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RE-EXAMINING SCIENCE COMMUNICATION:
MODELS, PERSPECTIVES, INSTITUTIONS

# Reorienting science communication towards communities

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**Abstract**

Communities are rarely seen as the ideal level at which to focus science communication efforts, compared to the individual, psychological or mass, societal levels. Yet evidence from allied fields suggests building interpersonal relationships with specific communities over time is key to meaningful engagement, so orienting science communication towards communities is warranted. In this paper, we argue this case. We review previous studies, identifying three existing models of community-oriented science communication, which we label *neighbourly*, *problem-solving* and *brokering*. We illustrate the effectiveness of the *problem-solving* approach and the desirable ideal of *brokering* using recent examples of community-oriented science communication from Australia.

**Keywords**

Community action; Science communication: theory and models

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## Introduction

Most science communicators would say they serve the community, but what do we mean by that word? In our discipline and profession, the term 'community' is frequently used in the singular generic, in a similar way to 'the public' or 'society'. If pluralised, it often denotes groups of people (or small regions) who might be of interest to communicate with on some specialised outreach or consultation projects, but inherently only of specific, localised significance. Communities are rarely seen to be a standard organising principle for science communication activities. Nor are they routinely seen as the ideal level at which to focus science communication efforts. In this paper, we seek to challenge those norms and propose re-centring communities within science communication.

While sociological studies foundational to science communication engaged with communities in deep ethnographic detail [e.g. studies in Irwin and Wynne, 1996], recent high profile science communication research papers barely mention communities. For example, in a 2013 special issue of *PNAS* devoted to 'the science of science communication', all papers focused on the individual, psychological

level or the mass, societal level, usually only using the word 'community' in the singular, or more commonly using it to refer to the 'scientific community'. The word was neither used in the editorial [Fischhoff and Scheufele, 2013] nor in editor Scheufele's [2013] contribution, despite its title 'Communicating science in social settings'. Evelend and Cooper's contribution to the issue proposed an integrated model of communication influence on beliefs, but it overtly focused on individual factors, stating they would leave 'for future theorizing the role of factors such as network structures and community-level influences' [Eveland and Cooper, 2013, p. 14093]. Dietz's paper focused on public deliberation and identified the importance of what he called 'community expertise' [Dietz, 2013, p. 14084], but did so cursorily and illustrated the concept with a society-level example about 'members of the public'. A paper by Kahan [2015] on the same topic ('the science of science communication') used the word 'communities', but it did not engage with its meanings for science communication. Kappel and Holmen's [2019] taxonomy of science communication aims mentioned communities only in the context of 'audiences' understanding local environments. For a body of literature framed by its authors as summarising the key evidence-based principles of science communication, the idea of communities is conspicuous by its absence.

### *Communities as a priority in allied fields*

Yet in other fields, there is a growing, if belated, understanding of the centrality of communities to any science-society relationship or enterprise. Biomedical researchers have slowly acknowledged the lack of human diversity in genetic studies and clinical trials, and when seeking to increase that diversity, found the most successful way to recruit wary and mistrustful research participants is to build long term, meaningful relationships with communities [Bentley, Callier and Rotimi, 2017; Hughson et al., 2016; Oh et al., 2015]. This is particularly the case when researchers have sought to increase diversity in ethnic heritage studies, only to realise members of target ethnic groups harbour deep-seated mistrust of Western science and medicine for a range of reasons, including awareness of Western scientists' past unethical actions towards ethnic minorities. To navigate these factors, researchers proposed (among other measures) ensuring research teams are diverse and include core members belonging to the communities of interest; conducting recruitment and research within community accessible spaces; and involving communities in research design and general communication about the research field [Bentley, Callier and Rotimi, 2017; Hughson et al., 2016; Oh et al., 2015]. In other words, researchers should place communities at the forefront of their endeavours.

In a more general sense, successful communication outside the Western mainstream is frequently community-oriented rather than pitched at individual or mass levels, and is communicated by community members within their own communities. This includes health communication with First Peoples on the continents of Australia and Africa, for whom the community level is one of the most important and common levels for discussing issues, building knowledge and making decisions [Finlay, Raman et al., 2021; Bagamoyo College of Arts et al., 2002; Chandler et al., 2015; Finlay and Wenitong, 2020; Junyent and Rasekoala, 2019; Levy, 2015]. The growing field of knowledge brokering is similarly predicated on building interpersonal relationships, in this case primarily between researchers and

policy-makers. Such relationships are essential for research to be applied in decision-making, particularly in high stakes areas such as environmental management [Cvitanovic et al., 2017; Michaels, 2009]. This is a specific kind of community-oriented science communication, where the communities of interest are government departments, research institutes, and other organisations.

### *Lessons for science communicators*

This work reveals the critical importance of deep, interpersonal relationship building at the level of shared identity — community — for forging the trust that enables meaningful conversations to take place. Some science communicators concerned about public information overload, lack of public trust in experts, the influence of fake news and social media bots may seek a one-size-fits-all, whole of society solution to change the state of affairs. Yet the evidence from other fields tells us there is rarely such a thing, and deep change often comes at the community level, where people can discuss, deliberate, challenge, question, reconsider and converse about matters at length with trusted others, or at least with people they understand and are mutually co-invested in. Social change is connected to a sense of self-efficacy, which on political matters means addressing the profound disenfranchisement and a lack of social power many people face, often from years or centuries of marginalisation, exploitation and oppression [Hardina, 2006; Rusch, Walden and DeCarlo Santiago, 2020]. The detail of such matters is best addressed at the community level, even if changing structural oppression also requires action at the broader level of the nation state.

This also demonstrates the unique, central role to be played by communicators who are already part of communities within which, and with whom, they are communicating. The science communication sector will benefit substantially if professional bodies, educators, trainers, consultancies and employers more actively invite, foster and promote diversity within our ranks because of the unique networks people are part of. Of course, some diversity in ethnicity, culture, language, gender, sexuality, class, religion and disability is already present among science communicators, at least to an extent, but its deep value and importance seems inadequately understood and often celebrated only at the superficial level of acknowledging its existence. This superficial measure aside, science communication remains profoundly exclusionary in complex ways that prohibit greater diversity and perpetuate marginalisation, as numerous authors have recently noted [Finlay, Raman et al., 2021; Roberson and Orthia, 2021; Brown, Roche and Hurley, 2020; Canfield et al., 2020; Dawson, 2019; Márquez and Porras, 2020; Orthia, 2020; Rasekoala, 2020]. Much more work needs to be done to redress this, and it will likely go hand-in-hand with a communities-oriented approach because of the deep engagement that it entails. Polk and Diver [2020] have demonstrated some success in this by centring equity for marginalised communities in communications framing. Wenzel [2020] advocates for community-centred journalism built on interpersonal relationships and intimate knowledge of shared place for similar, equity-based reasons.

In this paper, we argue that as science communicators, we must attune ourselves to the community level in more profound ways, and with the concerted attention to diversity that implies. This is necessary if we want our impact to be lasting —

whether we want to change attitudes and behaviours on controversies relevant to science, to foster democratic voice in policy or public governance of science, or simply to promote rich and vibrant exchange of ideas among people. We first review previous literature from the science communication research corpus, identifying three existing models of community-oriented science communication. We then present some recent Australian examples from public health communication, air pollution management and science centre inclusivity, which further elaborate the models and illustrate the value of community-centred approaches. In our conclusion, we draw together emergent lessons and suggest ways forward.

## Previous science communication studies focused on communities

To identify existing literature on this topic, we searched the Scopus database for the words 'community' or 'communities' in all years, limiting our search to the four main science communication journals: *International Journal of Science Education Part B: Communication and Public Engagement*, *Journal of Science Communication*, *Public Understanding of Science*, and *Science Communication*. The approximately 300 returned hits were manually refined to 37 after selecting papers that meaningfully engaged with the concept of non-academic 'communities' in their abstract and full text. Studies using a single community as a convenient study site, or using 'community' as a synonym for 'public', were excluded. Nine of those remaining concerned communities' attitudes or communication preferences, while 28 detailed science communication activities and programs. The full list is referenced in supplementary material.

Within the 37 papers, the working definition of 'community' was almost always geographic, and sometimes further defined by common demographics, identities, experiences, professions or interests. These definitions are in concert with studies of communities in other fields [e.g. Mills, 2004; Ragin et al., 2008; Simon, 2016]. Face-to-face interactions, or sometimes intensive online interactions, are often implied in definitions of community [Duchsherer et al., 2020; Mills, 2004], suggesting that building and maintaining interpersonal relationships over time is core to sustaining community. An active, multi-directional, sustained communication culture in fact seems to be a core principle for building and defining communities. As a result, Kim, Cho and Song [2019, p. 40] note community engagement is 'historically and socially situated', and each communication culture will operate differently. In addition, Roth and Lee [2002] use a community example to contend that phenomena such as science literacy are inherently collective, and socially and physically situated, not properties of individuals. This inter-relationship of knowledge, communication and communities suggests communities should be a prime focus for science communication activities.

Among the 28 program-detailing studies, we identified three models of existing community-oriented science communication, which we labelled *neighbourly*, *problem-solving* and *brokering*. The models complement rather than overlap familiar concepts such as one-way, dialogue or participatory science communication, any of which may be incorporated into community-oriented activities at different points. The same is true for 'traditional citizen science' or 'community-based participatory research'; examples of these may appear in any of the three models, though the former is most likely to coincide with *neighbourly* science communication [e.g.

Roger and Klistorner, 2016] and the latter with *problem-solving* [e.g. Hoover, 2016]. The primary difference between our three models is their priority: *brokering* science communication is primarily concerned with serving the community's interests, while *neighbourly* approaches tend to serve the interests of science, and *problem-solving* approaches prioritise practical solutions to a problem.

*Neighbourly* programs are not unusual among science communication outreach activities, and many more examples than the five we found would likely have appeared in our literature search if they had used the word 'communities' in their abstract. *Neighbourly* programs have a community-centred focus only in the mundane sense that offline science communication activities are inherently local to somewhere. For example, members of one university department characterised themselves as serving the local community because they organised forums city residents could attend, and encouraged dialogue between residents and researchers [Ward, Howdle and Hamer, 2008]. Organisers of a 'Nerd Nite' event took science communication to a city pub, 'to bring science to the target audience instead of expecting the target audience to go to places of science' [Tan and Perucho, 2018, p. 823]. While undoubtedly an important aspect of science communication, this approach is relatively weakly community-oriented because science communicators may engage in interpersonal conversations with local residents, but they do not specifically set out to build and maintain sustained long-term relationships with specific groups of people. *Neighbourly* aims are typically broad, to promote 'engagement with science' or similar, and while *neighbourly* science communicators are identifiable because they are affiliated with science-related institutions, we cannot necessarily identify other communication partners. That said, such programs may be the starting point for relationship-building with community groups. To promote greater community inclusion, some *neighbourly* programs have also worked with existing community organisations [Canovan, 2020].

*Problem-solving* science communication, in contrast, concerns specific risks to the local environment or to community members' health and safety. *Problem-solving* activities are strongly community-oriented for strategic or principled reasons, and seek a practical outcome of policy or social change on an issue. They differ in whether they are initiated by community members [e.g. Sannazzaro, 2016] or by external scientific or technical authorities [e.g. Yli-Kauhaluoma and Hänninen, 2014], though some programs initiated by external authorities become community-driven once long-term, two-way relationships are built with existing community networks [e.g. Boyer, Roth and Wright, 2009]. An essential component of this transformation is community members' ability to co-design the program based on their own experiences and priorities, and thus to commence co-producing its future iterations. Indeed, *problem-solving* programs frequently will not gain traction if they are imposed from outside because of community members' desire to protect local autonomy, including in modes of communication and decision-making [Griffin and Dunwoody, 1997; Putsche et al., 2017]. Kim [2012] argued that even global problems such as climate change can only be solved at the community level, with people working together to co-design solutions to it as a shared practical problem. Conversely, a weak sense of community may lead to failed community-oriented ventures when imposed from outside [Garland, 1999]. These are key reasons for supporting a genuinely community-embedded approach to science communication [Ofori-Parku, 2018]. However, *problem-solving* programs can drift away from a community orientation when competing interests are

involved. For example, a Colombian science centre developed a program to work with local residents living on a garbage dump to raise awareness of health risks and to redevelop the area under community control. The program was successful in raising awareness and redeveloping the area, but government relocation policies left community members in equally poor conditions elsewhere, prompting the study's author to recommend that science centres involved in community programs must consider the big picture carefully and adapt to supporting communities in new ways [Aguirre, 2014].

*Brokering* programs share the diffuse aim of 'STEM engagement' with *neighbourly* science communication, but they operate from within communities to enhance communities' opportunities for engagement. In this model, science communicators who share an identity with the target community, or members of the community who are specifically trained, act as *brokers*, matching community members to relevant science communication activities and resources. They may go further to co-design novel science communication initiatives with other community members. *Brokering* programs may consist of individual brokers [e.g. Allen et al., 2020], community-located facilities such as knowledge rooms [e.g. Streicher, Unterleitner and Schulze, 2014], camps for people from particular Indigenous or ethnic communities [e.g. Cheeptham et al., 2020] or technologies enabling community access to science-related information [e.g. Coleman, 2012]. Science communicators involved with implementing these programs emphasise the importance of being open to community interests and needs, tailoring activities and facilities to community norms, and welcoming community members who are less interested as well as the enthusiastic. Having a particular community lead their own communication journey, rather than engaging with communities to achieve a preconceived agenda, is what fundamentally differentiates *brokering* from *neighbourly* and *problem-solving* science communication.

Of the 28 papers studying specific programs, 18 fit the *problem-solving* model, which parallels well-established approaches to community change in other fields. *Brokering* science communication (5 papers) is the most novel, most community-oriented of the three models, and we suggest researchers and practitioners invest more in it. In the next section, we describe three recent examples from Australia that illustrate the value of community-oriented science communication under these two models. We start with two *problem-solving* approaches: programs for communicating health information with ethnic minority communities; and a case study of an environmental health problem solved by community-based engagement in a rural town. Our third example concerns a co-designed *brokering* approach to better welcoming local teenagers within a science centre.

## Examples of community-oriented science communication

### *Science and health communication for ethnic minority communities*

The need to effectively communicate scientific information to communities has become more apparent and pressing during COVID-19, considering the disproportionate impact of the pandemic on various minority communities [Finlay and Wenitong, 2020; Grills and Butcher, 2020; Tai et al., 2021]. There is a need to move from a 'deficit' or negative model of science communication, wherein minority groups need to be 'talked to' about negative attributes that they should

modify or practices they must adopt, to a more positive and engaged mode, where the aspects of a community's behaviour that can help in addressing a health threat are acknowledged [Airhihenbuwa et al., 2020]. Moreover, the content of scientific messages and the means by which they are communicated require tailoring to account for differences in culture, values, literacy, and concept perception [Scrimshaw, 2019]. Health communication needs to go beyond translating information intended for the general public and conveying it through usual online, media, and print channels. Instead, communities need to be engaged before, during, and after the onset of a pandemic to build trust and develop appropriate communication strategies and channels [Crouse Quinn, 2008]. Scientific communication *for* communities must be done *with* communities: coordinating with community leaders to sensitively relay information and model desirable practices for limiting infection spread; and working closely with in-community organizations [Van Bavel et al., 2020] to ensure that the key messages reach the most marginalised, disenfranchised, and vulnerable community members.

There have been successful efforts to engage with communities for communicating various forms of health information, lessons which can be used in designing and conducting effective communication strategies for minority groups during a pandemic. A good example of health communication for culturally and linguistically diverse (CALD) communities is the Pink Sari project [Macnamara and Camit, 2017]. Its purpose is to identify and overcome challenges and barriers to effective communication with CALD communities, with the goal of persuading 50-to-74 year-old women from Indian and Sri Lankan backgrounds in New South Wales, Australia to regularly undertake mammograms, or breast cancer screening. The project began with formative research, establishing a steering group with representatives from refugee health service providers and breast cancer screening clinics servicing areas with relatively large Indian and Sri Lankan migrant populations. As part of its formative research, the group also performed a global literature review on cancer detection programmes for CALD communities, surveys and focus groups among Indian and Sri Lankan women, and a cultural competency study in a breast screening clinic. From the findings on cultural beliefs of Indian and Sri Lankan women about breast cancer and their concerns regarding screening, the team developed health communication strategies focused on establishing community partnerships, identifying community champions, planning and designing programs collaboratively with the community, and having native speakers write information materials. The project then implemented a range of activities ranging from co-creating a logo, launching a website and Facebook page, conducting community forums and information sessions, marching in cultural parades, and holding a fashion show and photo exhibition. Through these efforts, they have managed to engage with more than 10,000 women of Indian or Sri Lankan backgrounds. In the year the project was implemented, there was also an 8% increase in the total number of New South Wales Indian and Sri Lankan women aged 50–69 having a mammogram [Macnamara and Camit, 2017].

For the current COVID-19 pandemic, there have been some efforts by health behaviour change scientists to engage with CALD communities. Wild et al. [2020] discuss some challenges in communicating COVID-19 information to minority communities in Melbourne, Australia, which were identified through dialogue events they initiated. These include a lack of: information translated into all spoken languages in Melbourne; contextualised health messages; engagement with CALD

groups for design and evaluation of informational materials; trusted messengers and CALD voices in the government and health departments; and accessible communication channels. Their work has highlighted the importance of going beyond simply translating COVID-19 health information, and instead ensuring that there is partnership with community leaders to integrate context into the translation, account for multiple dialects, and address misconceptions regarding COVID-19 tests. They have also underscored the critical role of religious and faith leaders in CALD communities in promoting and modelling desired behaviours, in addition to providing options for attending religious ceremonies online. CALD community leaders should also be engaged, given their familiarity with the communication platforms commonly used by community members and their ability to reach out to other members by phone or online videos. Scientific and medical communication should also be sensitive enough so as not to single out communities as the likely source of an outbreak, in order to prevent racism and stigma and to ensure that community members seek testing. Finally, it is vital to create a national advisory body for CALD communities that will not only support successful communication but also ensure that voices of new migrant groups, particularly those without established networks and representation, are heard.

Although COVID-19 is a global problem, a communities-oriented *problem-solving* approach involving co-design principles is a critical part of managing it, especially in communities and regions that are disproportionately affected. Methods and insights from the Pink Sari project and the community engagement work of Wild et al. [2020] can serve as bases for communicating critical COVID-19 information to other minority communities, ensuring that they are positioned not just as recipients, but also as co-creators and co-disseminators of health information.

### *Problem-solving through co-design of air quality monitoring systems*

In 2015, Kahan exhorted science communication be adopted as the 'new political science', needed by 'mature liberal democracies…suited to the distinctive challenge of enabling citizens to reliably recognise the enormous stock of knowledge that their freedom and diversity make possible' [p. 10]. Yet science communication still does not seem to provide mechanisms for communities to recognise and apply their enormous stock of knowledge. Nor do communities seem to be considered collaborators or co-deliverers of science communication initiatives. If communities were involved in co-design of science communication, what might that look like?

The concept of co-design can be applied to a broad range of fields, from literal design through to addressing social and economic issues [Szebeko and Tan, 2010]. At heart, co-design involves the people who will be the end users of a product, service or policy. They are involved throughout the development process as genuine collaborators [Sanders and Stappers, 2008]. One example of co-design between scientists and community members is that of the Environmental Protection Agency (EPA) in Victoria, Australia after the Hazelwood Mine incident.

On 9 February, 2014, a fire started at the Hazelwood Power Station, in Morwell in Victoria's Latrobe Valley, caused by embers from nearby bushfires spotting into the Hazelwood open cut brown coal mine [Teague, Catford and Petering, 2014]. This

type of mine is particularly susceptible to fire, and once a fire starts within one, it is difficult to extinguish. The fire in the Hazelwood mine burned for 45 days and covered the town of Morwell in smoke and ash for most of that time, creating both an environmental and a public health emergency, with vulnerable members of the community advised to leave [Teague, Catford and Petering, 2014]. Feedback from community members highlighted that the air quality information provided during the fire was not easy for them to understand, which added frustration and contributed to a breakdown of trust in the government response to the situation [EPA, 2017].

In the aftermath of the mine fire, inquiries and environmental monitoring assessments were implemented to inform and improve state responses to similar emergencies in the future [State of Victoria, 2014]. The EPA conducted assessments of air quality to determine if the fire created any ongoing changes. Air quality data were collected from mid-February 2014 until May 2015, with data compared across the sampling period and with historical data [EPA, 2015]. Draft reports of the environmental monitoring program were shared with Latrobe Valley community members who asked for clarification of certain specifications, graphs and the standards of air quality used in reporting. One of the questions asked during the community consultation process was what lessons the EPA had learned from the Hazelwood mine fire experience. Aside from changes in technical monitoring and emergency response and management systems, a key difference in process and procedure was community engagement and collaboration [EPA, 2015]. This builds on the mine fire inquiry report, which specifically recommended community engagement in order to use 'community-based information and local knowledge to make more informed decisions' [State of Victoria, 2014, p. 23].

One of the ways this manifested was in the community-assisted development of an air quality monitoring system. Calling it a citizen science project, air scientists and local experts from EPA Victoria worked with over 30 community members to design the monitoring network [EPA, 2020]. The system consists of a range of different relocatable sensors, fixed monitoring stations and video cameras to monitor signs of visible air pollution, like smoke [State of Victoria, 2018]. The resulting system, implemented in 2018, is adaptable to changing circumstances with air quality results publicly available [State of Victoria, 2018]. The information community members wanted to know about their air quality was embedded into the network design, allowing them to access information in a format that they could easily understand and providing them with the sense of creating something that would help keep their families safe and healthy [EPA, 2020].

### *Science centres brokering co-design with local teenagers*

Science centres and museums have long been a science communication domain where community involvement is paramount. They are inherently public facing and hence need to position communities centrally — and not just as visitors to their institutions. As with the two other cases, co-design processes are also increasingly being used by science centres as a way to ensure exhibitions and other programs are relevant to specific communities. Although historically museums have employed a deficit-oriented approach, where a knowledgeable few decided what is relevant to the masses, more participatory methodologies have emerged in

museums over the past two decades, with community co-design the pinnacle. Moreover, co-design can be a method to address exclusion of specific communities — a key problem for science centres [Dawson, 2019]. In her book, *The Art of Relevance*, Nina Simon [2016] sums up the approach:

> Instead of designing programming and then seeking out audiences for it, we identify communities and then develop or co-create programs that are relevant to their assets, needs, and values.
> (http://www.artofrelevance.org/2018/04/18/needs-assets-2/.)

As discussed in the Introduction, understanding a group's values and shared identity is key to defining a specific community, and to crafting relevant science communication for it. Recent research conceptualises relevance as a continuum of increasing personal meaningfulness [Priniski, Hecht and Harackiewicz, 2018], moving from (1) personal association (connecting to something of personal value), to (2) personal usefulness (connecting to a personal goal), and finally (3) identification (connecting to a person's identity). Priniski and colleagues [2018] argue that identification is most likely to lead to motivation — a hypothesis that has been demonstrated in science communication and science centres [Walker, 2012] — however, creating relevance that connects with an individual's identity is the most challenging. Crafting communication that establishes personal association or even usefulness is relatively straightforward once you understand an audience; however, understanding someone's identity, and which identity is most prominent in a given context [Oyserman, 2007], is significantly more complex and personal.

Extrapolating from individual relevance to what is relevant to a community thus requires a deep understanding of the key aspects of identity that are shared. For this reason, science centres typically work with a representative group of community members using co-design methods that reveal shared identity such as focus groups, boards or advisory groups. These collaborative approaches present a way for the community to express their shared identity and hence what is most relevant, which in turn influences design. Co-design also creates a forum where the community's needs and — critically — also their assets can influence design, aspects stressed by practitioners in science communication, museum studies and community development [Mathie and Cunningham, 2003; Nel, 2018; Simon, 2016; Walker et al., 2020].

The recent exhibition *Beyond Perception* hosted by Melbourne's science centre Scienceworks is an illuminating case study of how co-design can be used to create relevant programming with a specific community that feels excluded from the science centre. The co-design process involved creating a representative group of young teenagers aged 13–15 years in Melbourne. The group met monthly 21 times as the exhibition was designed, first establishing why they felt excluded, then going on to propose exhibition ideas and give feedback on content, aesthetics and all aspects of the exhibition [Museums Victoria, 2018b]. The basis of the teenage community's exclusion was having to share a space with young children and families, so the final exhibition was displayed in a separate, bespoke designed area of the science centre with racy aesthetics and dark lighting. The design leveraged varied parts of teenagers' shared identity, including their prioritisation of social experiences (e.g. including lounge areas) and their strong sense of agency and

self-determination. As such, the exhibition is non-linear, self-guided, open-ended, is careful not to talk down to or patronise, and has no instruction panels [Museums Victoria, 2018a; Perkins, 2018]. The co-design also resulted in place-based relevance, focussing on science and scientists from the Melbourne region. Finally, there were appeals to relevance and identity that may appear superficial for an outsider but are a fundamental part of the teenage identity: an area to charge mobile phones. The result was a place where teenagers felt included and where they found both the content, context and methods of communication relevant to them.

This is an example of how a *brokering* approach might work for a science communication institution based in a large city, though it was limited by needing to have some form of exhibition as the end point and being located at the institution's site. Nonetheless, to a significant extent it allowed community members to design the program to meet their needs. Further exploration of *brokering*-type models will be important in future to find out what further ideas are possible in this sphere.

## Discussion and conclusions

Because they are premised on relationship-building, communities-oriented approaches to science communication tend to be more complex than allowed for by our existing theoretical terminology (e.g. deficit, dialogue, citizen science, framing etc). Rather, they build on those concepts and their associated practices in a process of continual relationship negotiation and maintenance. This is particularly the case for *problem-solving* and *brokering* approaches, which are more deeply community-oriented than *neighbourly* approaches. Future work may map familiar theoretical concepts onto examples of community-oriented relationship-building to better understand how such relationships function and unfold. Given the diversity of communities, and the tailoring required to build relationships within and with them, this work is unlikely to produce the definitive 'roadmap' to effective community engagement. Rather, researchers and practitioners must recognise the complex and difficult work required and must operate with a more heterogeneous literature.

However, it may be possible to produce basic principles for community engagement in science communication, based on insights from genomics research recruitment, community health communication and knowledge brokering, as highlighted in the Introduction. These include:

- Committing to long-term relationship building.
- Acknowledging communities are all different, and what works for one community may not work for another.
- Having science communicators who come from within communities, or share an identity with prospective community partners.
- Working with, rather than against, a community's cultural norms, communication conventions and decision-making processes.
- Physically situating programs within communities' geographic space.

Using insights from the three case studies of science communication research and science communication communities literature, we may add some principles:

- Community-oriented science communication works vastly better when driven by communities themselves, not outsiders.
- Programs can become more community-oriented if external science communicators commence working with existing community networks, and transfer power to community members once the project is underway.
- Science communicators must be responsive to community interests, needs and priorities, in many cases working with communities without bringing their own agenda.
- We must welcome, and maintain relationships with, not just community members who are greatly interested in science, but also with those who have little interest.
- We must be savvy to vested interests exploiting our community-oriented approach, especially those that serve ends not in the target community's interests.

Undoubtedly, future studies will further refine and extend these lists, while maintaining the principle of recognising community heterogeneity.

We must persist in community-oriented science communication given its potential benefits. First, to the extent that community boundaries are at least partly defined by sustained communication cultures and shared knowledge cultures, any community-oriented communication efforts that gain traction are likely to have a lasting and meaningful impact. Second, communities have more power and resources to solve problems and make change than individuals, while remaining under the direct control of individuals — something that larger, more powerful collectives such as nations or global corporations do not offer. Third, a 'communities approach' is likely essential for redressing science communication's current exclusionary and inequitable culture.

Given the socially situated nature of knowledge, the efficacy of acting locally, and the primary importance of meaningful equity and inclusion, a 'communities orientation' for science communication seems an obvious imperative for any re-examination and re-orientation of our field.

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