NANO2ALL

SOCIETAL ENGAGEMENT ON RESPONSIBLE NANOTECHNOLOGY

DIALOGUE METHODOLOGY

MODERATOR MANUAL

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1. Introduction

1.1 NANO2ALL project

NANO2ALL is a 3,5-year-long European dialogue project that aims to contribute to the establishment of Responsible Research and Innovation (RRI) practices in the field of nanotechnology. It is focused on transparent co-production of knowledge through inclusive and participatory approaches, including national and EU-level dialogue sessions that engage both citizens and relevant stakeholders.

Funded by the European Commission and led by SPI (Sociedade Portuguesa de Inovação), the NANO2ALL project addresses the "societal engagement on responsible nanotechnology" topic of the Call for Nanotechnologies, Advanced Materials and Production of the Horizon 2020 Work Programme 2014-2015. In the past, various other engagement projects, public surveys and deliberative experiments related to nanotechnology have been performed. NANO2ALL will build on these activities to reach one step further by actually constructing an innovation agenda together with citizens and stakeholders, which translates into a roadmap towards responsible trajectories in research and innovation in the field of nanotechnology.

The main aim of NANO2ALL is to contribute to the responsible development of nanotechnology by establishing a European-wide sustainable platform for mutual learning and informed dialogue among all citizens and stakeholders involved in the co-production of knowledge. The project will yield insights into effective ways of enhancing societal engagement in responsible nanotechnology, and will illuminate the societal needs, expectations and concerns that should be taken into account in future nanotechnology innovation trajectories.

The project website is an online-tool which documents the NANO2ALL process and provides open data access to the results of the project's activities. Visit www.nano2all.eu for more information.

1.2 Dialogues

NANO2ALL employs a three-step dialogue methodology that consecutively encompasses the organization of national citizen dialogues and national multi stakeholder dialogues in 6 European countries, and the organization of a final European stakeholder dialogue event (Fig.1). Each new dialogue phase will build on the prior one, i.e. the outcomes of citizen dialogues will serve as input for the national multi-stakeholder dialogues, and the outcomes of the national stakeholder dialogues will serve as input for the European dialogue event. The dialogues will allow for deliberation of values and purposes underlying a responsible technological future for nanotechnology, and should result in the articulation of those processes and preconditions that are needed for the development of socially robust and responsible nanotechnology applications. The described processes and preconditions may serve as an innovation agenda for responsible nanotechnology policy-making as well as research and innovation in the nanotechnology community, both at national and EU level. A final step will be to translate the innovation agenda into a roadmap that presents an action plan to enhance societal engagement in nanotechnology.

Fig.1 Dialogues on project time-line. The months of dialogue execution mentioned on the time-line are an indication, and might still be subject to change.

1.3. Purpose of this document

The purpose of this deliverable document D3.1. is to provide an overview of NANO2ALL's dialogue methodology, clarify our methodological decisions and introduce the specific methods and dialogue formats that we will use. In addition, the document serves as a handbook for the science centres that will execute the dialogues, providing guidelines for facilitation to warrant deliberative quality.

The content of this deliverable, as presented in the grant agreement (at the time named "Multistakeholder dialogue methodology"), has slightly changed. Since application and techno-moral scenarios will not be developed before the citizen dialogues - as was initially planned -, but instead will be constructed based on the input from citizen dialogues, we did not include a full description of the construction process of these scenarios yet. In this document, we do provide our general ideas regarding how the citizen input can be used to produce scenarios that can be integrated in our multi-stakeholder dialogues. Note that this document will be further updated as the project progresses and the initial outcomes of citizen dialogues or national multi-stakeholder dialogues can be used to further organize the details of the subsequent dialogue round.

The several chapters of this document take you through the dialogue methodology, first explaining the general approach that we will apply and our topic focus, and then elaborating more specifically on each of the the dialogue stages and the tools and formats that we will use here. The two final chapters are particularly relevant for those who will execute the dialogue, presenting both guidelines for dialogue facilitation and the detailed script that should be used to moderate the dialogues in the first dialogue phase, which focuses on citizens.

2. NANO2ALL | The dialogue approach

2.1 Responsible Research and Innovation

Responsible Research and Innovation (RRI) is a term that has gained considerable ground over the past 6 years, particularly in the field of EU policy-making. Although the exact conceptualization of the term is still debated, the general idea behind RRI is that research and innovation should be sensitive to societal needs and values, and requires transparent and deliberative processes in which attention is paid to the collective responsibility of societal actors, researchers and innovators in producing (ethically) acceptable and socially desirable products.

Attention towards social desirability and responsibility in research and innovation is not a new phenomenon in itself. Over the past 20 years, awareness has grown that the impact of technologies is not always predictable, and unintended or unforeseeable consequences might occur. This unpredictability is inherent to the increasing complexity of new and emerging technologies and their development processes; most of the time, unforeseen effects do not result from the action of one particular player, but from the intricate interplay of actions amongst a multitude of players.

RRI aims to foster a sense of collective responsibility among actors and encourages a reflexive attitude. Actors should deliberate about the purpose of technologies and in what way technologies contribute to solving societal challenges. These deliberations should be inclusive, and open to all sorts of input from stakeholders and public. Research and innovation systems need consistent integration of deliberative processes to increase value-sensitivity and to stimulate thought about the right impacts of technologies. In addition, actors should be encouraged to explore plausible futures and to address "what if…" questions in order to increase our system's resilience in a world replete of uncertainties, and to help identify new innovation pathways. Crucial here is that deliberative practices should be tightly linked to policy and decision-making processes to ensure responsive action and change.

The NANO2ALL dialogue approach aims to bring RRI into practice by involving a wide range of actors, including citizens, in setting up a nanotechnology innovation agenda. Using creative exercises and dialogue tools, actors are encouraged to reflect on current practices and to anticipate potential impacts of future nanotechnologies. By ensuring the participation of policy-makers, researchers, industry and other relevant societal communities in our dialogues, we aspire to influence the actual decision-making processes and instil responsive action.

2.2 The added value of dialogue

The emergence of new technologies, such as nanotechnologies, may evoke complex problems in society. When a new technology is introduced in a particular context, it will have certain impacts. The nature of these impacts is often not clear in advance due to scientific and technical uncertainties that make it difficult to foresee the effects of an emerging technology, particularly when the technology is introduced in a social context that is shaped by the interplay of multiple factors. What could make problems related to emerging technologies even more complex is that there often is not a consensus on which impacts to consider be good (as in: acceptable and desirable) or bad. People's views may differ on this matter, since everyone understands and interprets situations based on their own moral perspective and reasoning. So what may be problematic to one actor might not be an issue to another, and what one actor, may see as the root of a problem, may be seen differently by another. The interplay of both technical uncertainties and moral diversity may lead to intractable controversies that are difficult to resolve.

In order to develop an effective and collaborative approach towards solving complex societal problems, it is pivotal to understand the perspectives (frames) of others, as well as one's own line of reasoning. This is exactly what constitutes the purpose of a dialogue. Dialogical conversation moves beyond convincing each other of one's own perspective; it aims to stimulate mutual understanding and encourages learning from the various perspectives that are present in the discussion. Underlying values and implicit assumptions are explored in order to initiate a process in which actors may construct an integrative perspective towards the issues at hand. This is not an easy process and requires both trust and time. However, in the end this is the only way to come to a collaborative solution that is supported by all actors.

2.3 Scenario work

Various methods and tools have been developed to stimulate interaction amongst citizens and stakeholder groups. For the development of a nanotechnology innovation agenda and a roadmap towards responsible development in nanotechnology research and innovation, it is particularly important to employ interactive methods and tools that stimulate thought about the future. A commonly used method is scenario work. Within the NANO2ALL project, scenario work, such as scenario building, scenario exploration and scenario reflection, serves as a prominent activity for shaping fruitful dialogue.

To recognize the added value of scenario work, one first needs to understand what a scenario is. The term is often associated with prediction of the future, but in the context of this project, this is most certainly not what scenario work is about. We see a scenario as a description of a hypothetical future; one potential way in which current trends, dynamics and predictable or unpredictable factors might play out. The scenarios are then used as an instrument to engage in reflexive inquiry and deliberation together. What is important to keep in mind here is that even though scenarios do not aim to predict the future, they should be considered plausible by actors in order to stimulate meaningful dialogue.

Scenario descriptions may incorporate quantitative or qualitative information. Within the NANO2ALL project, we mainly focus on qualitative aspects of the scenario, since these enable us to sketch out social complexities, and more easily capture scenario aspects related to ethics, controversy, underlying values and the intricate interplay between societal actors. Qualitative scenarios thus allow us to touch upon a broader range of (societal) issues and impacts compared to scenarios with a mere focus on numbers and graphs. Lastly, we would like to point out that qualitative scenario work comes in different formats. Within the NANO2ALL dialogues, for instance, citizens are asked to create their own nanotechnology-related future scenario (i.e. scenario building), and stakeholders are invited to experience certain nanotechnology scenarios by means of a game (i.e. scenario exploration).

Why do we consider scenario work as a valuable tool for the NANO2ALL dialogue sessions? Our main arguments are:

- Scenarios help to make the distant future more tangible and conceivable, and thus easier to discuss. Particularly a broad topic, such as nanotechnology, can be difficult to grasp in its entirety, and scenarios can help to focus the conversation, while also helping to envision the broad range of impacts that a (new) nanotechnology application might generate.
- Scenarios facilitate future thinking and thus contribute to an anticipative attitude of actors. They stimulate people to think of unintended or unexpected consequences of a new technology, and thereby increase

actors' resilience in face of the many uncertainties surrounding technological development and societal impacts. Moreover, thinking about unexpected twists and turns also enriches the discussion on whether we believe that a technological development is responsible or desirable.

- Scenarios provide a generous amount of context. This contextual information can be used by actors to connect to, and can help them to communicate their underlying values and believes more explicitly, since people are able to precisely identify which aspects and impacts of the technology they consider desirable or undesirable and why.
- Scenarios create a safe platform for actors to interact with each other, since it allows them to talk about hypothetical situations, instead of current practices. This focus on the future and potential situations reduces the number of sensitivities (e.g. current stakes, responsibilities, agreements, vested interests) and thus allows actors to open up a little more.

In the NANO2ALL project, we mobilize citizens to build several scenarios that we use to gain insight into their needs and concerns regarding nanotechnology development. The citizen-built scenarios serve as input for multi-stakeholder reflections. By sharing citizen needs and concerns, we aim to enrich and broaden the reflection processes of stakeholders involved in nanotechnology development.

2.4 Description of scenario application fields

To make scenario work effective and helpful, it is important to choose a clear topic focus that can provide sufficient context and brings stakeholders together who operate in the same field and are already related to or dependent on each other. Since nanotechnology is an enabling technology, it can be applied in a multitude of areas. This makes "nanotechnology" as topic on itself too broad of a focus for prompting fruitful dialogue. We have therefore chosen to centre NANO2ALL's scenario work and dialogues on three specific application fields. Our choice for these application fields was based on literature search, consultation of project partners during a consortium meeting, consultation of external (foresight) experts, and input from the participating science centres that will execute NANO2ALL's dialogues. We strived for diversity of topics to ensure variety in the types of concerns, hopes and solutions that might be elicited throughout the dialogues. However, we also considered it crucial that science centres have sufficient connections in a particular application field to recruit relevant national stakeholders and that the dialogue topics fit the national context. Therefore, we asked the science centres to study a variety of selected nanotechnology application fields (i.e. nano-foods, brain-machine interfaces, nanotechnology and energy production, nano-medicines, nanotechnology in architecture/construction work, and nanotextiles) and to express their topic preferences taking the following aspects into account:

1) The national research context. What kind of research is being performed and what matches best with the suggested application fields?
2) Availability of stakeholders. What connections do they have? And for which of the application fields will it be most easy to recruit stakeholders?
3) Public debate. What issues have recently received public attention? And which of the application fields will match best with current public discourse?

Based on all the input that we gathered, we came to the following division of dialogue topics:

- Nanotextiles | *Topic used in Poland and Italy*

- Brain-machine interfaces | *Topic used in Spain and France*
- Nanomedicine | *Topic used in Israel and Sweden*

Below, a short description of the three selected application fields is found. In the appendices A, B, and C, more detailed and technical information about the application field can be found. Note that both the short descriptions below, and in the descriptions in the appendices only contain an account of the possibilities and opportunities of nanotechnology in the application fields, not of the potential (moral) issues and concerns.

2.4.1 Nanotextiles

Nanotextiles have the potential to greatly tranform the textiles that we use in everyday life. In the textile industry, many technologies currently take place that exploit nanotechnologies to create new fabrics and materials with improved functionality (e.g. durability, strength) or new properties (antimicrobial, self-cleaning, UV-blocking, water and oil-repellent, anti-static, or wrinkle resitstance). Two relatively new and promomising developments in the field of nanotextiles are the embedment of both electronics and sensors in textiles. Certain nanomaterials allow for the creation of flexible structures electronics that can be woven into fabrics. The resulting “smart textiles” enable the user to measure bodily functions, or environmental conditions and thus opens up a new range of opportunities to integrate electronics in our everyday lives. For more detailed information on nanotextiles, see appendix A.

2.4.2 Brain-machine interfaces

Neural engineering is a growing field of interest for neuroscientists who aim to find cures for people who suffer from impaired brain functioning. Various devices have already been developed that are able to restore the functioning of impaired nervous systems and sesnory trajetories. Think of implants that are able to improve motor control in Parkinson patients, or devices that allow people suffering from “locked-in syndrome” to use willful thourghts for steering certain actions of external devices. Now, a new generation of neural interfaces seems on the rise that employs nanotechnologies and nanomaterials to allow for even higher levels of control over physiological functioning, yielding improved interfaces and greater application possibilities that offer people with motor or sensory disabilities the opportunity to regain part of their autonomy. For more detailed information on brain-machine interfaces, see appendix B.

2.4.3 Nanomedicine

Nanomedicine is defined as the application of nanotechnology to achieve breakthroughs in healthcare in the fields of diagnostics, drug delivery and regenerative medicine. It exploits the improved and often novel physical, chemical and biological properties of materials at the nanometer scale. At this scale, man-made structures match typical sizes of biological nanostructures, thus allowing potential interactions between them. Nanomedicines have the potential to improve detection and diagnosis of diseases, as well as their treatment. The use of nanoparticles, nano engineered structures and nanodevices enables us to work on health improvement at the molecular scale. Working at this scale will help to make disease treatment more efficient and less prone to side-effects (e.g. think of drug delivery systems that only target very specific tissues or cells in the body). For more detailed information on nanomedicine, see appendix C.

2.5 Participant recruitment

Participants for the national citizen and multi-stakeholder dialogue will be recruited by the 6 Science Centres. Each science centre sets out its own recruitment strategy, using communication channels such as information posters, newsletters, informal and social networks, websites, press releases, direct emails, and local science festivals. With respect to the recruitment of citizens, we build on the experience of science centres to engage and attract people to science-related events. The science centres are free to use those citizen recruitment methods and approaches that have proven to be effective in their own local contexts. For the recruitment of stakeholders, science centres will set out a double call: 1) an open call, which they will communicate through their networks, and 2) personal invitations. Science centres have also received budget to offer stakeholders financial incentives, if this appears to be needed. In the communication about the dialogues special attention will be paid to the nano-application fields on which the dialogues are focused. A specific topic such as “smart textiles” or “brain-machine interfaces” may attract more participants than a broad term such as nanotechnology.

In the citizen dialogues, we strive for balance in gender, age, and education level to ensure diversity of input and to increase the social representativeness of the group. The citizen dialogues should comprise approximately 12 to 16 participants (per group session). We would prefer an even number that can be split into groups of four, since the citizen dialogue exercises require participants to work both in pairs and small groups of four. However, if a dialogue ends up with another number of participants, we can rearrange sub group compositions during the exercises (e.g. in case of an uneven number, we have one group of 3 participants instead of a pair, or in case of total participant number that cannot be split into groups of four, one or two of the 4-person groups can be turned into 5-person groups). In the multi-stakeholder dialogues we aspire to bring together a heterogeneous group of participants with a diverse set of views, who all have an interest in the particular nano-application field on which the dialogue is focused. We strive for the inclusion of the following types of actors:

- Policy-makers
  This category of stakeholder does not only include people from parliament, but also refers to funding agencies, regulators and executives (i.e. people who make decisions about the shape and direction of research and innovation on national level).
- Civil society organizations
  This category of stakeholders includes – but is not limited to – actors, such as environmental organizations, labour unions, and consumer organizations.
- Business and industry representatives
  For this category of stakeholders, we will try to not only focus on big companies, but also invite small start-up companies that work with nanotechnologies. Furthermore, we strive for the inclusion of companies that work on different levels of a nano-application value chain.
- Researchers
  Researchers and innovators that work with nanotechnologies or nano-enabled products.
- Citizen representatives
  We will invite 2 citizens that participated in the citizen dialogue to the national multi-stakeholder dialogue to represent the concerns and needs that were expressed by fellow citizens.
- Sixth character: non-fixed position
  The sixth stakeholder category comprises an actor that does not have a highly fixed position or interest with regard to nanotechnologies (e.g. journalists, artists) and who can therefore bring air to the

discussion.

For the selection of stakeholder participants it is important to look for those people who work at an "intermediate" level in their organization, meaning that a stakeholder should not be too high up in order to ensure that he/she actually has room for manoeuvres, but at the same time make sure that the stakeholder does have a sufficient level of influence to instil change. The stakeholder dialogues should comprise approximately 15 participants. More details on the specific approach to engage stakeholders can be found in the activities and products of WP1.

2.6 Sources

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3. NANO2ALL | The dialogue method

This chapter aims to delineate the dialogue method and the dialogue structures that we will use for the co-construction of a responsible nanotechnology innovation agenda. In addition, an explanation is provided on how the data of the dialogues will be analyzed.

3.1 General structure of the dialogue methodology

The NANO2ALL dialogue methodology has a three-levelled structure (Fig. 2). First national citizen dialogues will be organized in six European countries: Poland, Israel, France, Sweden, Spain and Italy (level1). The results of these dialogue sessions will feed into national stakeholder dialogues organized in the same countries (level 2). Lastly, one EU-level multi stakeholder dialogue event (level 3) will be organized in which the results of both citizen dialogues and national stakeholder dialogues are further elaborated and solidified into a responsible nanotechnology innovation agenda. This agenda will describe desirable and acceptable directions for change and will particularly focus on the required (RRI) processes and conditions that are needed to move into such desirable and acceptable directions. This innovation agenda will then be translated into a roadmap towards responsible nanotechnology innovation trajectories. This roadmap has the character of an action plan of what policy-makers and the research community can do to make nanotechnology more responsible and to enhance societal engagement in nanotechnology research and innovation. Notice that the development of the roadmap is the main activity of work package 4. Of course, tight alignment of the innovation agenda and roadmapping activities is crucial to establish an impact at the level of EU policy-making. In-between the three different dialogue stages, time will be reserved to analyse the dialogue content and to process the data in such a way that it can be used in the next stage of the dialogue methodology.

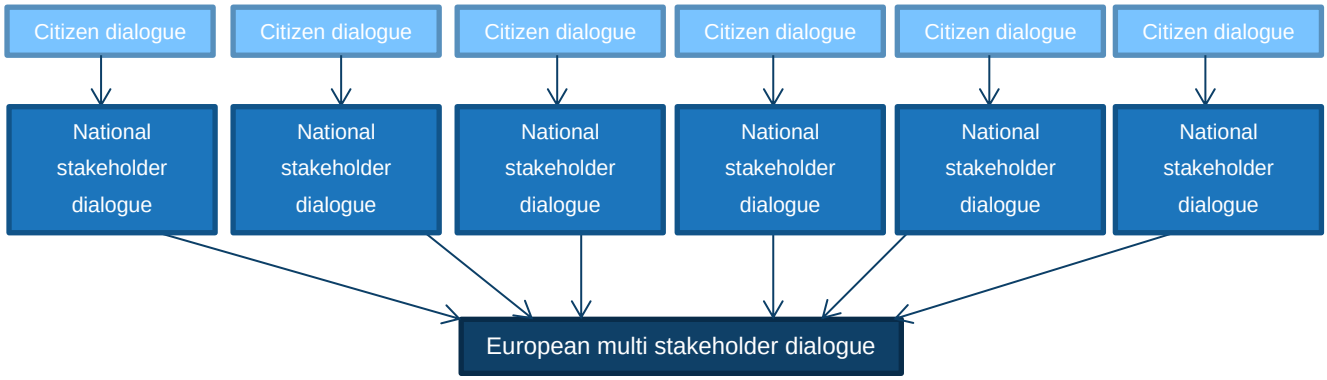

Figure. 2 General structure of the dialogue methodology

The dialogues serve as platform to stimulate deliberation on societal needs, values and purposes underlying a responsible and desirable technological future for nanotechnology. They seek to enhance the mutual understanding and trust amongst stakeholders, and aim to develop a shared understanding of the risks, benefits, and wider issues of advancing nanotechnology. However, the eventual aim to create a roadmap also requires us to think about the question: who should undertake which actions to come to a responsible and desirable nanotechnology future? In order to answer this question, it is crucial that we do not only deliberate on the directions of innovation that we would consider responsible and desirable, but also use the dialogues to explore and discuss the RRI processes that are needed and the future roles and responsibilities of those actors who are directly or indirectly involved in the development of nanotechnology innovations. We believe that the multi-stakeholder

dialogues on national and EU level function as the ideal site to have these important discussions. It is at this level that sufficient power is hold to make decisions and thereby truly influence the allocation of responsibilities and enforce action.

Yet, it is also crucial to give voice to citizen perspectives. We therefore aim to gather input from citizens about their views, values, desires, and concerns regarding nanotechnology, and feed this information into the multi-stakeholder dialogues using various tools. This way, stakeholders are not only encouraged to consider and work with input obtained from other stakeholders, but are also stimulated to enrich and broaden their reflection processes by taking citizen perspectives into account. To ensure that citizen perspectives are adequately represented in the multi-stakeholder dialogue sessions, two of the citizens who participated in the national citizen dialogue sessions will also be invited to join the national multi-stakeholder dialogues.

In each of the three dialogue stages, we will work with scenario tools to stimulate thought about the future and to support people in envisioning and exploring new (societal) practices that might emerge due to developments in nanotechnology. This kind of scenario work will help to anticipate the wide range of potential impacts that nanotechnologies could have, stimulates discussion on the desirability of these impacts, and contributes to the identification of interesting directions for future nanotechnology innovation. The scenario work in our dialogue methodology takes different forms in each of the three dialogue phases, and thus also helps to address different kinds of topics and insights in each of the dialogue sessions (Fig 3).

In the citizen dialogues, participants will engage in scenario building. They receive various cards with basic information about nanotechnology and the relevant application field. Using guiding tools and inspiration cards, participants are encouraged to compose narratives of the future. These citizen narratives will be used in several ways in the national multi-stakeholder dialogues. First of all resulting citizen narratives of the future will be used to shape a scenario exploration game that stakeholders will play during their dialogue session on national level. This game, developed by JRC, aims to let participants experience and act through plausible alternative futures (i.e. scenarios), by thinking and conversing systematically outside their usual frame of reference (see https://ec.europa.eu/jrc/en/research/foresight/ses). For the purpose of this dialogue project, we adapted the original version of the game and incorporated nanotechnology-specific elements into its scenario structure. After the citizen dialogues have been executed, we will also integrate various elements from the citizen narratives into the scenarios of the game. This allows stakeholders to experience nano-specific scenarios and reflect upon what is needed for responsible development in the selected application fields. Besides playing the scenario exploration game, stakeholders in both the national and EU level dialogue will engage in participative backcasting exercises. These exercises are used to stimulate interaction about purposeful change and place particular emphasis on discussing the processes and conditions that are needed for the development of desirable and acceptable nanotechnology research and products. At the start of these participative backcasting exercises, we will actively introduce various citizen narratives of the future[1] to broaden and enrich the stakeholder reflection processes throughout the exercises.

[1] The citizen narratives created in the citizen dialogues will be further developed/elaborated when needed before being used in the national multi-stakeholder dialogues.

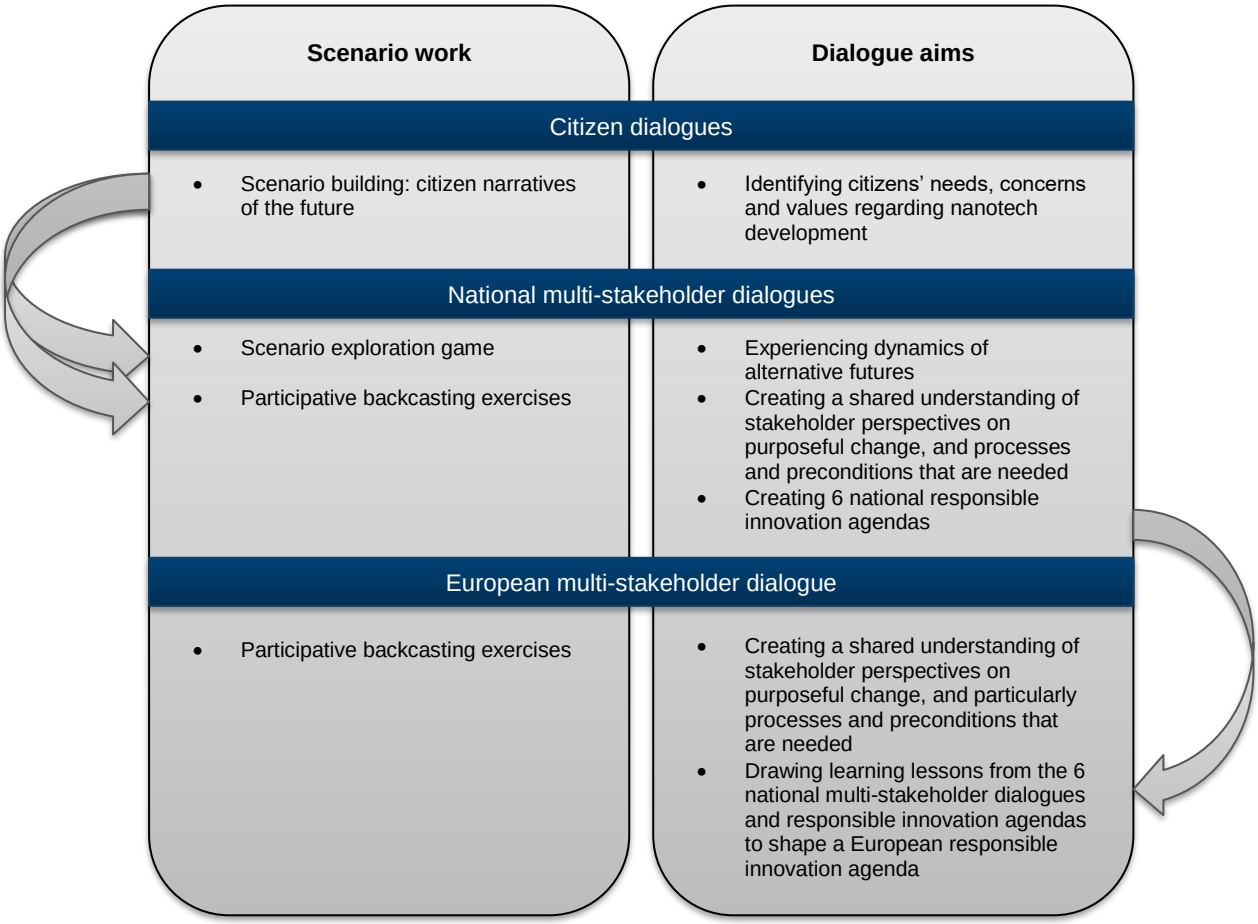

Fig. 3 Core elements of the dialogue sessions

3.2. Goals, format and output of the dialogues

Each level of the NANO2ALL dialogue approach has its own sub-goals, format and output. The output of the citizen dialogues should feed into the national stakeholder dialogues, and the output of the national stakeholder dialogues should feed into the European multi-stakeholder dialogue. The goals, formats and output of the three different dialogue stages cumulatively aim to contribute to the overarching goal of the dialogue: a responsible nanotechnology innovation agenda, which translates into a roadmap towards responsible trajectories in research and innovation in the field of nanotechnology. Below, an overview is provided of the goals, format and output of each of the three dialogue phases.

3.2.1 Citizen dialogues

Goal

The goal of the citizen dialogue in each country is to produce citizen narratives of the future that can be used to broaden the stakeholder reflection processes in the multi-stakeholder dialogue. In the citizen dialogue, we aim to identify citizens' needs, concerns and values with regard to the development of nano-applications[2] in one of the 3 selected nano-application fields. The citizens will engage in scenario work through the collaborative construction of various scenarios that consist of both a future object and narratives surrounding this object. This allows citizens to explore possible future directions of a specific nanotechnology application field and discuss potential impacts of these future directions and their desirability.

Format

The NANO2ALL citizen dialogues are characterized by a 4-hour dialogue format that allows the inclusion of approximately 15 participants. The dialogue takes the form of a scenario-building session with a diamond-shaped structure, i.e. a first half with exercises that stimulate divergent conversation and the generation of a broad range of ideas, and a second half with exercises that stimulate convergent conversation and the prioritization of ideas and themes (see Fig. 4). The exercises have a creative character, which stimulates citizens' imagination about the future, and helps people engage with the future in various ways. The creative approach also allows those participants who are less articulate to join the interactions and take part in the shared reflection processes.

At the beginning of the session, participants are introduced to the NANO2ALL project and the particular nano-application field on which the dialogue focuses. After an introduction round and a warming-up exercise, participants are asked to envision the future of the introduced nano-application field by physically building an object that one would encounter in that future. Participants work in pairs and are provided with a diverse set of crafts materials to work with. In addition, they receive a set of inspirational and informative cards to get them thinking about the future[3]. Besides physically building an object, participants also describe the object's functionality on a special form.

[2] With nano-applications we refer to any technological application that is created from nanomaterials, or has been manufactured using nanotechnology.

[3] Some of the cards that we use are inspired by PlayDecide, a discussion game that was produced by the European project "Decide".

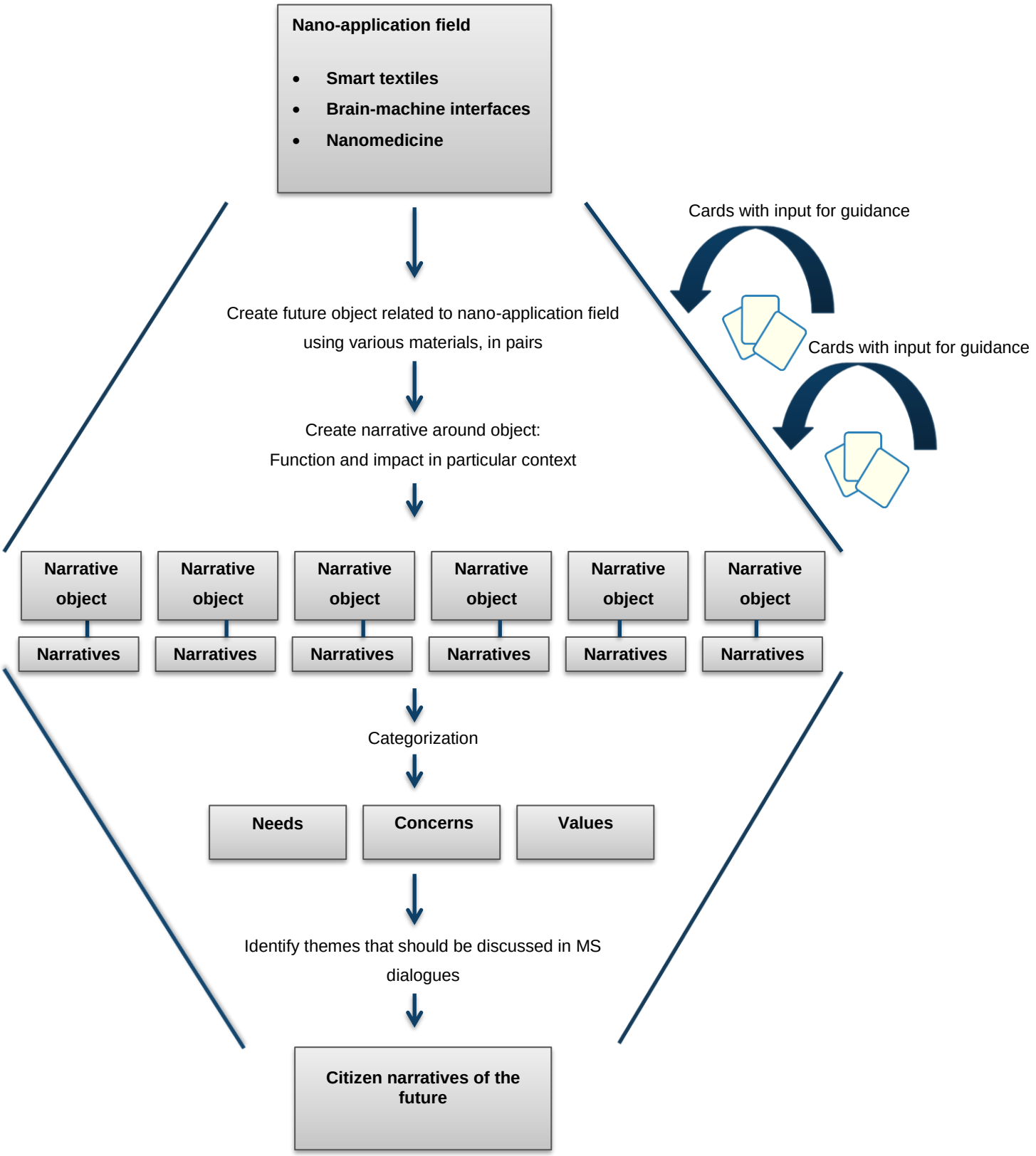

Fig. 4 Structure of the citizen dialogues

Subsequently, participant pairs merge into groups of four, and are asked to reflect on potential impacts of their self-created objects (both positive and negative aspects). They do this by writing a number of short narratives about the use of their object in a particular context. Story parameters that they should think of are partly provided on cards. Participants present their object and short narratives to the group, and then a plenary clustering exercise is performed in which the objects and narratives are used to elicit and categorize needs, concerns and underlying values that participants have in relation to the specific nano-application field. Based on the identified clusters, a final plenary discussion is started in which participants can indicate which themes, concerns, needs or values they consider most crucial to reflect upon in the national multi-stakeholder dialogues. In chapter 5, the citizen dialogue format and tools are more elaborately described in the form of a detailed script.

Output

The outputs of the citizen dialogue sessions are citizen narratives of the future. These narratives consist of 1) the self-created narrative objects that depict citizen's ideas about the potential directions that technological advances in a specific nano-application field might take, and 2) the written narratives, and 3) an analysis of these narratives with respect to underlying needs, values and concerns. Thus, the created objects do not serve as actual prototypes for future technologies that citizens wish to see realized, but they function as a device to explore future technological directions and provide both tangible and verbal leads for reflection on these directions. The citizen narratives of the future will be processed and elaborated where needed by the VU before being used as input for the national multi-stakeholder dialogues.

3.2.2 National multi-stakeholder dialogues

Goal

The goal of the multi-stakeholder dialogue is 1) to explore both the dynamics of change as well as future options and challenges, and 2) to create a shared understanding of stakeholder perspectives on purposeful change and particularly the processes and preconditions that are needed for the development of responsible and desirable nanotechnology research and applications. This will allow for the collaborative construction of a national responsible innovation agenda. The various dialogue exercises are aimed at establishing mutual understanding and learning, and also encourage the consideration of citizen perspectives that were expressed in the national citizen dialogues.

Format

The national multi-stakeholder dialogues are shaped as 7-hour events, in which approximately 15 stakeholders will participate. The structure of the session (Fig. 5) is characterized by a first half in which various futures of a one particular nano- application field are explored, and a second half in which backcasting exercises are performed that help to identify actions and approaches that connect desirable futures to the present. In the weeks prior to the dialogue session, participants will have followed the NANO2ALL online training course that is specifically targeted at the participant's learning needs. The training covers topics such as nanotechnology, RRI, and effective dialogue techniques (see deliverable D2.3).

At the beginning of the dialogue session, participants are shortly introduced to the NANO2ALL project and the specific nano-application field that functions as the central topic of the day. Then an adapted version of the JRC

Scenario Exploration Game is played in two parallel sessions. Each of the two participant groups experiences and acts through two plausible – but contrasting - alternative futures related to the particular nano-application field of interest. Using cards and other game elements, the participants are guided through the scenario that unfolds itself in three steps over a 15-year time horizon. The particular input that is used on game cards to steer the scenario into a certain direction is based on the trends and drivers that have been identified in the M3.1 expert survey, and on the values, concerns, and needs that will be identified in the citizen dialogues (e.g. a particular societal impact that worries citizens might be introduced to the game scenario and may function as a “scenario event” that stakeholders need to respond to). After the game, participants will reflect on what they have experienced during the game and point out the main lessons that they have learned. These will be written down on cards that are attached to a laundry line. Towards the end of the session, the collected learning lessons will be reintroduced to the dialogue.

During the second half of the dialogue session, the focus will shift from experiencing the dynamics of future scenarios, to discussing desirable scenarios and particularly the ways to get there, using participative backcasting exercises. The outcomes of these backcasting exercises should result in a responsible research agenda. We will start with actively introducing some citizen narratives and reflecting on the needs and concerns that underlie these stories. How do these relate to acceptable and desirable futures? And what does that say about responsible directions for change? By deliberating on these questions underlying values and assumptions are explored, and a shared understanding of the various stakeholder perspectives is fostered. A subsequent step is then to focus on the question: how to become more responsive to the types of needs and concerns that were expressed by citizens and stakeholders? And how can we be more open to being influenced at an early stage by citizens or civil society organizations? We will stimulate thought on what an RRI process means in the context of nanotechnology development and the specific nano-application field, by discussing the processes (e.g. collaborations, inclusion of actors, communication) that need to be in place to become more responsive, as well as the preconditions (e.g. governance structures, resources, role divisions, distribution of responsibilities). Participants are encouraged to also consider the lessons learned during the game when thinking of processes and actions that need to be undertaken.

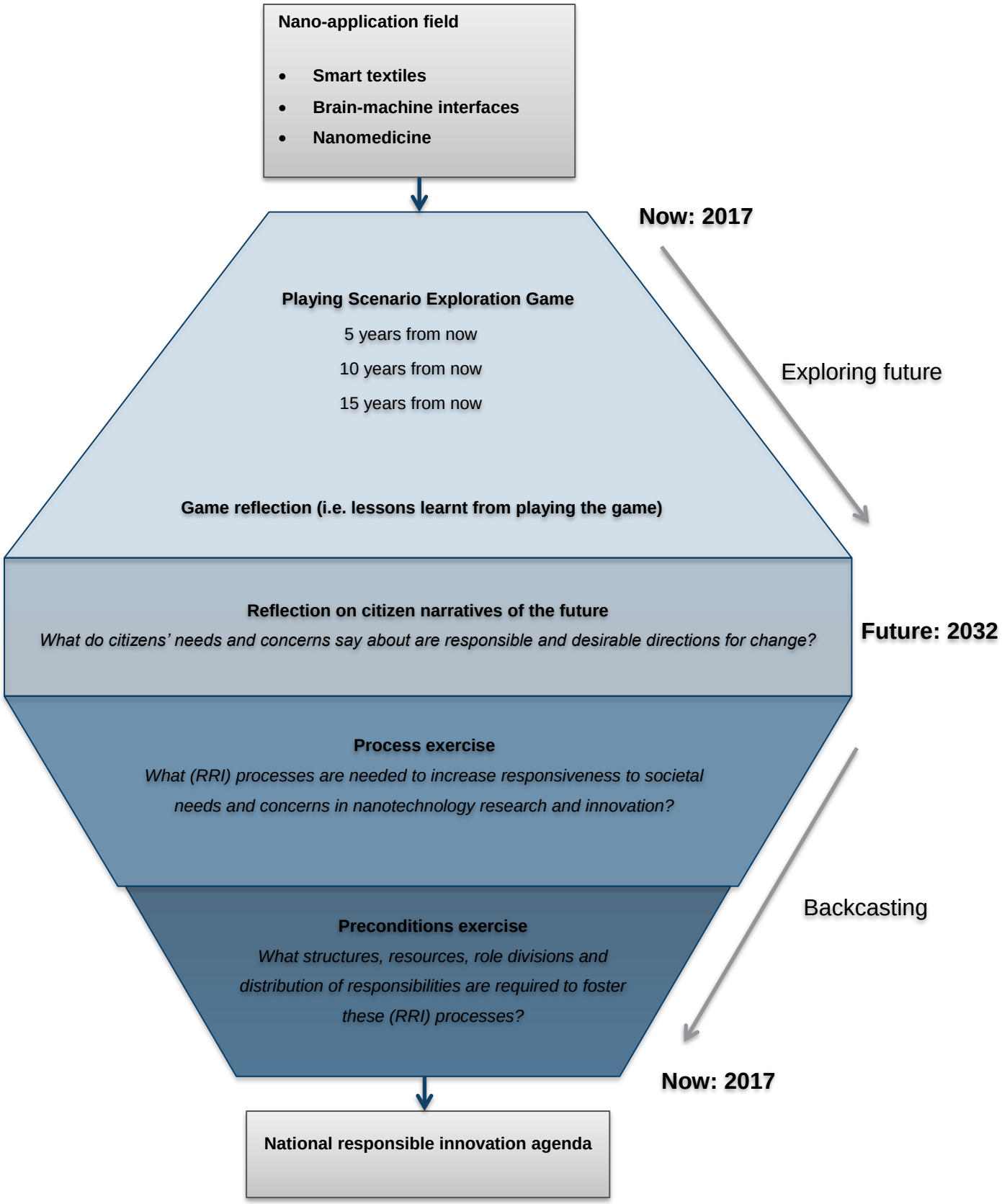

Fig. 5 Structure of the national mutlit-stakeholder dialogues

Output

The outputs of the national multi-stakeholder dialogues are 6 national responsible innovation agendas. These agendas provide a short description of the directions for change that are in line with the values, needs and concerns of both citizens and stakeholders. Yet, the main focus of the agendas is on suggestions for (RRI) processes and preconditions that are required to increase actors' responsiveness to societal needs and wishes, and thus move into desirable and acceptable directions. It should be noted here that the agendas do not necessarily require consensus among stakeholders. Existing or unresolved conflicts should also be mentioned and integrated.

3.2.3 European multi-stakeholder dialogue

Goal

The goal of the European multi-stakeholder is to draw learning lessons from the national multi-stakeholder dialogue sessions and their outcomes (i.e. the national responsible innovation agendas). We aim to establish a shared understanding on European level of the various stakeholder perspectives, and use the national responsible innovation agendas as a source of inspiration to come up with (RRI) processes and preconditions that are needed on the European level in order to establish purposeful change. These will serve as the basis for the roadmaps that will be developed in Work package 4.

Format

The format of this dialogue session is not yet fully developed, since it will only take place in 2018. Nevertheless, we do have some initial thoughts on elements that should be included in the format, and on the process of developing the dialogue format.

- The dialogue session will host both national stakeholders (some whom already participated in the national multi-stakeholder dialogues), and European stakeholders, such as European policy-makers, EU-level CSOs and EU-level industry and research platforms/networks.
- During the dialogue session, the national responsible agendas will be presented and assessed using several deliberative exercises fitting a dialogical exchange conference format.
- Similar to the national multi-stakeholder dialogues, participants will engage in exercises about right impacts and backcasting exercises. However, this time the focus of the exercises will be more concretely directed at the European level, while also reflecting on the alignment between the ideas generated on European en national level.
- During the development process of the European dialogue format, we aim to collaborate closely with the work package leaders of WP4, to ensure that we generate information that is useful to them to create the nanotechnology roadmaps. In addition, we we also aspire to include European policy-makers and representatives from the European Commission in the design process of the European multi-stakeholder dialogue. This will increase the chance of creating a dialogue end product that aligns with their needs and allows them to work with in practice.

Output

The output of the European multi-stakeholder dialogue is a European responsible nanotechnology innovation agenda that will feed into work package 4, in which the agenda will be translated into roadmaps that describe what policy-makers and the research community can do to make nanotechnology more responsible and to enhance societal engagement in nanotechnology research and innovation.

3.3 Data analysis

The dialogues will yield various types of qualitative data. First of all, sessions will be audio recorded to capture the dialogue dynamics and all arguments that are provided. In addition, participants create various products (e.g. future

objects and citizen narratives) and visualizations (e.g. flip-over sheets) throughout the dialogue sessions. These will all be gathered and digitalized, using a camera or scanner. Lastly, a note taker will be present during the dialogue, whose notes will also be collected.

After each dialogue session, science centres will fully transcribe and anonymise the audiotape data. They will translate the transcriptions into English before sending them to the VU research team. The VU team will analyse the data using a software program for qualitative data analysis. The analysis will encompass both deductive and inductive coding approaches. Here, a deductive coding approach refers to the use of coding sheets that were already created in advance of the dialogues, and based on earlier research and existing theories. An inductive coding approach refers to the creation of codes while reading the dialogue transcripts. The predesigned coding sheets will help us to identify topics and themes that are considered relevant according to earlier research, while the inductive coding approach allows us to be open to unforeseen insights that have not been described in previous research yet.

The data of the citizen dialogues will be analyzed as soon as possible, to make sure that the obtained insights can be fed into the national multi-stakeholder dialogue set-up. The same holds for the data of the national multi-stakeholder dialogue, which should be used to structure the eventual European multi-stakeholder dialogue.

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4. Preparing for dialogue: setting and competencies

This chapter focuses on the crucial role of the moderator in the dialogue sessions, and functions as a guide for moderators to create a physical and social setting that stimulates fruitful dialogue. This guide was originally developed by the VU in the context of another dialogue project: Voices for Innovation (see http://www.voicesforinnovation.eu), but we consider it valuable for the NANO2ALL dialogue project as well. Therefore, we decided to share this existing guide in the current chapter.

4.1 The dialogue setting

In guidelines on the organization of dialogue sessions the physical environment is often neglected, despite its major importance. Below, we have summarized a few important points that each moderator should take into consideration with respect to the physical setting of dialogue:

- The environment should be noise free to make sure that both participants and moderator are not distracted by irrelevant stimuli and to ensure sufficient quality of the audio-recordings.
- There should be enough space to relax, walk around and engage in the conversation.
- Participants should be seated in such a way that they can make eye contact with the moderator and with all the other participants.
- Try to prevent organizing your dialogues in a narrow rectangular room, or using a narrow rectangular table set-up to prevent participants in the back from becoming too distanced from the moderator and the central conversation.
- The use of clear nametags may help to establish rapport with participants. The nametags allow the moderator to address each participant using his or her name, which gives the interaction a personal touch. In addition, it makes it easier for participants to approach each other.
- The presence and use of creative materials may help to stimulate fruitful interaction between participants. It allows those participants who are less articulate to express themselves in alternative ways. It also creates a more informal atmosphere, which may help some people to feel comfortable and open up.

Besides the physical setting, one should also attend to the social environment, which should be positive and non-threatening. Everybody should feel free to express his or her own ideas and concerns and participants should feel appreciated. As the group moderator, it is your job to model a positive atmosphere and make people feel that way. In the following section, various moderation skills will be discussed that may contribute to creating this positive atmosphere.

4.2 Moderator competencies

The moderator's role is to maintain the focus of the discussion. After all, in a limited amount of time sufficient insight should be acquired to contribute significantly to the project's objective. Maintaining the focus implies making sure the key themes are covered while managing group dynamics. The moderator's role is to guide and stimulate the discussion. He or she facilitates the discussion using a script with all the questions and exercises to guide and ensure equal individual input as well as group discussion. The moderator should create an open and safe environment so people feel encouraged and free to speak up and be actively involved in the discussion. The

moderator can be imagined as the conductor of an orchestra. He or she obtains the research objectives by getting the best out of every participant.

The competencies moderators should have to fulfil these roles can be subdivided in to competencies for interpersonal communication, process management, and understanding. Below a table that lists the most important competencies.

Category	Competency	Explanation
Interpersonal communication	Perceptive listening	Using sensing and intuition to elicit cognitive and emotive meanings
	Verbal and nonverbal speaking	Clear and unambiguous use of words, language, tone, posture and signs
	Sensitivity	Openness to generate empathic understanding of individual and group needs
	Trustworthiness	Can gain high levels of trust from individuals and the group
Process management	Lead the group	Flexible in working with the group and adopting both directive and facilitative leadership styles
	Challenging	Stretch and challenge the group. Encourage creativity without losing safety
	Modelling neutrality	Postpone judgment and demonstrate interest in all contributions offered
	Conflict resolution	Resolve challenging conflicts
Understanding	Intellectual agility	Thinking on your feet; assimilate information quickly and conceptual flexibility
	Helicopter view	See connections between statements and the whole
	Reflexive awareness	Recognizing underlying values and beliefs in uttered statements
	Self-awareness	Reflection on the influence of own role on group dynamics and the ability to adapt

4.2.1 Moderator skills: listening

As a dialogue moderator you need a specific selection of facilitation skills. This paragraph concentrates on listening skills.

During a dialogue, the aim is to understand what participants really think of a certain subject. Therefore, the information you collect should be framed in the participants' own language, concepts and understanding of the world. It is important to minimize the influence of your own views and understandings of the world. Therefore, it is crucial to listen without judgment or filters. Furthermore, you do not only want to hear what a certain participant thinks, but also gain in-depth understanding of the arguments why that participant thinks in that way. Dialogues are all about exploring the underlying reasons for certain views, opinions or ideas. A highly effective way to achieve this in a dialogue is the LSC procedure (Listen, Summarize, Clarify). Following it enables you to:

Listen	carefully to what a participant has to say. It is important just to focus on what is said, postponing judgment or critique.
Summarize	what has been said to check whether you have got it. Always let the decision of what a statement means and how it should be put down with the participants.
Clarify	with questions to gain an in-depth understanding of a participant's view. Ask 'get questions' ("what do you mean") and 'why questions' ("why do you think that").

As a dialogue moderator you use different types of listening in order to manage the group process and achieve an understanding of the participants' ideas and concerns. Two of the most needed types of listening are empathic and analytical listening. One of the most difficult aspects of moderating group discussions is the continuous switch between empathic and analytical listening and back. Empathic listening supports the positive interaction with the participants and helps you to understand their perspectives. Analytical listening helps you to structure what is said and bring it in relation to the research objective.

Empathic listening is usually contrasted with autobiographic listening, unfortunately the most common form of listening in daily life, in which people listen with the intention to answer, not to understand. Listening is accompanied by filtering the heard information through one's own paradigms. Aiming at recognizing one's own autobiography in the life of others, projecting one's own experience on the experience of others.

The tables below contrasts empathic and analytical listening:

Empathic listening	Listening with the sincere intention to understand the other person. Engage in the other's way of thinking, understanding the other's frame of reference. "Standing in other people's shoes".
Importance	You want to understand how your participants think, framed in their words, language and understanding of the world. Therefore, you need to create a safe and friendly conversation environment in which participants are encouraged to talk about their own ideas and views.
How to	Ask 'get-questions': "What do you mean by..."; "Can you give an example of.."; "How do you see...". Open up your body posture, make eye contact, smile.

Analytical listening	Listening in order to structure the heard information, recognizing concepts central to the theme of discussion, establishing connections to what has been said already and the direction in which the conversation should be heading.
Importance	You want to gain an in-depth understanding of the participants' ideas and perceptions. Therefore, you need to structure what is said to unravel underlying arguments and themes.
How to	Ask questions of clarification: "Why do you think that.."; "is what you have said related to..", and so on. Always let the decision be with the participants. Make drawings, mind maps. Take time.

Not only a balance between empathic and analytical listening is important, also the skill of active listening largely contributes to the success of a dialogue.

Active listening	Focus on listening rather than talking; treat what is said with care
Importance	The dialogue is all about the explorations and discussions of the group participants. A moderator should not interrupt or fill in too much, and nurture the generation of ideas amongst the participants instead.
How to	Make a conscious effort to listen. Repeat what is said out loud or in your mind. Open up your body posture, make eye contact, smile.

4.2.2 Moderator skills: positive accepting

A crucial skill of the dialogue moderator: his/her ability to respond to the participants' stories in a positive accepting way. This attitude is most important to create a safe and trustworthy environment where participants feel free to express their ideas. Also, the positive accepting attitude enables and encourages the creative and constructive flow of ideas.

Positive accepting attitude	Creating a safe and friendly conversational environment. Stimulate the flow of ideas.
Importance	Approaching every idea as a potential contribution to the session output. All ideas are valuable.
How to	Always say 'yes' in your mind to what is brought up. Be aware when to use 'yes-but' responses (aimed at sharpening ideas) and 'yes-and' responses (aimed at building on ideas). Be in the moment. Postpone your judgment. Add to what is there.

As a moderator, your own assumptions, ideas and judgments may hamper your sensitivity and response to what the participants have to say. Accepting what your participants offer, enables you to see the possibilities in their utterances rather than their shortcomings. This will in fact make it easier to manage the dialogue process and to reach your goals. It is not about you or your ego. It is about the collective activity in which the dialogue participants are engaged.

4.2.3 Moderator skills: process interventions

It is the task of the dialogue moderator to manage the group process and dynamics. The table below lists several levels of process interventions in the case of group work.

Content	Respond to the content of group work, for example to change the topic, ask for more explanation, etc. Use techniques like LSC, clustering, information provision, clarification of setting and goals.
Procedure	Respond to the group process by referring to procedures like the conversation rules, agenda, boundaries, and exercises.
Interaction	Respond to the way the participants and the moderator are treating each other and responding to one another by making these interaction patterns explicit or changing your interaction pattern yourself using techniques like stating roles and positions, ask for recognition, sharing concerns, meta-communication acts.
Being	Respond to the way participants are in the group by making that explicit or change your way of being yourself, using techniques like self-revealing, giving acknowledgment, postpone judgment, functional silence, stimulate openness and respect.

The best way to use these process interventions is situational. Skilful moderators are able to switch between the different levels of intervention depending on what the situation needs.

4.2.4 Moderator skills: dealing with resistance

It is the dialogue moderator's task to manage the group process. This means being sensitive to what the group needs. Sometimes you will have to deal with resistance. This is not directly something to worry about. Resistance is just an aspect of group dynamics. Often, participants showing resistance do not do so because they want to

undermine your goals, but do so out of insecurity or out of a strong concern for something. This paragraph deals with three types of resistance: repetitive questions, dominance and passivity.

It is very common that participants ask questions to the moderator during the discussion. Of course it is important that you develop a high level of 'rapport' with your participants in the sense that they understand why they are there, what they have to do and how the roles and responsibilities are distributed. At the same time, questions may disrupt the flow of the discussion or the safety of the conversational environment. Therefore it is important for a dialogue moderator to respond to questions in a balanced way. Questions can take two forms: questions about procedures, questions about content.

Questions about procedures may concern the dialogue session itself, but also the entire project (NANO2ALL) of which the dialogue session is a part.

- Questions about the nature and background of the project, such as: why are we supposed to do this, who wants to know, who paid for this, might be asked out of curiosity, but may also have something to do with a lack of trust. In the first case, directly postpone these questions to some time after the sessions. In the latter case, the trust issue is something that you have to deal with right away. Otherwise, the negative attitude of that specific participant may disrupt group dynamics or even spread across the group. Try to establish trust by answering the question as good as possible, being transparent about your role, goals and intentions. Emphasize that you are there to understand how these participants think, in their words and their ways. What they think is important, is important to you too. Tuning in to the participants' feelings and choosing the appropriate response is a matter of experience. The decision between postponing and direct treatment is one you have to make yourself.
- Questions may also concern the session itself, the programme and assignments. In this case it is often wise to answer those questions immediately. If you do, make sure your response is direct and concrete and also to the group as a whole. This way you make sure everybody knows what to do, at the same time avoiding that too much time is spent by you talking and explaining. Furthermore, you turn the focus of the group from one participant's personal needs to the level of the group.
- Also about the session itself, if participants ask questions about assignments that seek a participants' opinion, it is best just to tell them to do the exercise as best as they can. Otherwise, you'd pretty soon be filling in what they should be thinking. Sometimes participants can also explicitly ask you to fill this in for them. Then, it is best just to state that you are interested in what they think; it is not important what you as a moderator think.
- Questions about the assignments and their purpose may also come forth out of a participant's uncertainty or desire to 'do it right'. In this case, explain that all answers are right; the session is not about right and wrong but about the ideas of participants themselves.

In most cases, the participants of the dialogue will be friendly, and willing to cooperate. Occasionally however you will run into more problematic behaviour of dialogue participants. The behaviour is problematic in the sense that it obstructs the group process and flow. It can be intentional, but not necessarily. Participants may very well be unaware of the effect of their own behaviour. It can be verbal, or nonverbal. It can be directed towards the moderator, or towards the group, or even not directed to anything particular at all. Anyway, the moderator has to deal with it. Often, this kind of behaviour is easy to get round by the use of procedural 'tricks'.

Problematic behaviour can be both of a dominant and passive character.

Passivity	A participant drops out of the discussion, sits back, unfocused and drifts away.
Problematic because	Active engagement in the dialogue is important for the research results, but also more directly for the group atmosphere. It is the moderator's job to make every participant actively and enthusiastically engaging in the discussions.

Dominance	A participant dominates the conversation, lectures the other participants and obstructs the flow of ideas in all directions
Problematic because	Dominance can be produced by overly enthusiasm or aggression. The effect of this behaviour is that it creates an unpleasant and hostile atmosphere, which inhibits other types of participants to actively participate.

There are some very easy-to-install procedural tricks to get round the dominant behaviour of certain participants. Being transparent about your procedures (why you use them) often helps. Some examples are:

- Go-rounds: when asking for participants' opinions or inputs, make a round about the table, so as to let everyone speak. Also, explain to the group that this is the reason why you do it.
- Write-down exercises: first let participants think of answers, have them write the answers down, then make a go-round asking them out. This is a very nice way to let every individual have her say. Also, you commit participants to what they have written down themselves. If you make go-rounds without write-down, you run the risk of participants being influenced by the dominant, self-assured.
- Respectful parking: participants can be overly enthusiastic about something at that particular time not relevant to the group process. Or a participant can continually be riding his/her hobbyhorse. In those cases you use the virtual parking lot. The lot is a flip chart with a large 'P' on it. Introduce the lot as the space for interesting ideas out of the dialogue's focus. This is how you may use it as well. Make sure parking is done with respect, in order to avoid frustration on the side of the participant.
- Referring to dialogue session program and procedures: explaining that there is a time and a place for everything often helps.

The best way to approach aggressive dominant behaviour is to address it directly and concrete. You will find out that often, if you address the behaviour without judgment, the dominant person will attenuate his/her behaviour. Often, dominance will not take a very aggressive form (after all everyone volunteered to participate), but still be disturbing for the process. Usually the other participants will be thankful for your intervention, because they were enduring this aggressive behaviour as well. Try to respond to this behaviour in such a way that the group atmosphere revives the most. There should be a gradual increase of directness and firmness in the moderator's response in relation to the participant's dominant behaviour. It is better to address problematic behaviour in a subtle implicit way, but it is not always enough. Sometimes you have to become explicit or even confronting to regain direction and control.

Acknowledge & zap	Acknowledge the participant's input (people want to be heard) but then move on directly to another participant
Summarize & zap explain procedures	Acknowledge even more by summarizing (making sure that you got it) and then move on to another participant

Explain procedures	Explain that you want to collect the ideas of every participant in the group. Explain that this is why you want everybody to have a say.
Address behaviour directly	Describe what you observe. Explain how this interferes with the group process. Ask the participant to adjust behaviour.
Decision time	For the most dominant participants: there comes a moment that it is 'change or leave'. Ask the participant why he/she is here. He/she does not have to be here. Make clear that this behaviour is not tolerated.

Your own posture and behaviour can help you enormously in regaining control. Open up, stand up right, express a clear focus to the group or other participants, use your arms to demarcate your focus of attention (even a hand-stop sign can work very elegantly).

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5. Citizen dialogues
Script

NANO2ALL SOCIETAL ENGAGEMENT ON **RESPONSIBLE NANOTECHNOLOGY**

This chapter provides all the details to facilitate the citizen dialogue. Attention is paid to the planning of the event, the materials needed, and the instructions that participants should receive during all exercises. Make sure to study this chapter closely before executing the dialogues. Note that this document will be updated as the project progresses. Scripts for the national multi-stakeholder dialogues and European stakeholder dialogue will then be added.

5.1 Objective of the citizen dialogue

The objective of the citizen dialogue is to produce citizen narratives of the futures that can enrich the stakeholder reflection processes in the multi-stakeholder dialogues. We aim to identify citizens' needs, concerns and values with regard to the development of nano-applications in [chosen nano-application field]. In order to produce citizen narratives of the futures, we want participants to explore possible future directions of nanotechnology in [application field] and discuss potential impacts of these future directions and their desirability.

5.2 Timeline of the citizen dialogue

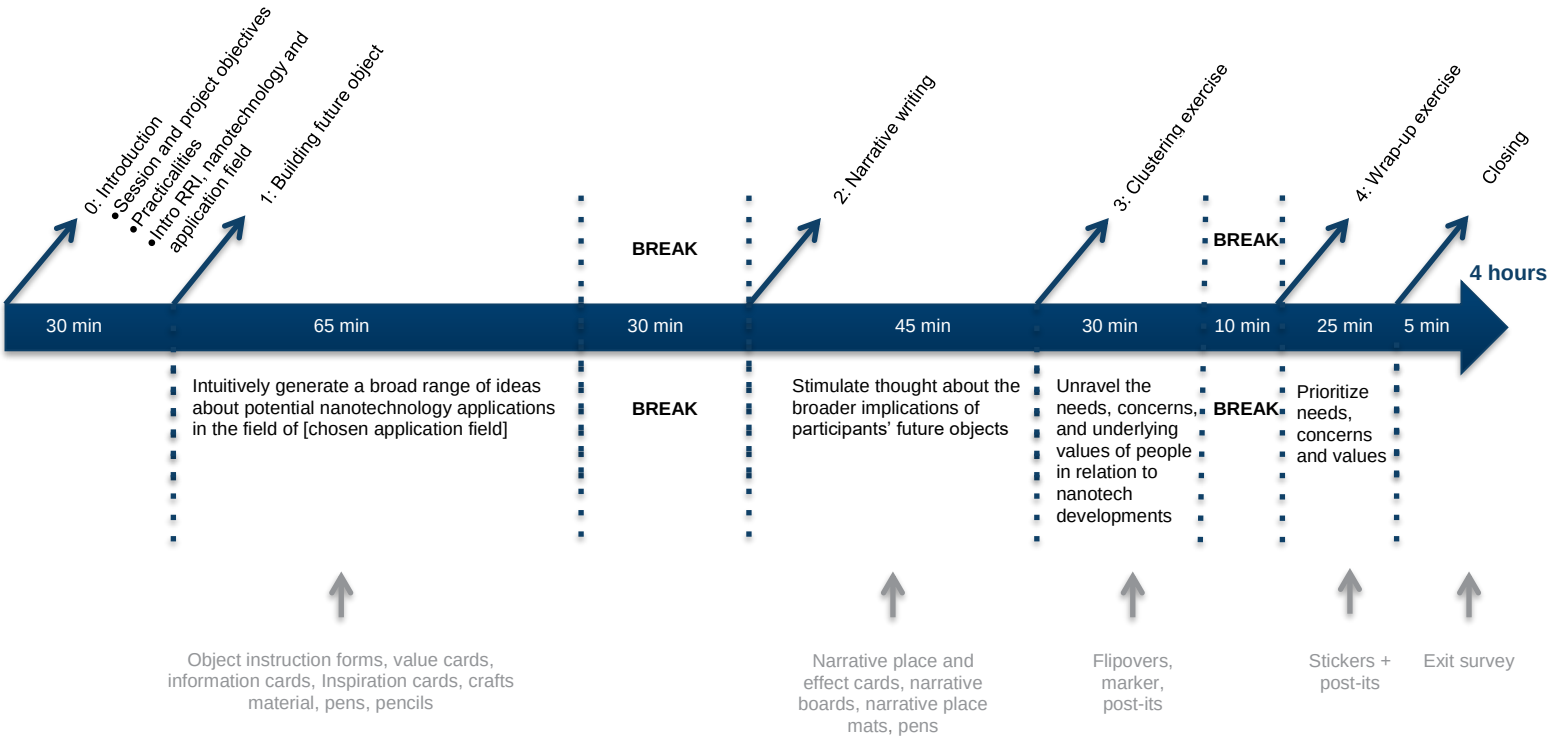

Figure 6. Timeline of the citizen dialogue

5.3 Necessities

- 1 Audio recorder
- 1 Beamer
- 1 Laptop/PC station linked to beamer
- PowerPoint presentation of NANO2ALL (translated in local language and including your name on slide number 2 and the proper email address on slide number [?].
- Script in your own language
- List of participants (with empty column in which participants can write down their email addresses)
- Name cards
- Crafts material
    - Scissors (x8)
    - Glue (x8)
    - Tape (x8)
    - Marker sets of 3 different colours (8x)
    - Wire (metal, iron)
    - Fabrics
    - Coloured paper
    - Cardboard
    - Empty plastic bottles
    - Other interesting materials, such as: small pieces of wood, Styrofoam, wool, buttons, nail fasteners, round objects, aluminium foil, rope
- 8 Object Instruction Forms
- 8 Sets of value cards
- 8 Sets of information cards
- 8 Sets of inspiration cards
- 16 Pens
- 16 Pencils
- 4 stacks of narrative person cards
- 4 stacks of narrative place cards (make sure that each stack is shuffled differently, to prevent each participant pair from having to work with the same space cards)
- 4 stacks of narrative societal effect cards
- 16 Narrative place mats (on which participants can cluster their narrative ingredient cards)
- 16 Narrative boards (on which participants can write narratives)
- 1 Black marker
- 4 Flip over sheets
- 1 Stack of post-its (colour, size) [?]
- Round stickers (red and green, 40 of each)
- 16 Exit surveys

5.4 Preparation of the room

- Be on time! You will need time to arrange the room. This should be done before the participants can come in.
- The tables are arranged in such a way that participants can sit together in groups of 4. So, ideally there should be about 4 table “islands” that can each accommodate 4 participants. Each of these table “islands” should be easy to reach for the moderator and note taker when walking around.
- On each of these table “islands” the following materials should be present:
    - 2 scissors
    - 2 glue bottles
    - 2 marker sets of 3 different colours
    - 2 object instruction forms
    - 4 name cards
    - 4 pens
- Beamer is turned on, connected to a computer, and PowerPoint slide 1 is presented.
- Think about your group composition. The dialogue exercises require participants to work in pairs (exercise 1) or groups of 4 (exercise 2). This is easy when you work with a group of 12 or 16 participants. However, if you have a different group number, this is what you can do:
    - 11 participants:
        - Exercise 1: 4 pairs, and one group of 3
        - Exercise 2: 2 groups of 4 (pairs merge), and one group of 3 (same group as in exercise 1)
    - 13 participants:
        - Exercise 1: 5 pairs, and one group of 3
        - Exercise 2: 2 groups of 4, and one group of five
    - 14 participants:
        - Exercise 1: 7 pairs
        - Exercise 2: 1 group of 4, 2 groups of 5 (one pair is split, and they separately join another group of 4).
    - 15 participants:
        - Exercise 1: 6 pairs, one group of 3
        - Exercise 2: 3 groups of 4 (pairs merge), and one group of 3 (same group as in exercise 1)

5.5 Detailed script

Exercise 0: Dialogue introduction (30 minutes) **0:00**

Objective: get the participants acquainted with each other, the NANO2ALL project, and the goal of today's dialogue

Participants enter

- *Welcome each participant who enters. Explain where they can put their coats and offer them something to drink. Try to establish a friendly and open environment.*
- *Tell each participant that they can find a place to sit and ask everyone to write down their names on the name card.*

Personnel

- Welcome to this dialogue session, I am happy that all of you are here.
- My name is [your NAME] and I am the moderator of this dialogue. I work for [NAME ORGANIZATION]
- My role is to maintain the focus and to guide and stimulate discussion and interaction.
- Besides me sits [NAME NOTE TAKER]. She/he will take notes throughout the session, keep track of time, and will assist me in other things during this dialogue.
- If an observer is present: In the back there is [NAME OBSERVER]. He/she won't take part in the discussion, but is very interested in what happens during this dialogue.

Practicalities

- I want to ask you to sign an informed consent form before you leave today. This form provides some information on the topic and asks if it is okay to audio-record the dialogues and use the data. Everything will be anonymised. Please sign this form and give it to the note taker during the break or after the dialogue session.

Turn on audio-recorder

- Do a safety briefing: tell the participants what to do/where to go in case of emergency
- Tell participants where they can find the toilets

Participants

Take 10 minutes time for the participants to introduce themselves. You can choose your own method to do this, but we do suggest to pick a method that also allows participants to shortly explain why they joined today's dialogue.

NANO2ALL training/introduction

The project and dialogue introduction have been integrated with the citizen training deliverable, and will be designed by the leaders of work package 2. Below you find a short description of topics that will be addressed.

- *Introduction nanotechnology and dialogue topic (starting from the perspectives and knowledge of participants)*
- *Introduction RRI*
- *Introduction NANO2ALL*

Program of today

- The dialogue takes 4 hours, with a 30-minute break halfway and a 10-minute break towards the end. In this time frame we take you through 4 main exercises, some short and others a bit more elaborate.
- In these exercises you will work with crafts materials, cards, flip-over sheets, post-its, and markers to express your ideas and views.
- We are interested in each of your individual ideas and opinions, and want to emphasize that all of your input is valuable. There are no wrong or right answers. Please feel free to speak up and be actively involved. In order to have a fruitful dialogue and understand other people's perspective, it is also important that you pose questions to each other when an idea or reason behind an opinion remains unclear to you.

House rules

- Please turn off and put away phones, laptops and iPads etc.
- It is important that we all listen to others, reflect on what is said and respect alternative points of view
- Together we are responsible what is written on flip over sheets which in turn will inform the written report of the dialogue session
- In the spirit of a frank and open exchange of views, you can of course talk about this dialogue but please avoid attributing comments to specific people.

Data processing

- After this dialogue session with you here today, the results of the dialogue will be summarized in a brief report.
- You will be asked to comment on this dialogue report before it is finalized to make sure that we understood everyone correctly throughout the session. We really hope that you take the time to send us your comments, since we want to make sure that we use the right input in the subsequent dialogue sessions that we will organize.
- The note taker has a list of participants. If you would like to receive a summary, pleas write down your email address behind your name on this list during the break or after the session.
- After you've received the summary report, you will have 2 weeks to respond.
- A team of researchers from the VU University in Amsterdam will analyse the data of the dialogues.
- Your perspectives and ideas will then be used as input to another round of dialogues with various people who are involved in the [chosen nano-application field]. Think of policy-makers, researchers, and industry representatives. For each country that participates in this project, a report will published around May 2019. In addition a report with European recommendations will be published around June 2019.

Exercise 1: Building future object (65 minutes) **0:30**

Objective: to intuitively generate a broad range of ideas about potential nanotechnology applications in [chosen application field]

- Now that you have been introduced to the NANO2ALL project and the aims of today's dialogue, it is time for our first exercise. In this exercise, we want to understand what your ideas are about the future of nanotechnology with respect to [chosen application field], and collaboratively generate a broad range of ideas about potential nanotechnology applications in this field.
- In this exercise we ask you to work in pairs. Together with another participant you will explore the future of [chosen application field] by designing your own object of the future. And when we talk about the future, think about 2032.
- To help you design your object, we will provide some contextual input on cards.
- Each pair of participants will receive 3 stacks of cards. Stack 1 consists of cards with information about nanotechnology and the specific application field on which we focus our dialogue today. Stack 2 consists of general inspiration cards to trigger your senses, and stack 3 consists of value cards with value pairs, such as equality versus difference or efficiency versus quality. You can use these values to think about the purpose or effect of your future object.
- After having formed pairs, we first ask you to browse through the stacks of cards and select a direction or area that you would like to explore further. Maybe you find a specific technological direction quite exciting, promising or daunting. If a direction evokes mixed-feelings it might be particularly interesting to work with.
- If you have chosen a particular direction for your object of the future, walk over to the boxes with crafts material. Now use any of the materials that you like to give shape to what you find important about your future object.
- Each pair will also receive an instruction form on which you are asked to write down the details of your future object.
- You have approximately one hour to work on your future object design. Make sure to start building in time, and not get stuck in the card exploration phase. After 10-15 minutes I will give a sign to indicate that it is time to start building if you haven't already started yet.

Encourage the participants to form pairs. During the exercise, you can walk around the room (together with the note taker) and answer questions when needed. Make sure that by the end of the exercise, each pair has also filled out the Object Instruction Form.

End the exercise by taking a few minutes to let each participant pair present their future object to the rest of the group.

BREAK (30 minutes)

During the break, you can already hand out materials that are needed in the second half of the dialogue session. Put the stacks of narrative ingredient cards, narrative boards, and narrative place mats on the tables (2 sets per table group of 4). In addition, put the flip-overs for exercise 3 in place (3 flip-over sheets: values, concerns, needs), so you won't have to do this anymore at the start of exercise 3.

Exercise 2: Creating a narrative around future object (45 minutes) **2:05**

Objective: to stimulate thought about the broader implications of participants' future objects

- Hopefully all of you are feeling refreshed after this break and ready for the next exercise.
- Before the break, you worked in pairs on the design of your future object. This exercise builds on the work that you've just done, and challenges you to think about the broader implications of some of the objects that you've just created.
- When designing a technology it is tempting to solely focus on technological aspects of your design: how should it work? What should it look like? What is its purpose? But a technology or technological object does not exist in a vacuum. It will be used in practice, in particular social contexts. And these contexts might not always be the ones that you foresaw your object to be used in. Sometimes, unintended user groups start to make use of your product. This is not necessarily good or bad; the use is just different from how you envisioned it when designing your product. When transferring your object into particular social contexts, it is likely that you discover new possibilities and limitations. We want you to further explore the possibilities, limitations and impacts of your object by envisioning its use in a hypothetical situation.
- This exercise consists of two rounds. In the first round, you work in the same pairs again, but in the second round, you work in groups of 4. So two participants pairs – each having created their own future object – are then merged.
- In the first round, we would like each participant pair to think of the use of their object in two potential social contexts.
- In order to help you give shape to that context and stimulate your imagination to think beyond the intended user domains, we provide you with context "ingredient" cards and a narrative place mat (*show the narrative place mat by holding it up)* on which you can use to organize your narrative ingredient cards. Each pair will receive 2 stacks of cards. The first stack consists of potential places in which your object could be used, and the second stack consists of effect cards that describe types of social/societal effects that your object might elicit (e.g. loss of skills, change in existing roles and responsibilities) or particular societal areas that might be influenced by your object (e.g. health, environment, character of leisure and cultural activities, standards of normalcy).
- The idea is that you use the ingredient cards to describe a future situation. First, randomly pick a card from the "place" stack and put it on the designated spot on your narrative place mat. Then think of a person that might use your object in this particular place. Draw that person in the designated drawing box on your narrative place mat and elaborate on some of his/her characteristics (*the narrative place mat requests to fill in name, gender, age, job and interests*). Lastly, browse through the stack of effect cards and choose those effect cards that you think would be most interesting to work with in describing a future situation. You can choose 1 card, but you are also allowed to use more. Put your selected cards on the designated spots on the narrative place mat.
- Each participant pair has 10 minutes time to develop and describe two future situations. You can write your ideas down on the narrative boards that will be handed out. Your description does not have to be too elaborate.

- Then, we start the second round. You merge with another participant pair and read through the future situations everyone in your group has developed (i.e. four descriptions). Together with your group members, you pick out the two future situations that seem most interesting to further develop into a short narrative.
- Together with your group members, you add extra details to the two chosen future situations. Think about why and how exactly the person in your future situation uses the object. What is the effect? And how does this effect come into being? What does the person in your story think of this effect?
- Write these two more elaborate narratives down on the narrative boards. You have approximately 20 minutes for this second round.
- After the second round, each group will share their narratives plenary.

During the exercise, you and the note taker walk around and see what participants come up with. If participants have difficulty with integrating card elements into their story, you can tell them that it is okay if they want to adapt the card input to their taste.

After 10 minutes, indicate that the second round will start. Encourage participant pairs to merge.

After the 20 minutes of the second round have passed, indicate the start of a plenary round in which the created stories are shared. Take approximately 10 minutes for this final part of the exercise.

- You have all worked hard to create various stories around your future objects. Now it is time to share these stories with the rest of the group. Could that group [*point at one of the groups]* start with sharing the two stories that you have created?

Make sure that each group gets a turn.

Exercise 3: Clustering exercise (30 minutes) **2:50**

Objective: To unravel the needs, concerns, and underlying values of people in relation to nanotechnology developments

- In the previous exercises, we have been exploring quite a bit; we looked at possible directions for future innovation (i.e. your future objects), and explored various ways in which your future objects could influence social contexts. Since we invited you here today, to collaboratively generate input for the multi-stakeholder dialogues that will be organized in a few months, we would now like to harvest from all of your explorations by analysing what we hear underneath your future narratives.
- We will cluster your observations on these three flip-over sheets (*point to the three flip-overs that you've put up during the previous exercise)*.
- As you can see, each of the sheets represents a certain cluster: needs, concerns, and values.
- "Needs" refers to those things that you want a technology to supply in order for a desired state to be achieved.
- "Concerns" refers to those things that worry you about a technology, or technological development.
- And lastly, we have "values", and this term actually refers to a deeper level of analysis. It is about what we find important in life. Your needs and concerns might be influenced by the values you hold dear.

The moderator stimulates a group discussion by posing several questions to the group that help to explore the participants' needs, concerns and values. It is important to ask participants to explain themselves and understand the "why" behind their answers and remarks in order to gain insight into their deeper values and beliefs. Make sure

to reflect upon answers and remarks and decide together with the group what should be written down on the flip-over sheets. Below, several questions are provided that you could pose to the group.

- Now my first question to you as a group is: what is it that we hear underneath the variety of stories that we just shared?
    - What are the dilemmas/opportunities that we hear in these narratives?
    - In which stories did you recognize this dilemma/opportunity? And how?
    - Why do you consider this a dilemma/opportunity? Can you explain?
    - Do others recognize this as well?
- Although the narratives themselves might explicitly address particular needs, concerns and values, these stories might have evoked other reactions in you as well. So, what did these narratives evoke in you? You can think of anything, ranging from thoughts and feelings to new ideas.
    - What particular element of the narrative(s) caused this reaction in you? Can you explain why?
    - Do others recognize this as well? Why/why not?

When people experience difficulties with articulating needs, concerns and values, or find it hard to become explicit and concrete, the moderator can ask questions that are more targeted at specific narratives, to encourage participants to use the context of particular narratives in their line argumentation. Examples include:

- If you were to make an improvement to one of or more of these future objects, what would it be? And why?
- What do you need to know about this object/these objects in order to accept or reject it/them? And why?
- When you hear this particular story, what do you worry about/makes you feel enthusiastic?

Exercise 4: Wrap-up exercise (30 minutes) **3:20**

Objective: to prioritize which needs, concerns and values are most important to talk about in the multi-stakeholder dialogues

- In about 6 months, a group of 12 people who are all somehow involved in the development of nanotechnologies in [chosen application field] will be sitting here to discuss about the future of nanotechnology innovations.
- For this last exercise we want you to think of all that we have been talking about today, and the needs, concerns and values that we have just clustered on these 3 flip-over sheets. What do you think is most important to share with them? What do you really want them to talk about?
- You will each receive two green stickers and two red stickers. Walk towards the flip-overs that we created in the previous exercise and place a green sticker to those elements written on the sheets that you think are most important to talk about in the next dialogue round. Put a red sticker next to those elements on the sheets that you think are not important to talk about.
- You don't have to use all your stickers. If a particular need, concern or value is not written down on the sheets yet, and you do think it is important to discuss in the next dialogue rounds, than take a post-it and write it down. You can add this post-it to one of the flip-over sheets.

Hand out the stickers and post-its (2 per person) and let the participants come up to the flip-over sheets to prioritize. Make sure everyone is seated again after 10 minutes, and then collectively reflect what stands out when looking at the division of stickers. Which concerns/needs/values received many green stickers, and why? Which received

many red stickers, and why? If no clear prioritization pattern can be distinguished, discuss with the group why this might be the case and what this reflects. Also discuss the content of post-its that some participants might have added to the flip-over sheets.

Closure (10 minutes) **3:50**

Objective: to thank the participants and check whether there are any remaining questions

- Thank you very much for your time today and the valuable input that you provided us.
- We aim to use your input to broaden and enrich the multi-stakeholder dialogues on responsible directions for innovation. Is there anything you think we have missed in our discussion today?
- Then, we are curious how you have experienced this dialogue session. [Name], would you want to share your thoughts with us first? *Make a short roundabout.*
- I would like to remind you all to write down your email addresses in order to receive the summary report of this session. The summary will be about 2-4 pages. Your feedback on the summary report will be of great value to our research team.
- There is also an exit survey that we would like you to fill out. This will only take you about 5-10 minutes, and will greatly help us to improve future dialogue sessions. On this exit survey, you can also indicate whether you would like to join the next round of dialogues in this project. As we explained, a group of people involved in nanotechnologies will also discuss the topic of responsible nano in [application field]. We would also like to invite 2 people who participated in this dialogue, to join that session to make sure that the views you expressed today are properly represented in the next stage of our project. If you are interested, or if you would like to know more, you can approach me after this session, or send us an email.

5.6 After the dialogue session

For the analysis of the dialogues, it is important to compile all the relevant data after the dialogue session. This section provides an overview of the data that needs to be sent to the VU research team.

<table>
<tr><th>Type of data</th><th>How to present it to the VU research team</th></tr>
<tr><td>General dialogue information</td><td>To get an overview of the general dialogue details, we would like you to fill out the following table:

<table><tr><td>Code</td><td>Country-city CD_data
Example: Netherlands-Amsterdam CD_data</td></tr><tr><td>Location</td><td>Location where the dialogue took place</td></tr><tr><td>Date & time</td><td>Date and time when the dialogue took place</td></tr><tr><td>Moderator</td><td>Name</td></tr><tr><td>Note taker</td><td>Name</td></tr><tr><td>Observers</td><td>Name (if present)</td></tr><tr><td>Participants</td><td>#men and # women</td></tr></table></td></tr>
<tr><td>Transcripts</td><td>The audio recordings should be transcribed for the following parts of the dialogues:
Object presentation
Narrative presentation
Entire clustering exercise
Entering wrap-up exercise (i.e.prioritization)
Transcripts should be translated into English and sent to the VU digitally. Make sure to anonymise the participants in the transcript.

File Name Code: Country-city CD_transcript</td></tr>
<tr><td>Future objects</td><td>All future objects should be photographed and sent to the VU as jpg-files.

File Name Code: Country-city CD_object#</td></tr>
<tr><td>Object instruction forms</td><td>All object instruction forms should be gathered and scanned and supplemented with a translation in English. The documents can be sent to the VU digitally.

File Name Code: Country-city CD_object_instr#</td></tr>
<tr><td>Flip-over sheets</td><td>All flip-over sheets should be photographed and supplemented with a table (in English) in which the data is clustered (see example below). The documents can then be sent to the VU as jpg-files.</td></tr>
</table>

Sheet	Input	Rating in stickers
Needs	• Need • Need • Need etc.	Indicate number of red or green post-its that were added to each of the listed items in the input column. Use a + for each green sticker, and a – for each red sticker. Example: • ++++ ----
Concerns	• Concern • Concern • Concern etc.	Indicate number of red or green post-its (see example above)
Values	• Value • Value • Value etc.	Indicate number of red or green post-its (see example above)
Added post-its	• Text from any post-it that participants might have added during the last exercise	Indicate number of red or green post-its (see example above)

File Name Code: Country-city CD_sheets

Notes from note taker	Notes should be processed and organized in such a way that the VU researchers will understand what they are about. Make sure to include comments about observations that might have influenced the dialogue outcomes (e.g. noise, dominant participants, particular word choices that affected the dialogue etc.) The notes should be translated in English before sending them to the VU digitally. *File Name Code: Country-city CD_notes*
Summary of facilitation experiences	We would like science centres to write a short summary in English about their experiences during the dialogue. What was it like to facilitate this group? What went well? What could have gone better, and why? Do you have any recommendations for improvement of the dialogue format? This summary should be approximately ½ to 1 A4. *File Name Code: Country-city CD_facilitation_summary*

We kindly ask the science centres to send all the translated material as soon as possible to the VU research team, but no later than by **the end of May 2017**.

6. Concluding remarks

This prior chapters have provided an overview of the dialogue methodology that will be employed in the NANO2ALL project. We elaborated on our general dialogue approach and the various dialogue methods that we aim to use in the project, and provided a detailed script for the first set of dialogues that will be organized: the citizen dialogues.

Yet, in this concluding section we would like to stretch that NANO2ALL is not the first dialogue project on nanotechnology. The methodology and specific methods that we present in this manual build on the documented experiences of earlier projects and initiatives related to nanotechnology, as well as prior dialogue experiences in other fields that the Athena Institute has worked in. In addition, we interviewed several people who were involved in the organization of earlier nanotechnology dialogue projects, such as the European project NanoDiode and the Dutch NanoPodium initiative, on the pros and cons of certain dialogue methods and strategies. We subtracted various valuable learning lessons and inspirational approaches and tried to translate these into our own dialogue methodology. We learned, for example, about the importance of focusing on a specific nanotechnology application field, which allows for the provision of sufficient context to actually engage in fruitful dialogue. In addition, we were inspired by various dialogue guiding tools that have been used in prior (nanotechnology) dialogue projects to stimulate participants to talk about complex topics that involve new or emerging technologies. Examples include the use crafting material and object building exercises to engage participants at a different level (Shaping Futures), the use of cards to provide information on nanotechnology and to stimulate reflection in the dialogue exercises (PlayDecide), and the guidelines for writing technomoral scenarios that have provided a valuable overview of the types of societal impacts that would be interesting for participants to reflect upon when talking about the future of nanotechnologies. By using the experiences and insights of earlier (nanotechnology) dialogue projects, we have strived to create a dialogue methodology that stimulates fruitful interactions between the various actors that will be involved in this project.

Appendices

Appendix A – Smart textiles

Nanotechnologies may drastically transform the textiles that we use in everyday life. In the textile industry, many developments currently take place that exploit nanotechnologies to create new fabrics and materials. In some cases, nanotechnologies are used to improve the functionality of materials, such as their durability and strength. In other cases, however, nanotechnologies are used to introduce completely new properties to garments or fabrics. For instance, several nanotextiles have been developed with antimicrobial, self-cleaning, UV-blocking, water and oil-repellent, anti-static or wrinkle resistant properties. Two relatively new and promising developments in the field of nanotextiles are the embedment of both electronics and sensors in textiles. A novel concept of a smart textile embedded with components such as energy-harvesting fabrics, energy-storing fabrics, sensing fabrics to monitor vital signs or the environment, and communication/logic fabrics for sending, receiving, and interpreting information has been proposed. Nanomaterials, such as graphene (i.e. one atom-thick sheets of carbon atoms) and carbon nanotubes (i.e. cylindrically rolled sheets of graphene) have an incredibly high mechanical strength, extraordinary structural flexibility, thermal and electrical conductivities, novel corrosion and oxidation resistivities. Fibre devices that can generate and store energy, respond to stimuli, or even store information, have been fabricated using CNT fibres or functional-guest-incorporated nanotube fibres. These functions combined with the fibre's capability of weaving allow the development of smart textiles incorporating flexible electronics, sensors and actuators. These so-called smart textiles thus enable you to measure bodily functions (e.g. heart rhythm, body temperature) or environmental conditions (e.g. gasses in the air, humidity) and opens up a new range of opportunities to integrate electronics in our everyday lives.

For example, there is a growing interest in the development of smart textiles for medical applications, driven by the aim to increase the mobility of patients who need a continuous monitoring of physiological parameters. In this respect, electronic textiles (e-textiles), i.e., textiles incorporating an electronic circuit, could be used for neurological rehabilitation (e.g., motion sensing and measurement or stimulation of muscle activity). E-textiles appear able to reliably measure gross movement and whether an individual has achieved a predetermined movement pattern. However, the technology still remains somewhat cumbersome and lacking in resolution. The measurement of muscle activity and the provision of functional electrical stimulation via e-textiles are in the initial stages of development but show potential for e-textile expansion into assistive technologies. Smart textiles based on the use of fibre optic sensors instead of electronic sensors can be considered a potential new market niche in the field of healthcare monitoring. The potential impact of FOS is related to their good metrological properties, small size and flexibility, as well as to their immunity from electromagnetic field. Their main advantage is the possibility to use textile based on fibre optic in a magnetic resonance imaging environment, where standard electronic sensors cannot be employed (e.g., MRI, pace maker). This last feature makes FOSs suitable for monitoring biological parameters (e.g., respiratory and heartbeat monitoring) during magnetic resonance procedures. On the other hand, future studies should address the robustness of these textiles against stress and washing cycles or their sterilisability, and the signal-to-noise ratio should be further improved to develop a commercial monitoring system. For any patients, a wearable, invisible, and comfortable monitoring device will allow for a more self-determined life and thus improve their quality of life substantially.

At this point, it should be mentioned that, with respect to practical application of smart textiles, many problems still need to be solved. Firstly, it is difficult to fabricate highly efficient fibre- and textile-shaped electronic devices on a large scale, since most of the reported fibre devices have length dependent performance and the conventional textile-weaving technology may have compatibility issues. Secondly, device sealing is a critical issue for maintaining device performance and user safety. Thirdly, washing the electronic textiles is problematic as they may

stop working after contact with water. To this end, coating a thin protecting layer on the surfaces of fibre-shaped devices has been proposed. Another possibility is that it will not be necessary to wash electronic textiles if a superhydrophobic layer is coated on the surface. Finally, such wearable sensors must maintain their sensing capabilities under the demands of normal wear, which can impose severe mechanical deformation of the underlying garment/substrate. Strong cooperation between industrial textile designers and functional fibres researchers is needed to address the abovementioned challenges.

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Appendix B – Brain-computer interfaces

Neural engineering is a growing field of interest for neuroscientists who aim to find cures for people who suffer from impaired brain functioning. Various devices have already been developed that are able to restore the functioning of impaired nervous systems and sensory trajectories. Think of implants that are able to improve motor control in Parkinson patients, or devices that allow people suffering from “locked-in syndrome” to use wilful thoughts for steering certain actions of external devices. These kind of neural interfaces often use metal electrodes to stimulate neural pathways and record activity of neurons. However, a new generation of neural interfaces seems on the rise allowing for even higher levels of control over physiological functioning. This new generation employs single-walled carbon nanotubes to interact with neurons on the molecular level. Just like neurons, these carbon nanotubes have an incredibly high electric conductivity, which allows them to form tight connections with neuronal networks and boost their excitability. This technology promises to yield improved interfaces and greater application possibilities, offering people with motor or sensory disabilities the opportunity to regain part of their autonomy.

Neuroprosthetic intervention is an increasingly popular method for alleviating symptoms of returning function to patients suffering from neurological injuries and disorders. Despite the impressive results of some electrical therapies, such as auditory implants, deep brain stimulators, functional electrical stimulation of the spinal cord and vision prostheses, considerable improvement in device technology is required to enable greater control of physiological outcomes. Current state-of-the-art neuroprotheses generate an electrical field in the target tissue using metallic electrodes to elicit or suppress neuronal action potentials. Many such devices also use the same metallic electrodes to record neural responses.

Traditional neuronal interfaces utilize metallic electrodes, which have reached a plateau in terms of their ability to provide safe stimulation at high resolution. To achieve higher resolution it has become clear that reducing the size of electrodes is required to enable higher electrode counts form the implant device. The limitations of interfacing electrodes including low charge injection limits, mechanical mismatch and foreign body response can be addressed through the use of organic electrode coatings which typically provide a softer, more roughened surface to enable both improved charge transfer and lower mechanical mismatch with neural tissue. Coating electrodes with conductive polymers or carbon nanotubes offers a substantial increase in charge transfer area compared to conventional platinum electrodes. These organic conductors provide safe electrical stimulation of tissue while avoiding undesirable chemical reactions and cell damage. However, the mechanical properties of conductive polymers are not ideal, as they are quite brittle. Hydrogel polymers present a versatile coating option for electrodes as they can be chemically modified to provide a soft and conductive scaffold. However, the in vivo chronic inflammatory response of these conductive hydrogels remains unknown. A more recent approach proposes tissue engineering the electrode interface through the use of encapsulated neurons within hydrogel coatings. This approach may provide a method for activating tissue at the cellular scale; however, several technological challenges must be addressed to demonstrate feasibility of this innovative idea.

The development of microelectrodes capable of safely stimulating and recording neural activity is a critical step in the design of many prosthetic devices, brain machine interfaces and therapies for neurologic or nervous-system-mediated disorders. Metal electrodes are inadequate prospects for the miniaturization needed to attain neuronal-scale stimulation and recording because of their poor electrochemical properties, high stiffness and propensity to fail due to bending fatigue. Neural recording and stimulation using carbon nanotube (CNT) fibre electrodes has been demonstrated. In vitro characterization revealed that the tissue contact impedance of CNT fibres is remarkably lower than state-of-the-art metal electrodes, making them suitable for recording single neuron activity without additional surface treatments. In vivo chronic studies in parkinsonian rodents show that CNT fibre microelectrodes stimulate neurons as effectively as metal electrodes with ten times larger surface area, while eliciting a significantly reduced inflammatory response. The same CNT fibre microelectrodes can record neural activity for weeks, paving the way for the development of novel multifunctional, dynamic neural interfaces with long-term stability.

Furthermore, neural chips, which are capable of simultaneous, multi-site neural recording and stimulation, have been used to detect and modulate neural activity for almost 30 years. As a neural interface, neural chips provide dynamic functional information for neural decoding and neural control. By improving sensitivity and spatial resolution, nano-scale electrodes may revolutionize neural detection and modulation at cellular and molecular levels as nano-neuron interfaces. Carbon-nanofibre neural chip with lithographically defined arrays of vertically aligned carbon nanofibre electrodes have been developed and their capability of both stimulating and monitoring electrophysiological signals from brain tissues in vitro and monitoring dynamic information of neuroplasticity has been demonstrated. This novel nano-neuron interface can potentially serve as a precise, informative,

biocompatible, and dual-mode neural interface for monitoring of both neuroelectrical and neurochemical activity at the single cell level and even inside the cell.

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Appendix C – Nanomedicine

Nanomedicine is defined as the application of nanotechnology to achieve breakthroughs in healthcare, in the fields of diagnostics, drug delivery and regenerative medicine. It exploits the improved and often novel physical, chemical and biological properties of materials at the nanometer scale. At this scale, manmade structures match typical sizes of biological nanostructures, thus, allowing potential interactions between them.

Nanomedicine has the potential to enable early detection and prevention, and to essentially improve diagnosis, treatment and follow-up of diseases with a real benefit for patients. Examples of nanotechnology applications in diagnostics, drug delivery and regenerative medicine are presented below (*Nanomedicine Strategic Research & Innovation Agenda, 2016-2030*):

Diagnostics	• Nano-enabled biomarkers, vectors and contrast agents with high-sensitivity and specificity: functionalized nanoparticles (NPs) for diagnostics and therapy/ Molecular monitoring of markers/Multifunctional contrast agents • Nanotechnologies to cross biological barriers (BBB), using nanoformulations, nanoemulsions or nanodevices • High throughput systems for multiplexed detection of biomarkers of diseases, for optimization of therapy and sensing interfaces • Nanostructured surfaces for biosensors tailored to work within the body, on the body, or out of body • Non-invasive and painless monitoring (diabetes and endocrine disorders)

Drug delivery	• Nanotechnologies to cross biological barriers, using nanoformulations, nanoemulsions or nanodevices • "Smart" nanocarriers: Encapsulation of actives into nanodelivery devices / Highly targeted and fast acting drug delivery systems and nano devices for localised drug delivery and release in critical regions / enhanced bioavailability (nanoemulsions) and increased target specificity • Biocompatible nanoparticles: Lipid/micellar or polymeric nanoparticles to reduce toxicity (biocompatibility) and improve efficacy • Activable nanoparticles providing physical therapeutic effects (crystalline inorganic nanoparticles) • Monitoring of therapeutic efficacy • Theranostic NPs and nanodevices carrying a drug and acting as a diagnostic tool: diagnosis and monitoring / active and passive targeting (cancer)
Regenerative medicine	• "Smart" nanostructured and functionalized surfaces: functionalization of 2D-3D materials • Scaffolds and nanoparticles for new and advanced therapeutic treatments • 3D printing of cells and biomaterials for implants and/or reconstruction • Intelligent biomaterials/bioactive materials: site specific delivery of active molecules /nanoparticles with spatial and temporal control over the release of biochemical molecules and/or in vivo activation of stem cells / mimic the morphological, mechanical and biochemical environment of tissues / Biomimetic, biocompatible, biocompetent biomaterials • Nanofunctionalization for increased biocompatibility of implants: polymer coated medical implants to improve biocompatibility

The evolution of nanomedicine results in a wide range of innovations that impact nearly every medical specialty (e.g., internal medicine, orthopedics, ophthalmology, dentistry, etc). Nanotechnology's applications in surgical oncology include tumor localization, tumor margin detection, identification of important adjacent structures, mapping of sentinel lymph nodes, and detection of residual tumor cells or micrometastases via nanoimaging as well as nanocarrier-aided targeted delivery of anticancer drugs. With respect to cardiovascular science, nanotechnology developments comprise among others nanofiber-based scaffolds for vascular grafts mimicking the structural properties of the endothelium, nanostructured drug-eluting stent coatings with improved biocompatibility, thromboresistivity as well as enhanced vascular healing, and functional heart tissue constructs. NPs that target damaged artery walls and release on-site their payload to treat atherosclerosis and other inflammatory cardiovascular diseases as an alternative to drug-releasing stents, in-vivo heart tissue regeneration via NPs releasing compounds that promote regeneration instead of tissue-engineered patches are also potential nanotechnology developments. Nanostructured scaffolds with enhanced material-cell interaction for bone and cartilage repair are important nanotechnology applications in orthopedics. Nanostructured scaffolds have also been used for the growth of human dermal fibroblasts (e.g., cases of chronic wounds such as diabetic ulcers or burns) and wound dressings containing silver NPs have been used with excellent results against Gram-positive and Gram-negative bacteria. Monitoring of intraocular pressure for glaucoma management using a nanosensor embedded in a contact lens and scaffolds for delivery of stem cells to replace defective retinal pigmented epithelial cells in age-

related macular degeneration are nanotechnology applications in ophthalmology together with the treatment of choroidal new vessels using NPs, treatment of oxidative stress, prevention of scaring after glaucoma surgery etc. Nanotechnology advances in the field of dentistry include dental implants with nanostructured surface enhancing osteoblast adhesion, implementation of nanoparticle technology into restorative materials with superior esthetic features, nanocomposite-based artificial teeth, treatment of periodontal diseases with DDS, etc. Nanoendoscopy has been introduced with the PillCam capsule endoscope which allows peristaltic movement of a video-camera capsule down to the gut to produce intermittent imaging of the small intestine. A pill-sized camera could potentially be also used to replace the existing and much more invasive colonoscopy.

Beyond the current nanotechnology applications lies the promise of introducing a nanoneedle that can be accurately inserted into the nucleus of a cell without causing fatal damage, femtosecond lasers able to perform a cut size of 100nm with applications in eye surgery, neurosurgery, etc. Nanotechnology is also expected to advance neurosurgery regarding nanomanipulation (i.e., techniques to perform surgery at the level of the neuron), nano-imaging, non-surgical nanorepair (i.e., techniques and substances able to promote axonal regeneration, halt deleterious processes like hemorrhaging, extent neuronal lifespan and provide solutions for neurodegenerative diseases and consequences of neurologic deficits after stroke or brain tumor treatment) and nano-neuromodulation (i.e., interaction with the nervous system at the nano/neuronal level in order to control pain etc.) (*Kiparissides and Kammona, 2014*).

As any medical devices or drugs, nanomedicines are strictly regulated and have to follow thorough characterization, toxicity assessment and multi-stage clinical trials before reaching commercialization and benefiting patients. Nowadays, nanomedicine has more than 70 products under clinical trials, covering all major diseases including cardiovascular, neurodegenerative, musculoskeletal and inflammatory. However, it should be noted that the major part of the research efforts are focused on cancer treatment

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