<sup>13</sup>

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12. GoNano D3.3. Online: <http://gonano-project.eu/d3-3-briefing-report-on-the-outcomes-of-the-online-consultation/> [20-02-2020]  
13. GoNano D4.2b (forthcoming).

# Why the gender dimension and diversity matter

The present white paper introduces rationales for why and policy recommendations for how to realise an increased focus on gender, diversity and culture in nanotechnology R&I contexts and processes. Gender and equality are both highly relevant to RRI and nanotechnology, as this White Paper will show. For example, teams have been proven to benefit from diversity, including gender, ethnicity, nationality, scientific discipline and work experience, to name only a few aspects (Nielsen et al., 2017). It is important to highlight that while the term ‘gender’ is used throughout this White Paper, we use it to refer to ‘gender equality’ as opposed to the semantic meaning of the word ‘gender’. In terms of gender specifically, research focusing on gender aspects in nanotechnology and related fields is rare (European Commission, 2011). The lack of inclusion of a gender approach from the very outset in relation to new technologies such as nanotechnology ultimately affects the outcome of the process (European Commission, 2011). RRI as a concept builds on previous governance frameworks that have dealt with uncertainty and a lack of knowledge about the effects of science, technology and innovation (Owen et al., 2012). In contrast to earlier research and governance frameworks, RRI is concerned about both the negative and positive consequences of science and technology development and innovation, and it promotes collaborative attitudes and orients itself towards possible future consequences in a prospective and proactive way. It builds on traditional governance instruments (hard and soft law) but emphasises the notion of self-regulation as key to responsibility in RRI.

As a concept, RRI is inherently normative when it comes to the goals it aims to achieve and the processes it would like to facilitate. As such, RRI can be understood as a holistic integrative approach in which gender equality and the gender dimension more broadly play an important role. The issue of gender equality is the second among the core issues (six keys) of RRI as defined by the European Commission, after public engagement and followed by science education, open access, ethics, and governance (Strand et al., 2015).

In line with the normative setting of RRI, GoNano as a project has taken on the agenda of raising awareness of issues of gender equality and diversity and outlining ways of addressing these issues. Thus, this White Paper in particular is focused on gender, diversity and related concepts and also addresses practical implications such as culture and communication in the area of nanotechnologies.

Generally speaking, we relate differently to new technologies like nanotechnology depending on the different roles we take up in society, and we do this in various ways.

One of the fundamental conditions shaping our social behaviour is our gender identity: however, in research and public discourse the difference between biological sex and socially constructed gender complicates the tasks of addressing the issue of identity (Deutsch, 2007). The term gender is not the same thing as biological sex; however, the two are often mistakenly used interchangeably. Gender refers to the socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women, whereas sex refers to the biological and physiological characteristics a person is born with (World Health Organisation, 2010). It is also important to note that neither sex nor gender is exclusively binary (male or female, man or woman); a person can for example be intersex, or identify on a broad gender spectrum. This is relevant to GoNano on several levels: first, the quota and role of women in STEM (Science, Technology, Engineering and Mathematics) research, as well as gender representation in the concrete co-creation process. Thus, the entire nanotechnology realm profits from incorporating a holistic gender perspective.

Nevertheless, the question of women in science, especially with regard to STEM fields is of great importance because as things stand the core values and assumptions in STEM fields, including nanotechnology, have been fundamentally shaped by men and male norms (Savath and Gage Brainard, 2013). The European Commission eloquently describes

the issue with the help of the example of product customisation: “One very powerful idea, for instance, is that of product customisation, which means paying more attention to the specific needs of each individual user. These individuals are not necessarily average white males, but can be women, children or people with disabilities, and can have all sorts of ethnic and genetic make-ups, cultural and social backgrounds, etc. They all still have the right to see their specific needs addressed.” (European Commission, 2011, part 3.2) The gender imbalance has the effect of excluding women’s voices from the STEM fields, including nanotechnology, whether as academics, researchers, innovators, consumers, or product end users, to name but a few roles. Having a field as large and as important as STEM, and specifically nanotechnology, dominated by male norms means that balance and innovation are affected and thoughts and concerns that question the status quo are all silenced; this in turn contributes to one-sided research, poor innovation and inferior products in relation to co-creation and engagement. These considerations may also be reflected in addressing the diverse needs of citizens/consumers in relation to social, cultural and biological diversity (gender, ethnicity, age and other factors).

The GoNano project strove to implement gender equality from the very outset of the project. The issue of gender was therefore at the forefront in the partner workshops.

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. (‘Working paper on GoNano stakeholder workshops’<sup>14</sup>)

Being related but not limited to the concept of gender, diversity can be an even more difficult term to define – does it refer to gender, ethnicity, sexual orientation, age, ability, religion, social class? Diversity can mean many things, and a person may be diverse in one way and not in another.

For example, does including a woman on a team make it diverse, even if she is from a privileged, white middle-class background? Or is a team more diverse if it includes a middle-class man but one who comes from a minority background?

When considering such questions regarding diversity, it is crucial to look at how these multitudes of social identities intersect with each other. Intersectionality is the interaction between gender, race, and other categories such as sexual orientation, age, disability, and so on, and the outcomes of these interactions in relation to power structures and oppression (Davis, 2008).

To include and analyse not only gender but other intersecting factors such as ethnicity, socioeconomic background, and so on is therefore vital, as it improves science and innovation and may also reveal sub-group differences (Schiebinger, 2017). This fact is also important as it clearly demarcates diversity from gender. While a proper gender balance contributes to diversity it does not replace it, and vice versa.

It is also important to highlight that while the term ‘gender’ is used throughout this White Paper, we use it to refer to ‘gender equality’ as opposed to the semantic meaning of the word ‘gender’. Gender equality is an issue for both men and women, and both groups are affected in different ways and have needs and issues that must be addressed for gender equality to be achieved. However, for this particular subject area, that is to say STEM, nanotechnology, RRI

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14. GoNano D4.2. Online: [http://gonano-project.eu/wp-content/uploads/2019/07/GoNano\\_D4.2\\_Working\\_paper\\_on\\_the\\_designs\\_and\\_outcomes\\_of\\_round\\_1.pdf](http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes_of_round_1.pdf) [2020-01-21]

and co-creation, the focus of the gender equality issue was the involvement of more women. Women are seriously underrepresented at all levels of STEM, and therefore it is this experience which this White Paper is concerned with. Nevertheless, it is necessary to clarify that gender issues can also have an impact on men, and as we explore the issue of gender in this paper we do so in terms of gender equality.

## **Citizens and consumers – another facet of taking on roles in society**

However, identities are shaped by many more factors than the ones mentioned above, e.g. by political participation or participation in the economic system. In the contexts of product development and science, the roles the actors take up (e.g. of citizens and consumers) may fundamentally steer individual behaviour and relations to technology, from early adopters to reluctant users or objectors. Roles may also be affected by socioeconomic circumstances, levels of education, gender, ethnicity, age, and other demographics (Lee et al., 2005). Therefore, this may also shape how risky we consider nanotechnologies.

Citizens can engage in political or policy-related debates in different ways such as societal debates, environmental engagement, local initiatives etc., via mass media, social media, CSO membership, in addition to ‘regular’ political participation (i.e. voting).

As consumers, however, our perspectives and approaches are rather different. Consumers as customers are concerned with the safety of the products they purchase, with new and hopefully improved product properties, with price, availability and so on. The right to safety and the right to be informed are two of the most relevant rights for nano consumption, and they are linked to our consumer role (Throne-Holst and Strandbakken, 2009).

Today, however, consumers are not necessarily just individualised customers/buyers. The consumer role can be and has been politicised. One example is when groups of consumers use their collective purchasing power to boycott certain products for political-moral reasons, or – the other way around – endorse certain products. *“Political and ethical consumption and boycotts are not a new phenomenon. However, in late modernity, the complicated relationship between our role as consumers and citizens has been revived by the shift in political paradigm from government towards governance.”* (Stø et al. 2008, p. 239)

Additionally, apart from political convictions as a moral guideline for consumption, we need to take into account the fact that end users/consumers are affected differently for a variety of reasons – be it their diverse biological condition, different behaviour in relation to a particular product (different user scenarios), or life circumstances.

# Policy recommendations for better consideration of gender equality, diversity, culture and communication

This White Paper describes the policy recommendations that resulted from our analytical work in preparing the engagement methodology, and introduces the lessons learned in implementing that methodology in practice.

The five policy recommendations are:

- Recommendation 1: Strengthen gender mainstreaming from the outset
- Recommendation 2: Include diversity from the outset
- Recommendation 3: Adopt a strategic engagement and a two-way communication effort
- Recommendation 4: Visualise future applications in everyday life contexts
- Recommendation 5: Challenge implicit discrimination and gender issues

Explicitly discussing issues of gender, diversity, culture and communication in a White Paper on nanotechnology innovation may enrich the discussion considerably, both on the level of research objects and participants and in terms of the research questions to be addressed. We will argue that connecting these issues allows for an increased innovation capacity and the opportunity to develop nanotechnology-enabled products that are better aligned to societal needs and values (for more information see White Papers 1 and 2).<sup>15</sup>

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15. Further lessons concerning gender and diversity have also been explored in other EU projects such as RRI tools: <https://www.rri-tools.eu/gender-equality#how-to> [2020-02-19]

RECOMMENDATION

1

**Strengthen gender  
mainstreaming  
from the outset**

There is a growing recognition of the benefits that the presence of female professionals in STEM brings, not least the fact that their mere presence may help to hasten the diversification of the sector by acting as role models for future entrants; nevertheless, women remain underrepresented at all levels (Sapleton and Takruri-Rizk, 2008).

To avoid the deficits within the scientific enterprise which result from the underrepresentation of women (Toumey, 2012), one good place to start is by adopting policies of gender mainstreaming. Gender mainstreaming is defined as “the integration of a gender perspective into the preparation, design, implementation, monitoring and evaluation of policies, regulatory measures and spending programmes, with a view to promoting equality between women and men, and combating discrimination” (European Institute for Gender Equality, 2016).

## ! WHY?

By integrating sex and gender into all aspects of development, research and discussion, value is added by allowing diverse and new viewpoints or ideas, by ensuring innovation, excellence and quality in outcomes and enhancing sustainability, and by making research more responsive to social needs (Schiebinger, 2017). Probably the most well-known area where this applies is medicine, including pharmacological development, where the standard norm ‘human’ was historically defined in a non-diverse manner – typically as a young white male, an assumption that has extensive consequences for the medical treatment of the rest of the population (Health Canada 2013; Kim et al., 2010).

Another example, in the context of nanotechnology, is that men and women have differing attitudes towards the risks and benefits associated with nanotechnology; women are less enthusiastic about it and above all less willing to tolerate nano-related risk (Toumey, 2012).

Gender mainstreaming was used in the multi-stakeholder engagement and co-creation process in GoNano to strengthen it from the very outset. By including this in the engagement methodology, the GoNano project provides both citizens and stakeholders with an opportunity to innovate in an informed and aware manner and to avoid the pitfalls caused by a group that is too homogeneous and does not ask questions or think critically. We would therefore strongly recommend including gender mainstreaming in all parts of any co-creation process.

Additionally, the recognition of participants’ individual and diverse inputs and viewpoints is crucial in order to implement gender equality, as well as allowing for the extension and reconsideration of societal norms (see Bogner, 2012). This implies that arguments and contents brought forward by the participants that are not in line with social norms or mainstream opinions are explicitly given a space. “Deliberation norms become established which lead to the exclusion of those participants who cannot or do not want to fit in with those norms.” (Bogner, 2012, p.519)

## 🔧 HOW?

For example, from the outset, the information leaflet specifically covered gender issues.

The information given to the citizens before the workshop specifically encouraged participants to think along the lines of gender and diversity. The three information leaflets (GoNano Citizen’s Meetings Information Material: Future Healthcare & Nanotechnologies, Future Food & Nanotechnologies, and Future Energy & Nanotechnologies) all included the following:



*“Research has shown that because nanoscience is dominated by men, ideas of future nanotechnology products are also male oriented. Men and women also think differently about risk. Perceptions of risk vary between some ethnic groups, with some men having a lower perception of risk. Women are more likely to think nanotechnologies are dangerous, and are less likely to engage with nanotechnologies because of this.*

*Research has also shown that religious beliefs and differences in culture can play a role in how we judge the potential of nanotechnologies, as well as how we*

*believe nanotechnologies should or should not be used.”*

*What do you think?*

*Do you think culture, gender or religion influence how you think about using nanotechnologies for application in [healthcare, food or energy]?*

*Do you think there are some traditional and cultural values we should support with new technologies for [healthcare, food or energy]?”*

In GoNano, an effort was made to address gender both as biological sex and as a social construct. This was done to ensure that both physical representations and the ideals/expectations of behaviours exhibited by men or women and the value judgements made on those behaviours were included.

- A target was set to achieve a 50/50 gender balance in the citizen workshops and the stakeholder workshops as far as possible.
- For the stakeholder workshops, special effort was made to explicitly invite female experts. Because of the lower systemic representation of women in STEM, more efforts may be required to identify female experts with a specific area of expertise for which finding a male expert would be easier.
- The actual content of the workshop needs to reflect gender aspects – e.g. by including risk perception of nanotechnology, an area where gender divergence is noticeable (Toumey, 2012; Savath and Gage Brainard. 2013), in the topics under discussion.

However, within the workshop the discussions showed that participants were aware of gender issues and sometimes addressed them explicitly.

**The effect of diversity was especially noted in the workshops run by the Czech partners, both for stakeholders and for citizens. As far as gender was concerned, the composition in all of the groups was set so there would be a precise gender balance. From the perception of moderators there was no general difference observed between the participants, and if there was the moderators would intervene to give equal space to all participants. The discussions were balanced due to good recruitment strategies and due to the work of moderators, who were able to provide space to most of the participants in an equal manner (in both citizen and stakeholder workshops); furthermore, due to a gender-balanced composition it may have been easier to steer the discussions in a more equal manner.**

**In the Netherlands, during the debate on how to implement the diagnostic device for detecting diabetes type 2 at an early stage the business developer and other stakeholders were specifically asked whether they saw any differences between men and women in this regard. One stakeholder mentioned that women might be more used to a population screening, which was one approach to implementing the diagnostic device, as women between 50 and 70 get a 2-yearly population screening for breast cancer. Nevertheless, the stakeholders emphasised that more differences would be expected based on social economic status (SES), as diabetes type 2 is more common among people with a low SES.**

**„The Czech citizen consultation showed that factors connected with accessibility, such as high price, could make the difference between customers who would buy or not buy a certain future product rather than gender, age or any other factor.“**

**In the Dutch citizen consultation about nanotechnologies for health, for example, in various groups a comparison was made between the diagnostic device and pregnancy tests. In these groups women often came up with this example and explained how home diagnostic tests, just like pregnancy tests, could empower patients. Both men and women further deliberated on the example. These discussions would probably be less likely to appear in groups with only men.**

RECOMMENDATION

2

**Include diversity  
from the outset**

As with gender, STEM, including nanotechnology, tends to suffer from a lack of diversity in all areas, including research, academia, and innovation and creation activities (European Commission, 2011). The lack of diversity in the nanotechnology field is an issue that, while not as widely acknowledged as the gender imbalance, is one that is of utmost importance and deserves to be highlighted just as much.

When a scientific community like the nanotechnology community lacks diversity, it is less likely to consider the needs and concerns of all those potentially affected by future nanotechnologies, especially those in populations that have been historically vulnerable (Savath and Gage Brainard, 2013). For example, a study on risk perception, gender and race found that while risk was judged as lower by men, it was consistently judged as much lower by white, well-educated, high-income, politically conservative males. Finucane et al. (2000) speculate that this result is because the world seems safer, and hazardous activities more beneficial, to white men than to other groups. Women and males of colour tend to be in a position of less power and control, benefit less from technologies and institutions, are more at risk from discrimination, and are therefore more cautious when judging risks (Finucane et al., 2000). Diversity is therefore helpful for more long-term and social benefit.

## Why?

The lack of diversity in the nanotechnology field is an issue that, while not as widely acknowledged as the gender imbalance, is also of utmost importance.

First, including diversity needs to be understood as a desirable societal norm: representatives of both sexes/all genders should be included.

Second, the concrete benefits of diversity are many. Teams have been proven to benefit from diversity, including gender, ethnicity, nationality, scientific discipline and work experience (Corley et al., 2016; Savath and Gage Brainard, 2013; Schiebinger, 2017; Nielsen et al., 2017). Encouraging diversity creates an innovation dividend for scientific organisations that leads to smarter, more creative teams with more new discoveries (Nielsen et al., 2017).

## HOW?

Bearing this in mind, the GoNano methodology took a number of measures to ensure a balance when it came to diversity. However, ensuring diversity does not just mean replacing the word 'gender' with diversity, and a number of additional steps were taken (Bechtold et al., 2018).

Based on the thorough investigation of gender and inclusion in the report 'Understanding the role of culture, gender and communication traditions, and their implications for engagement methodologies, communication and dissemination', efforts were made to enhance inclusion with regard to both the affected and unaffected public, with the goal of not being restricted to the somewhat homogeneous type of group that would have had prior interests in nanotechnology. This was done in order to allow for a more diverse discussion.

**The workshops aimed at integrating different forms of expertise in constructive ways, thereby ensuring that not only a generic nanotechnology expert would be invited to participate. It was also crucial to include diversity in the recruitment sample and make it transparent.**

**For the Dutch citizen consultation on health, a diverse sample was recruited based on gender, age, and residential area (city vs. rural area) by distributing leaflets and invitations among different groups of people. Additionally, by recruiting via the website of Diabetesfonds and the regional hospital, the invitation was targeted at (diabetes) patients or family members of (diabetes) patients. The aim was to also include participants with different levels of education. However, this was difficult, as only people with relatively high levels of education responded to the invitation. Efforts were made to include less well-educated people as well, but they declined their invitations. When asked face-to-face why they had**

**not responded to the invitation, they answered that they thought nanotechnology was a complex topic to which they would be unable to contribute.<sup>17</sup>**

Also, the facilitation concept encouraged moderators to pose provocative questions to prompt thinking along different perspectives (see Recommendation 3).

These steps are all important to introduce diversity as often and as early as possible and to ensure that it actively contributes to and shapes nanotechnology development. Much like gender, including diversity is an ongoing process and needs to be continuously evaluated, critically reviewed so that new and different tactics can be introduced and improved where necessary. Reflection questions such as those proposed by the RRItools<sup>18</sup> self-reflection tool or the NewHoRRIZon thinking tool<sup>19</sup> may support this process. Therefore, evaluation of processes needs to be oriented towards increasing diversity in order to make sure that these issues are taken up consistently and continuously within the different processes.

With regard to diversity, some of the workshops showed that rather than gender, it was education, age, and/or economic activity that provided noticeable impact. It is worth mentioning that age and education could be considered in the forefront in terms of impacting the results regarding diversity.

*In the Czech citizen workshop, for citizens as potential customers, moderators had the impression that the economic situation of an individual and the cost of an application would be a number one factor that could impact the future acceptance of such products. During the stakeholder workshops, it was rather occupation or age that seemed to bring out different perspectives on the development of nanotechnology applications: For example, the businesses would be less risk-concerned than researchers, and PhD students would seem critical than senior researchers.*

*Lower age and a higher number of PhD students in the Spanish stakeholder workshop may have contributed to a more enthusiastic atmosphere during the workshops.*

*The composition of the Czech stakeholder workshop, which was dominated by highly educated and elder participants, may have resulted in what moderators saw as a more critical and passive debate about new ideas for nanotechnology products.*

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17. For further thoughts on this topic, see Ilse Marschalek, Public Engagement in Responsible Research and Innovation. A Critical Reflection from the Practitioner's Point of View. Saarbrücken: Südwestdeutscher Verlag für Hochschulschriften, 2018, p. 94.

18. <https://www.rri-tools.eu/self-reflection-tool>

19. <https://newhorizon.eu/thinking-tool/>

RECOMMENDATION

3

**Adopt a strategic  
approach to  
engagement  
and a two-way  
communication effort**

## WHY?

In order to interact with citizens, and to ensure that issues of gender and diversity described in Recommendations 1 and 2 are addressed, a specific and strategic effort targeting engagement and two-way communication is necessary. In order to reach all relevant parties, including society at large, it is necessary to make an effort to understand in what way to engage with citizens and how their opinions about nanotechnology are formed. Also, it is necessary to explain why an understanding of this is relevant for the broader society.

The extremely wide potential application of nanotechnology means its effects are difficult to predict.. Alternatively, the citizen/consumer may not know that nanotechnology or nanomaterials are used in an item or product, as it may not be obvious (Throne-Holst and Strandbakken, 2009) and is not labelled with the exception of specific product groups and sectors (e.g. Cosmetics, Food, Biocides, Medical Devices, REACH; for further information see ‘Risk governance and research & innovation priorities in Nanotechnologies’, p. 26<sup>20</sup>). This can be interpreted as both a positive, in that there are no limits to how much and in how many ways we can benefit from nanotechnology, or a negative because we do not know how it may affect us. But how does the general public decide what to think of nanotechnology? By understanding this, the GoNano project can plan how best to approach specific groups and how to start a dialogue on their take on societal concerns relating to nanotechnology and future nanotechnology product development.

Decades of research into political communication (Lee et al., 2005) have shown that if information is presented in a certain way the level of accessibility of the presentation can change the intended audience’s interpretation; however, interpretation of information will generally be based on pre-existing values, no matter how neutrally the information is presented or how much care is taken to maintain a balance (Scheufele, 2006). Also, trust in those communicating messages has also been shown to be key (Ho et al., 2010). Generally speaking, trust in relation to emerging technologies such as nanotechnology can be defined as a citizen’s willingness to rely on the endorsement of experts such as scientists and regulators, and/or institutions such as the government, to manage risk associated with new and emerging technologies (Ho et al., 2010). It was therefore essential for the GoNano project to capture a breadth of opinions, including a representative demographic sample in citizen workshops and online engagement, as well as to ensure that questions important to different demographic groups were included as discussion points.

This is partly because different demographic groups have different concerns, but also because the success of aligning nanotechnology R&I development with societal needs depends on the level at which all parts of society, and all those in the public discourse, are represented.

## HOW?

By having an idea of how a lay person may come to form an opinion on nanotechnology, the next step is to ensure that the material the person is presented with, the way it is framed, and the extent to which attempts to engage the person in genuine conversation, are done appropriately and with differing cultural and intersecting social identities in mind.

The GoNano methodology adopted a number of strategies to reach participants with information, while bearing in mind the importance of communication style when doing so (Bechtold et al., 2018):

- Strategic engagement from the beginning – tools were adapted to suit the level of engagement and vibrancy of discussion that was sought

With regard to the citizen workshops, the GoNano team found that different parts of the co-creation process required a different kind of interaction. During the first part (inspiration), oral discussion was the most important way of communicating. This part was dominated by people with good oral skills, who happened, on this occasion, to be men, while more visual and manual skills were investigated during prototyping who happened to be women. A balance in different types of communication and discussion is important in order to get everyone's opinion.

- Two-way communication is very important – a conscious effort to engage fully with participants and speak with and not at them is crucial
- Emphasis on and time for opinion exchange during the workshops (participants listen to each other)
- Opinions on nanotechnology diverge among different demographic groups, and scientists are of course also influenced by predispositions. In order to hear these groups and listen to their thoughts and concerns about societal issues, the communication strategy therefore had a goal of mutual and ongoing engagement with each group.

RECOMMENDATION

**4**

**Visualise future  
applications in  
everyday life contexts**

## ! WHY?

Due to their omnipresent but abstract character, nanotechnologies can be hard to explain and possibly even harder to imagine. They have been hailed as the basis of the next industrial revolution, transforming almost any field imaginable and providing rapid technological and societal progress. We can say of these two characteristics: 1) they are hard to imagine, and 2) the widespread and diverse nature of applications areas makes it a challenge to assess the future impact of nanotechnologies. Therefore, in order to connect development of nanotechnologies with issues of gender and diversity, we recommend situating visions of future applications of nanotechnologies in everyday life contexts.<sup>21</sup> Furthermore, situating future visions in a concrete context of use makes it easier for diverse participants in a co-creation process to have a conversation on nanotechnologies.

## 🔧 HOW?

In the GoNano project our concerns were about making nanotechnologies, as well as potential ethical and societal challenges, tangible to the participants in our co-creation processes. Gender and diversity issues were among the issues we wanted to illustrate so that the participants could start reflecting on them and providing feedback. Therefore, we developed scenarios that illustrated possible future applications of nanotechnologies in the areas of Health, Energy and Food.

Also, the information leaflet for each strand (healthcare, food, energy) contains a number of imaginary scenarios from everyday life in which nanotechnology is involved. The scenarios, while fictional and involving futuristic inventions, depict situations and conversations that mirror demographic and socioeconomic diversity, such as a conversation depicting different viewpoints between a man and a woman; income disparity; religious concerns; older people's thoughts; families; and younger single people. Below is an example from one of the leaflets.



**In the cartoon about a 'home doctor', a visualisation was shown of a woman who tests for diabetes type 2 with a home-test device and who thinks about potential treatments. One of the issues she has with regenerative medicines is based on religious values, and in the cartoon a picture of three women is shown with one wearing a headscarf and one wearing a crucifix. They represent different religions.**

**This visualisation illustrates that at this point there are no analytical methods available that would enable the state authorities to completely detect the content of a food product, including the possible presence of nanoparticles.**

**This was one of the citizens' needs most frequently expressed during the citizen consultation in the Czech Republic.**



**In the Spanish citizen consultation, the visualisation of doing the laundry tackles the issue of gender stereotyping by not associating housework chores with a particular gender and presenting both parents on an equal footing. The story also raises the question of financial inequality by introducing households with different income levels and the implications this can have for decisions.**

21. The everyday life context to illustrate applications could differ according to the specific application area. The GoNano project aims to increase responsiveness to societal needs and values, and therefore focuses on the everyday life context of lay citizens (consumers?) in order to illustrate and stimulate reflection on the possible future ethical and societal impact of nanotechnologies. One could imagine that if the aim was to discover and explore issues in e.g. a clinical setting, it would be the everyday life context of clinicians or patients that would be used to stimulate reflection on possible impacts and issues.

RECOMMENDATION

5

**Challenge implicit  
discrimination and  
gender issues**



## WHY?

With new technological or scientific developments come hype, hope and uncertainty. The hype and hope around nanotechnologies came in the form of expectations that it would enable the next industrial revolution, bringing with it hopes for progress in e.g. health technologies for diagnostics, therapeutics, and regenerative technologies, and finally uncertainty in the form of possible risks to human and environmental health. With expectations come visions of future scenarios of use. How will the new technology realise its potential? Visions include imagining who the users, consumers and producers will be and what the societal, political, ethical, legal and organisational context of the new technology looks like. Perhaps less obviously, visions also include assumptions with gender and diversity implications; however, these visions are subject to the creators' own prejudices as well as their imaginations. It is therefore important to envisage the potential actors, their reactions, and their behaviours and to reflect on and challenge ex ante existing assumptions or stereotypes in order to present more realistic visions.



## HOW?

In the GoNano project, assumptions about gender and diversity were explicitly teased out by illustrating:

- How gender can influence one's thinking about risk
- How choices can be influenced by issues related to gender and diversity
- Inequalities in the distribution of new technologies
- Therapeutics that work better for some ethnic groups

**During stakeholder workshop 2 in the Czech Republic, moderators had the impression that in one expert group where there was a domination of female experts a slight increase in attention to the possible safety issues was apparent. However, at the same time this could have been caused by the topic itself – novel foods were perceived as the most 'unsafe' during the online consultation, and a further analysis of the results did not reveal any difference in gender. In the other expert groups, where female experts were representatives of research or business – as in the smart food packages discussion group – there was no apparent difference between the perceptions of (un)safety of the technology.**

**At the citizen consultation about nanotechnologies for health, citizens discussed the development of regenerative medicines and the potential opposition based on religious values in this regard. One group of citizens agreed that religious values should never guide developments in healthcare. This same group also emphasised that if there was a danger to public health, health technologies should be made mandatory. They made a comparison with vaccinations, which some people do not want to take based on, amongst other things, religious values. In another group of citizens, one of the participants explicitly stated that she was not in favour of the development of regenerative medicines because of her Christian faith. The discussion on regenerative medicines in this group was much more nuanced than in the other group.**

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