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A Resurgence of Cooperation between Scientists and Laypersons

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Abstract: After a long period during which the involvement of laypersons was considered undesirable in the Western tradition of science, we have recently witnessed numerous collaborations which suggest that the desirability of societal involvement in the scientific practice is becoming recognized. This article argues that the historical considerations that once led to this division in cognitive labour have been in transformation, having undergone diverse shifts. In a first instance, the exclusion of laypersons from science is analysed in terms of the key concepts of systematicity, universality, and authority. For that, two examples are given: the case of the British photographic survey and that of the American Museum of Natural History. Next, the dissolution of these barriers between scientists and laypersons is discussed and illustrated by examples: the Dystrophic Epidermolysis Bullosa Research Association in Austria, Fukushima nuclear monitoring stations, and the French Association of Muscular Dystrophy. It is concluded that, for science to be truly democratized, co-produced knowledge needs to be integrated in political decision-making processes, which is currently still lacking. Furthermore, since expertise can also be found *in* society, non-certified experts should work in conjunction with scientists, yet at the same time, the divide between experts and non-experts must be maintained. The inclusion of non-scientific experts in decision-making is fundamentally different from the inclusion of lay stakeholders. Hence, different participatory roles should be expected from stakeholders, experts, or scientists, and the most important challenge now is how to formally define such roles.

Keywords: *co-production of knowledge, democratization of science, expertise, history of science, lay knowledge*

Introduction

Ever since the 18th century, a divide began to emerge between expert and lay knowledge, leading by the end of the 20th century to a fundamental dichotomy between the positions of scientists and laypersons (Fehér, 1990; Wynne, 1996). In this article, I argue that the historical considerations that led to the division of the cognitive labour, we see today, underwent a process of transgression in the last couple of decades and are now, once again, being reconstructed and reframed. The long-established view which asserts that "laypersons cannot and should not interfere in the process of scientific knowledge production" (Fehér, 1990, p. 230) is gradually being overcome in favour of a trend captured by the term 'co-production of science and society,' where the main keywords are consultation, participation, and public debate (Callon & Rabeharisoa, 2003, p. 194).

The first step of this article is, thus, to briefly describe the historical considerations against the cooperation between scientists and non-scientists that led to the gap we have been witnessing. For that, two examples are given: the case of the British photographic survey and that of the American Museum of Natural History, which help to illustrate how this rift was formed in these two particular instances, when it comes to the process of scientific knowledge production in the Western tradition of science. In a general manner, the examples show how the scientific method and the concepts of systematicity, universality, as well as objectivity were the key concepts that served as the foundation upon which this division was first built.

Next, three additional examples are presented in order to showcase contemporary efforts and studies made in searching for ways to transgress the opposition 'lay *versus* expert knowledge.' The fact that the popularization of science, co-production of knowledge, and citizen science are becoming increasingly prominent[1] supports the argument that, for the last two decades, there have been more considerations in favour of the cooperation between scientists and laypersons than against it. Nevertheless, questions surrounding systematicity, universality, and objectivity have not yet been completely resolved.

[1] The European action 'Cooperation in Science and Technology' (COST, n.d.), from the European Commission, is cited here as one of the several examples of actions by governamental states to promote science democratization, indicating that research funding agencies reward projects in these lines.

Finally, the last section of this article aims to discuss the main arguments for and against the democratization of science, as well as the challenges that lay ahead in this road, and what a democratized science should in fact look like. Having established that the co-production of science and society is being once again valued and desired, it is important to consider why the establishment of the line that divides the public from its epistemic authorities is still relevant and should not be completely broken.

Overall, the aim of this article is to provide a comprehensive—and illustrated (by concrete examples)—view of these shifts that have happened in the history of science, starting from an era when cognitive labour was not divided, to an age of strict separation, then again to a moment of transgression, and finally, to the reconstruction and reframing of this relationship. By offering an organized and straightforward way of surveying these changes, this article presents a holistic overview of the main questions that have been historically addressed in the field of science democratization and co-production of science and society.

Historical considerations against the cooperation between scientists and laypersons

Before the 18th century, laypersons occupied certain roles in the process of scientific knowledge production that went beyond the making of policies and administration of funds. The public was seen as a valuable source of information as well as the most reasonable witness to scientific experiments, that is, citizens were epistemological contributors, who were considered honest observers and trustworthy collectors of empirical data (Fehér, 1990). For that reason, laypersons could also evaluate alternative approaches in an unbiased manner, in a way that their testimony "was considered cognitively more worthy because it was more neutral" (Fehér, 1990, p. 231) than those of the people inside the philosophical system.

In the 18th century, however, there was a shift, and a new understanding of science emerged. From this emerging perspective, the application of the 'scientific method' became central. In search for the production of 'true' knowledge, "the seat of moral certainty shifted meanwhile from the reliability and trustworthiness of the citizens to the reliability and trustworthiness of the method of justification" (Fehér, 1990, p. 233). In order to achieve the intellectual universality associated

with truth and objectivity (after all, natural laws should be, most importantly, *universal*), science needed to attain "social control over the standardisation of what are varied situations" (Wynne, 1996, p. 71). In this sense, the centrality of the scientific method pushed away the participation of laypersons, who did not possess the means to carry out this methodology. As a result, cooperation between scientists and the public became undesirable.

As it happens in most historical accounts, the process of change is a gradual one, affecting different fields of study at different times. The main paradigmatic turn may have started in the 18th century, yet some authors witnessed the diminishing status of lay participation in the natural and life sciences up until the 20th century (Cain, 2011), depending on the specific subject of study. Accordingly, the examples given here are from different time periods and fields, to demonstrate how this shift in favour of the scientific method served as an argument against the participation of laypersons in scientific enterprises.

The case of the British photographic survey

The work by Edwards (2008) discusses late nineteenth-century photographic surveys which aimed to record images of British society for future generations. This scholarly enterprise involved amateur photographers and, as it developed, revealed the many tensions surrounding the cooperation between scientific and lay epistemic authority.

According to the author,

> These scientific aspirations of the survey movement were most clearly articulated through rhetoric of the "straightforward" and "systematic" as a basis for this photographic work. The desire for "system," as a set of interrelated principles, resources and objectives, constituted both a way of working and a way of knowing. The words "system," "systematic," "uniform," "structure," "consistency," and "regularity" are used repeatedly in discussions of photographic survey activities, and anxieties about the idea of the "systematic" and to what extent a practicable concept of "system" could be realized was the focus of extended debate. (Edwards, 2008, p. 187)

As follows, the notion of 'systematic' ensured control over something that is inherently subjective, fragmented, incoherent, and ambiguous (i.e., photography). At the same time, the concept of 'system' served to differentiate useful information from that, which was understood as unproductive from the scientific perspective

of the time (Edwards, 2008). United under a flag of institutional rigour, a single standard methodology was applied to the photographic survey: research material was gathered using lay knowledge according to a manual for observation which instructed how and what to observe. This material would then be interpreted by scientific experts, "transforming local knowledges into national inventory through centralized structures of scientific validation" (Edwards, 2008, p. 190).

Nevertheless, the photographic survey movement could not fully convince the learned British society and universities of its impartiality and scientific value. Despite all attempts to do otherwise, the survey failed to "establish its data within clear scientific principles" (Edwards, 2008, p. 203), in a way that photography was deemed to be only *applied* knowledge, not formative. Besides, the ambiguity of photography thwarted the very idea of a system. Ultimately, despite all efforts to structure the rendering of these photographs and the lay observations that produced them, the photographic survey movement was doomed to fail due to its inability to translate the particular realities it observed into a universal code.

The case of the American Museum of Natural History

Another example of how the cooperation between scientists and lay people gradually ceased is described in the work by Cain (2011) on the preparation of exhibitions in the American Museum of Natural History. Throughout the 1910s and early 1920s, laypersons continued to participate in fields such as meteorology and ornithology, both of which relied on observational data provided by citizens (Cain, 2011). According to the author, by the early 20th century, "scientific professionals and serious amateur naturalists were not yet clearly separated by standards, practices, or status" (Cain, 2011, p. 218).

This situation started to change in the course of the 1920s, when museums started to focus on visitor attendance and public enjoyment. The sudden appreciation of preparators over curators, that is, lay artists over scientists, threatened the position of scientists in the museum hierarchy, as well as scientific research itself, demeaning the focus on scientific education and the credibility of scientists. This meant that, by that time, artists and preparators were working in the field without the supervision of scientists and curators, whose role had been reduced to planning expeditions (Cain, 2011).

This surprising effect demonstrates a complete inversion of what was expected: instead of scientists pushing laypersons outside of the scientific environment, lay knowledge started to overshadow the scientific authority. As such,

> many exhibit-makers believed they should be recognized not as scientists, but as "scientific." This concept was appropriately and perhaps intentionally vague, allowing exhibit-makers to claim authority over those matters they wished to control without requiring them to comply with all the practices and standards associated with professional science. (Cain, 2011, p. 227)

These practices and standards that Cain refers to concern the previously mentioned values of objectivity, universality, and the scientific method. The scientific community argued that, if fifty preparators around the world were given the same data, they would reach fifty different conclusions (Cain, 2011), whereas in science, this should not be the case; the same data would have to lead to the same results regardless of processual circumstances. Hence, "arguing that exhibit-makers' observations and subsequent creations should not be considered valuable scientific currency," scientists and curators "fought to separate themselves from exhibit-makers" and to preserve their authority within and outside of the scientific community (Cain, 2011, p. 234). Differently from the case of the photographic survey, the matter of the preparation of museum exhibitions relates more to the concept of scientific authority than to systematicity *per se*. As Wynne (1995, p. 362) has put it, there is a "history of recurrent concern about public acceptance of 'scientific' authority." Even though the museum curators used the scientific method as argument, their motives were rooted in matters of validation and legitimacy.

After World War I, a general lack of public interest in the study of natural history led museums once again to introduce changes in their practice and objectives.

> Museum staff no longer treated observation or exhibit-making as proxies for scientific authority in public rhetoric or private conversation. The scientific staff of the American Museum still admired preparators for their keen eyes, gifted hands, and careful minds. But they agreed that exhibit-makers did not qualify as scientific. (Cain, 2011, p. 234)

Hence, the lay/expert demarcation line was drawn. On the one side, there were scientists who have the *stricto sensu* knowledge that is the outcome of a justificatory, methodological, and 'trustworthy' process. On the other, there were laypersons, who have only beliefs—not knowledge—and accept propositional contents on the basis of trust instead of logic (Fehér, 1990).

Accordingly, this section aimed to describe, through the means of two examples, the paradigmatic closure of modern Western science and the resulting

epistemological gap between scientists and society. It is understood here that this rupture was "not a sociologically motivated perversion, but a methodologically necessary development resulting from the institution of cognitive authority" (Fehér, 1990, p. 235), which was ultimately something both positive and necessary to society (for reasons that shall be discussed below).

Bridging the gap: rise of considerations in favour of cooperation

After the barrier was built between scientists and laypersons, the public (no longer a cognitive agent in the production of scientific knowledge) resigned itself to the role of a target or consumer of popular scientific indoctrination, providing only moral and/or financial support to research (Fehér, 1990). Late-modern thought claimed that society is composed of functionally distinguishable subsystems, meaning that science, as a system of its own, produces knowledge solely according to its internal rules, "relatively uninfluenced by other systems like the economy or politics" (Fochler, 2003, p. 14).

As we move into the 21st century, this separation and, consequently, autonomy of said subsystems has been weakening—that is, their functional differentiation is progressively becoming more flexible and vague (Fochler, 2003). In the case of science, this mainly means forgoing of the monopoly on truth (Beck, 1997, p. 112). Nevertheless, conflicts between experts and laypersons go further than a matter of authority over truth, having a strong hermeneutic dimension (Fochler, 2003; Wynne, 1996). In other words, there are often strong differences "between the situated lay understanding of a phenomenon and the scientific explanation" (Fochler, 2003, p. 34) that not only concern legitimacy but have now been understood, at least for the last three decades, as a matter of *interpretation*.

This hermeneutic conflict can be more clearly understood through the well-known case study presented by Wynne (1996), in which the author studied the reaction of Cumbrian sheep farmers to certain administrative restrictions that had been imposed on the movement and sale of sheep due to risk of radioactive contamination following the Chernobyl nuclear accident in 1986. According to the author,

> The farmers interacted over some years […] with scientists from a variety of agencies who were responsible for official views of the behaviour of the

> radioactivity, and of the likely duration of the restrictions. These interactions, between a relatively well defined lay public and a particular, but fairly typical, form of expert system, illuminate several more general points about the social basis of scientific knowledge and its public credibility, and about the nature of lay knowledge. (Wynne, 1996, p. 62)

Wynne argues that the experts were imposing abstract truth claims without considering the local context or heeding to the problems of the farmers. The author advertises for the fact that laypersons do have expertise (complex, situated, historically rooted, methodologically different, and experience-based expertise), and that ignoring such knowledge can only be detrimental to science that would benefit from its contribution (Wynne, 1996).

What is most interesting about this scenario, from the perspective of the present article, is that the work by Wynne (and others like him) reflects an effort by the scientific community to re-evaluate expert/layperson relationships on different terms than the ones on which they had so far been understood (at least ever since the eighteenth-century turn). It is possible to see how "there have been increasing numbers of empirical studies focused on public participation in the past decade, with an accompanying proliferation of potential techniques for evaluating the success of these various mechanisms" (Douglas, 2005, p. 157). In other words, ever since the late 1990s and 2000s, many works in literature can be seen relating to the investigation of this relationship (Wynne, 1995; 1996; Collins & Evans, 2002; Callon & Rabeharisoa, 2003; Felt, 2003; Fochler, 2003; Douglas, 2005; Solomon, 2009; Grasswick, 2010; Kitcher, 2011; Reiher, 2016, Schütz *et al.*, 2019; Elliott & Rosenberg, 2019, to name a few). Besides, as stated by Elam and Bertilsson (2003, p. 234), "calls and entreaties for major reforms in science and society relations," moving away from "authoritarian forms of government towards more open and inclusive patterns of governance are clearly starting to impact on policy discussions." As it was mentioned in the introduction to this article, the term 'co-production of science and society' as well as 'democratization of science' are becoming increasingly popular among scientists, as interpreted by the fact that "applied and problem-driven research is much more likely to be supported than projects without immediate or expected future applications" (Fochler, 2003, p. 111). By definition, 'democratization of science' refers to, according to Kurtulmuş (2021, p. 146), three main movements: "the increase of the public's influence over various aspects of science;" "the equalization of the opportunity for influence among members of the public," and "an increased ability of members of the public to form an accurate conception of what will

promote their interests and values." This reflects the focus that science is applying to the appreciation of lay knowledge, indicating that the relationship between scientists and laypersons is in the process of being reconstructed once again.

The case of Debra Austria

Fochler (2003) describes a case study regarding the Dystrophic Epidermolysis Bullosa Research Association (Debra), an association of patients affected by epidermolysis bullosa (EB) in Austria. The research investigates the degree of participation in scientific research of people affected by EB, who are organized in Debra, and asks whether this participation can be understood as democratization of science. For the author, this case can only *partially* be considered a case of democratization/participation, since:

> On the one hand, the affected people have a very direct influence on research in the sense that they demand it to be focussed on applied concerns and to have an expected benefit for people affected by EB. On the other hand, […] their ability to understand the dynamics of research and thus to really actively shape its direction are rather limited. Thus, the participation metaphor hold only in the "weak" sense of users voicing their needs, not in the "strong" sense of lay people engaging and actively altering scientific practice. (Fochler, 2003, p. 118)

Some of the biggest problems that Fochler noticed in this study have to do with the fact that despite scientists' efforts to present their findings in understandable manner, laypersons still could not grasp "the science behind the research projects, or even the projects themselves," feeling "overwhelmed by the complexity of different theories, methods, and the 'jungle' of research politics" (Fochler, 2003, p. 116).

From the description of this case study, one can understand that the efforts of the scientific community to include laypersons in scientific activity were successful as far as it comes to the contextualization of science, "in the sense that the concerns and wishes of the respective lay group are listened to and also heeded in the research process" (Fochler, 2003, p. 119), which was one of Wynne's biggest concerns. Nevertheless, the focus on the scientific method appeared to have been in the way, hindering further participation of laypersons in knowledge production. For that, Fochler proposed that "the model of a pure science, which follows its own autonomous logic and course, has to be abandoned to do research in cooperation with a patients' association" (Fochler, 2003, p. 118). In this light,

a new model of scientific practice needs to be created in order for there to be a real democratization of science.

The case of Fukushima nuclear monitoring stations

This next example concerns the work of Reiher (2016), who analysed citizen radioactivity monitoring stations (CRMS) in Fukushima after the nuclear catastrophe in March 2011. According to the author, due to mistrust in the ability of the government to regulate food safety as well as lack of official information, "many citizens started to acquire scientific and technical knowledge to learn about radionuclides and their possible effects on human health," which "led many citizens to collect data to help them judge what was safe to eat" (Reiher, 2016, p. 57).

Stating that the concepts of laypersons and experts are not static but rather processual, Reiher (2016, p. 58) aimed to "show how lay people can become experts by engaging in the monitoring of radionuclides in food." Along the same lines as Fochler (2003) and Wynne (1996), Reiher (2016, p. 58) argues that "it is not the status of the actors involved, but rather the context in which science takes place that creates the differences between lay and expert knowledge." This idea indicates that we no longer understand lay and expert knowledge as being distinct or incompatible due some sort of essence they might possess, but that they are merely contextually different. Thus, there is a foreseeable dissolution of the barrier between science and society as distinct entities in conflict, and the possibility of the formation of hybrid groups or coalitions between expert and lay domains, leading to the creation of an alternative body of knowledge. On this subject, Reiher writes:

> CRMS have produced a large body of open-access data on the radioactive contamination of food in post-Fukushima Japan that can be accessed via the internet by everyone. […] This was initiated by lay people, and thereby empowers nonprofessional scientists, offers professional scientists alternative contexts for the production of knowledge […]. By incorporating professional scientists into CRMS activities, the distinction between lay and expert knowledge also becomes blurred. (Reiher, 2016, p. 69)

Yet, despite its successes, the knowledge produced by the CRMS was not included in political decision-making processes, revealing that policy makers as well as the majority of the professional scientific community still depend heavily on the notion of scientific authority. According to Reiher, different kinds of

knowledge are still placed on a rigid hierarchy and their ranking depends not on quality but on the affiliation of the people who produce said knowledge. Once again, we notice how the notion of authority is still tied to the idea of legitimacy and truth, hindering the development of a deeper relation between scientists and laypersons.

Even though "knowledge production itself has already changed—because the CRMS' knowledge is out there, and accessible to everyone" (Reiher, 2017, p. 71), it is still not possible here to speak of total democratization of science, not if the knowledge produced in cooperation is not included in decision-making processes and is not considered equally valuable in the eyes of policy makers and the scientific community.

The case of the French Association of Muscular Dystrophy

One last example of efforts made towards cooperation can be found in the work by Callon and Rabeharisoa (2003), regarding a case study of the French Association of Muscular Dystrophy. The authors suggest that it behoves the scientific community to consider certain people, whom they call 'concerned groups,' as potentially genuine researchers who can competently collaborate with scientists in professional work. This new form of research generated from such cooperation would be called research "in the wild" (Callon & Rabeharisoa, 2003).

The authors also argue in favour of the recognition of lay knowledge, without neglecting the importance of scientific expertise, appealing for mutual enrichment and not competition or substitution of one over the other, since, for them, the two forms (expert and lay knowledge) are not mutually exclusive or even intrinsically different.

> It would, for example, be wrong to say that the former are explicit and codified while the latter are tacit, or that the former are formalized while the latter are informal. Everything depends on the equipment used on both sides and, more broadly, the conditions in which the expertise is produced. This explains why some collaborative research is possible. (Callon & Rabeharisoa, 2003, p. 196)

Here, one can understand that, for the authors, the scientific method should not be an impediment to this collaboration since lay knowledge can also be formalized. Moreover, the main findings of this study show how research "in

the wild" can strongly contribute to science in the sense that it allows for the formulation of problems that might be inaccessible to confined scientists. Not only that, it helps the scientific community to understand how collaboration is not only possible but should be desirable (Callon & Rabeharisoa, 2003), as will be further discussed in the next section.

Taken together, these three examples lead us to an awareness that the dichotomous thinking of lay expertise *versus* scientific expertise is no longer pertinent. As Wynne (1996) and others who followed him have sought to show, there is no absolute boundary, but rather a "much greater interdependence than is conventionally recognised between what come to be defined as lay and expert knowledges" (Callon & Rabeharisoa, 2003, p. 74). That does not mean, however, that this boundary has already been completely overcome, or that it should be, for there are still many challenges and reservations regarding the complete dissolution of such distinctions between expert and lay knowledge.

It is still possible to state that the relationship between scientists and laypersons has been shifting, once again, away from this idea of an isolated, detached, and autonomous science towards a notion of collaboration and public involvement (Latour, 1998). This emerging new contextualized process of knowledge production will need new quality criteria for analysing and will potentially lead to a "socially robust" knowledge (Nowotny, Scott & Gibbons, 2001) that is more acceptable and inclusive for a wider portion of society.

The first section of this article demonstrated how the concepts of scientific method, universality, and authority served to erect a barrier between laypersons and scientists, rejecting the former from what was understood as the domain of the latter. Regarding the scientific method, two views can be highlighted in the case studies mentioned: (1) Due to the inability of the general public to fully comprehend it, this notion is still preventing science from becoming completely democratized. This way, for democratization to happen, a new model of science must be developed, one that considers lay participation in its very structure (Fochler, 2003). (2) Since lay knowledge can also be formalized, and there are no intrinsic differences between this type of knowledge and the expert one (Latour, 1998), there are apparently no reasons why collaboration on deep levels should not work (Callon & Rabeharisoa, 2003; Wynne, 1996).

When it comes to the concept of authority, it seems there is still a tendency to value one type of knowledge over another for reasons that are not based on the quality of said knowledge (or even on the method by which it was developed),

but on the positions and affiliations of the people who produce it (Reiher, 2017). Thus, it can be argued that the matter of authority, as something related to legitimacy and, thus, to the acceptability of lay knowledge by people in power, is still preventing a complete democratization of science.

Finally, as far as universality is concerned, although these examples do not explicitly address this issue, it is still possible to see how this concept is also in a process of transformation. First, as has been mentioned, applied or localized science attracts funding more easily. Besides that, for Wynne (1996), the fact that lay knowledge is localized does not make it less valuable or desirable for society, it makes it even more so. Lastly, the democratization of science can also contribute to making research more objective and universal. It can be argued that, "if science is going to successfully fulfill the function of objective knowledge production, it must rationally ground trust" (Grasswick, 2010, p. 389), and that "democratization can help build well-placed trust" in sciencists and their work (Kurtulmuş, 2021, p. 148). By rationally grounding the trust of lay persons (through democratization and cooperation), science succeeds "in the function of objectivity understood as pushing in the direction of universal *acceptability.*"

Discussion on the current challenges, reservations, and arguments for democratization of science

The above examples show that there are still challenges to be faced in the process of inclusion of laypersons in scientific knowledge production. Moreover, there is also the question whether co-production and democratization of science are even desirable in the first place. Accordingly, this section aims to summarize the main arguments against and in favour of science inclusivity today, while also presenting a discussion on further problems that have not been considered until now, as well as potential ways in which these challenges can be overcome in the future.

In a general manner, Kurtulmuş (2021) proposes two main reasons as to why we should support the process of public inclusion in science: (1) the argument of impact and instrumental benefits, and (2) the argument of collective self-government. The first refers to "the principle that all affected by a decision should have a say in it" (Kurtulmuş, 2021, p. 147). Since science deals with subjects that often have an enormous impact on human lives, people should be able to protect

their interests, thus participating in the governance of science is one way to better achieve this. As such, knowledge dispersed across society could be better applied to scientific research, contributing to the development of new and alternative paradigms once the public is included in the discussions, while also helping to identify their needs and shape research to better serve them (Kurtulmuş, 2021, pp. 147–148). As an example, the idea of research "in the wild" by Callon and Rabeharisoa (2003) entails the inclusion of citizens in research, based on the notion that it contributes to the formulation of problems that an isolated science would not otherwise be able to access. The case of Debra (see above) described by Fochler (2003) can also be interpreted as a successful case of inclusivity in this particular sense, where laypersons had a direct influence on shaping research towards their concerns and needs.

For the last decades, studies have been concerned "with the ways in which the research agenda is set and those in which research is directed towards human needs," with a special focus on the "conception of the sciences as providing certain practical goods for human beings" (Kitcher, 2011, p. 106). In this sense, including the public in research "can serve to legitimize research trajectories" and "provide access to more diverse, directly applicable knowledge" (Schütz *et al.*, 2019, p. 131). This view, however, raised an objection regarding how an overly pragmatic vision of science would hinder research that does not necessarily offer practical or direct responses to human needs. Kitcher (2011, p. 108) responds to this objection by arguing that if ideal deliberators understand and appreciate the needs of others, they will be able to recognize the achievements of science and successfully defend the demands for pure knowledge.

This, in turn, relates to the second argument proposed by Kurtulmuş, regarding research agenda-setting power to influence and determine "what becomes an issue to be addressed politically and which options the public can choose from" (Kurtulmuş, 2021, p. 150). There is an influence that experts and citizens have over each over. As has been stated previously, the functional differentiation and autonomy of the subsystems of our society is becoming progressively blurred, as subsystems are seen to influence one another. Therefore, since science shapes policy as well as policy shapes science, both research and political decision-making should be subject to democratic control (Kurtulmuş, 2021, p. 150). In a similar manner, Douglas (2005, p. 157) argues that "if deliberation is truly needed to inform analysis, and analysis to inform deliberation, experts and citizens need to be working in close contact to address our most difficult science-based policy questions." Thus, when the involvement of the public takes place prior to policy

decision-making, in the earlier stages of a scientific endeavour, citizens can inform the scope of research—as it happened in the cases described by Fochler (2003) as well as Callon and Rabeharisoa (2003)—even improving data quality by providing local knowledge (Douglas, 2005, p. 169)—as was the case with the Fukushima nuclear monitoring stations, described by Reiher (2016).

On the other hand, a principled criticism that can be made against the democratization of the governance of science in terms of how the public participation in science is open to abuse by other actors (Kurtulmuş, 2021, p. 151). That alone, however, is not a reason to reject democratization altogether, seeing how it is already a matter of manipulation by "the independent political role of members of the scientific community, by the research interests of prominent scientists, and by the growing influence of private entrepreneurs" (Kitcher, 2011, pp. 106–107)—in a way that, realistically, an "invisible hand" manipulating scientific production can always be found, even if we have not yet achieved a model of democratization. Regarding the political roles and interests of scientists, it is possible to state that "it is not inherently problematic for those engaged in citizen science to bring a perspective of advocacy to their work," but rather "what is more important is that the values they bring are made sufficiently transparent" (Elliott & Rosenberg, 2019, p. 5). Furthermore, although political influences from private entrepreneurs or government over science already exist, despite the matter of inclusivity that does not mean that those influences configure *legitimate* inputs (Collins & Evans, 2002, p. 245). Faced with this problem, the challenge "is to devise economic incentives that draw private funding into scientific research, without allowing those funds to be directed indifferently with respect to—or even contrary to—the public interest" (Kitcher, 2011, pp. 109–110).

Yet another problem related to these matters is indicated by Solomon (2009, p. 41), who finds that arguments for the democratization of science "based on the premise that entitlement should belong to all citizens with a stake in the social organization of society" inadvertently "blur the distinction between experts and stakeholders," leading to the philosophically incoherent understanding that democratizing science is the same as democratizing expertise. According to the author, "it is possible, and desirable, to 1) democratize (understood as including all stakeholders) many aspects of current science practice and 2) maintain an epistemically coherent (i.e., nondemocratic) notion of expertise in science" (Solomon, 2009, p. 42). As such, it would be understandable that "calls for democratization of science can demand *partial* democratization" (Kurtulmuş,

2021, p. 146, *my italics*).

Therefore, the concept of democratization of expertise, which would involve the "redistribution of epistemic authority between scientists and lay people to make it more equal" (Kurtulmuş, 2021, p. 147) is understood as undesirable,[2] and not what democratization of science should strive for. Rather, "the challenge of scientific citizenship is, therefore, one of political decision-making" (Elam & Bertilsson, 2003, p. 240), that is, "decision-making at those points where science and technology intersect with the political domain because the issues are of visible relevance to the public" (Collins & Evans, 2002, p. 236). Thus, the democratization of science that should be sought is that of the decisions about the "production, dissemination, and application of science" (Kurtulmuş, 2021, p. 147), that is, deliberative democracy.

In comprehensive terms, a deliberative democracy of science should be, in one way or another, egalitarian, inclusive, reciprocal, publicly disclosed, and accountable to the public (Solomon, 2009, p. 45). The main problem is that "the relationship between experts and laypersons is inherently neither egalitarian nor inclusive, but rather hierarchical and exclusive," as well as "incapable of reciprocity," since "expert decisions are based on reasons that nonexperts are not in a position to directly evaluate," which inevitably means that experts "are not directly accountable to criticisms of the public within their expert domains" (Solomon, 2009, pp. 49–50). The term 'lay' by itself is mostly associated with "communities who, relative to a particular area of knowledge production, lack the expertise to assess the relevant knowledge claims" (Grasswick, 2010, p. 389). This way, a crucial issue for democratization concerns the competence of citizens to shape decisions about science based on uninformed views (Kurtulmuş, 2021, p. 150).

Concern about the quality of scientific works that involve laypersons—which has sprouted with the eighteenth-century shift, exemplified by the cases of the photographic surveys and the museum—due to the potential lack of knowledge on the part of non-scientists, is something that is considered by both the scientific community and the general public. A study by Schütz *et al.* (2019, p. 136) found that the lay participants who joined the analysed experiments "voiced concern

[2] The concerns expressed by Latour (2004) in his article 'Why has critique run out of steam?' point to how the complete desconstruction of epistemic authorities can be harmful to society, as seen by the increase of the spread of mis- and disinsformation—or what Latour calls 'instant revisionism': "the smoke of the event has not yet finished settling before dozens of conspiracy theories begin revising the official account" (Latour, 2004, p. 228).

that the public may simply lack the necessary information to fully understand the subject under study, particularly with regard to basic research, and would have to rely on their gut instincts in most cases." Thus, concerns about competence do not only emanate from those with epistemic authority, but are recognized by laypersons and experts alike.

This leads us to conclude that the transcending of the barrier between science and public does not need to (and should not) "completely break down the division of cognitive labour on which our society relies" (Landrum & Olshansky, 2019, p. 206), but rather should accept the "well-established intuition in both science and society that some people are in a better position than others to know about certain aspects of our world" (Solomon, 2009, p. 50). This is not to say that these people are always necessarily affiliated with academic or scientific institutions—it is possible, after all, to recognize expertise even from a layperson's position (Solomon, 2009, p. 53; Collins & Evans, 2002, p. 261), as, for example, in the case of the Cumbrian sheep farmers, reported by Wynne (1996). In that situation, the scientists were not the only experts; the farmers could also be regarded as a "group in possession of a body of knowledge as esoteric as that of any group of qualified scientists" (Collins & Evans, 2002, p. 261). Therefore, those who are often referred to "as 'lay experts' are just plain 'experts'—albeit their expertise has not been recognized by certification," in a way that, in the study by Wynne, there is "the working out of the interactions, not of experts and the public, but of two groups of experts" (Collins & Evans, 2002, p. 261). In this sense, the input of non-certified experts from the public into matters of science can be justified without raising questions in terms of competence.

Nonetheless, it is still possible to question the limits of expertise, that is—even if we accept that scientific and technical expertise go beyond what is "encompassed in the work of formally accredited scientists"—we are still left with the problem of finding "clear rationale for the expansion of expertise" (Collins & Evans, 2002, p. 237). How do we define who is an expert in a given field and who is not? I believe that we have yet to arrive at a formalized method of assessing this matter that does not comprise academic certification and would be more inclusive of the public.

Regardless, it is important to note that the idea of 'lay' or 'local expertise' should not replace scientific expertise, but work in conjunction with it. Democratization of science should encompass the expertise of both the general public and scientific communities so that they can "become integrated into scientific questions, methods, and results," taking "the domain of scientific inquiry beyond the

bounds of scientific training and into the bounds of specialized experiences of specific non-scientific populations" (Solomon, 2009, p. 54).

Furthermore, there is also the problem of "distinguishing stakeholding from expertise," that is, "stakes are economically and politically transitive while expertise is not" (Solomon, 2009, p. 55). The involvement of non-certified experts in decision-making processes is different from the involvement of people who may be affected by a scientific endeavour. For one, the ways in which these two kinds of actors enter this debate is fundamentally distinct, since contributions to decision-making "are made by right by stakeholders in the political phase" (laypersons), and "by merit in the technical phase" (experts and scientists)" (Collins & Evans, 2002, pp. 261–262). Still, discussing Wynne's case of the Cumbrian sheep farmers, one can understand that, as non-expert stakeholders,

> if the London financiers were put in the exact same geographical location, given the sheep, and given the experience of the radiation fallout, without the years of experience and training that the sheep farmers had on the Cumbrian fells, they would not have known how to interpret and understand the phenomena. (Solomon, 2009, p. 58)

Therefore, decisions about science "are not justified by being subject to egalitarian votes among all stakeholders," but will depend on their expert capacity, whether they are "credentialed scientists or not" (Solomon, 2009, p. 58). As stakeholders, the London financiers should not have the same input as the farmers, who are understood as non-scientist experts. However, these matters can get more complicated, for instance, if one considers the case of Debra. Patients suffering from epidermolysis bullosa were included in the research of the disease, however it can be argued that these patients were only stakeholders? Does the fact that they have EB not mean that they possess knowledge of this disease that is inaccessible to scientists? Then again, does having a disease automatically make you an expert on it? These questions once again lead us back to the problem of how to define expertise.

It is also interesting to consider that "competence is not a given, but can change" (Kurtulmuş, 2021, p. 151). An example of this is the case of the Fukushima nuclear monitoring stations, described by Reiher (2016), where citizens acquired scientific and technical knowledge by *learning* about radionuclides and their effects on health. Hence, a way to ensure that the people being included in the scientific decision-making process are adequate is to couple the "efforts to increase public participation in science […] with efforts to increase citizen competence"

(Kurtulmuş, 2021, p. 151), in order to "boost political and scientific legitimacy among the citizenry" (Schütz *et al.*, 2019, p. 131). A deliberate democratic 'open science' thus entails "a broader communication of scientific findings," granting citizens with "unlimited access to research and documentation" so that solutions may be developed collaboratively among scientists and public (Schütz *et al.*, 2019, p. 131).

Kitcher (2011) also highlights the importance of education in the process of including laypersons in science. The author points to how, due to serious deficiencies in science education, the current ways of teaching people about science are "profoundly antithetical to democracy" (Kitcher, 2011, p. 109). According to Kitcher, science education should not be concerned primarily with memorization and problem-solving, but rather with developing a form of scientific literacy that would enable people "to appreciate what is currently known […] and above all to form reasoned opinions about issues that will affect them as citizens" (Kitcher, 2011, p. 109).

Furthermore, when it comes to science communication and popularization, "it is not just any and all knowledge we expect scientific communities to share with us as lay persons then, but rather *significant* knowledge" (Grasswick, 2010, p. 401). The scientific community is also entrusted with the epistemic task of sharing "their judgments as to the significance of particular studies based on their understanding of the body of literature currently available," thus acting as a "sound *filtration system* for the circulation of knowledge" (Grasswick, 2010, p. 401).

Nevertheless, it is necessary to be cautious with regard to the potential oversimplification of science communication. Research has shown that information simplification in popularized articles often leads to a so-called "easiness effect," which "may tempt lay recipients to overconfidently rely on their own judgment, despite lacking the deep-level knowledge to make adequate evaluations" (Scharrer *et al.*, 2017, p. 1014). Simplified representations of science may thus have the side effect (which has already been deemed undesirable) of blurring the epistemic differences between laypersons and experts. Therefore, as important as it is, making scientific knowledge more accessible and informing laypeople about scientific topics that are relevant to their lives must "not be achieved at the price of having laypeople overlook the limitations of their own epistemic capabilities" (Scharrer *et al.*, 2017, p. 1014). Once again, the task falls to science education, which can facilitate an "awareness of the fact that making reliable judgments often requires deference to scientific experts," especially because science is the opposite of simple (Scharrer *et al.*, 2017, p. 1015).

Besides, in science popularization, it is important to see all scientific knowledge as being "part of a communicative process, involving appropriation, resistance and cultural contestation" (Topham, 2009, pp. 19–20), which is to say that laypeople are not merely passive consumers of what is characterized as 'popular science,' but rather interpret messages in their own way and shape their particular opinions in ways that can even be opposing to those of epistemic authorities. For this problem to be addressed, the notion of "'popular science' needs to be considered as part of science" (Topham, 2009, p. 20), and science needs to be understood as a process of communication between scientists, lay experts, science communicators, politicians, as well as lay citizens.

Hence, a closer identity between science communication and processes of deliberative democracy is needed if we are to achieve a more ideal relationship between science and society. As stated by Elam and Bertilsson (2003, p. 241), "within deliberative models of democracy, deliberation is itself seen as a process for becoming informed and for receiving continuous education and training." For deliberative democratization of science to be possible, laypersons must "simultaneously gain new rights of scientific citizenship, while receiving the political [and scientific] education allowing them to exercise these rights" (Elam & Bertilsson, 2003, p. 241). According to the authors, 'scientific citizens' have new duties and responsibilities that come with these new rights and freedoms, being thus more capable of taking part in making decisions about science. Therefore, to satisfactorily bridge the divide between science and society, two parallel processes need to be carried out: "a growing socialization of science, and an advancing 'laboratorization' of society" (Elam & Bertilsson, 2003, p. 246).

Even in this light, there still remains the problem of "how to weight the opinions of the myriad potential contributors" to a scientific enterprise (Collins & Evans, 2002, p. 249). In any given research project, it would be simply unfeasible to attempt to include everyone who has the right and competence to be included, therefore the question arises: "which subpopulation is considered to properly represent the stakeholders in a project?" (Solomon, 2009, p. 48).

In the three given examples (Debra, the Fukushima monitoring stations, and the Association of Muscular Dystrophy), non-certified experts and laypeople were included in research, yet it has remained unclear how exactly it was decided "who has [the] status to contribute and who is marginal" (Solomon, 2009, p. 47) in these studies. This problem relates to the fact that, as mentioned, we do not have a way of clearly defining what expertise entails, but it also goes further, since we likewise need a way to assess which social groups of laypersons—often non-

experts, also called 'concerned groups' in the work by Callon and Rabeharisoa (2003)—are or are not to be included in decision-making processes.

Kurtulmuş (2021, p. 151) argues that, at times, "the competence required of citizens will only be the ability to identify those who will successfully act on their behalf," which might be in line with the idea that a citizen with proper scientific literacy also understands when it is time to defer to experts (Scharrer *et al.*, 2017, p. 1015). In this sense, a way to answer the previous question, as proposed by Solomon (2009, p. 58), would be to first

> determine, in each stage of exploring a particular research project, whether the questions are those that require specialist training and evaluation of local phenomena—whether atoms, cells, or cultural dynamics—or whether the questions are issues of broad social priorities, social values, and social distribution of scarce resources. (Solomon, 2009, p. 58)

In such a manner, what is needed from experts outside of the scientific community is what will determine "which communities, with which experiences and training, should be recognized" as necessary to be included (Solomon, 2009, p. 55). In other words, two judgements should be made in sequence when determining who are the legitimate contributors to making decisions about science: a judgement "about what fields of experience are relevant" and a "choice of who is an expert within a field" (Collins & Evans, 2002, p. 252). Although the latter question has yet to be formally answered, for now it suffices to say that knowing what research requires should be enough to assess what set of skills and knowledge are necessary for one to be deemed an expert.

What is important in this context is the definition of clear standards that are still missing for the description (and prescription) of this process. Questions such as: "how do participants get involved?", "how is their role delineated?", and "who gets to set the agenda?" (Douglas, 2005, p. 167) still elicit responses that are far too vague. The challenge thus concerns "the proper formulation of goals and application of appropriate methods to participatory processes" (Schütz *et al.*, 2019, p. 140). Collaboration and participation require a clear understanding of objectives and functional roles on the part of all parties involved. As Douglas (2005, p. 158) has put it, "there seem to be three distinct ways in which citizen input to technical assessments and analyses can be valuable," namely: "1) Citizens can help to better frame the problem to be addressed" (as in the case of Debra and the French Association of Muscular Dystrophy); "2) Citizens can help provide key knowledge of local conditions and practices relevant to the analyses"

(as in the case of the Cambrian sheep farmers and the Fukushima monitoring station); and "3) Citizens can provide insights into the values that should shape the analyses."

In essence, it can be argued that during the eighteenth-century shift, when the barrier between scientists and the public was built, all expertise was confined within the limits of the scientific community. To bridge this gap and democratize science, the most important thing today is to avoid confusing expertise with political rights. The distinction between experts and non-experts should not be destroyed, but rather reconstructed and reframed, by setting the dividing line "in a different place within the population" (Collins & Evans, 2002, p. 250). Therefore, what is being proposed is dissolving the barrier between science and society, but preserving the division between experts (scientific and non-certified) and non-experts (stakeholders). A democratic science can better address its issues while affirming rather than denying the "distinction between expert contributions and stakeholder contributions to the scientific enterprise" (Solomon, 2009, p. 59), incorporating both in it, but assigning roles to each party, and understanding what their respective duties, responsibilities, rights, and freedoms are.

Conclusion

This article argues that the relationship between laypersons and scientists has been undergoing a profound change in the last couple of decades. After a long period in which the involvement of laypersons in science was unwelcome, a new view has emerged, one that recognizes the desirability of such a relationship. Thus, the historical considerations that once led to the divide between science and society are in the process of being overcome. As a result, numerous collaborations between scientists and laypersons can be observed.

The first section of this article mentioned how the collaborative relations between experts and laypersons functioned prior to the eighteenth-century shift, which led scientists to disregard lay participants in the process of knowledge production. It is important to note that such substantial shifts in society take time, and so, although these movements did start at the 18th century, they were far from over for at least the following two centuries, when we can still observe processes of change. The main arguments against the collaboration of the public

in scientific production were based on the concepts of truth, objectivity, and universality, achieving of which depended on systematicity and the scientific method. This reliance on the scientific method, as well as matters of authority and legitimacy, were the main reasons for raising a barrier separating scientists from the general public.

This article argued that this divide is gradually being replaced with a new way of doing science, which is captured by the term 'co-production of science and society,' a trend in the life sciences in the last decades. I illustrated this change with some examples of studies that aim to overcome the old barrier between scientists and laypersons, where the key words are consultation, participation, and public debate. The works quoted here represent enormous consideration given to lay knowledge and point to how it is already possible to carry out research involving laypersons and how this is to be desired. The main arguments that can be understood from these examples relate to how co-produced knowledge is more localized and contextualized and, thus, more acceptable for the society, not to mention more relevant to society's needs. These works point to the value of lay knowledge as something that can contribute to science, and to which isolated experts have no access.

The studies mentioned here show that, for there to be true democratization of science, some challenges still need to be overcome—namely, the inclusion of co-produced knowledge in political decision-making processes. Moreover, the scientific community as a whole has not yet fully accepted knowledge produced in cooperation with laypersons.

A crucial issue that has been raised here has to do with the concern that citizens may lack the competence to give input to science. In this context, the transcending of the barrier between the scientific community and the public should not lead to a complete destruction of the division of cognitive labour (which is healthy for our society), but rather, it should mean that the distinction between experts and laypersons does not depend upon the opposition science/society. In other words, from the understanding that expertise may also be found in society, the idea of 'non-scientific' or 'local' expertise should not replace scientific expertise, but work in conjunction with it, while at the same time, the divide between experts and non-experts should be maintained. On a fundamental level, the inclusion of non-scientific experts into decision-making processes about science is different from the inclusion of lay stakeholders. Hence, different participatory roles (as well as rights and duties) are expected from different subjects (stakeholders, experts, or scientists).

The problem of how to define expertise has also been pointed out as a relevant issue. A possible answer lies in the aims of the research, which will dictate what kinds of knowledge and skillsets are necessary for a subject to be considered competent enough to be included in a scientific endeavour. In this sense, science education, communication, and popularization are central to the issue of democratization, seeing how citizens need to have scientific literacy to be able to provide input that are not uninformed. What is thus most important—and still a challenge that needs addressing—is the definition of clear standards for the description (and subsequent prescription) of the process of participation. A clear methodology is needed to assess precisely which subjects are necessary, competent, and have the right to be included in the process of scientific knowledge production.

This article argues that the historical considerations that led to the division of cognitive labour between science and society have undergone a process of transgression in the last couple of decades and are now, once again, being reconstructed and reframed into a different kind of relationship. In its aim to provide a comprehensive view of these shifts, through the use of concrete examples, this article traced the transformations that the concept of science democratization has been going through, starting from no division between science and the public to their full separation, then again to the deconstruction of the barriers, and finally, to the recreation of the relationship between laypersons and expertise in different terms.

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