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Citizens Shaping Complex Technological Issues? Participatory Processes in Bioeconomic and Biotechnological Contexts

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Abstract In sustainability governance, the reliance on deliberative participatory processes has greatly increased over the last decades due to expectations that such processes can mobilize additional creative potential, foster better understanding of problems and acceptance of the costs of relevant solutions, and mediate the decline in traditional forms of participation. However, in complex technological contexts such as bioeconomics and, especially, biotechnology, participatory processes are still rare, at least partly because of concerns that citizens might lack the necessary information and skills. Yet bioeconomic innovation trajectories often imply societal, political, and economic changes that also affect citizens' lifestyles and budgets and may cohere or conflict with individual and collective norms. Thus, citizen participation in relevant deliberations and decisions would seem opportune. In this paper, we therefore inquire into the potential and challenges for participatory processes in bioeconomic contexts. Specifically, we identify pivotal criteria for the democratic quality of relevant participatory processes on the basis of the rich literature on citizen participation in sustainability governance. We then explore how (well) these criteria can be achieved in participatory processes on the bioeconomy and biotechnological

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innovation strategies, drawing on two such processes we carried out in 2021 and 2022. On this basis, we propose further questions and implications for research and practice.

Keywords Participation · Citizens · Bioeconomy · Inclusivity · Empowerment

Gestaltung komplexer technologischer Fragestellungen durch Bürgerinnen und Bürger? Partizipative Prozesse in Bereichen der Bioökonomie und Biotechnologie

Zusammenfassung Der Rückgriff auf deliberative, partizipative Prozesse hat in der Nachhaltigkeits-Governance in den letzten Jahrzehnten stark zugenommen, da erwartet wird, dass solche Prozesse ein zusätzliches kreatives Potenzial mobilisieren können, ein besseres Verständnis von Problemen sowie die Akzeptanz der Kosten entsprechender Lösungen fördern können und den Rückgang traditioneller Formen der Partizipation auffangen können. Gleichwohl sind partizipative Prozesse in komplexen technologischen Kontexten wie der Bioökonomie und besonders der Biotechnologie immer noch selten. Dies ist zumindest teilweise bedingt durch die Befürchtung, dass den Bürgerinnen und Bürgern die notwendigen Informationen und Fähigkeiten fehlen könnten. Wege hin zu bioökonomischen Innovationen implizieren jedoch oft sozialen, politischen und ökonomischen Wandel, der sich auf die Lebensstile und Lebenshaltungskosten von Bürgerinnen und Bürgern auswirken und mit individuellen sowie kollektiven Normen in Einklang stehen, aber auch in Konflikt geraten können. Die Beteiligung von Bürgerinnen und Bürgern an entsprechenden Deliberationen und Entscheidungen erscheint deshalb angebracht. In diesem Beitrag untersuchen wir daher das Potenzial und Herausforderungen partizipativer Prozesse in Kontexten der Bioökonomie. Genauer werden grundlegende Kriterien für die demokratische Qualität entsprechender partizipatorischer Prozesse auf der Grundlage der umfangreichen Literatur zu Bürgerbeteiligung in der Nachhaltigkeits-Governance identifiziert. Anschließend wird untersucht, wie (gut) diese Kriterien in partizipativen Prozessen zu Bioökonomie und biotechnologischen Innovationsstrategien umgesetzt werden können. Dabei stützen wir uns auf zwei solcher Prozesse, die wir in den Jahren 2021 und 2022 durchgeführt haben. Auf dieser Grundlage werden weiterführende Fragen und Implikationen für Forschung und Praxis vorgestellt.

Schlüsselwörter Partizipation · Bürger · Bioökonomie · Inklusivität · Empowerment

1 Introduction

Employing participatory formats to involve citizens in democratic political processes regarding societal problems has become more and more popular over the years, especially but not only in sustainability governance (Jager et al. 2019; Theocharis

and van Deth 2016; Walker et al. 2015; OECD 2020, 2021). Both scholars and practitioners recommend a stronger reliance on deliberative citizen fora and similar approaches to improve awareness problems and acceptance of policy change, reduce power asymmetries in the system, and improve the quality of policy output via the mobilization of additional creative capacities (BioSTEP 2017, 2018; Kasymova and Gaynor 2014; Ianniello et al. 2019). They also argue that citizens themselves increasingly demand more involvement in political decisions, apart from constitutionally provided possibilities such as voting and referenda (Butzlaff 2022; Saurugger 2010). At the same time, participatory, deliberative approaches involving citizens are supposed to provide an answer to the decline in traditional participation, especially voting (Fung 2015; Rosenberg 2006).

However, involving citizens in governance via participatory formats is not without critics or problems. Some scholars question the approach as such or highlight structural conditions of its implementation as fundamental challenges (Blühdorn and Deflorian 2019; see also Machin in this special issue). Others show that participatory formats do in no way guarantee improved sustainability outcomes but instead indicate that such results depend on a variety of conditions (Bohn and Fuchs 2019; Challies et al. 2021). These inquiries demonstrate that who participates, how, and with what degree of control over outputs and outcomes requires attention. The skepticism about participatory formats thus concerns different aspects, ranging from the design of participation processes all the way to their outcomes, with the former being the focus of this article.

Participatory processes would seem particularly challenging in the context of complex technical issues and indeed are still more rarely employed there due to perceptions that citizens may lack the necessary expertise to form informed opinions (Huttunen et al. 2022; Willis et al. 2018). Yet societal input is just as necessary when decisions regarding technological innovation trajectories need to be made. As the examples of nuclear power, the use of genetically modified organisms in agricultural production, and recent debates about vaccines in the context of the COVID-19 pandemic show, technological innovation offers the potential for substantial normative conflict in increasingly pluralistic societies. Citizens diverge in their evaluations of trade-offs, for instance between different social and/or ecological (sustainability) outcomes associated with given technological options as well as in their evaluation of and propensity to accept risks. Thus, participatory processes would also seem particularly opportune here (Gawel et al. 2019; Kirschke and Newig 2017).

Bioeconomic processes, especially in the context of biotechnological innovation strategies, provide an excellent example for this situation. The concept of the bioeconomy aims at replacing fossil-based resources with biobased, regenerative natural resources to generate energy, material, and products through the use of microorganisms. At the general level, the concept draws on the idea of learning from nature for our economic processes. Accordingly, a considerable number of scholars and practitioners argue that biotechnological innovation has the potential to strongly foster the sustainability transformation, or even view their broad implementation as a condition for a successful transformation (European Commission 2018; Gawel et al. 2019). Others, however, highlight the social and ecological challenges involved that arise, for instance, from the remaining risks associated with the use of genetically

modified organisms, the competition between the use of land and plants for food or fuel or habitat, or the changes in prices that expensive biotechnology implies (Fritsche and Rösch 2017). More broadly speaking, the realization of a bioeconomy implies societal, political, and economic changes that also affect citizens' lifestyles and budgets and may conflict with individual and collective norms (Eversberg and Fritz 2022; Moesenfechtel 2020). Yet participatory processes in decision-making about the bioeconomy are still rare. Traditionally, only actors of the so-called triple helix or golden triangle—namely, science, governments, and industry—have been involved in relevant discussions, thus excluding the public and risking serious legitimacy problems (Biostep 2018; Huttunen et al. 2022; Mukhtarov et al. 2017). Accordingly, it is important to ask how citizens' participation in the shaping of these trajectories can be accomplished.

Our paper aims to contribute insights on this question. Based on the rich literature on citizen participation in sustainability governance, we identify pivotal criteria for the democratic quality of relevant participatory processes. We then explore how (well) these criteria can be achieved in such processes in complex technological contexts, specifically the bioeconomy and biotechnological innovation strategies, drawing on two such processes we carried out in 2021 and 2022. In doing so, we deliberately focus not on the content of a participatory process but on the process itself, since the fulfillment of certain criteria within this process is, in our view, decisive for the democratic quality of participatory formats—the core topic of this paper.

The paper is structured as follows. First, we discuss potentials for and challenges of participation in the context of sustainability by drawing on the state of the art and develop a set of criteria for a sustainability-oriented, democratic design of relevant processes. Then we briefly present background information on two citizen dialogues we conducted in 2021 and 2022, in which citizens discussed the sustainability potential of specific microbial biotechnological processes in particular and of bioeconomic innovation strategies as such. We subsequently analyze these dialogues with respect to the achievement of these criteria. The article closes by summarizing our findings and delineating implications for science and practice.

2 The Democratic Quality of Participatory Formats in Sustainability Governance

Scholars attest participation and cooperation among different actors from science, politics, or society in diverse constellations and settings as major potential for the sustainability transformation (Musch and von Streit 2019). Indeed, the Sustainable Development Goals (SDGs) themselves (see especially target 16) stress the importance of citizen participation in sustainable development as a way to ensure the involvement of an ever-changing society (Meschede and Mainka 2020). For the purpose of our article, we focus on deliberative participation as an element of political processes (in the broadest sense) that aim to improve democratic outcomes via dialogue and decision-making among citizens and potentially with other public or private actors on topics of relevance to the sustainability transition. We draw on

the rich and further burgeoning literature on deliberative participatory formats in the context of sustainability governance to identify core criteria suggested by this literature as a condition for their democratic quality, as a basis for our efforts to create such formats in the context of the bioeconomy.

The literature, in turn, has provided both theoretical arguments as well as empirical insights (ranging from individual case studies to systematic, large-scale, comparative investigations at the local, regional, or national level) on the role of participation in sustainability governance.[1] Interestingly, a few core criteria for the democratic quality of the processes show up again and again across the diversity of studies, both theoretical and empirical. These can be summarized under the terms "inclusivity" and "empowerment," while different studies name and categorize these factors in different ways, of course. In the following, we delineate the relevance and central characteristics of both variables before we turn to our empirical application.

2.1 Inclusivity

One of the core criteria for the democratic quality of participatory formats in sustainability governance is their inclusiveness. This condition goes back to the most fundamental ideals of democracy in terms of governance by the people. It thus refers to the general normative assumptions underlying all democratic systems in terms of equality and fairness in the organization of collective control (Warren 2017). For participatory formats, inclusivity implies the aim to create as representative a public as possible, in terms of the population (potentially) affected by a relevant topic or decision (Dryzek 2000; Karpowitz and Raphael 2016). The objective has to be to include an adequately diverse picture of opinions and perspectives (Burgess 2014).

Indeed, a lack of inclusivity in participatory formats has long been a concern regarding their democratic legitimacy (and effectiveness). In 2002, Beierle and Cayford had already noted that lack of socioeconomic representativeness was a pressing problem in public participation (Beierle and Cayford 2002). Observers frequently question to what extent today's deliberative participatory processes provide disproportionate influence to citizens with more financial, temporal, and educational resources, given their higher likelihood of participation, rather than truly dissolve power asymmetries in societies (Lee et al. 2015; Lund et al. 2022; Taylor 2007).[2] Moreover, some scholars and practitioners doubt the willingness of citizens to pursue public rather than private interests in such deliberations (Gent 2022; Scally and Tighe 2015; Schwenkenbecher 2017). Such a balancing of public and private interests may be particularly demanding for citizens in the context of "costly" decisions, such as the siting of wind power plants close to one's home (Bobbio 2019). It is not surprising, therefore, that participatory processes in the context of siting deci-

[1] Theoretical arguments tend to draw on different schools of thought, with a particular emphasis on liberalism, republicanism, and deliberative democracy (e.g., Barry 1999; Bell 2005; Cannavò 2016; Willis et al. 2022). For systematic empirical studies, see, in particular, Challies et al. (2021), Ernst (2018), Huttunen et al. (2022), and Jager et al. (2019).

[2] Of course, this challenge also applies to electoral participation in representative democracy as well (Smith 2021).

sions suffer a particular risk of providing influence to particular rather than general interests, often summarized under the "NIMBY" label in the literature.

These examples show that it is not only the general normative ideal of democracy that presupposes inclusivity in participation. Most, if not all, of the specific promises associated with participatory formats in sustainability governance actually depend on a diverse and representative group of participants for their realization. Achieving a qualitative improvement in outcomes due to citizens' practical knowledge and creativity requires the presence of multifaceted perspectives and knowledge (Dryzek et al. 2019; Newig et al. 2011). An improved fit of outcomes with societal needs and practices will be broadly achieved only if problems and solutions are evaluated by citizens with a diversity of backgrounds, viewpoints, and routines (Meyer 2021; Willis et al. 2018). To the extent that large-scale participatory formats aim to strengthen awareness of problems or to get citizens to accept the costs of specific policies, they also depend on the participation of representatives of all segments of society to reach their goals (Fritz and Binder 2018; Glaab 2016).

Thus, the transformative challenge involved in sustainability governance in pluralist societies implies that inclusivity is a precondition for societal deliberation and participation (Gross 2017; Huttunen et al. 2022). But how can inclusivity be achieved? Inclusivity applies, first of all, to the question of presence, i.e., who is at the table (or, more likely, in the circle). In other words, it is important to recruit a group of citizens who are sufficiently diverse and representative of the relevant segments of society affected by the focal topic of the participatory process. Given that different segments of society diverge in their inclinations toward and resources for participation, an open invitation to a given participatory process will rarely lead to such diversity and representativeness of participants. Socioeconomic, educational, and time resources tend to be strongly correlated with asymmetries in participation. Thus, sophisticated *recruitment* methods are required to counterbalance these asymmetries and reduce participation hurdles, especially for typically marginalized segments of the population (Ianniello et al. 2019).

However, inclusivity considerations go beyond the question of recruitment, as inclusivity in terms of *fairness in the process* is a challenge as well (Eckart et al. 2018). Acceptance of different forms of knowledge as well as approaches to argumentation and issues (e.g., "rational" and "emotional") need to be ensured (Bohn and Fuchs 2019). Differences in general communicative and social skills as well as mentalities also need to be considered, as they affect how likely somebody is to speak up and how considerate individuals are of awarding communicative space to others (Diduck and Sinclair 2002; Hofmann et al. 2019). Thus, deliberative processes also require sophisticated moderation that takes into account and aims at balancing these differences in skill and inclination as well as a mix of communicative, deliberative, and decisional methods (Spada and Vreeland 2013).

2.2 Empowerment

The question of empowerment also goes back to core normative ideals of democracy in terms of government by the people. It focuses on the question of to what extent the participating citizens are awarded actual control over a process and its outcome,

i.e., to what extent a real transfer of decision-making power from politicians or bureaucrats to citizens takes place. This is a concern that has accompanied discussions about citizen participation from early on. Arnstein's (1969) famous "ladder of participation" identified differences in the level of control achieved and highlighted the potential for manipulation and alibi participation. Indeed, there is considerable concern as well as empirical evidence regarding the creation of participatory processes for the sole purpose of legitimizing predecided outcomes (Mukhtarov et al. 2017).

Again, the importance of citizen empowerment via participatory processes is not just a question of satisfying democracies' most fundamental normative goal; it is also important for realizing more concrete promises associated with participatory processes. Scholars associate a range of such promises with participation, beyond the chance of influencing political actions. Specifically, they suggest that citizens profit individually via the generation of feelings of belonging and control, activation, opportunities to exercise and improve general communication skills, and the development of trust and understanding toward other citizens as well as toward democratic institutions and processes more broadly (Eckart et al. 2018; Jager et al. 2019).

To allow for actual empowerment and give citizens control in participatory processes, a range of aspects needs to be considered, however. First, the process design has to be built around dialogue and cooperation, allowing for a multidirectional rather than one-directional flow of information. Such a format is also important for creating trust, promoting understanding of differences in values and interests, and allowing for social learning, which are crucial intermediate variables in participatory processes (Ernst 2019; Jager et al. 2019; Miller et al. 2014). Moreover, neutral and sophisticated moderation is essential in this regard (Ernst 2019).

In addition, it is crucial that the process is *open in terms of its results*. If possible, citizens should be involved from the early beginning to the end, i.e., from the definition of its focus and objectives to the communication of its output. We have to acknowledge, however, that the definition of the pursued goal by the citizens themselves is an ideal condition (Blöbaum and Baasch 2017) that will often be at odds with the political realities leading to the creation of a given participatory process. Still, creating a substantive and sufficiently broad discussion in which citizens have an actual voice and develop choices rather than just having to make and accept them is indispensable for allowing them to exert their power.

Closely linked to this requirement is the condition of *transparency*. Citizens can exercise control in participatory processes only if these are intelligible to them in terms of roles, procedures, and substance. To be more precise, both internal transparency about the process itself and external transparency in terms of the later use of the results are equally important (Hofmann et al. 2019). Thus, a clear, open, and continuous communication strategy is needed, and all relevant information needs to be provided in an easily accessible manner.

To allow citizens to exercise actual control, moreover, some form of *integration* of deliberative formats *into the processes of representative democracy*, such as governmental decision-making at the local, state, or national level, is necessary. Indeed, this is one of the major challenges in this context (Smith 2021). Even if factors

such as a precise coordination of participatory processes with policy needs can be supportive, the chance of actually influencing democratic processes remains limited (Schweizer and Renn 2013). However, an important incentive for citizens to engage in participatory processes is the chance of actual influence on political processes by participating, as well as reliable, binding results, and the experience of a lack of such impact can become a serious barrier for future citizen engagement (Vetter et al. 2013). Information on the use of the outcomes of a given participatory process should therefore be provided from the beginning.

Furthermore, citizen empowerment will depend on the provision of the relevant *substantive information*. Providing such information, especially on potentially complex topics, and creating the potential for relevant learning processes is necessary for building an informed and equal basis for discussion and for enabling participants to take part in them. Importantly, this information will have to be as accessible and comprehensive as possible, while taking into account time constraints (Abdullahi et al. 2020). Inadequate, inaccessible, or overly complex information might not only hinder empowerment but also discourage citizens from engaging in participatory processes at all (Diduck and Sinclair 2002). Moreover, the information provided should cover a representative set of perspectives to avoid manipulating the deliberative outcomes (Bobbio 2019). In this context, the methods of providing the relevant information, which may involve expert participation as well as other forms of provision of transdisciplinary expertise using suitable media and technology, require attention as well (Wehnert and Beckmann 2018).

Finally, the empowerment of citizens via deliberative formats will depend on a *supportive organizational structure* and general setup of the process. In consequence, high-quality formats require a considerable amount of personal and financial resources in order to allow for careful planning and professional project management (Lund et al. 2022). Only on such a basis is a sophisticated orchestration of the conditions and elements mentioned above—including active, transparent, and continuous communication with the citizens involved as well as with the interested general public—possible.

2.3 Inclusivity and Empowerment in Participatory Processes on the Bioeconomy

The literature thus provides rich information regarding criteria for the democratic quality of participatory processes. Inclusivity and empowerment are of particular concern here in terms of various aspects (Table 1).

However, fulfilling these criteria can be challenging. This is particularly the case in the context of complex issues such as the bioeconomy. The technological complexity of a significant share of what is considered part of a bioeconomy implies asymmetries, if not a lack of knowledge, on the part of citizens (Fraune 2018; Lund et al. 2022). Thus, attempts to integrate citizens in the respective discussions and decision-making have to address serious challenges regarding how to encourage citizens to participate and how to enable their meaningful participation, including the basic question of how to provide sufficient and nonmanipulative information within a limited amount of time (Willis et al. 2022). Technological complexity can result

Table 1 Criteria for the democratic quality of participatory processes

Inclusivity	Empowerment
Recruitment Combination of methods to reach different segments of the population Reduction of barriers to participation, especially for population segments less inclined to participate	*Dialogue/cooperation-oriented process* Multidirectional flow of communication and information Strengthening of understanding and cooperative orientation
Fairness in the process Acceptance of different forms of knowledge and argumentation Balancing of asymmetries in communicative skills and inclinations	*Openness in terms of results* Opportunity for citizens to develop own understandings, choices, criteria
	Transparency Clear, open communication strategy on process, its aims, and handling of results
	Integration into processes of representative democracy Actual use of process results in democratic institutions (strategic placement)
	Information Sufficient and easily accessible substantive information Broad spectrum of perspectives
	Supportive organizational structure Sufficient human and financial resources

both in a fear of inadequacy on the part of citizens and in hesitancy to attend a participatory process or speak up in it. It might also lead to different levels of influence on the process, given different levels of specialized knowledge. Furthermore, communicating and working together can be difficult due to diverging information and perspectives, which can impair the establishment of a common ground for discussions, potentially leading to frustration and conflict in turn (Morrell 2018). Given these challenges, then, it is interesting to explore how and to what extent inclusivity and empowerment can be achieved in participatory processes, focusing on the bioeconomy and especially on its technological facets. Below, we do so drawing on experiences from two citizen dialogues on the bioeconomy and biotechnological innovation trajectories that we carried out in 2021 and 2022.

3 Empirical Application: Participatory Processes on Microbiological Applications in the Bioeconomy

We designed and implemented two participatory formats with citizens ("bio-dialogues") on the bioeconomy and biotechnological innovation trajectories with the purpose of improving citizens' partaking in the shaping of the bioeconomy. This involved two objectives:

Citizens discussed microbial biotechnological processes, specifically microbial wastewater treatment, biogas production from organic waste, and fermentative production of biobased chemicals. These topics are potentially controversial and therefore interesting for various reasons. To name just a few examples, genetic engi-

neering can be used in all three processes, which could be criticized by citizens. In addition, their actual sustainability benefits are quite contentious, trade-offs exist between different ecological and social sustainability benefits, and the success of the processes partly depends on the behavior of the citizens (e.g., biogas production requires single-origin biowaste). The participants evaluated the processes against (self-developed) sustainability criteria and developed an overall list of sustainability criteria for bioeconomic innovation strategies as such. It became apparent that the citizens considered the creation of political framework conditions to be essential and called for a demand-oriented—not purely profit-oriented—development of biotechnology. Its use should also clearly be aimed at solving societal problems. They also considered it important to communicate with and educate society about the potential and risks of the bioeconomy, to question individual consumer behavior, to respect morals and values in the transformation to the bioeconomy (e.g., with regard to global inequality and distribution problems), and to enable a closed-loop circular economy through biotechnological advances. The aforementioned list was then communicated to relevant actors in politics, civil society, and business, including the German Bioeconomic Council.

At the same time, we were interested in the question of how such participatory processes could be designed in the best possible way. Accordingly, we evaluated and compared the bio-dialogues with respect to their ability to achieve inclusivity and empowerment. The current paper focuses on this aspect.

The dialogues took place in 2021 and 2022. They were each attended by about 20 citizens (for composition, see below). We gathered relevant data via pre- and postquestionnaires as well as at the dialogues themselves. The pre- and postquestionnaires were implemented electronically and the results evaluated in basic quantitative terms (i.e., focusing on mean and standard deviation, as the limited size of the sample would not have allowed reliable results from more advanced quantitative methods). Data from the events themselves include result sheets from the group and plenary works as well as data generated by participant observation and recorded during the event using prestructured observation forms as well as memory protocols. The qualitative data were examined via a content analysis.

3.1 Inclusivity

3.1.1 Recruitment

For the purposes of inclusivity, it is important to *recruit* as representative a "public"[3] in citizen dialogues as possible, as we argued above. Thus, appropriate recruitment methods and especially the reduction of participation hurdles for those most unlikely to participate are required. A variety of recruitment methods exist. For our dialogues, we compared recruitment via advertising in many different channels, including social media, advertisements in stores, and through mediating organizations, with recruitment via a representative sample drawn from the public register (taking

[3] In our dialogues, the "public" consisted of citizens. Experts were invited to provide diverse inputs (see below) but were not part of the citizens' deliberations on sustainability criteria.

into consideration sex, age, and place of residence) and sent invitations by traditional mail (1500 letters). The focus was on three cities in North Rhine-Westphalia with different socioeconomic characteristics in order to increase the chances of achieving diversity. Citizens interested in participating were invited to fill out a short online survey, on the basis of which the project team invited a set number of participants as diverse as possible in terms of sex, age, migratory background, household size, education, and political and religious orientation. Both advertising as well as the invitational letter tried to convey the necessary information in easily accessible language and content and—in the case of the first recruitment method—easily accessible images. We also tried to generate interest via reference to everyday objects and experiences, such as eating vanilla ice cream. Moreover, we made an effort to reduce participation hurdles by offering child care, financial compensation, and the choice of attractive and easily accessible locations.

Both approaches led to a size of the "mini public" that was close to the aim of 25 participants. A majority of them were from Münster, where the dialogues took place, which may be due to less effort in getting to the event venue but also a function of the different socioeconomic and educational characteristics of the city's population. The gender distribution was quite balanced, being nearly equal and thus representative for the population in both dialogues (36% male; 40% female; 24% not specified in 2021; 44% male, 56% female in 2022; Fig. 1). However, in 2021 the group was rather young (mean age 30 years; Fig. 2) and academic (68% had a university degree or were in the process of obtaining one; Fig. 3), on average. In 2022, the group was more mixed in terms of age (mean 50 years; Fig. 2), and the average educational level was not as high (62% university degree or obtaining one; Figs. 3 and 4), although it was still higher than the average educational level in the three cities of origin of the participants. Moreover, ethnic diversity was not achieved, with only one person with a migratory background participating in the 2022 dialogue and none in 2021.

When the two dialogues are compared, recruitment via the sample drawn from the public register clearly was more successful than relying on multichannel advertisement alone (requiring, however, more financial investment as well as negotiations with the municipal guardians of the public registers). But even this approach, which also involved sending an enormous number of letters (1500, with a response rate of 2.6%), did not really achieve inclusivity in terms of a representative group of citizens, as the numbers show. Of course, all participatory processes suffer from this challenge, and even the recruitment process for a citizen assembly at the national level in Germany achieved only a response rate of 5.7% (Dean et al. 2022). But with 2.6%, ours was substantially lower. Unfortunately, only the people who attended the dialogues can provide us with information on what made them come or helped them to come (e.g., substantive interest, financial compensation), not those who did not respond. Thus, we do not know to what extent the term "bioeconomy" or a lack of understanding or relevance increased any uninterest or hesitancy for some. For others, answering via an online tool also may have created a hurdle. The aspects of who invites and what impact of deliberations and decisions can be promised are likely to also make a difference. Moreover, the communication in German in the

invitation and at the dialogues disadvantaged the participation by those lacking the ability or comfort in communicating in that language.

In the end, it is clear that we were not able to sufficiently motivate participants from diverse backgrounds to attend the dialogues with either recruitment method, despite all of the additional steps taken. This underlines the need for including additional recruitment strategies, such as direct recruitment efforts in spatial proximity to areas where segments of the population most unlikely to participate in citizen dialogues live, which research and practice have recently been starting to explore. Even then, however, recruiting a representative sample of the population will remain a core challenge when it comes to deliberative participation formats (not to mention representatives of affected populations abroad or in the future). Even the German citizen dialogue, which was more successful in terms of recruiting a set of people from diverse socioeconomic backgrounds, suffered from an overrepresentation of highly educated citizens (op. cit.).

3.1.2 Fairness in the Process

As pointed out above, equality considerations go beyond the question of recruitment and have to address *fairness in the process* as well. A combination of different methods of communication, deliberation, and decision-making is necessary to balance differences in communicative skills and inclinations. Thus, we combined plenary and small working groups for phases of dialogues to help those who were willing to speak up but uncomfortable doing so in larger groups. Furthermore, we provided opportunities for written rather than oral comment, including opportunities to comment anonymously and to use simple voting elements via the online voting tool Mentimeter (Stockholm, Sweden). Moreover, we invited the citizens to (jointly) create rules of discussion at the beginning of each dialogue to raise awareness for the need to provide communicative space to each other and ensure respectful interactions. Over the course of the dialogue, the moderators then monitored and enforced compliance with these rules, as well as supported those less likely to engage in discussions or less skilled in doing so.

Our data show that fairness in the process was mostly achieved with the help of this mix of methods. The team observed that almost all participants were strongly engaged in the process, and participants stated that they experienced the process as balanced, respectful, and open. They gave positive feedback on the use of variation in methods and discussion formats, and they highlighted the benefit of the small working groups in particular. The process of agreeing on rules of discussion was welcomed by a majority of the citizens (mean 5.5 of 6), and participants generally complied with the rules. Our data also show that participants overall very much appreciated the search for understanding and the culture of error. Interestingly, the use of Mentimeter was welcomed in the first dialogue but met with criticism in the second and therefore was dropped for the latter parts of the second dialogue. Participants overwhelmingly argued that they enjoyed the lively discussion and would rather not include virtual elements. This may also have been a result of the long COVID-19 experience and a resulting lack of direct interaction, even if some citi-

zens proposed using additional digital elements such as online surveys to generally increase the participation rate in the population, independent of the subject.

3.2 Empowerment

3.2.1 Dialogue-/Cooperation-Based Procedure

Beyond the fairness of the process, we argue that multidirectional communication and a cooperative atmosphere are core elements of deliberative formats with citizens. Thus, it is important to create a setting in which citizens interact with each other as well as collaborate in developing and answering questions or solving problems.

In our dialogues, we combined short phases of information provision with extensive phases of questions and discussion (in different groups). To foster multidirectional discussions, we set up the rooms (e.g., communicative table groups) and provided for different forms of interaction with experts. We also organized group activities outside of the more formal deliberation, such as guided tours of the botanic garden, in which one of the dialogues took place. In addition, we used icebreakers and opportunities for socializing (over coffee or dinner) as means to create a certain level of familiarity and trust among the participants.

Based on the data we collected, the participating citizens rated the atmosphere and degree of dialogue positively (mean 5 of 6). A large majority of participants remarked that the content of the bio-dialogues was designed to be easily understood (mean 4.57 of 6). They also valued the informal setup of discussions as an invitation but not a pressure to exchange opinions (mean 5.1 of 6). In general, the observations by the project team supported this evaluation as well.

However, the project team felt that the two-day length of the first dialogue constrained flexibility too much in terms of allowing sufficient time for discussions and questions by citizens. Therefore, we switched to a three-day design for the second dialogue. We found that this did indeed further aid to overcome communicative predispositions and participants' openness to other experiences and opinions. In the first dialogue, moreover, participants felt that they would like to know even more about who was in the room with them (despite icebreakers and opportunities for socializing). Therefore, we asked participants to fill in short profiles before or at the beginning of the second dialogue, which were then posted on pinboards on which we again included icebreaker-type questions about things such as dream vacations. Participants appreciated and used this pinboard for their information, as the project team observed. Of course, they needed to disclose only as much information as they wanted to.

3.2.2 Openness in Terms of Results

An additional condition for empowerment via participatory formats, which we derived from the literature, was the openness of the process in terms of results. This is to be understood broadly. Not only should a specific result not be predetermined, but choice sets should not be predefined and targets should not be overspecific (e.g., predetermining a number of criteria to be defined).

In our case, the substantive focus (bioeconomy/biotechnology) and normative orientation (sustainability) of the dialogues were predetermined. Between these guiding poles, however, we let citizens develop and decide as much as possible. Thus, we did not present a definition of sustainability but enabled the citizens to develop their own understanding. We provided them with input on bioeconomic processes and the relevant microbial technologies, as well as on both ecological and social sustainability aspects with respect to those, using expert input as well as scenarios, thus allowing citizens to envision and evaluate different bioeconomic futures. However, we went to great lengths to make this input diverse in perspectives (see below) and refrained from giving any constraints for the citizens' sustainability evaluation.

Our data show that participants appreciated the openness in terms of results provided. In the discussion, experiences were mentioned regarding other participatory formats in which they had taken part or of which they had heard, and these were linked to concerns about alibi participation. Both participant responses in the postquestionnaires as well as observations by the project team during the dialogues show that these concerns or critiques did not arise in our dialogues, however. Rather, participants emphasized the positive experience of being in control of the dialogue's results.

3.2.3 Transparency

Transparency is a further condition of empowerment. Citizens need to be provided with all relevant information about the process in as accessible a way as possible to be able to exercise real control. To allow for as much transparency as possible, we provided participants with relevant information before, during, and after the process using various media channels as well as continuous opportunities for direct questions. We maintained the project's website accordingly, had a phone line just for the dialogue, communicated about all relevant issues at the dialogue, and made sure that members of the research team were accessible during the dialogue at all times. We also documented dissemination efforts of the dialogues' results for the participants and invited them to take part in these.

Still, our data show that we were not completely successful in achieving full transparency from the perspective of the participants. In particular, the objectives of our participatory formats and the intended use of the results appear to have been only semiclear for the participants, even after we made further efforts in this respect in the second dialogue (objectives of formats: mean 3.22 of 6 in 2021, mean 3.88 in 2022; use of results: mean 2.83 of 6 in 2021, mean 4.31 in 2022). Part of this result may be due to the complexities of political processes and the unavoidable indeterminacy of the effects of information provision to such processes. The individual tasks and foci of the different working sessions were better understood (mean 4.19 of 6); however, even in this regard there was room for improvement.

A fundamental challenge with respect to the criterion of transparency is that the provision of too much information a priori may reduce the likelihood of participation, as invitees may be deterred by long letters. A large amount of information may also be a particular burden for potential participants facing severe time constraints, thus exacerbating the challenge of unequal participation. So, this is a fine line to walk.

3.2.4 Integration into Processes of Representative Democracy

The integration of the results of participatory processes into processes of representative democracy is a particularly challenging condition of empowerment given the length, complexity, and indeterminacy of the latter processes. This is all the more the case if a given participatory process is not conducted as a specified task for a given governmental actor. Moreover, elected representatives may be disinclined to constrain their own decision-making power via a commitment to the consideration of results from citizen dialogues.

In the case of our dialogues, there was no authorization by political actors to develop a concrete input for a defined policy process or such. On the contrary, our dialogues were part of a research project, the broad purpose of which was to arrive at insights on how to enable citizens' partaking in the shaping of the bioeconomy. Thus, we fed the results into relevant political discussions and communicated them to relevant political actors, using multiple channels and forms (e.g., recommendations for action, hands-on guidebooks). Thereby we provided for at least a potential impact.

3.2.5 Information

For empowerment, citizens also need to be provided with relevant and easily accessible substantive information on the thematic focus of a participatory process, as pointed out above. Such informational inputs and corresponding opportunities to have questions answered are important for allowing informed decision-making and for reducing information asymmetries among the citizens. This involves covering an appropriately diverse set of perspectives as well as attention to the (distribution of) means of information provision. Moreover, while citizens will benefit from the interaction with diverse experts, it is also necessary to create "safe spaces" where they can freely discuss among themselves.

In our dialogues, we explored various forms of information provision. As inputs, we created videos, had longer and shorter expert presentations, and developed scenarios of future bioeconomic worlds. The experience shows that including the right amount of information in the right manner is a challenge. In the first dialogue, the experts we invited to provide input on their perspectives partly dominated the discussion too much, in the eyes of the observing team and the citizens. At the same time, some participants mentioned that they would have needed more information to arrive at informed decisions (mean 3.38 of 6). Also, the evaluation of the information provided as "neutral," "too positive," or "too critical" of the bioeconomy and biotechnological processes varied among participants (and the experts present). This was especially evident in the conflicting feedback on explanatory videos, which some citizens and experts judged as neutral and informative, others saw as rather critical, and still others deemed "advertising." So even though participants' overall evaluation of the provision of information was positive, and even though our data indicate that the content conveyed was generally easy to understand by citizens (mean 4.57 of 6), there was clearly room for improvement.

For the second dialogue, we therefore reduced the input by experts to short statements and organized discussion rounds, during which citizens could quiz them on specific aspects of interest or questions that had remained unclear. We also provided citizens with opportunities to conduct small experiments, such as water filtration, themselves, to make the topic at hand more intuitively accessible. We paid increased attention to providing the relevant information in as neutral a manner as possible from our side, while continuing to do everything possible to have a balance in perspectives among the invited experts. The feedback from this last dialogue shows a positive effect of these measures, with strongly favorable feedback from participants: "I took a lot away with me (...) and will further seek to deepen my understanding," and "I learned a lot about biotechnology and other new, interesting things and was able to reflect on them." Other comments emphasized the value of diverse positive and negative perspectives on specific topics provided by different experts, which indicates that our efforts in providing balanced information were appreciated.

3.2.6 Supportive Organizational Structure

Last but not least, achieving an empowerment of citizens via participatory processes will depend on the existence of a supportive organizational structure. This, in turn, means that sufficient resources both in terms of personnel and financial means are needed. Indeed, the resources necessary for organizing such processes in a professional and effective manner are not to be underestimated.

For our dialogues, we had the benefit of external funding and, additionally, could draw on the institutional context of substantial and experienced research teams. This proved essential for preparing the dialogues and for organizing sufficient personnel for coordinating, moderating, observing, etc., activities during them. Participant evaluations also documented that they noticed and appreciated the setup and implementation details of the dialogue. In the written feedback, citizens positively emphasized the "very elaborate and effortful organization" of a "great" and "complex event on complex topics."

4 Participatory Processes for a Sustainable Bioeconomy?

In this paper, we explored the challenge of designing participatory processes regarding complex technological issues, specifically the bioeconomy and biotechnological innovation. To this end, we identified and detailed the criteria of *inclusivity* and *empowerment* as pivotal criteria of the democratic quality of participatory processes, drawing on the rich literature on participation in sustainability governance. In a second step, we delineated possibilities and challenges for actually achieving inclusivity and empowerment in participatory processes regarding complex technological issues on the basis of two citizen dialogues on microbial biotechnological processes, which we designed, implemented, and evaluated in 2021 and 2022.

Our results document a variety of methods and strategies that can be used toward making participatory processes in technologically complex contexts possible

and successful in terms of inclusivity and empowerment. They also highlight two remaining challenges that exist with respect to participatory processes in general, but especially in such contexts: (1) recruiting a representative group of citizens and (2) providing sufficient, easily accessible, and nonmanipulative information within a limited time frame. In addition, our experiences confirm the general challenges of integrating the results of participatory processes into the processes of representative democracy and the need for sufficient resources for organizing sufficiently sophisticated participatory processes, which again applies to such processes in general.

Clearly, with the limited evidence of two dialogues on a very specific topic, it is impossible to draw broad generalizations from the insights gained. Participatory processes on a different—even if also technologically complex—topic or with a different degree of political authorization and tasks may diverge in terms of the potentials for and barriers to the creation of inclusivity and empowerment. Still, we believe that at least some of the insights gained are likely to be relevant beyond our specific cases. Future research will have to show whether that is the case.

What implications for further research and policy do our results suggest? On a practical level, further investment in the development of recruiting methods, especially for reaching and including those segments of society typically least inclined to participate, is needed. Especially in technologically complex contexts, generating interests, explaining relevance, and overcoming participation concerns requires a sophisticated, multifaceted approach. In addition, the question of how to represent the interests of future generations as well as potentially affected members of present generations from across the globe, which we did not even attempt at our bio-dialogues, will require attention (Hara et al. 2019; Smith 2021). Moreover, broader questions of respecting the disinclination of some citizens to become involved also need to be pondered more in this context. Similarly, methods for selecting and providing relevant, easily accessible, sufficient, and nonmanipulative information in a short time frame also require (further) attention. Against the background of the different perceptions of citizens regarding the neutrality of information, further research on the understanding of neutrality also proves to be interesting and highly relevant under current conditions. In technologically complex settings, enabling citizens to access and use information from a diversity of perspectives requires particularly resourceful and sophisticated strategies. One has to acknowledge, of course, that even the question of what the appropriate range of perspectives is may well be controversial among experts. In addition, our results show that the line between too much and too little information is a thin one, as well as individually different. Thus, there is no perfect and final answer to this challenge.

What do these insights mean for democratic decision-making in broader terms? Identifying the above questions and challenges does not mean, in any sense, that we would advise against involving citizens in political processes via participatory formats in general or in bioeconomic or other technologically complex contexts in particular. We are convinced that such involvement is needed and beneficial in many cases and contexts for the reasons mentioned in the first sections of the article. Negotiating how to deal with risks (e.g., of new technologies), moral issues in the context of sustainability (e.g., regarding the use of genetic engineering), and costs and losses are just some of the questions that can hardly be solved without

the participation of citizens. Their knowledge of aspects such as the everyday use of resources such as water and food is also necessary to develop appropriate and effective solutions to sustainability challenges. Despite these and other potentials of citizen participation, we would also caution against too easily placing one's hope in any such formats. Participatory processes in general, and in bioeconomic and other technologically complex issues in particular, require sufficient attention to detail to achieve results that are reliable from a perspective of democratic legitimacy. Given the resources needed for this, both financially and in terms of time, a permanent institutionalization of, for example, citizen assemblies at various levels of governance may be advisable to increase efficiency. Still, setting priorities in terms of the issues to be discussed and decided via participatory processes will also continue to be necessary.

5 Appendix: Sociodemographic Characteristics of Participants in the Dialogues

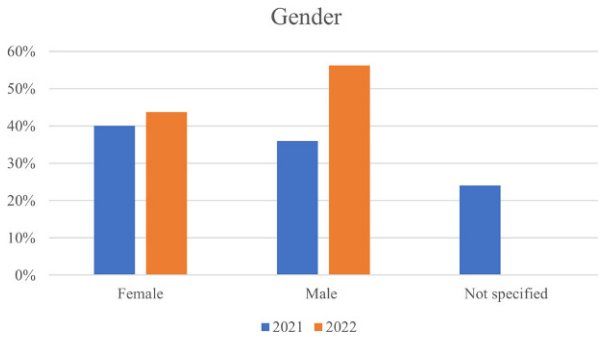

Fig. 1 Gender distribution among the participants

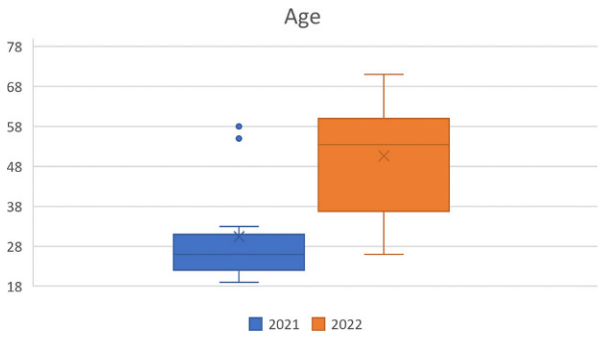

Fig. 2 Age distribution among the participants

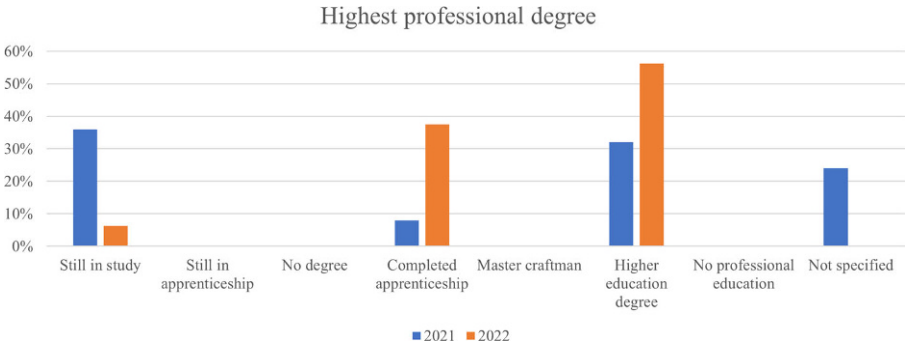

Fig. 3 Professional education of the participants

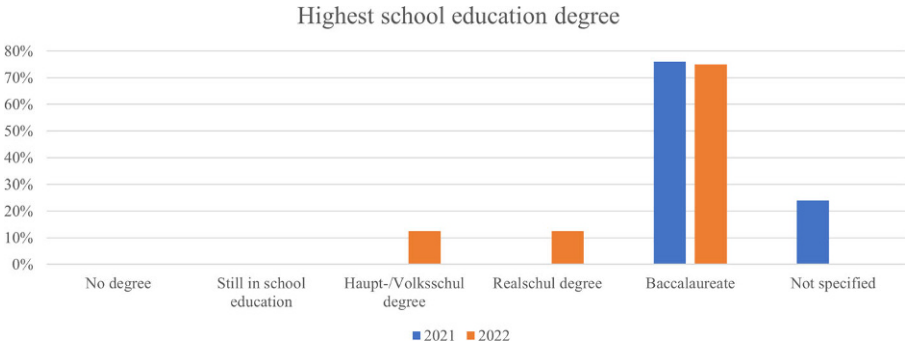

Fig. 4 School education of the participants

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