The theory needed to support science communication practice

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Abstract

With the rise of science communication professionals and the increase in associated theoretical research, it's important to find ways to bridge the gaps between theory and practice for mutual benefits. This paper summarizes the three main approaches to modelling science communication: deficit, dialogue and participation. I propose that engaging the public in science will likely need to embrace all three models of communication and that science communicators can use these models to explore questions that will help them to design engagement activities more effectively. The three key questions areas for science communicators to explore are: (1) the aims of the engagement, (2) who will be involved in the engagement, and (3) what is known about the perceptions, concerns and needs of the people they wish to engage. The 2012 Australian national audit of science engagement activities indicates that most public engagement is still about deficit or dialogue interactions. More effort and resources needs to be put into participatory modes of engagement.

Introduction

Engaging the 'public' in science has been an objective of scientists for many decades. This has been driven by the perceived need to interest the public in science, educate them about science and latterly to obtain their funding and policy support for science. With the rise of more publically controversial science in recent years, such as emerging technologies and climate change, the perceived need to engage the public has grown and with it the rise of the relatively new profession of the 'science communicator'. This is especially true for Australia, New Zealand, the United Kingdom (Metcalfe &

Gascoigne, 2012). In other parts of the western world, for example in the United States, the science communication or engagement professionals have also being employed but are often given other labels such as 'media liaison officer', 'engagement outreach officer' and so forth.

The actors involved in public engagement in science and technology include scientists, various publics, science communicators, journalists, and government policymakers. It's the relationships between these actors that will affect the nature of the public's engagement with science and technology. For the purposes of this paper, I define a 'science communicator' as anyone (e.g. scientist, research manager, media liaison officer, professional science communicator) wishing to engage the layperson in science.

At the same time as 'science communication' was being defined and shaped in the early 1990s as a profession, a number of universities began to research the public communication of science and technology (PCST) and theorize and model the relationships occurring, especially those between scientists, publics and governance authorities. However, often this research was and continues to be carried out in isolation from science communicators. This paper aims to highlight the mutual benefits of bridging this gap between science communication research and practice.

Theorized models of science communication

The theories of science communication or science engagement that have arisen in the past 20 years have largely been based on the relationships between the public, scientists and governments. The models that have been theorized can largely be divided into three different categories of models, some of which are given different names even though they mean more or less the same thing. A summary of these three models is provided in Table1 (Trench, 2008, p. 130-131 was a primary source for this table). This uses the three dominant models of deficit, dialogue and participation as an overall framework for the other models. Some theorists (Lewenstein, 2005; Höppner, 2009) see the dialogue model as also being about the public 'participation' in science, particularly with regard to the deliberation of science issues. However, I have separated this model out from the third participatory framework as it is unlikely that the layperson in dialogue model engagement will have a sense of influence over the direction and the creation of

science or any decision-making about that science. Second order thinking, still largely assumes that the public will have positive attitudes to science, at least once they properly understand it. The participatory model signals a more obvious shift in power than the dialogue model; from the scientists to publics.

PCST Theorist	***Model 1: Deficit***	***Model 2: Dialogue***	***Model 3: Participation***
Callon, 1999	Public education model where scientists teach the public everything	Public debate model where science involves specific sectors of the public who have different competencies and points of view	Co-production of knowledge model where the people are actively involved with scientists in creating knowledge of importance to them
Trench and Junker (2001)	The deficit model The dissemination model Both with one-way communication rom scientists to public	The duty model The dialogue model Both with two-way communication between scientists and the pubic	The deference model, where scientists engage with the public
Lewenstein (2005)	The deficit model	The contextual model where scientists consulted the public The lay expertise model where public knowledge is incorporated into scientific knowledge	The participatory model where the public participated in the science
Rowe and Frewer (2005}	Public Communication – from scientist to the public	Public Consultation – where scientists consult the public	Public participation- where the public participate in the science
Wellcome Trust map, UK (reported in Trench, 2008)	The deficit model	The consultation model – where scientists consult the public	The engagement model where scientists interact with the public
Irwin (2008)	First order thinking – one-way communication from scientists to public	Second order thinking – two-way communication about the nature of risk	Third order thinking – science-publics interact within a broader social context around issues of concern or need
Pouliot (2009,), based on Callon (1999)	Deficit model	Public debate model where scientists debated with the public about issues	Co-production of knowledge model where the public and scientists jointly produce knowledge
Kurath and Gisler (2009)	Informing – where scientists inform the public	Involving – where scientists involve the public in discussions of science	Engaging – where the public is engaged with the scientists
Höppner (2009)	Instrumental – engagement is a means to endorse favoured decisions; engagement is one way from science to the passive public	Substantive – engagement improves agendas and decisions by including diverse views and knowledge through public input	Normative – engagement empowers public in agenda-setting and decision-making as it is their democratic right

PCST Theorist	***Model 1: Deficit***	***Model 2: Dialogue***	***Model 3: Participation***
Palmer and Schibeci *(2012)	Type 1 – Deficit model	Type 2 – Professional science communication, where knowledge is exchanged between scientists Type 3 – Consultative science communication where knowledge is exchanged iteratively from scientists to the public and visa versa	Type 4 Deliberative science communication where scientists and the public have equal standing within a process that is democratic and deliberative

Table 1 Theorised Public Communication of Science and Technology (PCST) models

Theories helping science communicators make decisions

The three overall categories of PCST models demonstrate different levels and directions of interactivity. The first model has the least interactivity between actors with one way communication from scientists to the public. The second model of dialogue promotes higher interactivity through a two-way communication between scientists and the public, which sometimes brings in other actors like government agencies or non-government agencies. The third model has the greatest interactivity happening in multiple directions amongst multiple actors. But what does this mean for practically engaging the public in science and technology?

Models coexist in practice

Firstly, it is important to recognise that practically all three models can and possibly should coexist in a practical public engagement program. Researchers (Trench, 2008, Irwin, 2008) have found that deficit and dialogue models of science communication have survived despite the push to new participatory models.

Practically, this means that with any PCST activity, even with the most participative interactions, there is likely to be the need or even the demand from the actors at some stage to explain complex science in plain English to those involved (deficit model). For any ‘concerned group’ participating in an issue involving science and technology there will likely always be the need for a two-way interaction, where different views are heard and acknowledged (dialogue), especially in the group’s set up phase.

This will likely be an important pre-cursor to the 'concerned group' critically analysing scientific institutions or co-creating knowledge (participatory model).

Models can provide the basis for the strategies adopted in particular communication acts or initiatives. Science communication practitioners can use the models to more explicitly design and time their communication strategies. However, it is important for practitioners to differentiate clearly between models in their strategies and engagement activities.

I would argue that there is a place for all three public engagement models; sometimes as separate activities and other times within the one activity. This gives richness to science and technology engagement and recognises the benefits of each model as well as the limitations. This means the public, scientists and policymakers can play multiple roles; they can receive scientific knowledge, they can discuss and debate scientific knowledge and they can determine and shape scientific knowledge.

2012 national audit shows a spectrum of Australian engagement activities

In 2012, the Australian national government conducted an audit of science engagement activities happening across the country. In analysing the 416 diverse activities recorded as part of this audit, it was clear to me that most practical science engagement is happening across a spectrum which reflects various motivations from information dissemination to the co-production of knowledge, technologies and products (Metcalfe, Alford & Shore, 2012). Statistical analysis of the data shows significant differences ($p<0.05$) between the three levels of activities that I coded as being deficit, dialogue or participation. From this analysis I devised a spectrum of science engagement activities as illustrated in Figure 1.

Analysing this spectrum of practice against the theories, gave me insight into how theory could inform practice, especially for the decisions that science communicators need to make.

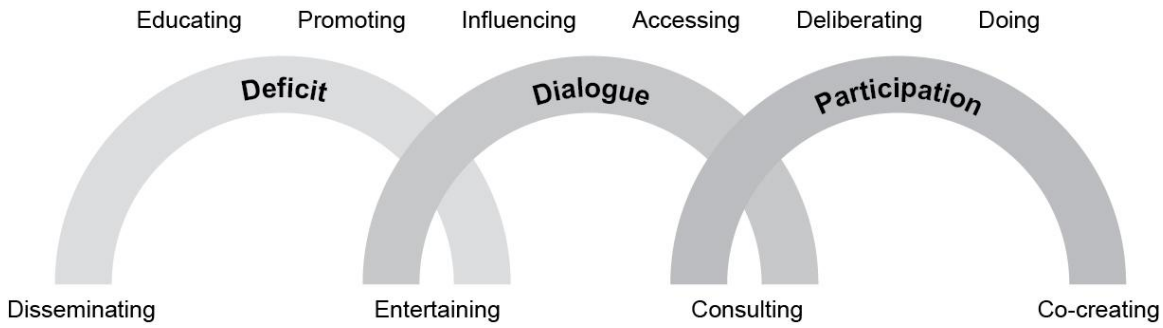

Figure 1 Motivation spectrum of science engagement activities across the three models of science engagement: deficit, dialogue and participation

Applications of PCST models for the science communication practitioner

In looking at the various characteristics of each of the three models, as seen in Table 2, I came up with a series of questions that science communicators need to answer when they are designing a public science engagement activity (see last column of table).

Characteristic	***Model 1: Deficit / 1st order thinking***	***Model 2: Dialogue / 2nd order thinking***	***Model 3: Participation / 3rd order thinking***	***Science communication questions***
Focus	Educate an ignorant public	Create a dialogue that opens up science to the public and builds trust	Explore the direction, quality and need for social change	What is the overall focus of your engagement? What are the desired outcomes?
Objectives	Science literacy	Support, funding, gain new knowledge	Co-creation of knowledge and public policies	What are the specific aims of the engagement? What are the outputs from the engagement?
Actors involved	Scientists, public, science communicators	Scientists, science and government institutions, public, science communicators	Many, depending on the scientific issue to be explored or the knowledge to be created	Who will be involved in the engagement? (try to be as specific as possible, don't just say 'public') What do you understand about their perception, concerns and needs?
Communication style	One-way, top down	Two way	Many publics and approaches	What sort of communication style will work best given the people involved and your focus and objectives?
Relationship between actors	Scientists have control	Scientific and government	Equal and shared	What sorts of relationships are

Characteristic	***Model 1: Deficit / 1st order thinking***	***Model 2: Dialogue / 2nd order thinking***	***Model 3: Participation / 3rd order thinking***	***Science communication questions***
		institutions have control but consult or converse with the public		desired or possible amongst participants in the engagement?
Place of knowledge	Scientists have all the necessary knowledge	Scientists have the most important knowledge, but they can gain new knowledge from publics	There are multiple sources of knowledge and expertise of equal worth and validity	Who has the knowledge that is needed for achieving the activity's focus and objectives? How is that knowledge best shared?
Acknowledgment of risk	No risk	Risks acknowledged as levels of uncertainty in scientific knowledge	Risk related to the social contexts and values	What are the messages of the engagement? Who will shape and interpret these messages?
Timing of engagement	Usually at the end of science production after peer review	During the science and after peer review to discuss implications or policy options	Throughout, starting from the beginning with 'upstream engagement'	How important is it that public actors shape the science? What does that mean about when the engagement should happen in the science process?
Scientific governance	Science led; separate to politics	Transparent and responsive to public opinion or input	Contestable by science, government and the public so it addresses society's concerns and priorities	What is the political context of the engagement? How will the engagement be managed and by whom? Is there knowledge that needs to be kept confidential?
Main challenges	Maintaining rationality, scientific independence and progress	Establishing broad social consensus / agreement Maintaining positive interactions	Viewing differences and disagreements as a societal resource	What are the risks involved in this engagement that might stop it working? How might these be overcome?

Table 2.Comparing PCST models and levels of thinking about science engagement (modified and expanded from Irwin, 2008, p208)

The three most important steps in designing a public engagement activity are to consider (1) the aims of the engagement, (2) who will be involved in the engagement, and (3) what is known about the perceptions, concerns and needs of the people being targeted.

Nisbet and Scheufele (2009) believe the deficit style of communication is unlikely to improve science literacy or understanding by the *wider* public and is most likely to only reach the minority who are *already enthusiastically engaged* in science. However, Wynne (2006, p. 214) suggests five motivations for the deficit style public engagement in science and technology where there is a perceived public deficit of:

– Understanding of scientific knowledge
– Trust in science, where "more information, transparency or explanation will restore trust" (p. 214)
– Understanding of the scientific process – "science cannot *be expected to* give certainty or zero risk" (p. 214)
– Understanding "that 'real' science has no ethical/social responsibility for its applications or impacts" (p. 214)
– Knowledge of the benefits of science

Understanding the perceptions, concerns and needs of the people to be engaged with deficit style communication will be essential for ensuring the information is relevant and that knowledge and messages are not misunderstood or taken out of context. This understanding can only be gained through using dialogue style activities. Some publics are seen to bring some useful knowledge and resources to science and policymaking, and this may also be a motivation for using this form of engagement. Jackson et al. (2005) provides three broad purposes for dialogue:

> Increasing democracy by promoting open and transparent decision-making; greater trust and confidence in the regulation of science and the decision taken; and that better decisions will have been taken (p. 352).

However, a number of two way interactions, such as science shows, demonstrations, workshops, open days at research facilities and other such engagement activities can bring laypeople together with scientists in conversations or dialogue. Often the motivations for these activities are to promote science or a scientific organisation or to promote interest in science rather than for people to participate in decision-making.

There's nothing wrong with these motivations or objectives, and people are more likely to be engaged when there are such interactions rather than a one way static transfer of knowledge and information.

However, if the motivations for engagement are to help decision-making or to change behaviours or attitudes, numerous researchers have demonstrated that knowledge alone will not achieve this (Bulkeley, 2000; Nisbet & Scheufele, 2009). With third order thinking, what are at stake are various publics' decisions about science and technology (Irwin, 2008). Participatory engagement is designed to empower the public, lead to better quality decisions, gain mutual trust, and change public attitudes and behaviours (Höppner, 2009). Participatory engagement at its most intense is about the co-creation of knowledge (Rogers-Hayden & Pidgeon, 2008). This requires "the involvement of concerned groups in the negotiation and construction of socio-technological options" (Joly & Kaufmann, 2008, p 231). To go even further, some researchers call for the public to have more influence over what science actually gets done or not in the first place (Wilsdon & Willis, 2004; Rogers-Hayden & Pidgeon, 2008).

Challenges and opportunities to bridge theory with practice

While the three models of science communication can coexist in practice and in most cases probably should, there is no doubt that the deficit and dialogue models still dominate our science engagement and more effort needs to be made with third order models of science engagement. This is especially true for high profile societal issues such as climate change, use of genetically modified foods, alternative energy and power sources, new medicines, and nano and bio technologies.

Many of the activities (almost 75%) collected in the Australian audit of science engagement activities (Metcalfe, Alford & Shore, 2012) included a significant component of passive and one way communication connected to lectures, science shows, science fairs or educational activities where people were engaged through watching, reading, listening or viewing. There were a significant number of activities (almost 60%) that also included dialogue between laypeople and the public but most of these interactions were conversations around traditional communication such as public talks or debates, science shows, hands-on-activities for children, science festivals and visits to laboratories. There

were relatively few engagement activities that included any third level participation. Most of the activities in the third level of participation were about citizen science activities with only a few activities being directed at critical thinking or the co-creation of knowledge or products. So why aren't there more examples of participatory engagement happening in Australia and likely elsewhere?

Analysis of focus groups with science communicators in Australia (Metcalfe, Alford & Shore, 2012) shows that most professional communicators appear to be aware of more participatory forms of engagement, but they cite a lack of organisational will or resources to help make them happen. Certainly, participatory models of engagement are chaotic and can be time consuming and expensive. So are these sorts of engagement activities possible or even necessary? For some sciences, such as particle physics where large laboratories and expensive equipment is needed, co-creation of knowledge and participation by citizens in the research is not likely to be feasible or even desirable (Callon, 1999). However, for science and technology where there are clear public risks involved, such as for health, safety and the environment, it is desirable for the public to participate in the science and the decision-making around that science.

Public engagement in such science and technology requires processes that draw in everyone with the relevant knowledge and values, insight and memory (Jasanoff, 2003, p. 243). Chilvers (2008) says that when participatory models are put into practice they need to focus on: "(1) staging engagement early and throughout the process; and (2) integrating and breaking down the distinctions between scientists, public and stakeholders" (p. 472-3). Participatory style engagement in science issues means sharing the diverse views of all those involved or affected by the issue and any consequent decision-making to achieve both mutual understanding and social learning. Such engagement needs to be supported by sufficient resources and processes need to be:

– transparent for those inside and out of the engagement
– conducted in an independent and unbiased way
– cost effective and timely.

This is perhaps easier said than done, but if science communicators can apply some of the concepts in theoretical models, they are more likely to make better decisions about designing their participatory engagement activities within set budgets and contexts.

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