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The "Citizen Scientist": Reflections on the Public Role of Scientists in Response to Emerging Biotechnologies in New Zealand

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Abstract Much of the traditional discussion on science and society engagement has concentrated on the role (and even duties) of citizens in response to science, and on attempts to scientise civilian consciousness to appreciate the benefits of scientific progress. Irwin's (1995) concept of "Citizen Science" was an important milestone in our understanding of "science and society" relations, which focused attention on the needs and concerns of citizens and looked to a new form of science "enacted by citizens themselves" (Irwin 1995: ix). In this paper, I consider the other side of the science and society relationship by focusing on the scientist as citizen. Over time, a significant minority of scientists have been active in raising public concerns around the social impacts of science and technology, particularly around biotechnology and nanotechnology. This paper presents results from a New Zealand study that engaged scientists with community groups in dialogue about biotechnology. I discuss how this may represent an emerging form of scientific reflexivity and consider the implications for future engagement practice.

Keywords Scientific citizenship · Citizen scientist · Scientific reflexivity · Science and society engagement · Biotechnology

1 Introduction

In 1973 a group of biologists published the following statement:

> We are writing to you on behalf of a number of scientists to communicate a matter of deep concern. Several [recent] scientific reports have indicated that we presently have the technical ability to join together, covalently, DNA molecules from diverse sources… This technique could be used, for example,

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> to combine DNA from animal viruses with bacterial DNA, or DNA's of different viral origin might be so joined. In this way, new kinds of hybrid plasmids or viruses, with biological activity of an unpredictable nature, may eventually be created… There is serious concern that some of these artificial recombinant DNA molecules could prove biologically hazardous… to laboratory workers and to the public….
> (US National Academy of Sciences 1973)

At this time science was embarking on a world of new discoveries that would radically enhance the power of human intervention in biological systems. Techniques in recombinant DNA initiated a massive acceleration in the biological sciences, generating whole new areas of knowledge that now dominate modern science and technology.

The translation of this new knowledge from the science laboratory to the supermarket shelf, however, has not followed an easy path. Public controversy around the social, cultural, ethical and ecological effects of biotechnology has raised significant issues for government policy and has undermined confidence in the contract between science and society. These debates have challenged the governance of science, exposing underlying tensions in modern representative democracies and in practices for public participation.

Much of the research agenda in Science, Technology and Society studies has been dedicated to enhancing "science and society" engagement. There is now wide recognition of the limitations of early deficit approaches to the "public understanding of science", which positioned the public as scientifically illiterate and privileged "expert" knowledge over "lay" knowledge. In response to the "sterile dichotomies" this produced Irwin (1995: x) advocated the concept of "Citizen Science" to recognise the "contextual", "less systematised" and "local" knowledge generated outside formal scientific institutions (xi). Rather than a scientist's view of citizens as "ignorant, misled or plain contrary" (5), Irwin argued for a citizen's view of science, to create a more symmetrical relationship between public and formal expertise. This had implications for notions of citizenship in the face of technical progress, and "the issues of knowledge, trust and identity on which it hinges" (5).

In this paper I revisit this theme of citizenship and identity by focusing not on the role of citizens in relation to science, but on scientists' role as citizens. Irwin's "Citizen Science" invoked the potential for a reduced power differential between scientific and public knowledge. This would, in turn, create new dimensions of citizenship in which non-scientists were seen as capable of occupying a legitimate role in technological decision-making. In effect, their identity as citizens would be augmented through their enhanced agency in scientific engagement. Irwin's hope was to bring the concerns of citizens and the understandings of scientists closer together. This would require greater scientific reflection and self appraisal. He highlighted emerging social experiments in "Citizen Science"—such as constructive technology assessment and science shops—as new institutional possibilities for the future.

While it represented a significant advance beyond the deficit model, the theoretical platform of "Citizen Science" was still constructed across a fundamental divide between "science" on the one hand and "society" on the other. Approaches to science and society engagement developed since 1995 have shown potential to

overcome this conflict, but many initiatives still tend to position actors in their first order identities as either "scientist" or "citizen". Recent innovations predicated on dialogue represent a step forward; even so, "the dialogue" is still often between these two monolithically constructed identity positions.

Today, there has been significant progress in reshaping the identity of citizens in relation to science. This has involved deconstructing the one-dimensional view which, as Irwin noted, presented the public as homogenous in character and essentially passive in the face of technical change. Less attention appears to have been paid, however, to the changing identity of scientists in relation to society. Even in the midst of dialogue, there is a tendency to represent all scientists as committed to a single vision of science and technological progress, and essentially passive in the face of social change. In overcoming the deficit view of citizens lacking in scientific literacy, is there a risk that we have created a new deficit: of scientists lacking in civic literacy? We have begun to recognise and support the voice of the Scientific Citizen, but have we fully recognised the voice of the "Citizen Scientist"?

This paper presents recent research from New Zealand to reflect on these themes. To set the scene, I begin with some comments on the concept of scientific reflexivity in relation to science and society engagement. This is followed by a brief review of studies into New Zealand scientists' approach to the social dimensions of their work, including their participation in discussions in the public sphere about the social, ethical and environmental implications of emerging biotechnologies. To what extent are scientists reflecting not only on the social context and consequences of their work but also on their role as both scientists and citizens? Is there evidence of an emerging citizen scientist identity among New Zealand biotechnologists? To answer these questions, I then draw on findings from a New Zealand research project that engaged biotechnology scientists in dialogue with community members on the development of genetic engineering (GE) applications in biotechnology.[1] These findings indicate a blurring of the distinctions between the scientific and citizen identities and domains of knowledge which have tended to dominate science and society discourses particularly in the GE debate. I consider the way in which the scientists in this project regarded themselves as both citizens and scientists, the extent to which they were conscious of how these identity positions had been constructed in the wider public debate, and of how those constructions had affected them in the scientific world and in the public domain. I conclude with some observations on the implications for future research on science and society engagement.

2 Scientific Reflexivity and Social Engagement

Piekle (2007) observes that whether scientists are aware of it or not, they have to choose what role they play in society and how they relate to decision-making about

[1] This paper discusses one aspect of the findings of the MORST dialogue study, which was conducted as field work for my Ph.D. thesis in risk communication. Full details of the study methodology and results are published elsewhere (Cronin and Jackson 2004) and discussed in my thesis (Cronin 2007).

science. This requires a level of self awareness in scientists, and a level of awareness of the relationship between science and society, and of the meaning and effects of their actions in the context of that relationship. The key proposition in this paper is that a citizen scientist is a scientist who demonstrates strong levels of scientific reflexivity in regard to science and society engagement.

I define "scientific reflexivity" as the ability of scientists to see themselves and their activities in the social context in which they work, to recognise that their science both affects society and is affected by social processes and to alter their possible course of research in the light of this awareness. Pels (2000: 2) states that reflexivity presupposes that while saying something about the "real world" one is simultaneously disclosing something about oneself. This involves a refusal to separate knowledge of things "out there" with knowledge of the self "in here"; creating a radical challenge to the "traditional canon of impersonal, value free and dispassionate inquiry". Archer (2007) sees reflexivity as the crucial human capacity to reflect on ourselves in relation to our circumstances and vice versa. She refers to the "internal conversation" in which actors think about their situation, clarify where they stand and decide how to act in relation to their external circumstances. I suggest that this internal conversation can be related to the external conversation that scientists might have with "others" in the wider community outside of science. The degree of personal reflexivity shown by scientists, and institutional reflexivity shown by science organisations, with regard to their relations with society may be indicative of the priority given to public engagement and to the level of reciprocity generated in those conversations.

Gerhards and Shaffer (2009: 439–447) discuss two normative models of science in the public sphere, based on their analysis of the representation of science in the news media. They argue that in a "science dominated public sphere", science is portrayed according to scientific criteria which determine "which topics are important… which information is correct and which perspectives are fundamentally permissible." In contrast, in the "contextualised scientific public sphere", science is given no special epistemological status, and decisions about science must also recognise other values and social interests. Science is represented as requiring a social licence to operate.

I want to extend these concepts to critically reflect on science and society engagement. The contemporary relationship between scientists and the public, especially around novel technologies, is often problematic and reflects a struggle between two domains of authority and knowledge. I represent this, in Fig. 1 below, as an epistemological force field, with "science" and "society" at opposing poles in the conversation about science and technology, and its value and effects, which moves back and forth depending on the degree of influence that one has over the other.

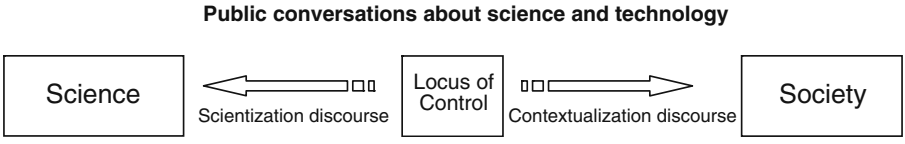

Fig. 1 Force field dynamics in science and society engagement

There is a growing body of literature on scientists' attitudes toward communication with society. Although studies on engagement around biotechnologies are not so numerous, some examples include Fisher et al. (2005), Burchell (2007), Egorova (2007), Small and Mallon (2007), Martin-Sempere et al. (2008), and Meisenberg (2009).

These studies report an approach to science communication largely consistent with the deficit model of public understanding of science (Irwin and Wynne 1996). The majority of scientists see their role as "providing information" to educate and persuade the public about "scientific facts" (Davies 2008) and to advocate for techno-scientific approaches in risk assessment and decision-making. Such approaches to social engagement can be described as "weakly" reflexive in the sense that little attention is paid to non-scientific framings: scientific knowledge is privileged over other knowledge, and there is an expectation that the communication exchange itself should be conducted in "scientific" terms (for example, based on "evidence", "objectivity" or "sound science"). This form of communication is closed or only mildly tolerant of other points of view, especially civic perspectives. Scientists expect to exert a strong influence over the public discourse about science, pulling the locus of social control towards the scientific worldview.

Alternatively, a strongly reflexive science response to engagement is open or highly tolerant of other points of view. In this context—and reflecting the principles of post-normal science (Funtowicz and Ravetz 1993)—scientists expect to exert less influence over science discourse and decision-making, and are more willing for the locus of control to be drawn towards the social context for and social judgments of science and technology, supporting greater democratic control of science (Davies and Wolf-Phillips 2006).

This consciousness, in turn, "bends back" into the conception that scientists have of themselves and of their work. Scientists employing a science-dominated engagement model expect science values and assessments to trump other assessments; they seek to contest non-scientific evaluations and to align public responses with scientific responses. Communication approaches can include disregarding or diminishing social evaluations or seeking to dissuade the public from their evaluations and move their thinking towards the scientific end of the spectrum. In the science communication and risk communication fields, the dominant approach has been to "manage" public perceptions of science and to steer social actors toward expert assessments, using a range of communication techniques; see for example, the "Mental Models" approach in Morgan et al. (2001), and also Hagemann and Scholderer (2009). When the discourse is pulled in this direction, the term "public engagement" is often used to imply that the public should "engage with" science, that is, to inform themselves about scientific matters, take on scientific framings and develop more positive attitudes and even "excitement" about science and what it has to offer (Cronin 2008b). This requires little effort from scientists to leave their "side" of the conversation and move out from their position to engage with social perspectives.

The discussion below will explore these notions of scientific reflexivity in relation to a key science and society issue, biotechnology. What do we know about scientists' responses to the social dimensions of biotechnology, and to what extent are these responses indicative of scientific reflexivity?

A recent cross-cultural study provides an insight into the way that genetic scientists see themselves and their work in relation to society. Following on the work of Kerr et al. (1997) regarding the relegation by scientists of social questions about science to the social realm, Egorova (2007) interviewed geneticists in the UK, the USA and Russia about the social implications of their research. Wearing their "Scientist hat", respondents put a firm boundary between their science and its cultural meaning, arguing that it was up to the public, social scientists and policymakers to construe the implications. When talking about their "personal" understandings, however, they revealed a wider awareness of the social dimensions. Nevertheless, they believed that "whatever their views of the wider cultural implications of their work were it was not going to affect their work on an epistemological level and hence it was not going to determine whether they were 'good' or 'bad' scientists" (57). These findings provide an interesting insight into scientists' construction of their identity: while recognising the existence of a wider social realm, their sense of scientific self was firmly anchored in the technical realm of science.[2] The scientists could identify social issues—they were able to don the citizen hat—but as a "Scientist", they would not be held accountable for these wider implications.

I was interested to see if similar constructions of the science and society relationship, and of scientific identity, might be found in New Zealand. In the next section, I note some key studies on New Zealand scientists' views on the social dimensions of science and technology, particularly biotechnology. This is followed by a discussion on the results of a New Zealand dialogue research project on biotechnology engagement, which indicate varying levels of scientific reflexivity and point to what might be an emerging citizen scientist identity, at least among some scientists.

3 New Zealand Scientists' Views on the Social Dimensions of Science

There is only a small body of literature on New Zealand scientists and their views about "science and society" engagement for emerging technologies. One of the earliest New Zealand references is the proceedings of a "Symposium on Social Responsibility in Science" published by the New Zealand Association of Scientists (Green 1979). Strong interest in this event by scientists underscored the "doubts and disquiet that many people are now experiencing about the power and practice of modern science" (Green 1979: Introduction). Scientists expressed concern about issues such as nuclear power, the global food crisis and genetic engineering. They also canvassed scientific objectivity, the commercialisation of science, scientific freedom and public accountability. A key theme was the responsibility of scientists to publicly highlight the potential hazards of science and technology. Fenwick (cited in Green 1979: 35) noted that earlier generations of scientists had spoken out in the 1940s about the proliferation of atomic weapons and in the 1960s about the social and environmental implications of their work. In the present day [1979], many scientists were adopting strong public positions and arguing that the problems facing

[2] Similar findings were found in a study of UK crop scientists by Burchell (2007).

society demanded political rather than merely technical/scientific solutions. There were calls for curbing scientific activity where it might have unwanted social consequences and recognition that the public expected a greater say in the application of scientific research.

In the mid-1990s, several New Zealand scientists contributed to *A Statement for Scientists concerned about Current Trends in the New Biotechnology* (Third World Network 1995). Some also went on to make public submissions to the government on biotechnology regulations or to publish on biotechnology regulation; for example, Wills (1995) and Heinemann (2004). Macer and Ng (2000) recorded declining public support for biotechnology in Japan and New Zealand and questioning of the technology by scientists.

Hunt (2009) documented the responses of agricultural scientists to restructuring of the science sector in the 1990s, and the prioritisation of biotechnology development as a driver of the New Zealand knowledge economy. Scientific workers believed that the scientific contributions they wished to make were less valued in the new commercial environment. They felt excluded from participation in both organisational and Government policy-making and many questioned the commercial outcomes expected under new science policies.

The Royal Society of New Zealand made a public submission to the 2001 Royal Commission of Inquiry into Genetic Modification (Eichelbaum et al. 2001), stating that "legislation and/or regulations should include not only scientific risk assessment, but also stronger mechanisms than currently exist to include cultural, ethical and social issues and concerns, where appropriate, at both the research and field trial levels.... more effective consultation mechanisms than currently exist must be developed to include cultural, ethical and social issues, and used to decide whether or not to proceed with commercial release [of a GMO]" (Royal Society of New Zealand 2001).[3]

Fisher et al. (2005) documented the ethical views of New Zealand agricultural scientists. While generally supportive, the results indicated that scientists held a diversity of beliefs and attitudes towards GE. Mirroring public opinion, research scientists' opinions were more favourable toward medical applications than agricultural/industrial applications. Small and Fisher (2005) reported that beliefs about the moral outcomes of a research project may be significant determinants of scientists' attitudes to their science.

The 2008 results of a major longitudinal survey of New Zealand scientists and technologists (Sommer 2010) also indicate a growing appreciation among scientists of the social dimensions of their work and the need for societal governance of science and technology. Over 60% of respondents (up from 43% in 1996) disagreed with the following statement: "In my professional capacity, I feel responsible first to science and the creation of new knowledge or products, and then to the concerns of citizens" (21). Sommer reported that scientists' sense of social responsibility had strengthened over the past decade. Questioned on whether the potential uses of science or the products derived from it should be considered before undertaking research, the survey revealed that scientists felt strongly obligated to consider the implications of the research that they pursue (22). Only 26% agreed with the

[3] Social scientists and biophysical scientists in the Royal Society made parallel submissions.

statement that that "the development of potentially dangerous technology should be decided, primarily, within the scientific and engineering community" (24). A small minority (some 13%) agreed with this statement: "My understanding of the science of genetic modification of organisms leads me to believe they pose sufficient threat to the ecosystem to warrant suspension of research endeavours" (25).

This brief review over three decades suggests an evolving level of reflexivity among New Zealand scientists. It highlights their understanding that science is conducted in a social context; their awareness of the consequences of their work; their social and ethical values in relation to new technologies; and their interests in learning more about social responses to the technologies they are developing and in improving processes of social engagement.

In the next section, I draw on the findings of a New Zealand study on "science and society" dialogue to provide qualitative data on the approach taken by scientists toward public engagement in biotechnology and to highlight factors contributing to the construction of their roles as both citizens and scientists.

4 "Hands Across the Water"—Scientists Engage in Dialogue with Citizens on Biotechnology in New Zealand

An action research project to engage scientists and the community on biotechnology (Cronin and Jackson 2004) was commissioned under a "science and society" Dialogue Fund by the New Zealand Ministry of Research, Science and Technology in 2002–2005. The aim was to trial new communications methods beyond the deficit approach, based on the principles of dialogue (Bohm 1996). This qualitative research project recruited 46 "science" participants including biotechnology scientists, programme leaders and business development managers in universities, government research institutes and private companies. "Community" participants (n=47) included members of environmental, public interest, religious and Maori[4] groups with concerns about GE. Three dialogue-based methods were trialled including adaptations of Public Conversations (Chasin et al. 1996), Appreciative Inquiry (Cooperrider et al. 2000), and a new method "Issues Mapping" which uses graphic representations of stakeholder acceptance rankings of technology applications as an input to dialogic conversations (Cronin 2007). The project concluded that these methods showed promise for reducing the conflict between science and societal views on biotechnology. It also provides a valuable indicator of scientists' approach to science and society engagement. (In the discussion below, scientists' comments are quoted in italics).

The *Hands Across the Water* project (Cronin and Jackson 2004) found varying attitudes about science and society issues among science participants. Following the definition of scientific reflexivity proposed earlier in this paper, these responses can be considered in terms of the following three attributes: (a) social awareness—scientists' awareness of how science is constructed and conducted in a social context, and awareness of the social meaning of their work and of how society affects and is affected by the practices and products of science; (b) social

[4] Maori are the indigenous people of Aotearoa New Zealand

responsibility—scientists paying attention to the potential consequences of their work, making social, cultural and ethical assessments of technological applications and choosing to make public comments on the impacts of science on society and on the need for social control of science; and (c) social engagement—scientists' understanding of social responses to new technologies and their interest in learning more about the drivers of social concerns, initiatives taken by scientists in science communication and their interest in improving processes of social engagement, including upstream methods that support the integration of social values into science decision-making and organisational strategy.

In terms of the first attribute, social awareness, Cronin and Jackson (2004) reported an apparent gap between the focus of many scientists on the technical operations of their research and the wider social, economic and ethical implications as seen by the community. Several scientists stressed the importance of separating science from the social realm. For example, one person commented that:

> There is this animist belief in nature as an entity... But we don't make decisions in this country on the basis of religious beliefs… I don't see why that belief should be enforced onto me. We've got to separate the ethical and social issues from the technical issues…

A number of scientists saw science purely in technical terms and were resistant to ascribing social meaning to biotechnology applications:

> People think it's putting a human gene in a cow. But all genes are just chemicals at this level, the coding is just different. Genes are just protein factories. People don't understand this….For me things are givens, they are now normal and I don't see ethical concerns because I understand the technology.

However, a small group of science respondents did make comments that were indicative of greater social awareness. Referring to the ethical and spiritual concerns raised biotechnology, one scientist stated:

> One of my friends has a deeply spiritual belief that it's wrong so you can't argue with it or change it. Similarly some Maori views, with a spiritual feel—you have to respect it. It's important not to argue because you're going into a realm where you are not qualified to argue…

Another scientist had a strongly developed view on the social context of biotechnology development and the social dynamics around its introduction:

> …it's fundamentally about the nature of our democracy and society, and about personal choices, and about the potentially competing desires of individuals and groups in society—and the desires of corporations… They can do what they want to do and society has to pick up the mess. Corporations are not elected. But here [with GE] is a thing that could change fundamental things about peoples' lives.

In terms of social responsibility, most of the scientists interviewed were positive about developing biotechnology but a notable minority had concerns about the risks. Unprompted, a number referred to the potential dangers of transgenic plants, impacts

on soil ecosystems, genetic contamination of conventional crops and the risks to farmers. There were also comments on unknown, unintended or unpredictable effects on ecosystems, the irreversibility of effects and the need for caution. A number of scientists also raised cultural, health and ethical issues and the economic implications of adopting biotechnology in New Zealand. Many wanted to be viewed as socially responsible:

> I think I am a person with reasonable ethics and I am concerned with that side of things.

> We are not the mad scientists the media may make us out to be and… we do take precautions and minimise the risk to others and the environment.

Finally, there were also varying degrees of reflexivity in terms of social engagement. Many scientists advocated traditional communication strategies to align public responses to expert interpretations and to overcome the apparent deficit in public understanding of science. A number of scientists suggested that, in an absence of scientific knowledge, people were not qualified to make judgements or influence decisions. Opposition to GE was frequently attributed to fear, which should be overcome with public education programmes. But other scientists expressed concern about how scientists generally tended to engage in public debate:

> I got into a shouting match with another scientist… at a public meeting. He had an old fashioned scientist's attitude—we scientists can control everything.

Several scientists were interested in a more dialogic approach based on listening to other concerns and reflecting on their own world view:

> I hadn't thought about the social dimension of the adoption of GM. I have a very Western view of science—as a tool to fix things or change things. Others have a different world view… I come from a very technical approach.

> What can I do to better understand what your concern is and what can I do to mitigate the risk, so that you can be less concerned?

A number of scientists in this study expressed concerns about the way science and society engagement around GE had been managed and were open to the idea society should influence what is done inside the science system:

> The public has to buy into it. Scientists have to acknowledge that there are some bits that we shouldn't do. You can't press on and do stuff that isn't sanctioned.

5 An Emerging Citizen Scientist Identity?

Reflecting on the biotechnology debate in New Zealand, Henderson (2005: 124) noted that identity may be seen in three ways: "belonging"—how people perceive their own position in the debate; "representation"—presenting a "face" to other publics and stakeholders; and "organisation"—creating structures that build an identity as an organisation or interest group.

The *Hands Across the Water* dialogue project was conducted at a time when the GE debate had been a major controversy in New Zealand and elsewhere.

Throughout that debate, "Science" and "Scientists" were constituted as institutional agents in favour of GE technology. "Science" in turn, was synonymous with evidence, logic and fact. To be in favour of GE was to be in favour of science. The project was set up to explore the possibility that views expressed by scientists and community members in the private space of interpersonal conversation might play out differently from the "pro and anti" GE scripts dominating the public discourse. It was able to demonstrate that providing a new discursive space, using dialogue methods, could have an effect on the content and style of communication. Contrary to the "Scientist" and "Community" identity positions that had played out in the public domain, only one or two participants expressed views that were either totally for biotechnology or totally against it. Overwhelmingly, they were able to articulate "shades of grey" on the issue and could identify preferences for specific applications or end uses of biotechnology.

Scientists in the study exhibited a range of responses in relation to their identity. Generally, they showed a higher level of risk acceptance of biotechnologies than community members, but nearly all expressed some reservations about their use. Interestingly, some medical scientists were concerned about GE in agriculture; and some agricultural scientists had concerns about medical applications. This reflects the "affiliation" effect discussed by Slovic (2000) and matches the findings of Sommer (2010). There was also evidence of a blurring of the line between civic and scientific identities. Many, but not all, spoke of themselves as both citizens and scientists:

> There is a view that members of the scientific community are bald-headed, bearded geeks buried in information, who have lost sight of the world of environmental and social issues. I point out that the environmental movement started off from people in academic departments and that scientists are active members of environmental groups.

They were also conscious of how the identity of scientist had been constructed in the wider public debate. Some sought to reclaim their own concept of what it means to be a "good scientist" but were also concerned not to adopt other identities:

> Do they [the public] think all scientists are old guys with glasses not able to think of anything but knowledge from experiments? There are a lot of good scientists out there with consciences and ethics and everything the public fears we don't have

> I'm not a greenie. I believe in technology. But is this what responsible science should be about? Technology is abused and society is left to pick up the mess... Society has reason to be sceptical of high tech science.

Scientists also expressed normative views about the role of science, observing that it is conducted in a social context and that this creates obligations on scientists:

> You have to do science responsibly. It cannot be done in isolation; it is done in a community context.

> We have a public that we're accountable to and that makes us responsible in science… We are also all responsible to ourselves and to society. Society does shape all of us. If we're not aware of that, we're living on an island!

After experiencing the processes used in this dialogue research project, a number of respondents called for new forms of engagement with society:

> A valuable insight was the finding that we really make initial assumptions and these shape our interactions with others. Defeating that might help achieve a more tolerant discourse.
>
> People are curious about the technology. As scientists we need to focus more on the community.
>
> I would hope that we learn to engage the public in a different way and before the debate [takes off].

Taking into account both the general studies on scientists cited earlier, and the dialogue project discussed above, what can we say about emerging signs of scientific reflexivity that might represent attributes of a Citizen Scientist? These studies illustrate that scientists exhibit a wide range of responses to the social context and social judgments of their work, express diverse accounts of science and society relations and hold widely diverging views on the purpose and value of public engagement.

Interviews with biotechnologists in New Zealand appear to be consistent with Egorova's (2007) cross country results on geneticists. The majority of New Zealand scientists showed only limited interest in what their work might mean for society and the environment, and they engaged in science communication primarily for the purpose of producing "scientific facts" and correcting public misconceptions (Cronin and Jackson 2004: 47–51). Many recognised that others might have different interpretations of genetic research but that this would not change their view of their work: an instance of low-mid level reflexivity. At the same time, the study found a significant minority of scientists who were not only open to other points of view and willing to explore the social, ethical and environmental implications of biotechnology, but who were also willing to take social questions on board and seriously re evaluate what it might mean for their research—even to the point that some applications should not be pursued. This indicates a high level of scientific reflexivity, which was even more remarkable given the heavily politicised and commercialised environment in which scientists were operating at that time.

The profile of the scientist cannot be painted as a monochromatic picture. Scientists, as a group, display diversity; and individual scientists display different responses to the scientific and social dimensions of their role. This leaves us with the fascinating and important challenge of exploring what factors make it possible for some scientists to move along the continuum from low to high scientific reflexivity and to reconcile their positions and interests in science and society, that is, to act as a Citizen Scientist?

The New Zealand dialogue project showed some potential for breaking through scientists' heavily constructed scientific identities. It used interventions such as ensuring confidentiality, conducting private one-to-one phone interviews on the issues around GE, and introducing workshop participants only on a first name basis. Working with a diagrammatic representation of science and community risk assessments, the Issues Mapping method created opportunities for scientists to contribute to the discussion without being constrained by their formal scientific roles. While these outcomes were encouraging, further work is still needed to extend these techniques.

6 Implications for Future Science and Society Engagement Practice

Drawing on the force field model of science and society engagement presented in the "Introduction" section earlier, and noting the results of the dialogue project above, we can observe that a variety of engagement strategies are deployed by scientists. At the "low reflexivity" end of the spectrum, engagement strategies are focused on anticipating and countering public responses, so that sociopolitical challenges have minimal influence on the scientific enterprise. Rhetorics of "information", "education" and "responsible development" are usually found here. In the middle of the spectrum, concessions are granted around the potential social, environmental and ethical impacts of technology; engagement strategies are focused on the identification and mitigation of effects, which are then "taken into account" under the tidy mechanisms of risk assessment and technology regulation. This focuses attention on questions of operational management and inhibits any substantive questions about the underlying trajectory of the technology itself (Cronin 2007). At the "high reflexivity" end of the spectrum, engagement strategies allow for a much wider consideration of the purpose and outcomes of the proposal, opening up discussion to consider alternatives, new trajectories or even the avoidance of some science and technology applications. With "upstream engagement", public involvement is enhanced both in terms of its timing in the innovation cycle and in the scope of issues that may be addressed. This is a reflexivity continuum that on the one hand allows little or no penetration of a science proposal by social evaluations, and on the other, might produce a significant shift in the choice of scientific applications and in broader science platforms and strategies, based on social evaluations and preferences.

Much of the current practice in public engagement is influenced by these underlying dynamics between scientisation and contextualisation. Approaches such as consensus conferences, citizen juries, citizens' assemblies, deliberative mapping and nanodialogues have been developed to improve communication and to mitigate social resistance to emerging science and technology (Cronin 2008a). While providing for science and technology to be discussed in the public domain, and creating novel opportunities for different actors to talk face to face, these approaches still tend to involve a "set piece" exchange between science and the public, between expert and lay knowledge. This serves to entrench "Scientists" and "Citizens" in two monolithically constructed and competing domains. The communication process is aimed at establishing a communication channel between the two subject positions, with outcomes such as "providing information" and perhaps, "increasing awareness" of different points of view.

Nevertheless, a discursive struggle still runs through these methods because they are predicated on the traditional positions of actors identified as either "Scientists" or "Citizens" and because they rely on communication formats that encourage the participants to act out these socially prescribed roles. The discourse of science participants is thus conducted in terms of scientific authority, and the discourse of citizen participants is frequently conducted in deference to that authority (see also Yamaguchi, 2010). Evaluations suggest that participants come away from such exchanges with feelings of dissatisfaction, a sense of not having been heard, and of distrust in the organisers of such events, which are often poorly connected to real-

world decision-making on science and technology (Goven 2003). Irwin and Wynne (1996: 220) noted that such exercises may only succeed in reinforcing the gulf between scientific knowledge and the general public.

How then to develop more progressive relations between scientific knowledge and citizenship? To move ahead, I suggest that we need to break open the two identity positions of "Citizen" and "Scientist" around which such exchanges have been traditionally designed. Work on the Scientific Citizen is well underway. Seminal research by Wynne (1996) has clearly shown that citizens are capable of grasping scientific information, interpreting scientific concepts and making valid judgments on science and technology questions using both scientific and extra-scientific criteria. Moreover, within civil society groups challenging science and technology proposals there are often members with science and professional backgrounds, well equipped for interpreting and articulating the technical as well as normative dimensions of the issue; see for example, van den Daele (1996) and Scharz (1998). In other words, scientific competency is often a salient feature in the citizen's profile. Work on the Citizen Scientist is less well advanced. An important priority in improving future engagement practice is to highlight and harness the extant social competency within scientists. This demands further inquiry into the processes of construction of scientific identity. We know that scientists are not a homogeneous group, but scientists and the public (and social scientists) often react as if they were. This underscores the need to look beyond a one-dimensional construction of "Science" in the science–society relationship and the importance of a more finely drawn picture of scientific actors as both scientists and citizens.

7 Conclusion

Irwin's (1995) "Citizen Science" drew attention to citizens' relationships to science. The aim was to recognise the concerns of citizens and their understanding of real-world phenomena and of scientific concepts. This was an important development, to rectify asymmetries in the science–society relationship. To avoid further asymmetry, however, we also need to recognise the social concerns of scientists and their understandings of society. While we no longer automatically construct citizens as passive and lacking scientific awareness (Hipkins et al. 2002), we also need to be alert to constructing scientists as passive and lacking social awareness.

Irwin recognised of course that "Science" was not homogenous "either at the level of its own institutional and cognitive structures or at the level of social assessment" (Irwin 1995: 107). He emphasised the diverse nature of contemporary science in terms of the social meanings and significances attributed to it by society. This view, however, may obscure the extent to which science actors are themselves diversely positioned with regard to the social meanings of science and the value of different applications of science and technology to society. Scientists, as well as citizens, have argued with the one-dimensional account of science as the prime source of rationality and legitimation (Irwin 1995). Along with citizens, scientists themselves have challenged the truth claims of science and have raised their voice in the public domain. In so doing, these scientists have acted as citizens in their reflexive critique of contemporary science, that is, as Citizen Scientists.

The concept of scientific citizenship has enhanced our understanding of the citizenship power of the public, expanding the meaning of what it means to be a citizen in a modern, technology-driven age. The citizen clearly has a place in science. We also need to focus our attention on the place that the scientist has in society. How do scientists regard themselves as social actors? How are scientists themselves shaping their identity as scientists and as citizens, in the context of social debates about science and technology? How is the scientific voice being heard in contemporary evaluations of science and technology applications? And what implications does this have for future science and society engagement? Exploring these questions offers a rich horizon for future research.

Progression towards a new, "civic science", requires boundary flexibility: not just between the realms of lay and expert knowledge, but between science and citizen identities within science. Reflecting broader developments in Mode 2 science (Nowotny et al. 2001), the initiatives being taken by scientists to engage with social issues signal the potential for more radical forms of communication between science and society. To achieve this, the civic instincts of scientists need to be highlighted and promoted. As well as nurturing citizen knowledge, we need to recognise and nurture the civic knowledge of scientists and incorporate this in public discourse on science and technology. The Chinese writer Kung Hsin expressed this elegantly in 1600 when he wrote:

> The enlightened physicians of today cultivate humaneness and righteousness in their attitude. Their study is extensive and embraces all of the writings in their entirety. For this reason they are well versed in theoretical medicine and its practical use. … They ponder over the best procedures, are [flexible] in their treatments and do not cling mechanically to any formulas. Enlightened physicians who act in this way will be remembered for their virtue in all eternity.[5]

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