Chapter 11
Situating Science in the Social Context by Cross-Sectoral Collaboration

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Abstract Research collaboration is increasingly interdisciplinary, with those working in traditional fields of science, technology, engineering and medicine recognizing the value of collaboration with those working in the humanities, arts and social sciences. This chapter explores the challenges and opportunities for communication within and from cross-sectoral research teams. The authors draw examples from researched case studies to describe how cross-sectoral collaboration positions science within the social context. They also look at how cross-sectoral communication relates to current models of science communication.

Keywords Science communication, cross-sectoral collaboration, multidisciplinary research, interdisciplinary research, social science, humanities, arts

11.1 Introduction

Collaboration across disciplines has risen in recent years, and a number of international and national initiatives are under way to increase such collaboration further. Cross-sectoral collaboration occurs when members of the science, technology, engineering and medicine (STEM) sectors collaborate with members of the humanities, arts and social science (HASS) sectors to solve common problems and reach common goals (Reback et al. 2002).

Initiatives and programmes to strengthen national economies through innovation and creativity have traditionally relied on the STEM sector to provide funding for solutions. Yet researchers such as Hjorth and Bagheri (2006) note a growing

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D. Cheng et al. (eds.) *Communicating Science in Social Contexts*,

feeling that science alone is not responding adequately to the challenges posed by society. They point to sustainable development as an example: science treats sustainability as a project with an end point rather than an ongoing process intrinsic to everyday work involving community and industry participation and decision making. Solving many of the world's big problems—natural resources conservation, security, climate change, energy and human health—requires new approaches to problems that can only be solved through cross-sectoral collaboration between the STEM and HASS sectors.

Cross-sectoral research is responding to community, industry and government needs. In the US, the National Academies (2004) argued that cross-sectoral research is being driven by four major drivers:

- The complex nature of society
- The desire to explore problems and questions that are not confined to a single discipline
- The need to solve societal problems
- The power of new technologies

Our research with Gardner (Metcalfe et al. 2006) shows that many of these cross-sectoral collaborations are occurring in the field of science communication, in projects engaging communities, industries and governments in the process of generating innovation, new knowledge and new understandings. One of the benefits of cross-sectoral collaboration is more engaged publics and end users (SCST 2002). To be successful, engagement activities must incorporate psychological, social, cultural and institutional knowledge that shapes public attitudes to, and acceptance of, developments in science and technology (S&T) (Irwin and Wynne 1996). Supporters of public engagement argue that when knowledge of human dynamic and processes, gained through humanities and social science activities, is applied to scientific endeavours it helps with assessments of the social impacts of those endeavours. In this chapter, we show that cross-sectoral collaborations have an important role to play in situating science within the social context.

In a review of science communication over the past 25 years, Bauer et al. (2007) describe three paradigms of science communication, each of which views the divide between the general public and the scientific community in a different way:

- *Scientific literacy*—where science communication efforts aim to address a deficit in knowledge about science
- *Public understanding of science* (PUS)—where science communication efforts aim to provide the right type of knowledge to suit particular individuals, audiences or groups
- *Science and society*—where science communication efforts aim to involve groups in the research process.

Bauer et al. (2007) believe that, whereas the first two paradigms see the public as deficient in either enough knowledge or in the right kind of knowledge, the third paradigm sees scientific or technological institutions or individuals as deficient. This paradigm attempts to address the lack of knowledge flow from the public back to scientific institutions and individuals that is inherent in the unidirectional communication models criticized by Miller (2001). More participatory models of communication attempt to address that deficiency by providing a means for engaging communities ‘upstream’ in the research process. However, researchers such as Rowe and Frewer (2007) believe that more investigation needs to take place to determine whether this new science communication paradigm is advancing the discipline or producing better outcomes.

We believe that cross-sectoral collaborative efforts in science communication contribute to more participatory models of communication by providing ways to incorporate social concerns and negotiate the way ‘scientific’ problems are framed and addressed. We have found that many of the challenges and opportunities in participatory science communication described recently by science communication scholars are similar to the challenges and opportunities involved in cross-sectoral collaboration.

11.1.1 Our Research

The Australian Government has placed S&T at the centre of its economic policies, investing in them and relying on their support for competitive advantage in the global marketplace (Australian Government 2001). While policymakers and decision makers want to see an increase in public involvement in science, there is also a growing sense that some Australian publics want more say in how science is used in their societies. This is one of the reasons that the Australian Government supported the Council for the Humanities, Arts and Social Sciences (CHASS) to research cross-sectoral collaboration.

In December 2005, CHASS commissioned a project to identify successful HASS–STEM collaborations and to explore areas of research, education and practice where collaborative approaches would be useful (Metcalfe et al. 2006). The most important phase of the project involved case study research examining cross-sectoral collaborations in Australia and elsewhere. The case studies were selected to illustrate a range of variables, including different:

- Collaborating disciplines across HASS and STEM
- Scales of collaboration
- Types of collaboration
- Stages of collaboration
- Management structures
- Funding sources for collaboration
- Planned and actual outcomes from collaboration

Interviews were conducted for each case study with at least three members of the collaboration, who represented the different disciplines involved. Data gathered from these interviews were interpreted using Leximancer, a content analysis software package that constructs a thesaurus of the most frequently occurring concepts in the textual data and maps the relational distance between those concepts. Such analysis produces an accurate description of the main themes and concepts in the data and their relationship to each other. The case studies yielded information about the benefits and costs of collaboration, incentives and impediments to collaboration, and the key ingredients for successful collaboration. The results from the cross-sectoral collaborations that focused on situating science in the social context are presented in this chapter.

Through an electronic survey, Australian researchers and practitioners also identified the key ingredients of successful collaboration. The key ingredients were organized according to the main themes emerging from the data collected in the case study research and other interviews. The survey was completed by 688 people. Almost 60% of responses were from people who had collaborated in cross-sectoral projects, 24% were from people who had collaborated only within their sectors, and 16% were from people who had not collaborated at all. Most of the respondents (60.6%) were from the HASS sector, 35.5% were from the STEM sector, and 3.9% were from ‘other’ disciplines. This probably reflected the fact that the survey was initiated by a HASS sector organization.

For this chapter, we reviewed the data and information collected in the project to look specifically at the role of science communication in cross-sectoral projects.

11.1.2 Participatory Communication and Cross-Sectoral Collaboration

Recent moves towards more participatory modes of communication (citizen juries, consensus conferences and national debates) in countries such as the UK (SCST 2000) have been prompted by many factors: growing public mistrust of scientists and decision makers; increasing media coverage of scientific processes perceived to be ‘secret’; and the demand by communities to participate in decision making about how science is used (Irwin 1995).

Science communication programmes that involve collaboration across the sectors are driven by the need to solve problems at the science–society interface and the desire to develop more effective community and industry engagement processes—that is, the participatory model of science communication. However, Trench (2006) argues that, while shifts in policy and practices in recent years have encouraged activities that involve the public as ‘lay experts’ and seek their input, the one-way science literacy and PUS paradigms of communication remain the basis for many of the projects undertaken and discussed in the science communication field. Programmes and policies using those models as the underlying foundation of their work can be identified by their focus on increasing public ‘literacy’ and scientific understanding, rather than on placing science in the context of society and social processes.

Genuinely participatory models of communication recognise that intellectual disciplines and cultural activities outside science, and the insights of 'lay experts', can contribute to science and science communication (Trench 2006). For some researchers, social and cultural aspects are central. Cribb and Hartomo (2002) believe that the new technologies of the 21st century involve reshaping communities, industries and societies, rather than providing quick 'fixes' to major environmental and ecological problems. Participatory models of communication are thought to be able to situate science within the social context, because they not only take social concerns and insights into account but treat them as central to the communication process. As Bauer et al. (2007) state, intervention activities cannot be separated from the research process.

Trench (2006) believes that science communicators have come to recognise that the issues and challenges associated with situating science in the social context are shared with other disciplines, such as sociology. Bauer et al. (2007) also show that science communication is an interdisciplinary field of enquiry, with researchers from sociology, psychology, history, political science, communication studies and science policy analysis engaged in PUS investigations. These disciplines have provided science communicators with new insights and identified the limitations of current science communication practices.

Trench (2006) calls for a greater willingness within science communities to create the conditions for citizen science and scientific citizenship. One way to achieve this is through collaboration between science and disciplines that offer pathways of meaning negotiation and scientific critique. Those disciplines are in the HASS sector. Macnaughten et al. (2005) call for a social science of science, technology and society relations to advance the theory and practice of collaborations between the social sciences, humanities, natural sciences and engineering. These researchers believe that such collaborations are the key to achieving better decision making and regulation and robust debate about converging technologies, such as nanotechnology.

By incorporating social negotiation of meaning and social concerns within the science communication process, cross-sectoral collaborations can offer genuine opportunities for public participation and engagement.

An example of a cross-sectoral project of this kind is the Wellcome Trust's SciArt Programme in the UK. This programme encourages innovative public arts projects investigating biomedical science. In 2006, SciArt offered £500,000 to groups to innovate, experiment and stimulate fresh thinking and debate in the medical and artistic fields. Anthony Woods, head of the trust's medical humanities section, says:

> Looking at science in the social context is valid…the research affects people and society and we need to hear the public's voice…people's own experiences of medicine are as valid as what happens in the laboratory and we need to understand that more.

Another unusually large cross-sectoral programme in the UK is the National Endowment for Science, Technology and the Arts (NESTA). This programme was set up by an Act of Parliament in 1998 to foster the nation's creative and innovative potential. NESTA is funded from the National Lottery and uses the interest from the lottery to support cross-sectoral collaboration projects that have the potential to enrich the nation through commercial, social and cultural outcomes. Such projects get researchers participating with each other, the general public, or both. For example, the Cape Farewell project takes teams of scientists, artists, oceanographers, journalists and teachers on a voyage to the Arctic seas. Collectively, these participants interpret and explain global warming and are able to engage a broader range of groups than scientists alone. These cross-sectoral activities acknowledge the importance of lay expertise and the knowledge of publics.

An example from the US is the University of New Hampshire's Center for Integrative Regional Problem Solving. The centre supports key programmes of the university, regional non-profit organizations, government agencies, active citizens and the northern New England community to come together and find solutions to critical regional problems, such as conflicting conservation and development needs (UNH Center for Integrative Regional Problem Solving 2006).

Cross-sectoral collaborations may act as catalysts for new projects and activities that provide opportunities for community and industry participation in decisions about scientific research and science outcomes. They offer ways to incorporate different and potentially conflicting meanings of science in the research process. Cross-sectoral collaboration can also lead to participatory critiques of the process and outcomes of scientific research.

Engaging the public and industry is increasingly cited as a mechanism for gaining support for and acceptance of S&T (SCST 2002). To be successful, however, engagement activities must incorporate the psychological, social, cultural and institutional facts that shape public attitudes to S&T developments (Irwin and Wynne 1996). Supporters of public engagement argue that applying knowledge of human dynamics and processes gained through HASS activities to STEM increases public reception and helps with assessments of the social impacts of STEM endeavours. Collaboration provides ways to manage the huge amount of knowledge that the S&T sectors have generated and will continue to generate, and ways to make sure this knowledge is usefully directed and applied (PMSEIC Working Group 2005).

11.2 HASS–STEM Collaborations and Science Communication

Over time, the HASS and STEM sectors have developed useful and productive relationships that operate on a number of levels. At the most basic, those relationships are simple and one-directional, with one sector using the tools of the other. For example, tools from the social sciences can make the physical sciences of genetics, nanotechnology and environmental science more palatable to the community. In these cases, HASS disciplines are contributing to a scientific literacy paradigm of science communication. The reverse can also be seen where creative artists gather new tools and inspiration from S&T. While these relationships may be useful and productive, they are not genuine collaborations across the HASS and STEM sectors that situate science in the social context.

True cross-sectoral collaborations require the combined efforts of one or more individuals from each sector to achieve common goals. They result in new knowledge or understandings that could not be achieved through a single sector alone. With time, they can result in newly conceptualized subject areas. Science communication is one such subject area, where the approaches and practices of many disciplines are combined.

Cross-sectoral collaborations often bring different disciplines together to solve a common problem. For example, one of our Australian case studies involved an independent working group of the Prime Minister's Science, Engineering and Innovation Council. The working group produced an integrated approach to tsunami science in Australia by bringing together experts in geosciences, meteorology and social sciences, and emergency services, community assistance organizations and related groups.

The group presented a report on discussions to the Prime Minister, setting out practical initiatives and recommendations to improve emergency management coordination, encourage collaboration and engage the community.

Other cross-sectoral collaborations aim to situate science in the social context. One case study example we researched was a water reuse project being conducted by Australia's premier research organization, the CSIRO (see Box 11.1).

Collaboration activities can also be quite complex and involve major 'integration' initiatives to build more substantial and in-depth cross-sectoral collaboration for socially situating science. For example, one case that we examined involved researchers from the Australian National University investigating and supporting a new transdisciplinary area of integration that focuses on synthesizing knowledge, information and perspectives from different sectors of society to support decision makers in various domains (public policy, business, professional practice and

Box 11.1 Recycled water acceptable to society

Determining the social, economic and technical viability of water reuse is vital for Australia's future. A major collaborative project between social psychologists, engineers, water researchers, hydrologists and the water industry is investigating water reuse in Western Australia. Reuse will only be socially and economically viable with the support of the affected communities in the state's south-west.

The project is being carried out by Water for a Healthy Country, a CSIRO National Flagship. It integrates information on water reuse technology, including social acceptability, capital and operating costs, water quality, opportunities to link with waste energy, potential scale, human health risk, environmental impact and waste discharge and management.

community activism).[1] Participatory methods of conducting research are central to this emerging discipline, supporting the view that all the stakeholders have a contribution to make to understanding issues (Bammer 2005).

Cross-sectoral collaboration that situates science in the social context is mainly funded through:

- Philanthropic support, driven by the desire for cultural and community benefits from science
- University programmes that encourage interaction across traditional disciplines and community participation
- Public exhibitions and performances that bring together a number of disciplines to better engage audiences
- Organizations set up specifically to support collaborative projects

Dedicated spaces are important mechanisms for supporting activities that situate science in the social context. Another of our case studies, SymbioticA at the University of Western Australia, brings artists and scientists together in one space that can incorporate scientific advances as well as social critiques of science that engage the public and encourage debate (see Box 11.2).

The Synapse initiative of the Australia Council for the Arts also uses residency programmes to provide opportunities for artists and scientists to work together. The Fish–Bird project (Box 11.3) is an example. According to Andrew Donovan, director of the council's Inter-Arts Office, which manages the initiative, these cross-sector collaborations contribute to situating science in the social context:

Box 11.2 SymbioticA: Exploring the ethics of biological research through art

Artists and scientists at SymbioticA—a research laboratory at the School of Anatomy and Human Biology at the University of Western Australia—are working together to explore scientific and technical knowledge from an artistic and humanistic perspective.

The laboratory enables artists to perform in vitro experiments that explore developments in S&T (particularly developments in the life sciences, such as genetic engineering) that are having profound effects on society, its values and belief systems, and the treatment of individuals, groups and the environment.

Immersed in the laboratory environment, artists are dealing with bioengineering and its controversial ethical implications from a position of knowledge. Both the artists and the scientists gain insights in the ethics and community understanding of the science and the art.

[1] See http://www.anu.edu.au/iisn/index.php

Box 11.3 The Fish–Bird project: Robotic wheelchairs interact with the public

A team of robotics designers and a media artist have developed robotic wheelchairs that interact dynamically with humans. Funded by an Australian Research Council Linkage grant and the Synapse initiative of the Australia Council for the Arts, the Fish–Bird project has not only received international acclaim for its artistic innovation in public exhibitions, but it also offers advances in wheelchair technology and monitoring systems that may be applied in a variety of hospital and aged care environments.

Fish and Bird, the two robots in the exhibit, read and react to human body language by moving about and writing text. The project encourages people to confront their own ideas about the human–machine interface.

11.3 Benefits and Costs of Cross-Sector Collaboration for Participatory Science Communication

One of the major benefits of this type of participatory science communication is finding better ways to engage the public and industry in debate, activities and projects. For example, Terry Hillman, director of the laboratory of the Cooperative Research Centre for Freshwater Ecology (in Albury, Australia), believes it is essential to involve artists in the process of engaging the community in science:

> Scientists have some particular knowledge but it doesn't give them any particular right to make the decisions more than anyone else. There needs to be an opportunity in the process of knowledge building to allow individuals to question the safety of the reliance on scientific knowledge. Theatre can allow the public to raise these questions and challenge these systems. (Quoted in Mills and Brown 2004)

Digital media is an area of collaboration directed at engaging the community by making art more accessible to the public. Digital technology collaborations have been particularly successful in engaging the public in issues of health and well-being (Sakane 2003). A new school at Stanford University is taking a collaborative approach to bringing together commercial businesses and business studies, humanities, design and engineering staff and students to focus on human-centred design (Nussbaum 2005). Traditional arts practices are also being employed for collaborative efforts focused on public engagement, such as the UK's Wellcome Trust programme, Pulse, which provides funding for performing artists to engage the public in biomedical science.

Many of the cross-sectoral collaboration participants to whom we spoke to reported benefits from involving end users in their projects to ensure greater ownership of the final outcome, service or product. Some also thought that cross-sectoral collaboration provided useful ways to engage and motivate industry.

However, participatory science communication, like all cross-sectoral activities, has high transaction costs, so the benefits of these activities need to be significant

(Irvin and Stansbury 2004). The composition of cross-sectoral collaborations means that internal science communication problems can arise when team members:

- Are widely geographically dispersed
- Have limited or no experience of working with each other
- Have no experience in collaboration across sectors
- Have a high degree of personal connection to their own sector or workplace (or both)
- Have other priorities or commitments that take precedence over the collaboration
- Have used the 'tools' of the other sector in the past without genuine collaboration
- Belong to organizations with rigid administrative and reporting requirements

The costs associated with these factors create the need for more time and funding to make the collaboration a success.

Team-member attrition before the project is complete is another potential cost to factor in. This problem is particularly pronounced if those people leaving are 'champions' for the project. As one of our case study participants stated:

> The internal champion in organisations can move on and that changes the dynamic and priorities and volume with which things are spoken about. Internally with [our collaborative group] we are trying to divorce the delivery of research from that crucial dependency on the individual.

11.4 Community Engagement

Many cross-sectoral collaborations that we examined are based on the idea that community involvement and/or engagement will lead to better outcomes. Cook's (2006) recommendations for community involvement in collaboration are also relevant in participatory models of science communication. They include:

- Having a clear statement of purpose that is relevant to immediate local needs
- Focusing on community problems and issues
- Considering barriers to participation (e.g. attendance at meetings and costs of involvement, providing regular ongoing engagement and timely feedback)

Cross-sectoral collaborators believed that the main reasons for engaging the community were:

- To incorporate the needs of the community in the direction of scientific research
- To provide a social space for communities to access and interact with S&T
- To understand and improve new technology
- To incorporate critiques of science and new ways to negotiate the meaning of scientific and technological advances

Incorporating the needs of community was believed to be important to ensure that community trust is maintained:

> We can do all sorts of technical things that we know are safe and economically viable but if there is no community trust we have wasted our time—there are many documented

> examples. We are trying to work in the community and take their wants and desires into account. (CSIRO water reuse project)

Collaborators in this project believed that engaging the community early in the direction of scientific research will lead to better outcomes:

> One of the things that the project is looking at is management of water for aquifer recharge—it is a long way off. People like the concept but it is a long way off from being applicable to drinking water. Perhaps they are never going to drink it so we must look at uses that will be acceptable. We must come to some agreement on uses—that is in the future yet. (CSIRO water reuse project)

This type of involvement and engagement (referred to by science communicators as ‘upstream’ engagement) was believed to improve the technology by incorporating social dimensions as considerations:

> Understanding and improving new technology and the way in which humans interact through situating it in public settings [is important in our study]. Improvement of multi-sensory autonomous systems within social/public spaces [is what we are doing]. (Fish–Bird project)

The idea of spaces where community members can be engaged was a recurring theme in the case studies:

> This project is different because it takes robots out of the laboratory where general public (untrained people—different ages and social groups) have access to the robots in a social space such as museums/galleries. (Fish–Bird project)

These spaces also provide places where critiques of science could be incorporated into new ways of negotiating the meaning of scientific and technological advances:

> This is something where Australia leads the world. Bioscience has tremendous ethical problems. The whole Bioart field brings things up to the public mind. You don’t get the fear out of ignorance. Artists are addressing a lot of the problems. They make it [bioscience] more approachable for the public. The artists are independent. They are not funded by pharmaceutical companies. They provide an independent voice.
>
> It is allowing the public to engage with science less formally and perhaps provocatively. To ask questions that scientists don’t always have the time or inclination to engage with the dialogue. (SymbioticA)

11.5 Key Features of Collaborations that Situate Science in the Social Context

The key features of cross-sectoral collaborations that situate science in the social context are also described by researchers looking at participatory models of science communication. The key features common to these activities are:

- The willingness to take risks
- Identifying common issues or problems
- Developing trust in other disciplines
- Boundary spanners

11.5.1 Willingness to Take Risks

Cross-sectoral collaborative activities and participatory models of science communication both require those involved to take risks, as the outcome of the process can be unknown. Bauer et al. (2007) point to the UK GM Nation debate in 2003 as an instance where those involved were committed to achieving an outcome from public participation, but failed to do so. Government hoped for more public support for genetically modified (GM) crops and, when this did not eventuate, blamed the process of engagement for giving those critical of GM too much attention. This led to recommendations for more PUS-related activities to give the public the ‘right’ information and thereby change attitudes.

Groups and organizations may also be reluctant to engage in participatory modes of science communication because maintaining a positive public image can help to ensure a good citation record or ongoing funding. However, taking risks was seen to be a key feature of all the case studies we examined. Those funding participatory activities were emphasized as key groups inhibiting engagement because of their need for documented outcomes at the outset of a project:

> There needs to be more risk taking on collaborative projects on behalf of funding bodies, not forcing people to produce outcomes. Outcomes will come anyway but they discourage people from exploring and taking risks. Whoever is supporting these collaborations should be open to this. The best way of learning about things is to test and see whether they work or not. You need some room for that. (SymbioticA)

11.5.2 Identifying Common Issues or Problems

Kim (2007) reminds us that the public is not one large behavioural unit but is grouped around common problems and issues. He points to a number of studies in which collaboration between local communities and scientists has been crucial for problem solving (see Karl and Turner 2002, Roth and Lee 2002, Lee and Roth 2003). Kim recommends communicating the shared problems of science and society and their relevance in order to encourage participation. He also recommends that scientists and institutions reflect on what they can contribute to situating science within the social context, rather than focusing on problems framed by scientific research and facts.

Gorman (2004) promotes shared mental models for upstream engagement created through shared trading zones between social scientists, ethicists, scientists and engineers. He believes that social scientists may be able to represent broader society in the initial phases but need to be brought in as soon as possible.

This need to focus on a common issue or problem is demonstrated in the tsunami case study we researched:

> We were bringing a range of technical, government and institutional people together. It was a very disparate group. The collaboration showed me that disparate groups can work

> together without a big bonding period. It was important that we were clear with where we were going. (PMSEIC tsunami report)

Having space to allow for and incorporate differences was also emphasized in this case study:

> People view an issue within a university or agency perspective very differently. If you have been at international tables you see that people see things differently—they have a different lens or different set of values—not right or wrong but different. You need to allow space for that to percolate through the group. You are not going to win by being right but by bringing people with you. (PMSEIC tsunami report)

Another of our case studies highlighted the importance of ensuring that collaborators not only share the problem or issue but share a language in which to discuss it:

> There were some kinks of course—language differences for a start. The more technical language barrier. You need to find some common ground and a shared language—know what the terms mean and create a common vocabulary for the team. (Fish–Bird project)

11.5.3 Trust in Others

The need for trust in others involved in the project was highlighted in all case studies as a key feature. While it can be difficult to build or create trust, there are a number of ways it can be encouraged. For example, one case study suggested that trust is engendered more easily when members of a collaboration are already established in their own fields of endeavour:

> Having a track record in the respective disciplines gives you credibility and allows you to start at a higher level of trust than you would have otherwise. To have proven success in your own fields helps at the beginning to build trust. (Fish–Bird project)

Lamb et al. 1998 believe that a lack of trust in the contribution of other disciplines can be overcome by ensuring that all members of a cross-sectoral collaboration participate in all aspects of the project.

The issue of maintaining disciplinary boundaries can be a major problem both for participatory science models and for cross-sectoral collaborations. Some critics from the STEM sector have said there is a danger that science will be 'contaminated' by participatory activities. Some from the HASS sector have pointed to the danger that participants may become less critical of science and scientific outcomes over time:

> The notion that we might be contaminated. That we [artists] operate with scientists means that we have been contaminated by other approaches. This is the resistance for a lot of collaboration. You become something else by collaborating that can impact on your own discipline. (SymbioticA)

Members of SymbioticA refer to collaborations where participants do not set out to agree with each other as 'adversarial collaboration':

> The model we present is not working with emerging technologies but engaging with them. Artists working within the scientific environment but maintaining a critical outlook. We are not supporting the creativity of scientists nor are we a tool for science. We maintain our own research discipline and our own ways of dealing with emerging technologies. (SymbioticA)

However, such collaborations can produce direct benefits to the scientists involved by raising their awareness about how their science fits into a social context:

> It is exciting for the scientist to work with an artist, for them to step back and think about what they are doing. Also scientists do stop and think about what they are saying as well. (SymbioticA)

11.5.4 Boundary Spanners

One mechanism that groups use to overcome impediments to cross-sectoral communication is to employ 'boundary spanners'—people who can communicate across sectors (Petronio et al. 1998). Lele and Norgaard (2005) believe that boundaries are developed and maintained around scientific communities to provide strong points of identification for members. Those communities have a strong investment in maintaining the boundaries for their own survival. For these reasons, breaking down traditional boundaries through wide-scale cross-sectoral collaboration can face some resistance. All the successful case studies we looked at included people who acted as boundary spanners within the collaborations.

Bauer et al. (2007) show that individuals with time and expertise are needed to be able to engage the public and situate science in the social context. They refer to these individuals as 'angels' or mediators between scientific institutions, industry, government and the public.

Many science communicators act in the role of boundary spanner within their groups or organizations to bridge boundaries and ensure their maintenance. They can reduce the transaction costs associated with cross-sectoral collaborations. The long-term sustainability of cross-sectoral initiatives requires rewards and recognition to be given by the individual disciplines involved, rather than a move to breaking down barriers between the disciplines. With the rise of cross-sectoral collaboration, the role of boundary spanners in bridging the science–society divide will become increasingly important.

11.6 Conclusion

While Bauer et al. (2007) question whether participatory science communication activities are bridging the divide between science and society, the case studies we have investigated demonstrate the usefulness of cross-sectoral collaboration in providing new ways to situate science in the social context. By providing ways to incorporate the negotiation of meaning, social values and critiques of science, these projects are providing mechanisms of public engagement and also changing the approaches of institutions and the ways in which science is conducted.

The increase in cross-sector collaboration internationally means that the importance of boundary spanners in facilitating communication and maintaining relationships in such programmes and initiatives will increase. In many situations, science communicators already fill the role of boundary spanners between researchers and the various publics. With a greater understanding of the role they play in facilitating relationships within and outside their groups or organizations, science communicators can act more responsively and ensure greater participation and cooperation.

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