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Post-Normal Science Communication? The Role of Science Centres and Museums in an Uncertain Future

Introduction

The world needs equitable and democratic dialogue. As a global society, we face numerous so-called "wicked problems" related to the unsustainable use of the Earth's resources. The notion of wicked problems, developed by Horst Rittel and Melvin Webber in 1973, describes problems that are ill-defined and rely on value judgments for resolution – and are never truly solved. Today, such problems include climate disruption, the biodiversity crisis, and most recently, the COVID-19 pandemic. The process of tackling these problems is exacerbated by the widespread atmosphere of science scepticism and denialism along with delay tactics and misinformation. From a science communication perspective, the situation can seem overwhelming. Often, it is difficult to see how constructive space can be created for the discussions that are necessary to address the challenges we face.

In this paper, I will consider the role science centres, science and technology museums, natural history museums, and other public science communication institutions (referred to collectively as science museums) can play in creating inclusive spaces to address these challenges. As I discuss in the paper, science museums have the resources, the expertise, and the social presence to counteract mis- and disinformation and to engage a diversity of stakeholders in co-creating responses to the problems we face.

I enter this narrative by first considering the current interface between science and society, and specifically the post-truth phenomena that pervade public discussions in information- and media-rich societies. I briefly discuss historical and societal factors that have intensified this state of affairs, and examine the situation from the specific perspective of science museums. I then turn to the class of global challenges related to sustainability that are considered to be wicked problems, that is, problems that are multifactorial, dynamic, and have no clear resolution (Caron & Serrell, 2009). I discuss how science is evolving to address these wicked problems, and how science museums are uniquely situated to contribute to this work. I conclude by discussing the implications of the ideas presented here for the future practices of science museums.

I want to acknowledge the participants in the Reinventing Science Communication conference (October 13–14, 2022) which took place in Ljubljana, Slovenia. While the ideas I present in this paper are based on the presentation I gave at the conference, the dialogue with my fellow conference participants was instrumental in contextualising, qualifying, and critiquing my claims. I indicate in the paper where I have drawn on conference participants' observations and reflections.

We live in a post-truth era

Historically, objectivity and rationality have been important parts of the self-image of science. The ancient Greeks considered practitioners of science to be disinterested observers of the natural world, and considered science to be the inevitable product of these logical and systematic observations. This perception persisted well into our time. One well-known example can be found in Robert Merton's book *The Sociology of Science*, published in 1942, in which he describes the four normative characteristics that comprise the ethos of (western) science: communism, universalism, disinterestedness, and organised scepticism (or CUDOS). From this perspective, science was considered to advance steadily through critical albeit routine puzzle-solving, while values, attitudes and uncertainties were thought to have little or no influence on the process (Funtowicz & Ravetz, 1993).

In 1962, the philosopher Thomas Kuhn published the book *The Structure of Scientific Revolutions* which introduced the idea of paradigm shifts in science. Kuhn's ideas contradicted the existing image of science. Rather than a smooth and continuous accumulation of scientific facts (or "normal science"), Kuhn described science as periodically undergoing fundamental shifts governed by contingency and debate. These paradigm shifts, Kuhn claimed, were based on competing and irreconcilable differences between views of reality. Accordingly, "objectivity" could not be used as the gauge of scientific truth. Instead, the consensus of the scientific community eventually defined what was taken to be true.

In the following decades, the public image of science underwent further change as many of its traditional assumptions continued to be questioned. In their book *Laboratory Life: The Social Construction of*

Scientific Facts (1979), sociologists Bruno Latour and Steven Woolgar challenged many of the most deeply held intellectual notions about how knowledge is generated by amplifying Kuhn's observation that science constructed facts through social processes in addition to the scientific method (Kofman, 2018; Westrum, 1982). The publication of Latour's subsequent book, *Science in Action: How to Follow Scientists and Engineers through Society* (1987), and his well-known illustration of the two faces of science (Figure 1) helped cement the idea that science is – at times – uncertain, contingent, and changeable, and that there is no meaningful distinction between the social and technical elements of science (de Vrieze, 2017). The public questioning of science culminated in the 1990s with the so-called science wars, a number of academic and public debates that took place mainly in the US. These debates typically occurred between defenders of the authority of science based on objectivity and rationality, and "social constructionists" who claimed that scientific fact was constructed under the influence of social and institutional conditions (Kofman, 2018).

Figure 1: Bruno Latour's illustration of the two faces of science: the mature face (left), gazing back through time represents the established "ready-made science", while the younger face (right) looking towards the future represents the uncertain and changeable "science in the making". Redrawn from Latour (1987)

On one hand, the public questioning of science's social, institutional, and methodological structures has had many positive consequences. The decolonisation movement, as well as the Black Lives Matter and #MeToo protests, have directed much-needed public attention to structural inequities and unsustainable ideologies that pervade industrialised nations and western science. On the other hand, the relativist mindset that resulted from this public reckoning may have helped pave the way for science scepticism and conspiracist ideation to flourish (Kofman, 2018). In fact, Latour himself lamented how his and others' criticism of science created a foundation for anti-scientific thinking and for science denialism in particular (de Vrieze, 2017). Certainly, the ongoing COVID-19 pandemic has demonstrated how mis- and disinformation have driven vaccine hesitancy, health science scepticism, and the uptake of fake cures with tragic consequences in countries across the world (Rocha et al., 2021).

Today, we face a range of challenges related to the ability of ordinary citizens to know what is accurate and reliable information. These challenges include attacks on critical thinking, anti-science policies, science denialism, anti-intellectualism, manipulation, misrepresentation, and organised lying, often by way of appeals to emotion through online media (Braun, 2019). These methods are collectively described in terms of *post-truth*: "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief" (Oxford Dictionaries, 2016). As I discuss in the following sections, these shifting conversations about science and knowledge have important implications for the contemporary role of science museums.

Science museums and post-truth

Since their origins in the Renaissance, science museums have been closely allied with the scientific endeavour, and have thus reflected contemporary scientific discourse and epistemology (Achiam, 2021; Marandino et al., 2015). This means that these institutions have not always questioned *what* or *why* something counted as science, but rather promoted the versions established in scientific communities. For instance, Evans et al. (2002) describe how specimens in late- nineteenth century museums were displayed in ways that reproduced their "inherent" nat-

ural history and taxonomy, while more or less ignoring the perspective of the visitor. In a similar way, Crain et al. (2013) discuss how the prevalent "hands-on" script of science centres reflects ideas of science as objectively discoverable through systematic experimentation, leaving out other viewpoints. In other words, science museums have historically been aligned with the ideas of CUDOS and normal science described above (cf. Braet, 1992).

At first glance, science museums' positivist framing of science seems to provide the foundation for their authority and legitimacy in the public sphere. For instance, in a British study, members of the public felt quite strongly that museums should tell the facts, but refrain from telling the public what to think (Britain Thinks, 2013), while in an international study, Australian and Canadian citizens considered museums' maintenance of an apolitical position to be all-important to securing their trust (Cameron, 2007). In the same way, museum visitors in two US studies indicated that their trust in the museum was predicated on the neutrality of its messaging (American Alliance of Museums, 2021; Jones et al., 2020). For science museums, then, engaging with contentious topics runs the risk of compromising their public image as neutral and value-free, and undermining their trustworthiness (Evans et al., 2020; Navas Iannini & Pedretti, 2022). This state of affairs seems to disqualify science museums from being actors in the present post-truth climate.

However, closer scrutiny reveals that science museums are not (nor have they ever been) neutral. Rather, Cameron (2007) argues that they have succeeded in portraying themselves as apolitical or aperspectual through their institutional practices and purposes. These practices, she writes, have "served as a useful tool to disguise institutional politicality, [and] frame institutional legitimacy and trust with audiences" (p. 340). But as we have discussed elsewhere, this position of feigned neutrality is no longer tenable (Evans et al., 2020). Just as there is an on-going public reckoning with the inequities of western science, many science museums are publicly confronting their own attempts at neutrality (Janes & Grattan, 2019; Janes & Sandell, 2019; Jones et al., 2020). And it is precisely this reckoning that allows museums to play an important role in confronting and counteracting post-truth discourses (Ocampo & Híjar-Chiapa, 2021).

Although much remains to be understood about post-truth phenomena (indeed, this was a point of discussion at the Reinventing Science Communication conference), it seems clear that they cannot simply be addressed by stating the facts or appealing to some universal "truth" (Lewandowsky et al., 2017). Rather, the issues that are subject to post-truth attacks can only partially be answered by science, and this only in broader social and cultural contexts that include a diversity of ways of knowing. This means that empowering citizens to assess post-truth claims means supporting them as they engage in a variety of shared sensemaking situations where science is just one kind of knowledge (Feinstein & Waddington, 2020). And, of course, these are exactly the kinds of situations science museums can create (Achiam et al., 2021) – that is, once they emancipate themselves from the idea of science as the objective truth about the world.

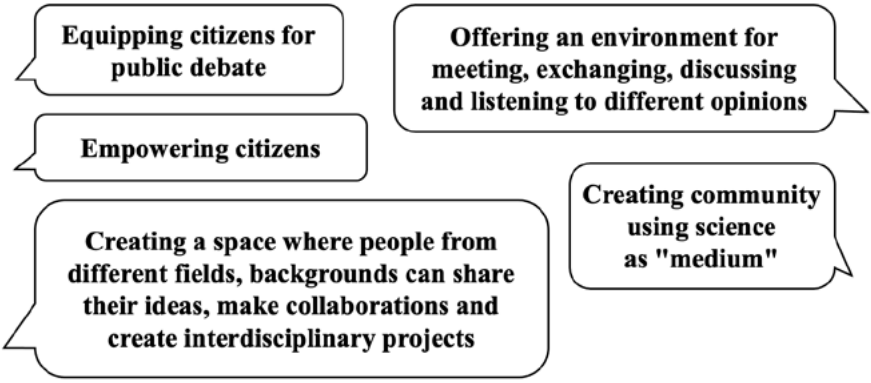

Figure 2: A sample of responses to the question "What is the most important role science museums can play in society?" posed at the Reinventing Science Communication conference in Ljubljana

Participants of the Reinventing Science Communication conference expressed support for this role of science museums (Figure 2) – and indeed progressive museums across the world are already beginning to play this role. Pedretti and Navas Iannini (2020) describe the emergence of a new type of "agential" exhibitions that encourage visitors

to critically engage with controversial socio-scientific issues and make informed decisions in ways that prompt changes in their own lives or communities. They offer several compelling examples of such exhibitions, including *Preventing Youth Pregnancy* at the Catavento Museum in São Paulo, Brazil, which promotes responsible decision-making about sexual practices, and *Heureka Goes Crazy* at the science centre in Heureka, Finland, which tackles misunderstandings and prejudices about mental health. Ocampo and Híjar-Chiapa (2021) offer other examples of exhibitions with similar approaches, and specifically discuss the exhibition *Towards an Investigative Aesthetics*, developed by the research agency Forensic Architecture, which raises critical questions about environmental destruction and other issues by engaging visitors in assessing and combining multiple sources of evidence. Finally, the project *Communities for Immunity* (Association of Science and Technology Centers, 2021) supports US museums in engaging vaccine sceptical and hesitant citizens in community discussions about COVID-19 vaccines.

Having briefly discussed the broader socio-cultural backdrop of the post-truth condition, and the challenges and opportunities it poses for science museums, I will now consider some of the more specific problems we face that are related to the unsustainable use of the Earth's resources. As we shall see, scientific practices are evolving in an effort to solve these problems, suggesting a new kind of interface between science and society. I argue that science museums have a unique and critical part to play in this interface.

We face a number of wicked problems

As mentioned above, the COVID-19 pandemic is just one of many complex socio-scientific problems with which we are confronted. We could add to the list anthropogenic climate disruption, the biodiversity crisis, global inequity, food shortages, pollution, and many others. These problems defy the established problem-solving strategies of science and engineering, which have generally focused on "tame" or "benign" problems that are well-defined and whose solutions are clearly recognisable. In contrast, the problems we face now are what Horst Rittel and Melvin Webber termed as "wicked", i.e. they are subject to real-world

constraints, meaning that they cannot be definitively described, but require extensive qualification; they cannot be meaningfully addressed in right (or wrong) ways; and they have no definitive and objective solutions (Rittel & Webber, 1973). In their 1973 seminal paper, the authors give examples of contemporary wicked problems that include, for instance, the location of a freeway, the adjustment of a tax rate, the modification of school curricula, or confronting crime. Although these problems are in the domain of social or policy planning, what is clear from these examples is that wicked problems do not remain within the boundaries of scientific disciplines or even within academia, but are deeply entangled with complex natural systems as well as societal structures and institutions. This means that science, with its mechanistic methodology of reducing the world to ever smaller elements that can be understood, controlled, and manipulated, is incapable of providing the solutions (Dürr et al., 2005; Funtowicz & Ravetz, 1993; Rittel & Webber, 1973). Instead, the situation calls for a post-normal science *for* sustainability (Spangenberg, 2011).

Post-normal science distinguishes itself in many ways from the normal science described by Kuhn. In contrast to the value-free, objective accumulation of scientific facts of normal science, post-normal science addresses issues where "facts are uncertain, values in dispute, stakes high, and decisions urgent" (Funtowicz & Ravetz, 1993, p. 744). Its structure, methods, and content are defined by the need to span a range of spatial scales, account for the temporality of the problems it addresses, deal with the complexity of these problems, and acknowledge a diversity of perspectives on what constitutes workable knowledge (Kates et al., 2001). This means that post-normal sustainability science responds to real-world (as opposed to academic) problems (Fang et al., 2018; Kauffman, 2009; Lang et al., 2012), is inter- and transdisciplinary (Brandt et al., 2013; Spangenberg, 2011), has an important temporal dimension (Martens, 2006; Seghezzo, 2009), and involves the participation of stakeholders such as policymakers, citizens, and other knowledge-users in a so-called extended peer community (Block et al., 2018; Craps, 2019; Ravetz, 2006).

Clearly, post-normal science requires a new kind of interface between science and society, not only in the communication of research results

but also in the research process itself (Spangenberg, 2011). This challenges the scientific community to shift from one-way "deficit" modes of communication to more relational and reciprocal models (Canfield et al., 2020). These participatory models should support participants' sensemaking about wicked sustainability problems, rather than the more familiar goals of generating enthusiasm for or interest in science (cf. Irwin, 2014). And this is where science museums have a unique and important part to play.

Science museums and wicked problems

Science museums are located in the borderland between science and society, and have gradually been turning toward more participatory and inclusive models of communication (Achiam & Sølberg, 2017). This makes them strong candidates for supporting the new kind of interface between science and society envisioned here. But the role of science museums goes beyond providing the settings and logistics for what we might call post-normal science communication (cf. Brüggemann et al., 2020). I have already briefly discussed how these institutions can offer environments and contexts to support shared sensemaking across different kinds of knowledge. I will now explore these different kinds of knowledge in order to make more radical claims about the communication of wicked sustainability problems and the potential role of science museums. The point of departure for this discussion is Blanche Verlie's assertion that:

> …positioning climate change as a phenomenon to be known primarily through science has led to approaches to public engagement that are highly disengaging, as well as ignoring the emotional pain of those who are already concerned (2022, p. 2).

I would argue that the same assertion could be made for a range of other wicked sustainability problems. Indeed, when humans make sense of the world, they are "multisensorial beings constituted by complex, interrelated cognitive, emotional, affective, corporal conditions" rather than simple information processing machines (Heinrichs, 2019, p. 5). Accordingly, engaging citizens and other stakeholders in experiencing and reflecting on wicked sustainability problems should utilize a range of aesthetic methodologies and imaginative practices that speak to sen-

sory, kinaesthetic, and imaginary ways of knowing (Heinrichs, 2019), rather than perpetuating the mechanistic idea that we humans are somehow separate from the wicked problems we face (Verlie, 2022).

Science museums are ideal places for these kinds of experiences. They have significant expertise in offering immersive experiences through their concentrated reality (Achiam & Sølberg, 2017), stimulating visitors to transcend time and place by imagining things "possibly being so" (Achiam, 2016). Using aesthetic methodologies in science museums is thus about embracing the entanglements and complexity with which wicked sustainability problems come. In this sense, exhibitions and installations become portals for intellectual, emotional, and physical experiences (Reymann, in Bonvik-Stone, 2023), rather than media for the straightforward transfer of information. One compelling example of this is the exhibition *KLIMA X* developed by the Museum of Science and Technology in Oslo. Visitors entering the exhibition were asked to wear rubber boots to wade through the 25 cm of water covering the floor (a scenario mimicking the effects of the polar ice caps melting). The exhibition also included a large ice block that was gradually melting, and simulated thunderstorms and rainfall, giving the visitors the impression of meteorological disturbances (Gorr, 2014). Another example, albeit not from a science museum, is the art installation *Pollution Pods* by Michael Pinsky. In this project, five geodesic domes emulate the atmospheric conditions in Beijing, São Paulo, London, New Delhi, and Norway's Tautra Island by recreating the air using safe chemicals. Visitors navigate the pods, moving through gradually worsening air conditions (Pinsky & Sommer, 2020).

Neither of these exhibitions illustrate sustainability problems in a 1:1 manner. Rather, they are what Ågren (1995) designates as *meta-realistic* exhibitions that "juxtapose objects from reality, in the form of fragments or quotes, in order to stimulate the imagination, suggest thoughts, or hint at ideas" (author's translation, p. 42). Note how these exhibitions collapse space and time in order to offer experiences that otherwise would be invisible and intangible due to their remoteness and incremental development (Pinsky & Sommer, 2020). Exhibitions like these allow us to experience ways of knowing about wicked sustainability problems that are otherwise not available to us.

Another way in which science museums can utilise aesthetic or arts-based approaches in support of a new interface between science and society is by harnessing the ability of artists to imagine the worlds that we want to live in (Reymann in Bonvik-Stone, 2023). This is important, because if we cannot imagine what a sustainable future might look like, it is difficult or even impossible for us to discuss it, consider what it might mean for us, and take on the work of moving toward it (Moser, 2019). Here, science museums can use their expertise to create immersive fictions about sustainable futures that portray complex phenomena and ideas from the perspective of ordinary citizens, without scientific jargon and technicalities. The experience of being immersed in fictional futures can, in turn, move discussions away from the "current technocratic paradigm and towards a more inclusive, participatory process in which citizens can recognise their own experiences and perspectives" (Raven, 2017, p. 165).

A recent example of an exhibition with a future fiction component is *Klimatopia* at the science centre Experimentarium in Copenhagen. In *Klimatopia*, visitors meet three girls from three different futures, corresponding to different scenarios of global warming inspired by the IPCC's Sixth Assessment Report from 2021 (Experimentarium, 2022). Throughout the exhibition, visitors encounter the three-time travellers' personal perspectives on themes such as food, consumer goods, electricity and heating, and transportation. For instance, Aka (from a future with an average global temperature increase of 4.5°C) says: "In my future, we drive around in old clunkers, but it's difficult to find anywhere with petrol, and the roads are terrible. We travel by boat every now and then, when it's possible" (Figure 3).

Figure 3: Detail from the exhibition *Klimatopia* at the science centre Experimentarium. The three girls Aka (in red), Kiiro (in yellow), and Midori (in green) have travelled back in time from three different futures that reflect average global temperature increases of 4.5°C (Aka), 3-3.5°C (Kiiro), and 1.5-2°C (Midori) respectively in the year 2121. The girls are present throughout the exhibition, offering personal narratives of their experiences in relation to a number of everyday themes (transportation in the above image). Photo: M. Achiam

Another relevant example is the public experiment *Climate Garden 2085* in the Botanical Garden at the University of Zürich. Similar to the previous example, *Climate Garden 2085* was based on IPCC scenarios scaled to northeast Switzerland, and included two greenhouses with temperatures corresponding to increases of 2°C and 4°C respectively in the year 2085. By incorporating local plants that people in the region were familiar with and would eat, the project allowed visitors to experience the future climate scenarios in local and personal ways (Schläpfer-Miller, 2021).

These two examples hint at how experiences of the future may function as mirrors of un/desirable realities (Lowe et al., 2006). Their fictional quality allows us to step back from how things are, and mobilise our critical imagination to explore what is plausible, ethical, and desirable (Garforth, 2019). Both *Klimatopia* and *Climate Garden 2085* go be-

yond just utilising art (in this case, fiction) as a way of increasing public understanding of climate change. They combine art and science in ways that effect change in both the object (the socio-scientific problem of climate change) and the relation between the object and subjects (the visitors). The fictional climate scenarios are not presented as finished or inert information, but rather as uncertain science in the making, allowing visitors to develop their own understandings of climate change that emphasise its local and personal implications (cf. Born & Barry, 2010). In this sense, the visitors become co-producers of knowledge.

Discussion

In the previous sections, I have examined what I see as the important intersections between science, societal discourses, wicked problems, and science museums. I certainly haven't provided an exhaustive exposition of these intersections; my reflections are inevitably conditioned by the sociocultural and academic context in which I am located. Nevertheless, I hope that some of the ideas presented here will stimulate further discussions as indeed they did at the Reinventing Science Communication conference. In the following sections, I will follow up on some of the reflections that arose on that occasion.

Generally speaking, science museums are in a state of flux. From their historical and mainly self-referential functions of preservation, communication, and research, they are gradually shifting their focus to more externally-oriented purposes and abandoning their authoritative stance in favour of more cultural and dialogic approaches to engagement (Achiam & Sølberg, 2017; Black, 2012). On the one hand, some argue that this transition is necessary for museums to remain relevant (Evans et al., 2020; Janes & Sandell, 2019), while, on the other hand, the shift makes some uncomfortable and even seems to contradict what many consider to be the ethos of museums. One measure of this discomfort is the failure of the planned revision in 2019 of the International Council of Museum's (ICOM) official definition of museums. The revision aimed to refine the wording of the existing definition to focus more on social justice, environmental awareness, and political advocacy – focus points that align with what I have discussed in this text. However, the suggested new definition met strong resistance

from a variety of figures in the international museum community who criticised it for being overtly political and ignoring the economic and political realities of museums (Noce, 2019; Robinson, 2021). In conclusion, despite the examples I have shared here (and many others) of science museum programmes and exhibitions that transcend the historical museum functions of preservation, communication, and research, it seems the museum community as a whole is not ready to commit to a more radical and critical approach to public engagement. Fortunately, this does not prevent individual museums from devoting themselves to approaches that include critical thinking, sustainability, and equity (Robinson, 2021).

What does it take for science museums to transition to more critical and participatory models of public engagement? Fortunately, progressive practitioners, institutions, and researchers have already shown the way through public consultations and co-creation processes that foreground the socio-cultural meaning of objects, ideas and problems, and de-emphasise a strictly academic viewpoint (see, e.g. the special issue of *Journal of Science Communication* on responsible science communication edited by Achiam et al., 2022). Although opening up science museum practices to the input of non-experts may raise concerns about the loss of scientific authority, I suggest that the experience and lay knowledge of citizens and other stakeholders may be thought of as complements to the scientifically-generated numbers and texts of scientists rather than as replacements for them (cf. Brüggemann et al., 2020).

Finally, it seems reasonable to question whether the suggestions I have given in this paper actually amount to science museums providing citizens and other stakeholders with opportunities to engage in post-normal science. In other words, can science museums and their visitors be considered part of the "extended peer community" that engages with post-normal sustainability science? After all, science museums aren't themselves scientists (although they may be closely allied with them) – so what claims can they make toward the production of scientific knowledge? I suggest two answers to this question.

The first answer emerges from the perspective of scientists and scientific practice. From this perspective, it soon becomes clear that the way that post-normal science is *enacted* can be different from the way it is

prescribed. Research shows that sustainability scientists don't necessarily welcome dialogical, participatory engagement with extended peer communities, nor do they necessarily incorporate societal concerns in their decisions about what problems to pursue (Achiam, 2023; Brüggemann et al., 2020). This means that post-normal science's objective of public engagement in the research process (Funtowicz & Ravetz, 1993) remains more recommendation than reality. However, I would argue that this gap provides science museums with the opportunity to facilitate border-crossing between science and society, supporting scientists in the challenging task of engaging with their publics by using a variety of formats and modalities (exhibitions, debates, citizen science, etc.) in which science museums have experience and expertise (cf. Evans & Achiam, 2021). In other words, science museums can become the facilitators of the public engagement prescribed by post- normal sustainability science, if scientists themselves are unable to.

The second answer is perhaps more pragmatic. Its point of departure is the definition of post-normal science communication as "communication among relevant actors in the field of science communication who react to post-normal situations" (Brüggemann et al., 2020, p. 3). In other words, if we are relevant actors (for instance, citizens) and we react to post-normal situations (for instance, climate disruption), then we are engaging in post-normal science communication. In this sense, visitors to, for example, *Climate Garden 2085* or the *Pollution Pods*, could be considered members of an extended peer community. Certainly, visitors to both *Climate Garden 2085* and the *Pollution Pods* reacted with concern, sadness, anger, and a desire to take meaningful action in response to their experiences (cf. Pinsky & Sommer, 2020; Schläpfer-Miller, 2021). These findings underscore the point that addressing the wicked sustainability problems we face presents an important imperative to science museums to more carefully consider the multisensorial reality of human life and how it could merge with natural and constructed environments to co-construct atmospheres and resonances (Heinrichs, 2019).

Final remarks

My main argument in this text is that science centres, science and technology museums, natural history museums, and related science communication institutions have an important role to play in creating inclusive spaces to discuss and address wicked sustainability problems. This role requires science museums to transition from an ethos of implicit neutrality to one of explicit subjectivity, and from a practice of passively sharing knowledge to one of actively promoting agency. While many science museums have already made significant advances in this direction, others prefer to stay with their established and – in many cases, publicly sanctioned – functions. As the urgency of the crises we face increases, difficult choices may be inevitable for these institutions. I will leave you, the reader, with a final question: if science museums, which we have trusted for centuries to be the stewards of our scientific heritage, cannot take on this task, who can?

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