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ENGAGING THE EXCLUDED
A PERSPECTIVE REVIEW

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ABSTRACT

The need for scientists to effectively communicate and engage the public with science has never been clearer. The pandemic in particular has highlighted the long-standing inequalities present within society. However, ensuring communication and engagement are delivered equitably remains a challenge for practitioners. This perspective review begins by revisiting some of the history of public engagement and science communication, to offer a contextual understanding of where we are today and how the relationship between science and society has changed over time. This initial overview illustrates that historic global inequalities are embedded in and continue to influence modern science, meaning that many communities remain excluded from the construction, communication and use of scientific knowledge. The literature suggests that despite calls to democratise science and much theorising on how this might be achieved from those within science communication and public engagement, in practice their activities are often criticized for reinforcing patterns of exclusion found in wider society which particularly impact marginalized groups at risk of other forms of social exclusion. However, as the world continues to turn its attention to issues of inequality, so has the scientific community, with many already attempting to break down barriers to accessing science and foster inclusive engagement. This review concludes by providing examples of how inclusive practice is being employed across a range of geographies and cultural contexts: sharing key learnings from each to suggest how we might better engage the excluded with science moving forward.

INTRODUCTION

Science and technology hold a prominent place within modern society. Increasingly they have been used to support government decision making and to deliver solutions to everyday problems. In particular, the Covid-19 pandemic has highlighted the ways scientific evidence and technology are used to shape our lives. Given their centrality to the organisation of society, there is a clear need for scientific knowledge to extend beyond academia and industry and into the public domain. As Emily Dawson (2019) notes, developing opportunities for non scientists (lay publics) to engage with science in ways that are equitable and accessible are important, because engagement of this kind can provide people with the tools, skills and opportunities to navigate contemporary life and or become our next generation of scientists (p. 20).

However, despite repeated calls to democratise science and improve relations between scientists and the public over the last four decades, it remains that current methods of science communication and public engagement are still not reaching many communities within society, particularly those that are already disadvantaged and/or multiply marginalised. These communities and the individuals within them have variously been named 'hard to reach' or 'underserved' in attempts to describe their exclusion from engagement activities. These terms often increase our focus on overcoming barriers while overlooking historic socio-political contexts which created them e.g., the unequal distribution of power and resources globally. They also prevent researchers and practitioners from looking inward, to themselves and the institutions they are part of, to understand where issues such as public trust and/or apathy towards science and the exclusion of public needs, wants and values from the scientific research, communication and engagement agenda originate and why.

Hoping to stimulate conversations that effect change in this area, Falling Walls Engage will be initiating a new project about inclusiveness in Science Engagement/Public Engagement/Science Communication with a focus on underserved communities from a global perspective this year. The perspective review that follows aims to support their efforts by providing a brief overview of the history of these interconnected disciplines (Science Engagement/Public Engagement/Science Communication) to demonstrate how their legacies continue to shape contemporary research and practice. We then look ahead to the future of public interactions with science, with a focus on those attempting to attend to issues of inclusion and equality. We include a small international sample of case studies from which we have attempted to synthesise key learnings that can both inspire and challenge us all.

DEFINITIONS

To support our understanding of the science communication and public engagement landscape, it is often useful to include definitions of the topics we will be discussing (Burns et al. 2003).

Science Communication

The landscape of science communication is vast and ever changing. Broadly speaking science communication or Sci Comm involves the dissemination of scientific knowledge and themes between, scientists and non scientists, also sometimes referred to as lay publics, for the purposes of increasing or creating awareness, enjoyment, interest, opinion and understanding (Burns et al. 2003). Communication itself has been widely theorised and can be thought of as "the practice of producing and negotiating meanings...which always takes place under specific social, cultural and political conditions." (Schirato and Yell, 1997). In some locations like Australia and the UK these practices are an academic and professional activity with varying degrees of government support and institutionalisation, while in others it is seen as an inherent part of science itself or even as a form of activism (Gascoigne and Schiele, 2020). As Dawson (2019) notes, much of the debate over terms here is to do with whether science is being communicated 'at' publics or 'with' them, with many activities falling into the former (p.8). Although there have been steps towards more participatory modes of communication which value the knowledge of publics alongside that of scientists, in reality much of this shift has been theoretical rather than practical with many individuals remaining either unwilling or unable to access scientific knowledge.

Public Engagement

Public engagement with science and technology (PEST) or public engagement refers to intentional and meaningful two-way interactions that provide opportunities for mutual learning between scientists and members of the public. The aim is to create space for genuine discussion to set research, policy and funding agendas with an understanding of what publics want from, or are concerned by technoscientific development, at a point sufficiently upstream where change is still possible. (Jones, 2011). Engagement activities have also been positioned as possible sites for regaining public trust in science (Wynne, 2006). However, it has often been found that these aims are not being met and public views are being sought out to assess the public mood regarding pre-determined policy or funding decisions, for example during national debates over the use of biotechnology to create genetically modified crops (Attar and Genus 2014) or on discussions on how best to tackle climate change. Melanie Smallman (2018; 2019) explains that the collectively held imaginary of science as societies epistemically and morally superior 'saviour' has made science-led policy options resistant to public concerns, even when public views are sought out under the banner of public engagement. An unwillingness to take public concerns seriously then ensures that societal progress aligns with scientists and policymakers, rather than the publics, visions of desirable futures (Jasanoff, 2015; Jasanoff and Kim, 2009). On the other hand, positive progress is visible when looking at Responsible Research and Innovation (RRI) (Owen et al, 2012). Many of PEST's aims

and the shift they created in the relationship between science and society are now visible within RRI, as well as the wide range of research and policy initiatives based around the co-production of knowledge that includes experts and the public.

Science Engagement

The work of Falling Walls Engage (FWE) brings together and promotes the various activities that mediate a relationship between science and the public. They aim to expand the recognition of Science Engagement practices worldwide, making use of their strong international alliance of partners and stakeholders, with the belief that a better understanding and appreciation of science can help tackle global societal challenges.

As such, they have coined the expression 'Science Engagement', which effectively positions them between the vast domains of science communication and public engagement. Science Engagement as defined by FWE includes "activities, events, or interactions bridging the gap between science and society to generate mutual learning and mutual benefits. Engagement is, per definition, a two-way process with the goal to shape and co-create science literacy and scientific processes together, to promote active involvement of the public, science engagers and researchers, in engagement with science and scientific knowledge production." Through Science Engagement, they seek participatory formats of all levels: from co-productive research and public panels (engagement) to arts-driven or entertaining approaches (communication) - ultimately aiming to implement practices of equitable inclusion and equality of impact for all those involved.

Exploring how and why we began to communicate science

Writing this review, I began by revisiting dominant narratives of the history of science communication and public engagement to consider whether/how they have shaped the field and how this might relate to contemporary underserved or excluded communities. As I moved down the historical timeline I reflected on the questions of early historians in this area: "why, for whom and how a science, at a particular time, was spread through the social fabric of an era; who made this science theirs in a particular era and by what means"? (Raichvarg and Jacques, 1991), in the hope that greater understanding of these factors could support improvements in the development of equitable and inclusive communication and engagement activities.

Literature from the history of science shows that the perceived value of science in society has long supported arguments for the communication of scientific knowledge (Thomas and Durant, 1987). The common-sense argument that 'science is valuable and therefore the public should learn about it', although true, has been effective in obscuring the underlying motivations of those educating and informing publics about science. One such motivation, the legitimation of science, is evident within the historic philosophical debate where positivists claimed there was only one kind of knowledge about the world (Hannam, 2011; Rouse, 1990 p.180). This idea that there was

only one way of knowing (western science, then called natural philosophy) and the desire to communicate this knowledge as a means of legitimising science (and in turn the moral and epistemic superiority of the West) is evident within the Early Modern history of science, particularly during Western colonisation of the rest of the world. For example, during the 18th century, Western natural philosophy was felt to embody the values central to Enlightenment thought: that truth as attained through rationality and empiricism would dramatically improve human life (Bristow, 2017; Outram, 2019 p. 109). This belief was used to justify the, often violent, spread of western ideologies, 'rationality' institutions and knowledge, to distant lands and peoples who, seeming to lack the means to achieve liberty and civility themselves, eagerly awaited the arrival of European settlers (De Condorcet, [1795] cited in: Carey and Festa, 2009 pp. 1-2; Outram, 2019 p.109; Raj, 2007 p.6; Watanabe, 2017).

For the public, the popularisation of science in the 19th century was used to encourage acceptance of "scientific authority". A respectable place for science and scientists within society was secured by creating a public that viewed science as important (Kuritz, 1981). Here, the moral values of science were stressed in the arguments for teaching science on a popular basis (Kuritz, 1981 p.26).

Further study across the social sciences has allowed us to challenge ideas of a singular knowledge or science developed exclusively in the West which was then disseminated to 'the rest'. Showing instead, that what we understand as 'science' changes through time and space, and the creation of these various forms of science has long been a global endeavour, often relying on the collaboration of both settler and native forms of knowledge (Daston, 2015 p.242; Outram, 2019 pp. 108-122). In other words, no one 'owns' the pursuit of scientific knowledge. It is a project that we all have the right, if not the resources, to participate in.

However, the legacy of Early Modern science and its links to colonialism and other systems of oppression, is one we must still be aware of in contemporary science communication/public engagement. As Lindy Orthia (2020) notes, "how a discipline's history is written shapes its identity" and although practices of science communication began centuries ago, the study of the history of public communication of science is a relatively young field of research (Massarani et al. 2017).

The dominant narratives of science communication and public engagements' origins that have emerged remain geographically, culturally, and temporally narrow e.g., Eurocentric and recent - reflecting existing narratives about the development and dissemination of science itself (Raj, 2007). This framing has created and sustained a rigid imaginary of what scientific knowledge looks like and who is able to create it (e.g., those that are white, western, male or able bodied etc. framed as the norm) which in turn sustains problematic boundaries between what we view as 'real' science vs. traditional or Indigenous knowledge: tacitly implying inferiority of the latter (Orthia, 2020).

Critiques from observers of contemporary engagement projects, including those attempting to deliver inclusive science outreach and engagement, suggest such projects are 'assimilationist', prioritising western knowledge and practices above others and positioning those who do not participate as lacking both culture and knowledge (Dawson, 2014, 2019; Yosso, 2005). In other words, by only showcasing western knowledge and practices they are tacitly pushing for this knowledge to be accepted or 'assimilated' as the norm by minoritised participants, exchanging their own cultures and knowledge for 'Anglo-conformity' (Kim, 2007): reaffirming the long lasting impact of the inequalities created during the spread of western science.

Similarly, Jones (2011) suggests that "some science communication is about the popularisation of 'well-established' and 'uncontroversial' science while others are designed to provoke or advocate for knowledge which is not universally agreed upon" (p.2). If we consider whose knowledge has historically been readily accepted as fact vs that which society must be persuaded to believe is valid (e.g., western knowledges vs. those variously defined as 'native', 'indigenous, 'traditional' or 'local' (Mazzochi, 2006)), how subjective categorisations can be and who gets to decide: we begin to see how a desire to popularise certain types of knowledge reinforces existing hierarchies and inequalities in the global knowledge economy.

Essentially, the way we talk about science (who conducts it and what it looks like) as well as the distribution of resources that provide access to the scientific knowledge economy (either providing or withholding the capacity for different groups to undertake and fund their own research or set the research agenda) have created deeply embedded patterns of exclusion within science communication and public engagement that are still present today. As such, there are many communities who do not have access to science and/or believe it is not an activity they can participate in or is not related to their everyday lives. It is these publics we can identify as being underserved, or more accurately excluded, from contemporary science communication and public engagement initiatives. As Orthia 2020 notes: "insofar as access to science communication facilitates social power, a desire to radically democratise ownership over it may be served by conceptualising its history as bigger than the West and older than recent centuries."

In other words, looking for or creating older and more polyvocal histories of science and science communication is a good place to start when thinking how best to engage those identified as underserved. Thinking critically about these histories can also help us begin to understand the complex and interlinking factors that have left many explicitly and implicitly excluded from science communication and engagement initiatives.

From attitudes and understanding to engagement and inclusion

Reviews of the last few decades identify several key turning points for science communication and public engagement as being related to wider political or cultural shifts that changed the nature of science-society relations. However, it should not be assumed that progress delivered

equitable or even increased access to science for all (Dawson, 2014) and tensions between public calls to democratise science and backstage motivations to make institutional dominant forms of knowledge normative, viewed as the standard and or superior to other types of knowledge, (Wynne, 1995) remain. Taking on Orthia's perspective regarding the importance of developing global histories of science, we review the modern histories of science communication and engagement from a small cross section of nations to see what we can learn about the current landscape that could support initiatives towards inclusive practice in the future.

THE UNITED KINGDOM

Before the internet or international crises placed science at the centre of public discourse, the widespread communication of science to publics was primarily facilitated by the mass media. In the Nineteenth century you could find lectures of popular scientists reprinted in the pages of national newspapers e.g., The New York Times (Weigold, 2001). And during the periods of world war that followed where science was viewed as integral to many nations' victory, positive stories of science were shared by journalists keen to engage with scientists. This good feeling seemed to have run dry amongst press outlets by the 1970s. In the United Kingdom (UK), for example, scientists felt the press had taken a more critical view in light of discoveries of the environmental harm caused by scientific advancement (Lock, 2011).

In 1985, The Royal Society (UK) released the Bodmer Report, now viewed as a watershed moment in the history of science-society relations. The report reproduced long-standing views within British society regarding the importance of science, not only able to improve national prosperity and the competitiveness of British industry but as a means through which the quality of publics personal decisions could be improved (Bodmer, 1985 p.6). Prior to this, politicians and scientists had focused on public attitudes to science or on, finding ways to measure levels of scientific literacy within the population, but communicating scientific research to the public was not considered an inherent part of a scientist's role. By linking science to national progress and prosperity, improving the publics scientific literacy was on the agenda once more and the public understanding of science (PUS) debate was relaunched and institutionalised with the formation of the Committee on the Public Understanding of Science. Much like measurements of 'scientific literacy' before it (Bauer, Allum and Miller, 2007; Durant, 2000) PUS mainly served to problematise the public and only offered limited interrogation of the ways the construction and communication of science had made scientific knowledge inaccessible or simply appear unimportant to non-scientists. PUS created a version of the public in the minds of scientists and policymakers that was homogenous and knowledge deficient, lacking desired levels of scientific understanding, and led to a one-way top down process of 'correctional' science communication (from scientists to the public) typically disseminated through the mass media working alongside scientists and government departments (Miller, 2001 p. 116; Wynne, 2005 p. 66).

Following the Bovine Spongiform Encephalopathy (BSE) crisis of the late 80s/90s, a gross mismanagement of science-policy-public relations (European Environment Agency, 2001), The House of Lords published their 'Science and Society' report (2000). Here, the once deficient public were reframed as one that now had meaningful knowledge that should feed into the machinery of scientific policy making. The emergence of a contextual PUS approach gave dialogue an important role in the development of new public knowledge and the need for increased participatory input of publics was recognised, igniting a 'gradual yet incomplete shift from 'understanding' [science] to public engagement with science: also described as a move from 'deficits to dialogue' (Bauer, 2009; Miller, 2001; Stilgoe et al. 2014).

JAPAN

A national shift from PUS to communication and engagement has also been observed in Japan. Beginning in the 16th century western science was brought to Japanese shores via Portugal and later, exclusively the Netherlands thanks to the 250-year rule of the Tokugawa shoguns who limited trade with foregin entities allowing only the Dutch to remain in Japan until they were overturned in the 1850's (Goodman, 2002). As Japan opened its borders following this prolonged period of relative isolation, there was a sense that the nation must now race to catch up and then surpass the west: a fate, they believed, would be achieved by simply leaving science in the hands of experts to progress (Watanabe 2010). Following the second world war, Japan looked to science and technology innovation to support its economic recovery. However, concerns were raised by The Council for Science and Technology that the general public lacked the necessary knowledge to build the talented workforce required, stating that the government would need to dedicate efforts to raising awareness with a view to improving the public understanding of science.

By the late 20th century there was growing public indifference to science and technology as the negative aspects of innovation became more visible to the public in the 1980's, the opening of a large scale science and technology exposition in 1985 in Tsukuba, followed by a shift towards interactive two-way engagement practices in the early 2000's with the emergence of newly published research, science cafes and networking and consensus building events with the public, held by the The Japanese Society for Science and Technology Studies to replicate those found in the US. Undoubtedly PUS/PEST research and practice extend far beyond the UK and America, however Locke (2011) notes the strength of their influence, especially regarding the development of institutional programs, where these nations were often used as examples when other countries developed their own (p.18).

Following science communication and engagement practices became institutionalised to repair science-society relations damaged by the mismanagement of the March 2011 earthquake that caused a sequence of explosions at the Fukushima Daiichi Nuclear Power Plant. The major event revealed a lack of real science communication policy, transparency, and accountability when the public needed it most. This loss of faith in government communications opened the

door for more bottom-up approaches, e.g., the development of local networks to exchange information, with these grassroots science communication efforts now being considered a possible way to deliver more inclusive engagement with science that centres the public (Watanabe 2010; 2017).

BRAZIL

Across the Pacific in Brazil the communication of science was largely absent until the 19th century. Portuguese colonial rule from the 16th century made the country a colony of exploitation for profit and laws that prohibited the publication of books in the 18th century kept the, then, small population illiterate and limited the spread of scientific knowledge to an elite, foreign educated few (Massarani and de Castro Moreira, 2020). This changed following the arrival of the Portuguese Court in the early 19th century which prompted a reversal on the laws on printing and the development of the first institutions linked to science and technology, concentrated in the former capital Rio de Janeiro.

Similar to Japan and the UK, world wars of the 20th century saw science gain prominence - viewed as the embodiment of progress. In 1948, the Brazilian Society for the Advancement of Science (SBPC) was born, and magazines and newspapers began creating regular science sections, advocating for better funding, infrastructure, resources, status and recognition for the sciences (Massarani and de Castro Moreira, 2020). In the 1950's public interest in science was piqued by debates regarding the use of nuclear energy and many references to the atomic bomb can be found in Brazilian literature and poetry of the time.

The military coup of 1964 had far reaching socio-economic impacts on the country, damaged the scientific community with many researchers forced to flee and slowed down efforts to engage the public with science (Massarani and de Castro Moreira, 2020 and Skidmore, 1988). Under a Military Dictatorship, the SBPC took on a key role in government resistance: advocating for democracy and the use of science to address social challenges and Brazil's underdevelopment. Like Japan, a narrative of 'catching up' to the rest of the world was deeply embedded in the minds of Brazilians. As Evangelista and Kanashiro (2004) describe it, the idea of a 'deficit' can be found in discussions not just by science journalists and researchers but also throughout political and economic discourses. As such, they suggest Brazil is attempting to overcome a 'double deficit': two levels of deficit that join together and empower each other. On the one hand you have the idea that the public lack sufficient scientific literacy and on the other is the "idea that the country itself is deficient in relation to the cultural, economic, political and scientific development of developed countries in the global North" (p.1).

Following the end of the dictatorship in 1985, science communication in Brazil has enjoyed a period of fragile growth. There are now approximately 260 museums in Brazil, although it is noted that the spread of informal learning spaces throughout the country remains uneven (Almeida et al 2015). It is also suggested that many do not offer interactivity and looking to the

future, the nation's science communicators will need to consider more participatory forms of engagement to make the knowledge accessible to improve the quality of public engagement.

In 2004, The National Week of Science and Technology was created by presidential decree and The Department of Popularization and Diffusion of Science and Technology was established alongside a national programme to support science communication. However, it is felt that support from the government has not been consistent. Many initiatives are plagued by unnecessary bureaucracy and remain vulnerable to changing political attitudes which manifests as a lack of institutional continuity in relation to programmes to popularise science communication and engagement. Furthermore, due to the size of Brazil's population, making science accessible to all citizens is already a considerable challenge for science journalists, researchers and practitioners. This is compounded by a lack of sufficient and consistent investment from government which limits the availability of resources making it particularly difficult to develop initiatives which reach poor and excluded groups.

Looking forward, Massarani and de Castro Moreira (2020) note that Brazil still has a long way to go on its science communication and public engagement journey in order for the development of scientific knowledge to meaningfully involve the public, beyond ideas of scientific literacy. However, they suggest that recognizing the cultural and social aspects of science as well as traditional knowledge is an important goal for the future. They also discuss the potential of citizen science projects, which tap into collective learning, as an effective way to educate the public about science. The hope is that despite various challenges to progress, the turn toward more inclusive and participatory engagement with science will continue.

LEARNINGS FROM THE LITERATURE

Looking at cross-cultural histories of science communication, public engagement, and dialogue as they evolve (more of which can be found in Gascoigne et al book 'Communicating Science: A Global Perspective (2020)) reveal interesting common threads and useful perspectives. One such similarity is the ways in which scientific knowledge embeds and is embedded with socio-political and cultural changes which affect the ways societies develop, disseminate, and use scientific knowledge. Jasanoff (2004) describes the 'untidy, uneven processes through which the production of science and technology becomes entangled with social norms and hierarchies as the co-production of science and society: the idea that natural (or scientific) order and social order are produced together. For example, the way colonial projects were shaped by emerging science and technology, e.g., the development of new weapons and technologies of sea exploration or poor political decision making that attempted to maintain public trust in science by offering false assurances (BSE and Fukushima). The lasting impact of these events is in turn shaping the way science and technology is or is not developing within and between nations. Co-production, which exists as a means for interpretation rather than a fully-fledged theoretical concept, also offers a challenge to scientism, which creates unrealistic expectations of what science can achieve or that engaging the public with science automatically equates to a public

good. It reminds us that the creation and communication of scientific knowledge, thought to only embody facts, objectivity, and reason, are inescapably human activities, and cannot be separated from "culture, values, subjectivity, emotion and politics" (Jasanoff, 2004 p.3).

Also present is recurrent use of the 'deficit model' which implies that the public are incapable of meaningfully participating in science and reinforces the idea that science needs to be communicated 'at' rather than developed 'with' publics. The literature contains sustained criticism of the 'deficit model' which assumes public resistance or indifference to programs advanced in the name of science, was due to lay persons misunderstanding of the science (Bodmer, 1985 p. 6-26; Irwin and Wynne,1996 p.6; Wynne, 1995 p.362). For example, research from science and technology studies (STS) has highlighted the complex social factors affecting the creation of scientific knowledge and its assimilation, acceptance, or rejection by the public (Miller, 2001 p.117; Wynne, 1995 pp. 361- 388; 1999 pp. 4- 13). This work has shown that there are many reasons publics might not interact with science that are not related to perceived levels of understanding (with understanding often aligning with assimilationist approaches). PUS initiatives have also been criticized as being a cover for the perpetuation of a tacit cultural politics of legitimation of science, and related institutions (Wynne, 1995). Here the decades-old 'backstage' or hidden motivation for communicating science to the public continues to problematically shape how projects are developed, whose knowledge matters and ultimately, who will be included or excluded from activities.

More recently there has been a move towards inclusive practice within science communication and public engagement, which seeks to re-visit and improve upon public engagement's ambition of two-way communication between science and the public to generate mutual benefits. Like global histories of science, research on inclusion and exclusion in science communication and engagement are relatively recent and in need of further study to understand the complex and intersecting issues at play. Some relevant insights from the literature include Emily Dawson's work (2014; 2019) which identifies the emergence of a 'barriers' approach to issues of inclusion and exclusion within science. They note that while identifying barriers is useful for describing what social exclusion from science communication might look like, it "does little to explain how or why the exclusion occurs", often underestimating the complexity of these issues. Her research has also shown that the removal of individual barriers such as cost or proximity to science do not increase engagement with previously excluded communities in the ways we might expect. Additionally, when barriers to science are identified as structural issues institutions and practitioners cannot rectify e.g., poverty, or with participants behaviour and attitudes, it becomes easy for them to overlook how engagement and communication practices themselves might be problematic. To that end Davies' (2014) overview of the participatory turn in science communication and PEST attempts to unpack just that. Although not specifically discussing inclusive practice, their work critiques the over-reliance on dialogue to foster inclusive and meaningful engagement, suggesting that it has caused us to ignore other important aspects of communication and engagement. They note that there is much for practitioners to learn by thinking about communication without or beyond discourse, as it

enables us to attend to other dimensions of engagement such as embodiment, materiality, affect and place (Davies, 2014).

"They are sites, full of objects and bodies, and they deal with experiences and knowledges (both 'lay' and 'scientific') which are similarly embodied and ordered through material practices. For instance, they take place in particular kinds of sites and spaces (a shopping centre, conference venue, venerable scientific institution, or café), produce different emotions (indifference, enthusiasm, annoyance, embarrassment, boredom), and deal with very different forms of embodied knowledge (the expertise of the lab scientist, the self-awareness of the patient in pain, the mundane rituals of everyday life in a technological society)." (Davies, 2004 p. 95)

This perspective overlaps with further research which looks at the use of the arts to communicate and engage publics with science. For example, Matias et al. (2021) case study 'Embodying Memories' which sought to engage a group of, mostly illiterate, migrant senior women, suggests that engagement with excluded or disenfranchised groups can be increased by focusing on the affective domain of learning rather than the technical and gave the community the opportunity to "explore and represent perspectives in their own terms". Importantly, they note the need to alter their objectives and measures for success when undertaking their artistic, collaborative approach to STEM engagement. By moving away from traditional ideas of top-down knowledge dissemination (communicating science 'at' participants) as the primary objective they were able to develop more nuanced objectives such as: "stimulating creativity, curiosity, abstraction and self-expression" and view achievement of these goals as valuable outputs of the activity in their own right.

Their work also describes the value in having 'boundary spanners' involved in inclusive science communication. Boundary Spanners are described as those who inhabit multiple social entities e.g., being a scientist who is also a member of the marginalised group you are trying to engage and is able to speak the same language/ dialect and or has an understanding of the culture and needs of the local community.

Overall, the literature makes clear that; imaginaries of the public as deficient are deeply embedded and resilient and the complex intertwining of science and social order means that even practices designed to combat issues of exclusion have the capacity to reinforce them, particularly when we overlook how science and the practices themselves perpetuate inequality - not just the wider structural issues we feel are beyond our control. Therefore, rather than problematising the public as 'deficient', we might consider reframing our own motivations and objectives for engagement e.g., are we attempting to legitimise the work we do rather than educate and empower? Are our practices assimilationist in nature? We might also reflect on whether/how our activities can better serve publics in the future e.g., are we able to address an unmet need in their community by making science useful and relevant to them. Or even think beyond written and verbal communication styles to consider embodiment, materiality, affect and place: focusing not only on what people say but considering how interacting with science

makes them feel. Here we can also begin to accept non-engagement as an active choice made by participants whose relationship to science has been shaped (historically, culturally, politically etc.) differently to our own.

Critical reflection of the intersecting contexts surrounding science communication and public engagement as well as power relations, impact, approach, transferability, sustainability, and diversity (in all its forms) could help us to move beyond 'barriers' framings of inclusivity to challenge and then reimagine current practices, perspectives and motivations: ultimately centring equity, intersectionality and the needs of communities in our work.

CASE STUDIES: How can we engage the excluded?

The pandemic has shone a light on the ever-present inequalities that exist within and between our societies. The centrality of scientific messaging to many nations' pandemic response has also reaffirmed the importance of making science and science communication inclusive and accessible to all. Amidst the tragedy of the last 18 months, we have been forced to take stock of what works within current systems to identify where and how positive changes might be made. As such, as part of this review we sought out individuals and organisations who have already begun incorporating inclusive practices in their communication and engagement work to better serve the underserved in their communities to see what lessons could be learned and adapted to support processes of diversity, inclusion, and innovation in the field. Continuing with our cross-cultural view of science communication, engagement and inclusion, the case studies that follow are a small sample of the great work already taking place across the world. Although a small cohort, they will hopefully illustrate what can be achieved when principles of equity and inclusion are made central to science communication and engagement.

Between March and May 2021, I spoke with science communication and engagement practitioners from five different countries to understand, who they had identified as being underserved, what strategies they had developed to deliver innovative, sustainable and community focused science communication and/or public engagement. In addition to dialogue our interviews paid attention to affect (how the projects made them, and the participants feel) time and place which made clear the context dependent nature of what exclusion means, what it looks like and how it can be addressed.

Each contributor answered the following six questions to support our discussion of their projects:

1. Please describe who the underserved individuals and/or community you are reaching are and how it was discovered that traditional methods were not reaching them
2. Please provide an overview of the intervention that enabled them (the underserved or excluded) to be included in science communication/public engagement (please include names of your organisation, team members and any funders who supported the work)

3. What was the impact of your science communication or public engagement project/intervention and how was this measured or evaluated?
4. How was your project, organisation or were you personally changed through your involvement with previously underserved communities?
5. What did you take away /learn from engaging with previously underserved communities?
6. Please share some take home messages (2 - 3) that we could share with other individuals/organisations trying to reach 'underserved' communities near them

CAIRO, EGYPT

Project: Fun Lab at The American University in Cairo (School of Science and Engineering)

Project lead: Mohamed Daoud - Science Communication specialist in the Department of Physics who is pursuing a master's in nanotechnology from AUC

Research has identified Egypt as the most central and interconnected node within North African networks of science, as well as being one of the most active in terms of size of research output and variety of international collaborations (Landini, Malerba and Mavilia, 2015). However, scientific research and innovation in Egypt has been marred by decades of underinvestment, mismanagement of funding and excessive bureaucracy alongside an uninspiring science curriculum (Bond et al. 2012). These factors have severely weakened the country's scientific capacity with "approximately 70% of young people opting for degrees in the arts of humanities or preferring to leave school to find jobs in industry and agriculture", Mohamed explained when I interviewed him back in March 2021. Middle school is the crucial moment in the educational journey for these students, who must make important life choices between gainful employment vs. higher education. From this perspective and with the hidden costs associated with higher Science, Technology, Engineering and Maths (STEM) education, the pursuit of science is seen as a luxury for many in Egypt.

As such, in 2013 Mohamed and colleagues from the American University in Cairo (AUC) collaborated with the Academy of Scientific Research and Technology (ASRT) (part of the Cairo Governorate) to create the *Fun Lab*, bringing the "wonders of science" to young people, many of whom are from lower socio-economic backgrounds/living in deprivation, racial minorities or have been orphaned. In its infancy, the project simply involved renting transportation to bring them to Egypt's science centres for the first time, of which there are only six (each covering 4-5 Governorates) separated by vast distances making them inaccessible for those in rural areas or without transportation. Using equipment brought from the university physics lab AUC staff developed a range of interactive, physics-oriented games and education activities, e.g., the 'Wonder of Science Show' which introduced participants to laws of motion, pressure, sound, light, electricity and magnetism or the Planetarium Show. Staff at the regional science centres helped AUC/*Fun Lab* faculty and staff to identify larger groups of previously underserved students whom they could bring to the science shows. The overarching aim of the shows was to challenge the misconception that STEM subjects were too difficult for students from a marginalized background to pursue and encourage them to study science. The success of their first outreach efforts prompted them to think bigger, reaching out to the Ministry for Education, who gave them access to all public schools, specifically more middle schools where students who had never met a scientist from a similar socio-economic background could talk about science in ways that felt familiar. Using money from a grant they were awarded in 2012, they purchased additional equipment that would allow them to replicate their engaging science shows at AUC and trained the staff at the

regional centres to continue delivering their shows to local communities, ensuring the project's longevity.

> "We train the staff for 3-4 months to make sure everything is clear and provide them with all the resources they are going to rely on later. Not just the expensive equipment but so they can also do science at home and run activities using household items ... We're going to teach these kids, yes, about astronomy, physics, and chemistry - but also about how science interacts with their daily lives and can tackle issues like water shortages or how they can use solar energy. We want to teach them about the social and economic impact science can have on their lives".

Lastly came the free science STEM summer camps, taking 50 students each week over the course of one - two months for full days of science education and engagement activities based around the natural sciences. The camps create a safe and open environment for students to explore new ideas and discuss science in ways that are personal to them: identified as key to successful informal science learning within the literature.

Speaking with Mohamed his passion for and wonder in science was clear. He tells me that when he began working with underprivileged communities, he was worried that they wouldn't have any interest in science, but as soon as he delivered the show, he could see the sparkle in their eyes and the tremendous hunger for knowledge from their side, which challenged his initial assumptions.

> "Actually, they adore science, they want to get as much knowledge as they possibly can. But they don't have the chance to do that, or they were not exposed to experiences where they can play with science or enjoy science as they are enjoying it right now. So, I think this is one of the discoveries I found, that they have tremendous knowledge, and they need to be reached."

Importantly, the ability of AUC and local science centre staff to build long-lasting and supportive relationships with the students who participated in any of the *Fun Lab*'s activities demonstrated genuine two-way processes of engagement, with practitioners learning just as much about the transformative power of science for the lives of individuals as students did about their own potential to participate in the creation of scientific knowledge, no longer viewed as separate from their lives or beyond their reach.

BANGALORE, INDIA

Project: Bangalore X

Project lead: Chandrakant Redican - Science Communicator specializing in educational outreach and engagement at the Bangalore Life Science Cluster.

Legacies of imperialism and colonialism cast a long shadow over discussions related to contemporary science in India. This has meant that research on emerging science and its communication in the sub-continent has focused on issues of post-colonial nation building, with less focus on dissemination or communication practices, whether institutional or community led, and less still on matters of exclusion (Chakraborty et al. 2020). Speaking with Chandrakant, who is based at the National Centre for Biological Sciences (NCBS) in Bangalore, he makes clear that even speaking about India's caste system and challenges around gender inequality is a "big step forward". The project he leads - *Bangalore X*, is designed to support this shift in the minds of the public: creating a space where the public are able to have honest conversations about the challenges they are facing. Having grown up in an 'scheduled caste' community (previously called 'untouchables' and considered to be outside/below the caste system) but having a white Irish-Canadian father, Chandrakant describes himself as having a mix of 'perspective and privilege' which enables him to understand the complex socio-cultural challenges facing underserved communities while also having access to STEM education, institutions and resources that he and NCBS are keen to share beyond their ivory tower.

Although running several projects simultaneously, the project we discuss focuses on the underrepresentation of women in STEM education and careers in Bangalore. It has been shown that science and technology practises and establishments in India are embedded in a 'male upper-caste ethos' which refuses to place the concerns of ordinary citizens on the science and technology agenda (Sur, 2011). Acknowledging this imbalance, *Bangalore X* teamed up with national NGO 'Care India' who work to alleviate social injustice and poverty and are interested, amongst other things, in the education and empowerment of young women and girls in rural parts of India. Together they created an open forum for students to ask women scientists from NCBS' labs questions about themselves and science, ensuring they had people who could speak the local dialects. They initially planned for the conversations to take place in-person but had to move online due to the pandemic and were concerned that zoom-fatigued students would not want to engage. In reality, the opportunity to speak to women who have successfully navigated careers in STEM was more appealing than expected, with students excited to have role models who could relate to their own upbringing and background. Additionally, they found that hosting the engagement online made it more accessible to a wider range of young women because, as Chandrakant explained:

> "Science engagement with girls is a different process than with the boys. You have to build trust with the families that they will be protected and taken care of. If you are able to build these connections then we can get them to come into the labs - in the

> longer term and participate in, for example, citizen science programs. Girls getting educated is difficult. They are very interested but don't always get the support. Also, you can't teach them ideology (feminism etc). The knowledge has to be economically focused, for example if something happened to your family/husband how would you look after your family."

Interestingly he notes that many of the ways he has built trust with excluded communities has nothing to do with science communication at all, for example the time he spent coaching girls' softball and baseball teams turned out to be a great informal way to build relationships not just for him, but for the girls with other members of their team who, again, may have been from a different caste. He also mentions accepting invitations to have dinners with their families which gave the parents the reassurance they needed to allow their girls to participate in extra-curricular programmes.

There is also the intersecting dimension of class/caste to contend with. For example, Chandrakant explains that women and girls from untouchable communities have to go out to work, meaning they have relatively more freedom than girls from the upper classes, but probably less social awareness. He notes that each girl attending may be from a different caste, so what they need in terms of support will be different based on their socioeconomic status. Upper-caste girls are taught how to navigate the issues with gender roles but aren't allowed to go out vs girls who have more freedom but are very socially naive.

In addition to taking the necessary time to build trust and meaningful relationships with the communities we engage, this outreach project also reminds us that successful engagement will look different depending on the wider context. In the case of *Bangalore X*, Chandrakant explains that "changes will be small and slow". For many of the women attending the program they may already be considered too old to change their career paths immediately, instead having to fulfil commitments to their families or husbands. In these cases, success would be the young women agreeing that their daughters will be educated or developing a desire to return to education themselves after starting a family. Whatever they decide, it is crucial that we respect their autonomy and do not pass judgement about the decisions they make for their lives. Next steps for the project include bringing boys into the conversation to get them used to seeing educated women in positions of power, this way Chandrakant and his team hope to address issues of exclusion multi directionally: changing minds from the top down and empowering those at the bottom to aspire for more.

GLASGOW, SCOTLAND

Project: STEM in the Gorbals, University of Glasgow

Project lead: Dr Saeeda Bhatti - Geneticist and experienced STEM Ambassador

The Gorbals is a densely populated area in the city of Glasgow. It has been classified as SIMD 1 and 2 within the Scottish Index for Multiple Deprivation (Scottish Government, 2020). Although positive changes are taking place due to interventions by networks of third sector and public sector services working towards the Thriving Places Agenda, residents of the Gorbals are still at an increased risk of experiencing a range of inequalities and social challenges compared to the rest of Glasgow, such as food insecurity, health inequalities and economic inactivity. Saeeda, now a Geneticist who is from the area, confessed that it wasn't immediately obvious to her that access to STEM education and resources in the Gorbals were limited compared to others. She optimistically viewed schools as a safe haven from the wider issues facing the area.

STEM in the Gorbals began almost accidentally, Saeeda tells me during our interview. While working a zero hour contract, she had the desire to give something back to her community and considered going into local schools to see if there was anything she could help with. That was until she received a 'New Year New Idea' leaflet from 'The Spirit of The Gorbals' asking people if they had ideas for their community. The initiative was part of the Glasgow Commonwealth Games legacy programme, supporting local people's ideas to improve the wellbeing of their community.

The first event Saeeda developed reflected more traditional science communication. Researchers from the University of Glasgow were invited to the local school to showcase their work. Saeeda also launched a magazine competition with the aim of encouraging school children to develop stories about science. Class teachers helped to create a shortlist of entries and then, with the help of the researchers who had attended the first event, selected winners to showcase their work at a national event called Explorathon - European Researchers Night. At this stage the class teachers Saeeda had worked with explained what a big moment this was for the prize winners, as due to cost and location, many of the students would not normally have the opportunity to go to the large-scale science events. That, Saeeda reveals, was when she realised that she was making science accessible and that she wanted to keep going. As she puts it "you live somewhere and you want to make a difference, don't you"? She warmly confirmed that it was the children's love for science that keeps her working on this, which she does voluntarily alongside a full-time job.

The *STEM in the Gorbals* project has now evolved into day-long Science Engagement events in local primary schools with workshops and children generating content for their own magazine. The events take about 6 ½ months to organise and the activities are completely driven by the children involved and the local community, with students and researchers from the local universities volunteering their time and even local supermarkets and community

groups donating healthy snacks for events. Much like *OSHub-PT*, Saeeda's ability to develop strong relationships with the local community as well as her selfless approach to engagement have been the cornerstone to her success.

Each event comprises various stations centred around a theme, for example, last year would have been 'DNA Day' if not for the pandemic and they have previously focused on cancer, astronomy, hypertension and more. Each class is assigned a stand for the event, and this is coupled with workshops delivered by the university student volunteers who go into each topic in greater depth following the event. Those who work as volunteers at the events (school pupils and university students) receive training and attend practice sessions with Saeeda ahead of each event. In that way, she says "they are receiving the skills and knowledge to become science communicators in their own right."

Saeeda makes clear that letting the children lead is an important aspect of the project and she has found collaboration to be far more empowering for them. For example, she informs me that their participation in the Science Engagement event gave them the confidence to call themselves STEM ambassadors, which Saeeda was surprised and delighted to discover during her introductions with the students. It has also allowed their peers, who are not yet involved, to view science and engagement as attainable.

> "I want to help people realise they can do it. That maybe sounds cliche, but I think we've all been in a position where we want something and then talk ourselves out of it. I think everyone should have the chance to at least try."

In that vein, the *STEM in the Gorbals* logo was also designed by the children. The process helped them to outline their aims, objectives, and priorities as a group as well as what they would like to get out of each event. The logo perfectly reflects the community spirit that underpins the project. One of the images is a picture of four girls from different backgrounds holding hands while standing on top of the world, when asked why they did it this way they said "it's because we are from everywhere" - recognition of the diverse and inclusive nature of the area.

With hundreds of attendees at each event, Saeeda also describes her innovative approach to evaluation that allows the children to be part of the process while reaching as many people as possible for feedback. Children from the school volunteered as "Investigators" or "Evaluative Podcasters" and were based at their self-made Gorbals Media Stand. Investigators had two roles, the first to identify fun and exciting facts about researchers attending the event and the second to provide evaluation. The Evaluative Podcasters used a slightly different form to gain feedback from adults (parents/teachers) at the event - some handed the form out while others asked the questions directly in the style of an interview. Both roles afforded them the opportunity to have maximum engagement at the event and to take ownership of their event.

Additional outputs from the project include the *STEM in the Gorbals* podcast, which is available on SoundCloud. Saeeda and her team support pupils from the school to find interesting topics

to cover each episode, typically linked to the most recent event that has taken place, and the children develop a set of questions to discuss. Also, at the event, children from the school had the opportunity to volunteer as "Reporters" where they worked in pairs to interview researchers attending the event. These interviews were then used as content for the community science magazine. As the events continue to develop, Saeeda hopes that the children involved will be able to take on even more responsibility, which would allow the project to remain sustainable and scalable, thus reflecting the progressive nature of the project.

The target audience for events is 5 - 11-year-olds (P1 - P7) however, Saeeda notes that as the project evolves children moving onto high school ask to come back and provide support for their younger peers, as well as wanting to have their own stands at the event. This confirms the longevity of the relationships the project builds with them.

Saeeda was also able to share key learnings from her experience running an engagement activity for areas with perceived low participation in STEM. Again, trust features strongly as something needing to be fostered overtime. Saeeda suggests that when working with children, trust is built by being reliable: "Be patient. Things can take time; trust takes a long time to build and sometimes we may never fully gain it but if someone asks for something - deliver in a timely manner." The project also made clear what valuable assets teachers are when working with younger people, "they are the ones who know the children best in that setting, so you must be willing to listen to their expertise and adapt activities accordingly". Finally, she emphasised the importance of letting others lead the engagement. "Let people lead. They will get so much more out of leading than you controlling the experience to match your vision. It also gives you the freedom to see things differently."

FIGUEIRA DE CASTELO RODRIGO, PORTUGAL

Project: Open Science Hub Portugal

Project lead: Dr Maria Inês Vicente, Scientific Coordinator of the Open Science Hub Portugal and international Project Manager of the H2020 Open Science Hub Network, Neuroscience PhD

The municipality of Figueira de Castelo Rodrigo is a low-density territory close to the border between Portugal and Spain, with limited job opportunities and no higher education institutions nearby. To put this into perspective, there are 12 people per sq. km there compared to Lisbon, which hosts 6000 people per sq. km. Despite having lots of natural scientific research potential including two UNESCO world heritage sites, there is a large divide between the public and the science that surrounds them. This sentiment is reflected in the 2013 Eurobarometer opinion poll on RRI which showed that most European citizens, despite feeling that research and innovation should incorporate public dialogue, do not feel adequately informed about the science and technology topics of the day (Eden, 2014).

Attempting to bridge this gap are the team at *Open Science Hub Portugal* (*OSHub-PT*), led by Dr Maria Vicente. The *OSHub-PT*, a project from the Municipality of Figueira de Castelo Rodrigo in collaboration with the University of Leiden (The Netherlands), began in 2017 and seeks to create collaborative learning spaces based on the principles of RRI: engaging communities currently excluded from engaging with Science Technology Engineering Arts and Maths (STEAM) (Vincente et al. 2021). Over time the *OSHub-PT* team has formed partnerships with local schools, Figueira de Castelo Rodrigo's general population and other stakeholders (families, universities, research institutes, industry, enterprises, media, local governments, civil society organizations, and wider society) to develop an exciting range of projects. Their offering includes educational science and communication projects for school children, as well as training for classroom teachers to ensure sustainability and scalability of innovative educational practices that are based on STEAM projects and follow Open Schooling approaches, where schools act as active agents for collaboration between stakeholders, by engaging in real-life projects that meet societal needs.

The *OSHub-PT* also bases its action on community-led research principles, which aims to develop sustainable citizen science projects. Here the *OSHub-PT* began by collaborating with the international project Drinkable Rivers (2021), to monitor the water quality of local streams and rivers with the help of the local population. Recently, the *OSHub-PT* started a new citizen science project, putting a call out to citizens to identify the local challenges they would most like to see addressed. The answers from this call will be turned into research priority areas and used to shape a later national call for researchers to come to the area to address the priority areas identified. After the initial year of funding for this project, the aim is to develop citizen science projects that mean the work the researchers start to address local challenges can be continued and sustained by residents of the area.

Maria also described their informal Science Engagement work, including the 'Figueira Circular' project. The environmentally focused initiative is based on the principles of circular economy to promote more sustainable consumption of plastics and recycling. Residents were encouraged to bring in the waste from their homes so it could be turned into useful long-lasting objects e.g., turning disposable bags into fabrics to create reusable tote bags or notebooks. In exchange for engaging with the initiative, participants would also receive a special local coin named "Sustento" that could be used to buy specific long-term items - "it's all about building the circle" Maria confirms.

We then went on to discuss how exactly the *OSHub-PT* had been able to deliver such successful engagement projects. She described what I understand to be a well-considered and person-centred approach, stating that *OSHub-PT* is about making science "a relevant tool to tackle local relevant challenges". The *OSHub-PT* team aims to find ways to work with local communities, to identify and understand the challenges they are facing and then see how science could be used to address these challenges, in this way science becomes relevant to their everyday lives "and not just a subject that they hear about from a distant world". In this way, the needs of the community come first and any engagement with, or communication of science, is tailored to meet those needs, rather than going to excluded communities with preconceived ideas for engagement which assume what their needs will be or what they should find important to satisfy our own motivations, as is often the case.

Offering a similar perspective to the work of Bangalore X, Maria, who is originally from Lisbon and was initially considered an outsider, quickly realised that the most important thing they needed to do was build trust with the local community. Maria explains that building trust requires patience and entering excluded communities with a willingness to serve in ways that are meaningful to them.

> "If you are able to support the local community in meeting their immediate needs in the short term, this can open the door for projects' representatives of the project to propose new initiatives and engagement activities that people will want to participate in later on."

For example, after a year of working with local schools, supporting teaching staff and volunteering at local fairs, when a new subject was added to the curriculum 'Citizenship and Development', senior leadership staff were open to hearing *OSHub-PT*'s ideas for developing the curriculum collaboratively with class teachers, based on an Open Schooling approach. At its heart, Maria stresses, *OSHub-PT* is about "building enduring social and human relationships". It is the strength of the relationships the team has built with the community, local institutions and even politicians, that have ensured their success.

Maria clearly loves what she does and is passionate about the need for people to constantly put themselves into the shoes of others. "You have to look at the problem through the eyes of the different stakeholders", she told me.

> "Really understand their daily needs, wants, values and relationships. Start first with the relevance - what are the needs here - and then build your strategy. There is no strategy without the needs and those come from the people."

It reminds us that no matter how exciting the initial idea you or external collaborators have, your primary concern must be: how it would be relevant to the community you are trying to reach and how you can serve them best?

PORTSMOUTH, ENGLAND

Project: The Tactile Universe at the Institute of Cosmology and Gravitation, University of Portsmouth

Project lead: Dr. Nicolas Boone - vision impaired astronomer and outreach and public engagement officer

The UK maintains a global reputation for having high scientific capacity and a strong base for research and development. Under the surface, however, are gross imbalances in the distribution of research and development funding within and between nations. This has created pockets of underdevelopment, exacerbating existing social inequalities found along intersecting issues of class, race, disability, sex and gender that pervade the nation (Blundell et al. 2020; Dawson, 2019; Forth and Jones, 2020).

Relevant to this particular outreach project is the fact that an estimated 2 million people in the UK are living with various forms of sight loss. As of 2017, approximately 350,000 people were on the registers of blind and partially sighted people and 173,735 were registered as severely sight impaired and 176,125 are registered sight impaired. Around ⅓ of registrants' report having an additional disability and less than 30% report being able to find employment or the support they need (NHS Digital, 2017; Royal National Institute of Blind People, 2021). It is against this backdrop of disheartening statistics that the unique qualities and positive impact of outreach and engagement projects like the *Tactile Universe* can be fully celebrated.

Led by Nicolas Bonne, an astronomer and public engagement officer who is vision impaired himself, the *Tactile Universe* uses 3D printed tactile images of galaxies to engage school-aged children in astrophysics research. The first iteration of the project, he explained, was trialled with a support group for older visually impaired people in Portsmouth. However, this trial received a lot of push back with most participants expressing an unwillingness to engage with science due to negative experiences with science education as children. They revealed how teachers, friends and family members had explicitly excluded them from learning about science with statements like "No, you don't need to learn about this, it'll be too difficult for you." The impact of these negative interactions had followed them into old age, likely reinforced by the aforementioned lack of support for the blind and visually impaired and an unspoken sense that they are unable to meaningfully contribute to science. Their testimonies, alongside research like the longitudinal ASPIRES project at King's College London (Archer et al. 2020) illustrate how important and effective early positive science communication and engagement intervention can be, with childhood as a site for developing either lifelong love or disinterest in science. As such, Nicolas and his team turned their attention to working with local schools with provision for vision impaired students to deliver the updated version of the project.

The project also highlights the importance of collaboration, involving members of your target audience in the development or your project as early as possible. No community is

homogenous, and Nicolas described how the involvement of a local support group helped the project to iteratively improve their offering to address the heterogeneity of the experiences of the blind and vision impaired students. A key part of this was providing participants with a range of methods for engagement, for example, either using the original photographs with tactile images as well as verbal and written descriptions.

Furthermore, by testing the projects with small groups of students first they were also able to create lesson plans that both vision-impaired and non-vision impaired students could complete simultaneously with the use of everyday objects to, for example, help describe the solar system, making the activities as inclusive as possible. Class teachers anecdotally reported increased engagement for both vision impaired and non vision impaired students who were able to work together in ways previously unknown to them. For Nicolas, creating adaptive materials for science lessons has made clear that inclusion benefits everyone:

> "The biggest thing, I think, is that accessibility helps everybody. So, you may start off designing something to work for a specific group of people that in the long run it's going to improve everything for everybody. Even though our models are specifically targeted at vision impaired people. People with perfect vision get a whole lot out of them as well because it's a new way of thinking about something that they might already be familiar with and generates a deeper level of interaction."

The *Tactile Universe* project shows us that both students and practitioners become better, and in this case more innovative, scientists when we operate with principles of equality and fairness in mind.

CONCLUSION

Engaging excluded communities with science remains a challenge for researchers and practitioners. Looking back to the history of science communication and public engagement, particularly the socio-political contexts and unequal power relations that dominated the 15th century onwards, can help us to understand contemporary patterns of exclusion from science today. These histories show how the dissemination of western knowledge was used to dominate native peoples and erase their knowledge traditions. As Lindy Orthia notes, this exclusion of minoritised people from science is perpetuated if we only think of science in narrow, Eurocentric and temporally recent terms, and emphasises the importance of creating more polyvocal histories of science as a possible remedy.

Having moved on from top-down corrective process of communication to dialogue and two way engagement with the public, for the most part, engagement practices of today are increasingly turning their attention to issues of inclusion, equality and diversity. The aim here is to ensure that all members of society have access to the construction, communication and use of scientific knowledge and, due to the revealing effects of a global pandemic, the need to address the life-limiting inequalities within our societies has become unavoidable. Literature on contemporary science communication and engagement practices reveals the messy relationship between science and society and how engagement initiatives, including those designed to be more inclusive, can perpetuate the exclusion of marginalised groups if we aren't willing to challenge our own assumptions and biases and reimagine what successful engagement looks like.

The case studies featured here remind us to look beyond academia and the literature, to local experts for examples of best practice. Their experience and community centred approaches illustrate what can be achieved if we are willing to challenge our own motivations when undertaking this work and ensure that the needs of the communities we serve are our primary focus. They also revealed the importance of; taking the time to build trust that goes both ways, early intervention, making science useful and relevant to people's everyday lives rather than our own interests, challenging preconceived ideas of what success looks like and co-producing each stage of the process to ensure sustainability, when planning our own work. By bringing their work together it also makes clear that the way exclusion presents is heavily context dependent, meaning we should be wary of any models of inclusion that suggest a one size fits all approach is either possible or preferable. As such, the learnings here should not be viewed as a to-do list or the final word on what inclusion should look like in your own practice, but as suggested points for consideration before you begin.

Ultimately, we must accept that there are no shortcuts or quick fixes to true inclusion. In many cases we are trying to address generations worth of inequality and marginalisation that has impacted some communities' relationship with science. As the world and the way we use science changes, so will the needs of marginalised communities and the types of social exclusion they face. Although certainly not exhaustive, we hope this perspective review and the presentation of cross-cultural case studies has begun to express why we should and how

we can think more critically about the very nature of exclusion itself: how and why it happens and who is affected, as well as how can we engage with instances of exclusion beyond a framework of overcoming barriers to something more complex which reflects the experiences of excluded communities more accurately and unapologetically centres their needs in both research and practice.

BIBLIOGRAPHY

Almeida C., Brito, F., Ferreira, R., Massarani, L. and Amorim, L. (2015). Centros e Museus de Ciência do Brasil. Rio de Janeiro: ABCMC, Casa da Ciência/UFRJ e Museu da Vida.

Archer, L., Moote, J., MacLeod, E., Francis, B., and DeWitt, J. (2020). ASPIRES 2: Young people's science and career aspirations, age 10-19. London: UCL Institute of Education. Available from: https://discovery.ucl.ac.uk/id/eprint/10092041/15/Moote_9538%20UCL%20Aspires%202%20report%20full%20online%20version.pdf.

Attar, A. and Genus, A. (2014). Framing public engagement: A critical discourse analysis of GM Nation?. Technological Forecasting and Social Change, 88, pp.241-250.

Bauer, M. W., Allum, N., & Miller, S. (2007). What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. Public Understanding of Science, 16(1), pp. 79–95. Available from: https://doi.org/10.1177/0963662506071287.

Blundell, R., Costa Dias, M., Joyce, R. and Xu, X. (2020). COVID-19 and Inequalities, Fiscal Studies, 41(2), pp. 291–319. Available from: DOI: 10.1111/1475-5890.12232.

Bodmer, W.F. (1985). The Public Understanding of Science. Report of a Royal Society ad hoc Group endorsed by the Council of the Royal Society. London: Royal Society. Available at: https://royalsociety.org/-/media/Royal_Society_Content/policy/publications/1985/10700.pdf

Bond, M., Maram, H., Soliman, A., & Khattab, R. (2012). Science and innovation in Egypt. London: The Royal Society.

Bristow, W (2017). Enlightenment. In: Zalta, E.N, The Stanford Encyclopedia of Philosophy (Fall 2017 Edition). Available from: https://plato.stanford.edu/archives/fall2017/entries/enlightenment/.

Burns, T.W. , O'Connor, D.J. , and Stocklmayer, S.M. (2003). Science communication: A contemporary definition. Public Understanding of Science, 12, pp. 183-202.

Carey, D. and Festa, L. (2009). The Postcolonial Enlightenment. Eighteenth- Century Colonialism and Postcolonial Theory. New York: Oxford University Press.

Chakraborty, A., Raman. U and Thirumal, P. (2020). Tracing science communication in independent India. In: Gascoigne T., Schiele, B., Leach, J., Riedlinger, M., Lewenstein, B., Massarani, L and Broks, P. (Eds.) Communicating Science: A Global Perspective. Australia: Australian National University, ANU Press.

Condorcet, M.De. (1795). Outlines of an Historical View of the Progress of the Human Mind: Being a Posthumous Work of the Late M. de Condorcet. London: J. Johnson. Available from: https://play.google.com/books/reader?id=SLs8AAAAYAAJ&hl=en_GB&pg=GBS.PP11

Dawson, E. (2014). Reframing social exclusion from science communication: moving away from 'barriers' towards a more complex perspective'. JCOM ,13 (02), C02. Available from: https://doi.org/10.22323/2.13020302.

Dawson, E. (2019). Equity, Exclusion and Everyday Science Learning The Experiences of Minoritised Groups. Oxford: Routledge.

Drinkable Rivers. (2021). Drinkable Rivers: Towards a world with drinkable rivers [Online]. Available from: https://drinkablerivers.org/

Durant, J. (1993). "What Is Scientific Literacy?," in J. Durant and J. Gregory (eds) Science and Culture in Europe, pp. 129-138. London: Science Museum.

Durant, J. , Bauer, M. , Midden, C. , Gaskell, G. and Liakopoulos, M. (2000). "Two Cultures of Public Understanding of Science," in M. Dierkes and C. von Grote (eds) Between Understanding and Trust: The Public, Science and Technology, pp. 131-156. Amsterdam: Harwood Academic Publishers

Eden, G. (2014) Special Eurobarometer 401: survey summary on responsible research and innovation, science and technology. Journal of Responsible Innovation 1(1):129–132. Available from: https://doi.org/10.1080/23299460.2014.882553,

European Environment Agency. (2001). Late Lessons from Early Warnings: The Precautionary Principle 1896–2000. Copenhagen: Office for Official Publications of the European Communities, pp. 157-167.

Evangelista, R. and. Kanashiro, M.M. (2004). Science, Communication and Society in Brazil, the Narrative of Deficit. Journal of Science Communication. 3(4), Available from: DOI: https://doi.org/10.22323/2.03040903.

Forth, T. and Jones, R.A.L. (2020). The Missing £4 billion: Making R&D work for the whole UK. London: Nesta.

Gascoigne, T and Schiele, B. (2020). Communicating Science. A Global Perspective. In: Gascoigne T., Schiele, B., Leach, J., Riedlinger, M., Lewenstein, B., Massarani, L and Broks, P. (Eds.) Communicating Science: A Global Perspective. Australia: Australian National University, ANU Press.

Goodman, G.K. (2002). Japan and the Dutch 1600-1853. Abingdon: RouteledgeCurzon.

Hannam, J. (2011). Explaining the world: Communicating science through the ages. In W. Bodmer (Author) & D. Bennett & R. Jennings (Eds.), Successful Science Communication: Telling It Like It Is (pp. 31-44). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511760228.005.

House of Lords, Select Committee on Science and Technology. (2000). Science and Society, Third Report. London. Available from: https://publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3802.htm.

Irwin, A. and Wynne, B. (1996). Misunderstanding science? The public reconstruction of science and technology. Cambridge: Cambridge University Press.

Irwin, A. (2003). Citizen science: a study of people, expertise and sustainable development. London: Routledge.

Irwin, A. (2014). From deficit to democracy (re-visited). Public Understanding of Science, 23(1), pp.71-76.

Jasanoff, S. (2004). The Idiom of Co-production. In: Jasanoff, S (Ed) States of Knowledge. London: Routledge, pp. 1-12.

Jasanoff, S. and Kim, S.-H. (2009). Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. Minerva 47(2), pp.119–146.

Jasanoff, S. (2015). Future Imperfect: Science, Technology and the Imaginations of Society. In: Jasanoff, D. and Kim, S.-H (eds.) Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power. Chicago, IL: The University of Chicago Press, pp. 1–33.

Jones, R.A.L. (2011). Introduction: Public Engagement is an evolving science policy landscape, in: Bennet, D. J. and Jennings R. C. (Eds). Successful Science Communication: Telling It Like It Is. Cambridge: Cambridge University Press.

Kim, Y.Y. (2007) Ideology, Identity, and Intercultural Communication: An Analysis of Differing Academic Conceptions of Cultural Identity. Journal of Intercultural Communication Research, 36(3), pp. 237-253. Available from: DOI: 10.1080/17475750701737181.

Kuritz, H. (1981). The Popularization of Science in Nineteenth-Century America. History of Education Quarterly, 21(3), pp.259-274.

Landini, F., Malerba, F. and Mavilia, R. (2015). The structure and dynamics of networks of scientific collaborations in Northern Africa. Scientometrics, 105(3), pp.1787-1807.

Lock, S. (2011). Deficit and Dialogues: science communication and the public understanding of science in the UK, In: Bennet, D. J. and Jennings R. C. (Eds). Successful Science Communication: Telling It Like It Is. Cambridge: Cambridge University Press.

Massarani, L., de Castro Moreira I. and Lewenstein B. (2017). A historical kaleidoscope of public communication of science and technology'. JCOM, 16 3), E. Available from: https://doi.org/10.22323/2.16030501.

Massarani, L and de Castro Moreira I. (2020). Brazil: History, significant breakthroughs and present challenges in science communication. In: Gascoigne T., Schiele, B., Leach, J., Riedlinger, M., Lewenstein, B., Massarani, L and Broks, P. (Eds.) Communicating Science: A Global Perspective. Australia: Australian National University, ANU Press, pp. 155 - 174.

Matias, A., Dias, A., Gonçalves, C., Vicente, P. N. and Mena, A. L. (2021). 'Science communication for social inclusion: exploring science & art approaches'. JCOM 20(02), A05. Available from: https://doi.org/10.22323/2.20020205.

Mazzocchi, F. (2006). Western science and traditional knowledge. EMBO reports, 7(5), pp.463-466. Available from: doi: 10.1038/sj.embor.7400693.

Miller, S. (2001). Public understanding of science at the crossroads. Public Understanding of Science, 10(1), pp.115-120.

NHS Digital. (2017). Registered Blind and Partially Sighted People [Online]. 7th December 2017. Available from: https://files.digital.nhs.uk/publication/o/j/registered_blind_report.pdf.

Orthia, L. A. (2020). 'Strategies for including communication of non-Western and indigenous knowledges in science communication histories'. JCOM 19 (02), A02. https://doi.org/10.22323/2.19020202.

Outram, D. (2019). The Enlightenment. (4th Ed.). Cambridge: Cambridge University Press.

Owen, R., Macnaghten, P. and Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. Science and Public Policy, 39(6), pp.751-760. Available from DOI: doi:10.1093/scipol/scs093.

Parliamentary Office for Science and Technology. (2003). Science and Society: Three Years On. Milbank, London: The Parliamentary Office of Science and Technology. Available from: https://www.parliament.uk/documents/post/13-may-proceedings.pdf.

Raj, K. (2007). Relocating Modern Science Circulation and the Construction of Knowledge in South Asia and Europe, 1650–1900. Houndmills, Basingstoke, Hampshire: Palgrave Macmillan.

Raichvarg, D. and Jacques, J. (1991). Savants et Ignorants: une histoire de la vulgarisation des sciences. Paris: Éd. Le Seuil, p. 8.

Rouse, J. (1990). The narrative reconstruction of science. Inquiry, 33(2), pp.179-196.

Royal National Institute of Blind People (2021). Key information and statistics on sight loss in the UK. Last updated: 1st September 2019. Available from: https://www.rnib.org.uk/professionals/knowledge-and-research-hub/key-information-and-statistics.

Schirato, T. and Yell, S. (1997). Communication and Cultural Literacy: An Introduction. Sydney: Allen & Unwin.

Scottish Government. (2020). 28th January 2020. Scottish Index of Multiple Deprivation 2020: introduction [Online]. Available from: https://www.gov.scot/publications/scottish-index-multiple-deprivation-2020/pages/5/.

Skidmore, T. E. (1988) The Politics of Military Rule in Brazil, 1964-1985. Oxford: Oxford University Press.

Smallman, M. (2018). Science to the rescue or contingent progress? Comparing 10 years of public, expert and policy discourses on new and emerging science and technology in the United Kingdom. Public Understanding of Science, 27 (6), pp. 655–673. Available from: DOI: 10.1177/0963662517706452.

Smallman, M. (2019). 'Nothing to do with the science': How an elite sociotechnical imaginary cements policy resistance to public perspectives on science and technology through the machinery of government', Social Studies of Science [Online]. Available from: DOI: 10.1177/0306312719879768.

Stilgoe, J., Lock, S. and Wilsdon, J. (2014). Why should we promote public engagement with science? Public Understanding of Science, 23(1), pp.4-15.

Sur, A. (2011). Dispersed Radiance: Caste, Gender and Modern Science in India. New Delhi: Navayana.

Thomas, G. and Durant, J. (1997). Why should we promote the public understanding of science? In: Shortland, M. (ed.) Scientific Literacy Papers. Oxford: Rewley House, pp. 1–14.

Vicente M.I. et al. (2021). Open Science Hub-Portugal: Toward Community Development, Innovation, and Well-Being Through Open Schooling. In: Sandu P., Tudisca V., Valente A. (eds) Co-creating in Schools Through Art and Science. SpringerBriefs in Research and Innovation Governance. Springer, Cham. https://doi.org/10.1007/978-3-030-72690-4_4.

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A. S. and Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sense-making, Journal of Research in Science Teaching, 38(5), pp. 529–552. Available from: DOI: 10.1002/tea.1017.

Watanabe, M. (2010). New wine must be put into new wineskins: The new keyword "Science Communication" has changed PUST policy in Japan. In: Proceedings of PCST2010 Conference in New Delhi. Available from: http://www.pcst.co/archive/paper/365.

Watanabe, M. (2017). 'From top-down to bottom-up: a short history of science communication policy in Japan'. JCOM 16(3), Y01. Available from: https://doi.org/10.22323/2.16030401.

Weigold, M. F. (2001) Communicating Science: A Review of the Literature. Science Communication, 23(2), pp. 164–193. Available from: doi: 10.1177/1075547001023002005.

Welsh, I. and Wynne, B. (2013). Science, Scientism and Imaginaries of Publics in the UK: Passive Objects, Incipient Threats. Science as Culture, 22(4), pp.540-566.

Wynne, B. (1995). Public Understanding of Science. In: S. Jasanoff, G. E. Markle, J. C. Petersen, and T. Pinch (eds.) The Handbook of Science and Technology Studies. Thousand Oaks CA: Sage. pp. 361–388.

Wynne, B. (1999). Knowledge in Context. In: Scanlon, E, Whitelegg, E and Yates, S. (eds.) Communicating Science: Context and Channels. London and New York: Routledge, pp. 4-13.

Wynne, B. (2005). Risk as globalizing 'democratic' discourse? Framing subjects and citizens. In: Leach, M, Scoones, I and Wynne, B (Eds.). Science and Citizens: Globalization and the challenge of engagement. London and New York: Zed Books, pp. 66- 82.

Wynne, B. (2006). Public Engagement as a Means of Restoring Public Trust in Science – Hitting the Notes, but Missing the Music?. Community Genetics 9, pp. 211-220

Yosso, T.J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. Race Ethnicity and Education 8(1), pp. 69–91.

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