Routledge
Taylor & Francis Group

RESEARCH PAPER

It takes two to tango: knowledge mobilization and ignorance mobilization in science research and innovation

Joanne Gaudet*

Department of Sociology and Anthropology, University of Ottawa, Ontario, Canada

The main goal of this paper is to propose a dynamic mapping for knowledge and ignorance mobilization in science research and innovation. An underlying argument is that 'knowledge mobilization' science policy agendas in countries such as Canada and the United Kingdom fail to capture a critical element of science and innovation: ignorance mobilization. The latter draws attention to dynamics upstream *of knowledge in science research and innovation. Although perhaps less visible, there is ample evidence that researchers value, actively produce, and thereby mobilize ignorance. For example, scientists and policymakers routinely mobilize knowledge gaps (cf. ignorance) in the process of establishing and securing research funding to argue the relevance of a scientific paper or a presentation, and to launch new research projects. Ignorance here is non-pejorative and by and large points to the borders and the limits of scientific knowing – what is known to be unknown. In addition, processes leading to the intentional or unintentional consideration or bracketing out of what is known to be unknown are intertwined with, yet remain distinct from, knowledge mobilization dynamics. The concepts of knowledge mobilization and of ignorance mobilization, respectively, are understood to be the use of knowledge or ignorance towards the achievement of goals. The value of this paper lies in its conceptualization of the mobilization of knowledge as related to the mobilization of ignorance within a complex, dynamic and symbiotic relationship in science research and innovation: it takes two to tango.*

Introduction

The main goal in this paper is to propose a dynamic mapping for knowledge and ignorance mobilization in science research and innovation.[1] The dynamic mapping is an attempt to reconcile knowledge mobilization and ignorance mobilization dynamics in science and innovation. It builds on the mapping of topologies for knowledge and ignorance developed by Gross (2010a) and deemed by Hess (2010, p.5) as '… the most complete and integrated to date'. This paper challenges this assessment with revisions to Gross' mapping. It also explicitly integrates mobilization dynamics in the new proposed mapping. The latter highlights the relationship and tension between knowledge and ignorance mobilization processes and the importance of multiple goals for actors (i.e. natural and social scientists, policymakers, stakeholders and funders) engaging in mobilization.

It goes without saying that knowledge typically retains the limelight in science research and policy; in spite of this, scholarship increasingly draws attention *upstream* of knowledge towards ignorance (e.g. Merton, 1987; Gross, 2010a).[2] What

---

*Email: jgaud041@uottawa.ca

is more, ignorance for natural scientists is mostly a non-pejorative concept. Within the natural sciences, for example, ignorance is frequently framed as a driver for knowledge production (i.e. Firestein, 2012) and a valuable resource (i.e. Williams, 2013). Here, I use ignorance as the limits and borders of knowing (Gross, 2010a, p.71) – what scientists know that remains unknown in any given area of science. The dynamic mapping proposed here helps extend understanding of knowledge and of ignorance mobilization beyond production by making the dynamics of knowledge and of ignorance inclusion and exclusion visible. The mapping is thus relevant to understanding science as a complex interplay among knowledge and ignorance mobilization related processes and practices. To reach its goal, the paper draws from burgeoning scholarship in knowledge mobilization (e.g. Halliwell and Smith, 2011; Levin and Cooper, 2012)[3] and in the sociology of ignorance (e.g. Moore and Tumin, 1949; Merton, 1987; Luhmann, 1998; Gross, 2007, 2010a; Davies, 2011; Kempner et al., 2011; McGoey, 2012b; Roberts, 2012).[4] It also contributes to an ostensibly general lack of theoretical framing of ignorance in science and innovation (see Bammer and Smithson, 2009, p.3; Gross, 2010a, pp.74–78, 173).

Fundamentally, how policymakers, funders, and social and natural scientists typically refer to knowledge in science and innovation reveals economic and material roots. Since the late 1800s, the value of science (measured at national levels) as scientific productivity has included measures of scientific efficiency (ensuring value for public money), output (e.g. bibliometrics for publications, patents) and outcome (i.e. economic and technological impact) (Godin, 2009). More recently, scientific, innovation and medical research policy in such countries as Canada, New Zealand and the United Kingdom has focused on outcome by advocating the potential use of academic knowledge in non-academic contexts. These policies can promote dynamics of knowledge use such as knowledge transfer, knowledge translation or, more predominantly in Canada and the United Kingdom, knowledge mobilization (Halliwell and Smith, 2011; Greenhalgh and Wieringa, 2011; Carter et al., 2012). Focus here is on knowledge mobilization.

Undue focus on knowledge mobilization in science policies, however, belies underlying complexity. A knowledge-only lens is similar to trying to understand manufacturing only in terms of downstream manufactured components and final outputs. This excludes consideration of manufacturing's upstream raw materials and dynamics. Ignorance in science and innovation can be likened to a raw material – an intellectual resource that drives knowledge production. Roberts and Armitage (2008), for example, argue that an ignorance economy is a foundation for a knowledge economy [also in relation to research (2008, p.351)]; so does Smithson (1985, p.153): 'conscious attention to what one does not know must occur before learning or invention can take place'. Hence the need to consider ignorance in any understanding of knowledge in science and innovation. Continual learning and innovation take centre stage in the ignorance–knowledge mobilization tango.

Such a simplistic analogy with manufacturing activities quickly breaks down on at least two levels. First, knowledge and ignorance dynamics are far from being linear. More knowledge can produce more ignorance, and ignorance itself can lead to even more ignorance production (see Smithson, 2009, p.24; Gross, 2010a, p.173). Second, what is (or what is not) considered knowledge and ignorance highlights inclusion and exclusion dynamics. An example is the long-term exclusion of investigating ignorance on cancer stem cells (with cancer constructed as a source and a sink) in favour of the established view of cancer as what Bains (2009, p.280) calls 'a

bulk of mutating cells': 'how much more might we know now about cancer if this idea had been able to penetrate the high wall of peer consensus in the 1980s rather than two decades later?'. In this case, the peer review process is purported to have hindered ignorance mobilization, at least at the beginning. Researchers producing new ignorance on cancer stem cells failed to have their ignorance further mobilized in the science community (or beyond). Ultimately, this impeded mobilizing new knowledge for therapeutic applications. Rather than addressing Bain's question directly, this paper attempts to untangle and map the dynamics and processes related to the mobilization and to the (in)exclusionary dynamics of ignorance (in relation to knowledge) in science and innovation (see Frickel *et al*., 2010; Kempner *et al*., 2011). Thus, this study of ignorance mobilization is nested within the epistemology of ignorance. Sullivan and Tuana (2007, p.1) suggest that 'the epistemology of ignorance is an examination of the complex phenomena of ignorance, which has as its aim identifying different forms of ignorance, examining how they are produced and sustained, and what role they play in knowledge practices'. This paper's focus on ignorance (albeit only one of its many forms, and specifically within science and innovation) and its interaction with knowledge in science joins a growing literature on the multiplicity and complexity of ignorance.

To be sure, the way in which scientific ignorance is conceptualized here – as socially constructed and negotiated, much like the social construction of scientific knowledge – is in contrast to a view of ignorance as simply being 'out there', waiting for scientists to identify it. The latter view frequently espouses an understanding of ignorance as an absence of knowledge, or as the other side of knowledge. Smithson (1985, p.168) notes: 'that ignorance is socially constructed follows from the observation that it is virtually impossible to speak intelligibly about ignorance without referring at least implicitly to a social standard of truth and falsehood, or irrelevance'. For actors engaged with science and innovation, the construction and negotiation of ignorance (its mobilization) are thus intricately related to knowledge construction and negotiation (its mobilization). Actors include researchers, collaborators, co-investigators, brokers, universities, as well as government, industry, and civil society stakeholders and funders.

The main argument here builds on Sullivan and Tuana's (2007) epistemology of ignorance – that knowledge mobilization must be conceptualized as linked with ignorance mobilization in the study of science research and innovation. Hence, knowledge remains provisory in relation to ignorance (and *vice versa*) in a complex, dynamic and symbiotic relationship: it takes two to tango. This leads to an understanding of the concept of knowledge mobilization and of ignorance mobilization, respectively, as the use of justified beliefs (knowledge) or the limits and the borders of knowing (ignorance) towards the achievement of goals (social, cultural, political, professional and economic) (see Levin, 2008, pp.11–12).

Knowledge and ignorance mobilization is therefore explicit rather than implicit in this paper. More precisely, the study is in the context of scientific and innovative inquiry, including collective experiments outside the confines of the laboratory (Gross, 2010b). This is in contrast to the use of the concept of mobilization by social scientists in a multitude of contexts. A first example: 'I term such practices of obfuscation and deliberate insulation from unsettling information "strategic ignorance", the *mobilization of the unknowns*' [emphasis added] (McGoey, 2012a, p.555). Second is the use of mobilization in a political critique of ignorance: 'in contrast, Bourdieu, Foucault, and the writers they influenced took a critical view, according to

which the domain of the unspoken and unspeakable are generated and mobilized in the interests of power and capital' (High *et al*., 2012, p.14). Two final examples are: 'mobilizing organizational ambiguity' (Roberts, 2012, p.12) and '… actors mobilize ignorance … by … displaying vulnerability or employing vagueness or ambiguity in negotiations' (Roberts, 2012, p.17). It remains unclear what these researchers mean by mobilizing the unknowns, the unspoken, the unspeakable or ignorance. In contrast, this paper proposes definitions for, and theoretical delineations of, knowledge and ignorance mobilization and their dynamic interaction, specifically in science and innovation. Knowledge and ignorance mobilization is borne of a need to construct the object theoretically and carefully (Lopez, 2009, p.35). It is necessary to step back from the ready-made constructions proposed by policymakers and granting agencies as 'win–win' for researchers, stakeholders, funding agencies and taxpayers (as practised in Canada, for example). A contribution highlighting ethical and power relations in action research with health system stakeholders (Nugus *et al*., 2012) corroborates a call for enhanced reflexivity and further theoretical refinement.

The paper is purposely overarching in order to yield a multi-layered conceptualization of knowledge and ignorance mobilization in research. It forgoes comprehensiveness in order to retain systemic complexity. The paper proceeds in two phases. First, it focuses on knowledge mobilization within a sociologically informed ignorance and knowledge mobilization research approach. This includes an interactive model of research impact. Second, it proposes a conceptualization of knowledge mobilization as dynamically linked with ignorance mobilization in science and innovation. Brief empirically oriented insights highlight the role of the conceptualization in helping to understand how knowledge and ignorance mobilization contributes to research impact. The paper concludes that the notion of knowledge and ignorance mobilized as tango partners can help capture the complex interplay between, and impact of, knowledge and ignorance, not only in science research and innovation, but also in business research and innovation.

Knowledge mobilization, the mobilization approach and knowledge impact

A concept such as knowledge mobilization would be unlikely to be relevant to policymakers if scientists had unlimited sources of funding to engage in research. If this were the case, scientists might also be less interested in the application of their newly constructed knowledge outside academia. Such a concept might also have little traction if issues of accountability did not dominate contemporary public governance debate. In many jurisdictions worldwide, however, limited sources of public funding combined with political goals to maximize the use or applicability of scientific knowledge (in great part framed as ensuring accountability and results for taxpayer funding), mean that policymakers promote approaches such as 'knowledge transfer', 'knowledge translation' and 'knowledge mobilization' for science and innovation research. The last has been especially prominent in Canada and the United Kingdom (Provencal, 2009; Halliwell and Smith, 2011; Hart *et al*., 2013). Knowledge mobilization for policymakers and funding agencies usually emphasizes application and impact outside academia. This includes the realms of policymaking, public service delivery (Nutley *et al*., 2007), scientific 'products' such as therapeutic or military applications, community or stakeholder partnerships, new business ventures and patents. Yet, impact outside academia can be intimately linked to impact

inside academia. Understanding the distinctions and related processes and actors is critical.

This paper does not dwell on the differences among knowledge approaches (transfer, translation and mobilization) as this has been considered elsewhere (Greenhalgh and Wieringa, 2011). It focuses on knowledge mobilization for three main reasons. First, its increased use, especially in natural and social sciences and in innovation in Canada [e.g. Social Sciences and Humanities Research Council of Canada (SSHRC), 2007; Networks of Centres of Excellence (NCE), 2012; Canadian Institutes of Health Research (CIHR), 2012]. Second, it holds sociological roots in mobilization-related theory. Finally, it offers the potential to inform social science research and policymaking when it is integrated into a non-linear understanding of knowledge and ignorance mobilization. First, the paper characterizes knowledge mobilization beyond the ready-made constructions proposed by policymakers and granting agencies. The characterization includes consideration of mobilization within and outside academia and proposes the new concept of ignorance mobilization. Second, the paper considers the value of an overall knowledge and ignorance mobilization approach. Finally, it looks at the need to understand impact within and beyond academia.

Definitions

The following definitions are in great part inspired by Gross (2007, pp.742, 749, 751; 2010a, p.71), who advocates stabilizing definitions within the sociology of ignorance. Fundamentally, in sociological definitions of knowledge it is not knowledge *per se* that is the object of study, but relevant social relations. Knowledge here refers to a justified belief connected to purpose (or use). Scientists engage in a multitude of relations and processes through which they justify scientific beliefs, including peer review and informal and formal exchanges with colleagues. From this broad category of knowledge, two knowledge sub-types emerge: existing knowledge and new knowledge. The former can be found in written publications, in formal or informal written or oral exchanges among scientists (explicit knowledge), and in laboratory settings (embodied tacit knowledge) in experimental manipulations. New knowledge, on the other hand, can be a justified belief held by a limited number of scientists until it is justified through processes within a wider scientific community.

The broad category of ignorance refers to the borders and the limits of knowing – what scientists know that is not (as yet) known in science (as opposed to individual ignorance or the opposite of knowledge). Within this category, there are two sub-types: active non-knowledge and latent non-knowledge. Active non-knowledge can be defined as the limits and the borders of knowing that are intentionally or unintentionally taken into account for immediate or future planning, theorizing and action. In contrast, latent non-knowledge is a sub-type of ignorance where the limits and the borders of knowing are intentionally or unintentionally not taken into account for immediate or future planning, theorizing and action.

The cancer example from above illustrates active and latent non-knowledge. For a long time, active non-knowledge of cancer (what was actively pursued as the limits of knowing in this area) portrayed cancer as '… a bulk of mutating cells' (Bains, 2009, p.280). At the time, latent non-knowledge (socially constructed at least in part by peer review dynamics) was that of cancer stem cells (with cancer constructed as a source and a sink). This latent non-knowledge was eventually constructed into active

non-knowledge, and scientists now readily engage in research to generate new knowledge (and new ignorance) on the topic. This example shows that to know what we do not know is to construct ignorance (see Smithson, 1989, p.260). To consider this ignorance, whether intentionally or unintentionally, is to construct it as active non-knowledge as opposed to latent non-knowledge (Ravetz, 1987) or specified ignorance (Merton, 1987).

By 'nescience' we mean the complete absence of knowledge. Nescience can be investigated only in retrospect. Otherwise, how could a scientist 'know' anything about a complete absence of knowledge? Nescience is relevant where it might have contributed to new ignorance, which catapults it into the scope of science in practice, usually through surprise. Surprise at the outcome of an experiment, for example, sometimes leads to the identification (the social construction) of nescience from which science actors can construct new ignorance. In contrast, ignorance (and its sub-types) and new (or existing) knowledge are within the actor's consciousness and can be socially constructed in science processes which render these observable (Gross, 2007, pp.750–51). An example of nescience is Prusiner (1995), who discovered prions, thereby revealing the total lack of knowledge of their existence (nescience) and the role of prion proteins in neurodegenerative disease (active non-knowledge).[5]

Characterizing knowledge and ignorance mobilization

Assorted knowledge mobilization definitions are currently used by Canadian funding bodies, including the Networks of Centres of Excellence, the Canadian Institutes of Health Research and the Social Sciences and Humanities Research Council of Canada. The wide spectrum of their conceptions of, and prescriptions for, knowledge mobilization is of little relevance in this paper. An understanding of the underlying dynamics, however, is relevant, and requires clear analytical and theoretical tools and a clear delineation between funding agencies' often instrumental conception of knowledge mobilization and a more analytical conceptualization to help capture knowledge and ignorance interaction.

Although less visible, it would appear that knowledge and ignorance dynamics are slowly permeating funding agency policy discourse in Canada. An example is the proposed consideration of expert opinion on knowledge gaps as a socio-economic indicator of the impact of science and innovation research (Expert Panel on Science Performance and Research Funding, 2012, p.41). In this paper, 'expert opinion on knowledge gaps' is understood as ignorance, or more precisely as active non-knowledge. This highlights scientists engaging in research framework changes and pursuing promising new avenues of research (Hellstrom, 2012, p.398). Furthermore, when policymakers pay attention to expert opinion on knowledge gaps, they are mobilizing ignorance – using active non-knowledge in attempts to reach political goals. In contrast, scientists can mobilize active non-knowledge in order to attain professional goals (e.g. publishing, presenting and seeking promotion) and sometimes economic goals (e.g. set up commercial ventures and secure patents). In addition, the paper draws from the debate on potential research limitations. Social science researchers must not fall prey to self-(re)producing understandings of the object of study (see Lopez, 2009, p.35).

What, then, is meant by mobilization? Building from a multiplicity of mobilization concepts ranging from political mobilization, economic mobilization

and resource mobilization to social mobilization, mobilization can be defined as the activation and application of individual or organizational resources towards a goal (see Scott and Marshall, 1994; Cress and Snow, 1996; McCarthy and Zald, 2001; Edwards and McCarthy, 2004; Peters, 2010). Consequently, knowledge mobilization and the concept of ignorance mobilization proposed here are the use of justified beliefs (knowledge) or the borders and the limits of knowing (ignorance) towards the achievement of goals (social, cultural, political, professional and economic) (see Levin, 2008, pp.11–12). Implicit in these definitions is the activation and application of resources by individuals or organizations, imported from the concept of mobilization – activating and applying resources in order to use knowledge or ignorance to achieve goals. This further implies a potential separation between individuals (or organizations) and knowledge or ignorance that requires activation and application of resources. So, the individual who constructs ignorance or knowledge is not the only one who can mobilize it. Other actors can just as easily activate and apply resources to mobilize ignorance or knowledge.

Finally, use in the proposed definition is multi-dimensional to capture actors' aspirations to achieve a range of goals. Use can be instrumental, conceptual, strategic/symbolic and inspirational (see Amara *et al.*, 2004; Elissalde and Renaud, 2010, pp.412–14; Levin and Cooper, 2012, p.18). Instrumental use refers to instances where decisions or actions are directly based on mobilized knowledge (or ignorance). Conceptual use refers to changes or adaptations in theoretical or conceptual understanding following mobilization. Strategic/symbolic use designates the use of knowledge (or ignorance) to legitimate or justify a position. Lastly, Elissalde and Renaud (2010) add inspirational use, which is particularly pertinent for inter- and multi-disciplinarity as it refers to the transposition of knowledge (or ignorance) from one discipline or area to another.

Actors and refinement of characteristics for knowledge and ignorance mobilization

This paper goes beyond issues of use and focuses on additional mobilization dimensions: the actors and institutions that (co)produce knowledge and ignorance; and the conditions that influence the mobilization of knowledge and ignorance, such as fungibility, transferability and property rights (Cress and Snow, 1996; McCarthy and Zald, 2001, pp.545–49; Edwards and McCarthy, 2004). Researchers, collaborators, co-investigators, brokers, universities, stakeholders and funders can all play important roles in mobilization. What is more, university–industry–civil society–government collaborations are often mandated in knowledge mobilization projects. It is important to be able to tease out the intricate mobilization dynamics such collaborations can foster.

Fungibility (as borrowed from mobilization theory) refers to context dependence. Knowledge or ignorance that is fully fungible is context independent (written knowledge or ignorance in publications, books or blogs with varying degrees of market-restrictive access such as pay-per-article) or almost not fungible when fully context dependent (tacit knowledge or ignorance) (see Edwards and McCarthy, 2004, p.128). Knowledge and ignorance transferability amongst individuals, organizations or contexts is closely linked to fungibility and receptivity (or absorptive capacity) of actors and institutions. Essentially, actors must not only have resources to activate and apply to knowledge or ignorance, but also the capacity to deal with fungibility and

receptivity. Dedicated knowledge mobilization units in universities attempt to counter the limited mobilization and impact of academic publications by producing 'clear language' research summaries. These brokers also ensure wider dissemination outside academia. Finally, property rights are relevant to control over knowledge and ignorance (from secrecy to open access) and include intellectual property (patents, trademarks, copyright, industrial designs, integrated circuit topographies or plant breeders' rights). Inversely, property rights can also relate to the ability to gain access to controlled knowledge and ignorance, countering intellectual property mechanisms (see Kapczynski, 2008; Evans, 2010a).

A knowledge and ignorance mobilization approach

Overall, therefore, a sociologically informed knowledge and ignorance mobilization approach looks at how academic scientific knowledge or ignorance is (co)produced, transmitted, received, evaluated, managed and integrated into existing knowledge or ignorance (see Burke, 2000, p.118; Levin, 2008, pp.11–12). This is a departure from linear conceptualizations of knowledge and ignorance from production to use. In addition, the mobilization approach does not assume a given degree of separation between production (within science as an institution) and use (outside science as an institution). This implies that mobilization impact is not restricted to a set context. From the perspective of policymakers and funding agencies (and other non-academic actors) managing research networks and projects with knowledge mobilization mandates, the impact context is usually assumed to be the (co)use context outside academia. In contrast, funding agencies providing grants directly to academics currently have reward systems that favour impact within academia (peer-reviewed papers, academic conferences and graduate supervision). The tension between the two funding model indicators for impact is of interest in mobilization research. It is not surprising that the (co)production context inside science as an institution is the assumed impact context from the perspective of academia. The growing potential for interaction between technological and social innovation worldwide (Howaldt and Schwarz, 2010; Phipps *et al.*, 2012) is an example of multi-context impact involving not only policymakers and stakeholders (outside science as an institution), but also scientists themselves (within science as an institution).

Understanding research impact

How, then, can we understand the impact of science research knowledge and ignorance? Figure 1 depicts a dynamic model of research impact with multiple actors. The (co)production, within-academia impact context is on the left side and the (co) use, outside-academia context is on the right side. The two main contexts of knowledge or ignorance – (co)production and (co)use – are distinct, but hold potential for dialog dynamics. Although the proposed interactive model was inspired by Levin and Cooper (2012, p.20), it has distinct theoretical and conceptual underpinnings.

Within academia, impact relates mainly to knowledge and ignorance (re)production. Researchers, co-investigators and collaborators (re)produce knowledge and ignorance to attain mostly professional goals within science as an institution. There are exceptions, of course, as when knowledge mobilization mandates encourage commercialization or stakeholder–researcher partnerships that can lead to impact outside academia. Such beyond-academia impact includes 'the influences of research on
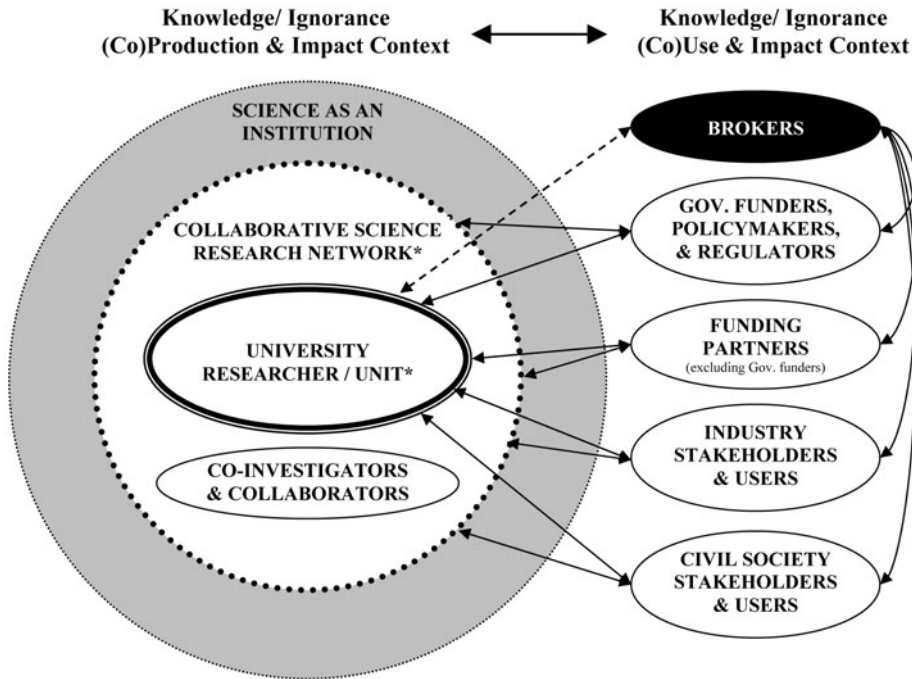
Figure 1.   Knowledge and ignorance research impact interactive model
Note: *Unit and network are only as applicable.

policy, managerial and service delivery practices, or on political and public discourse' (Nutley *et al*., 2007, p.282) and knowledge or material products (e.g. patents, commercializable products) (see Phipps *et al*., 2012, pp.181–83).

One critical underlying assumption in the conceptualization is a deliberate focus on the university researcher/unit/network as actively engaged in knowledge and ignorance (co)production (left side). This does not preclude knowledge and ignorance production outside academia. In addition, there is potential for ignorance co-production among government, industry, civil society and academic researchers within the academic context. In deliberative science, stakeholder participation in epistemic processes, such as research question development and research agenda setting (constructing active non-knowledge as opposed to latent non-knowledge), reflects robust social processes alongside robust epistemic processes in ignorance mobilization (see Gross, 2010a, pp.113–16). For example, funding agencies that prescribe knowledge mobilization approaches can mandate such deliberative science dynamics and processes for research projects.

In the (co)use context on the right side of Figure 1, each group listed can play an important role in knowledge and ignorance mobilization. The first group of actors – brokers – mediates between (co)production and (co)use contexts, and can also help (co)produce knowledge and ignorance between the (co)production and (co)use actors (see Bielak and deGraaf, 2011, p.19; Karner *et al*., 2011). The role of brokers is especially pertinent where individuals or organizations cannot activate or apply resources towards mobilization. Deficiencies in absorptive capacity or opportunities to increase capacity in order to integrate new knowledge or new ignorance are

captured in the study of mobilization receptivity (Shaxson, 2010; Elissalde and Renaud, 2010, p.10).

A second group of actors includes government funding agencies, policymakers and regulators. These can deploy mobilization strategies to identify academic research ignorance mobilization initiatives (Davies, 2011). The government role extends to funding research, regulating activities and overseeing policy development and implementation, some of which can also involve brokers (Bielak and deGraaf, 2011). Other funding partners, the third group of actors, include individual, industry and civil society donors. In each case, the relationship with a research project investigator or a research unit can be direct. How non-governmental funding can influence ignorance or knowledge mobilization frequency or functioning is particularly relevant in the context of understanding the impact on academic research (see Evans, 2010a). Understanding mobilization with the two remaining groups of actors (industry stakeholders and users, and civil society stakeholders and users) is equally critical. This is because collaborative science research is frequently in health, social and environment matters, areas in which there is wide social participation in knowledge and ignorance (co)production.

Dynamic model of knowledge mobilization and ignorance mobilization

The 'house of the unknown' model (Gross, 2010a, p.71) links nescience, ignorance and knowledge (and their respective sub-categories). Gross proposes the metaphor of the house with extended or new knowledge at the door, ignorance and its sub-categories inside the house, and nescience outside. Although Hess (2010, p.5) deems this 'the most complete and integrated [mapping of topologies] to date', there are three potential shortcomings in the Gross model. First, there is the problem of further non-knowledge leading outside the house and therefore to nescience, which seems to be a logical slip. Second, there is apparent lack of conceptual linkage in the model (though alluded to in the text) between the two sub-types of ignorance separated by the door of the house. Finally, there is no conceptual linkage between new (or extended) and current knowledge. It is useful to augment the model by integrating mobilization dynamics. This highlights the relationship and potential tension between knowledge and ignorance mobilization processes and the importance of multiple goals for actors (scientists, brokers, policymakers, stakeholders and funding partners) engaging in mobilization. The extended house of the unknown model, merging elements of sociology of ignorance and of mobilization scholarship, is presented in Figure 2. Sociological understanding of ignorance, for example, attends to elements of surprise and of the unanticipated. Luhmann (1993, p.xxvii) framed these theoretical reflections where what is not anticipated 'must be shown to have an order of its own, a secondary normality as it were'. In essence, this reflects a sociology that acknowledges and integrates surprise and what is not certain as 'normal' (see Simmel, 1906; Grossetti, 2004; Gross, 2007, 2010a).

Fundamentally, the model focuses understanding of science in practice through an epistemic lens that accounts for surprise and for the unexpected. The model attempts to capture complex, interconnected and temporally changing knowledge and ignorance processes and dynamics. Here, the metaphor of the tango achieves its full potential. Dramatic shifts and turns can lead to the construction of unexpected knowledge and ignorance, or replace outright old knowledge and ignorance. In the heat of the tango, multiple dancing partners (scientists, brokers, collaborators,
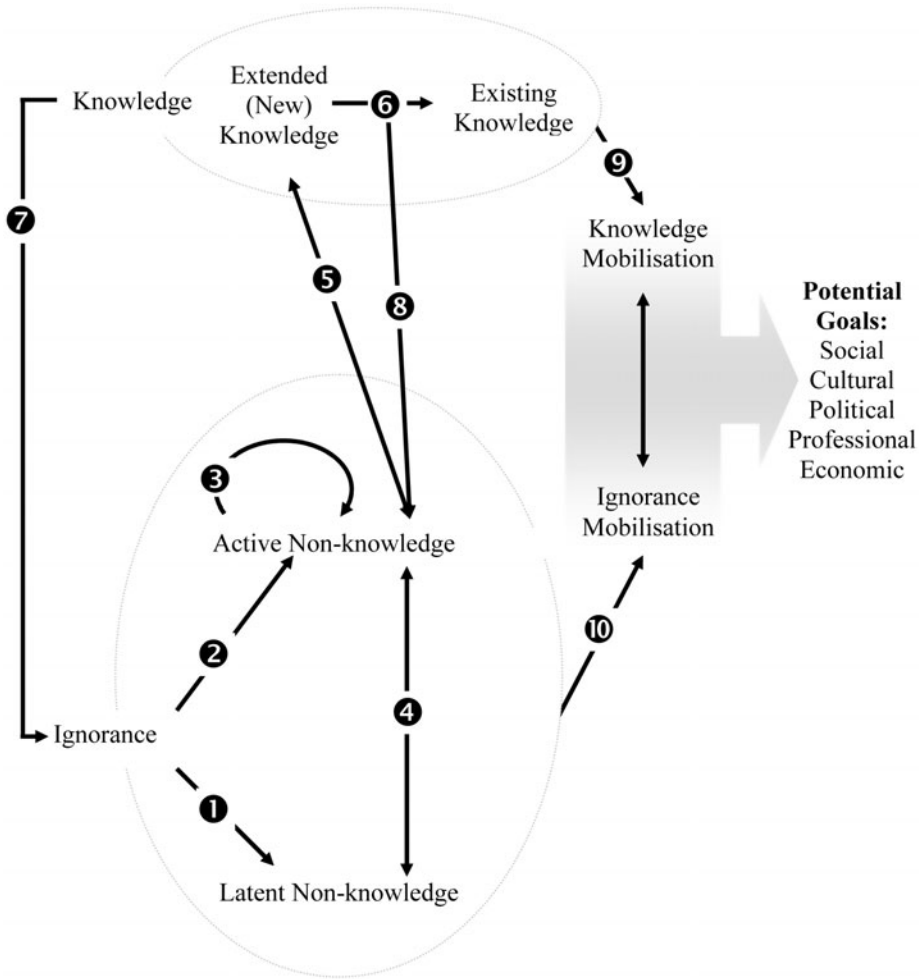
Figure 2.   Dynamic model of knowledge and ignorance mobilization
Note: *Numbering is for ease of reference. Arrows are conceptual and sometimes depict causal relationships.

co-investigators, policymakers, and industry and civil society stakeholders and funders) mobilize knowledge and ignorance – for different and sometimes competing goals. A quick overview of Figure 2 starts with an understanding that linkages are conceptual and can sometimes depict causal relationships. There is no steadfast rule that dictates when conceptual or causal relationships occur; this depends rather on specific instances of mobilization. Step numbering is solely for ease of reference (to locate processes and dynamics at particular junctures in the model). The aim is to capture, in a one-dimensional diagram, complexity and dynamic layers with recursive relationships that create new instances of ignorance or knowledge and their sub-components.

As Figure 2 indicates, active non-knowledge can lead to more non-knowledge (step 3), whereas knowledge can generate even greater ignorance (step 7). Social

innovations for the sort of problems posed by poverty, climate change, security and social determinants of health, for example, can generate new ignorance [framed as new problems in Phipps *et al*. (2012, p.67)] in the process of attempting to (co)produce and (co)use knowledge to deal with complex and sometimes interwoven physical and social phenomena. Peer review processes and dynamics (at step 6) can likewise impact active non-knowledge science research (through step 8). This includes peer reviewers recommending changes in active non-knowledge mobilization in order to enhance research and publication opportunities. Peer review epistemic processes are therefore not confined to narrow, written knowledge processes with professional goals, but can also be understood as dynamically influencing active non-knowledge processes. Also, the peer review process (at step 6) actively engages actors in (co)producing ignorance and controlling its mobilization to new knowledge. Whitley (1984, p.27) frames these processes as 'a way of exerting social control over novel ideas'.

Although undue attention is generally paid to knowledge, the interplay between steps 1 and 2 is particularly significant in relation to the impact of research. What is retained or bracketed out (either intentionally or unintentionally) as research agendas or objects of study? Why, and who, is involved in these decisions? These are only some of the questions where social scientific inquiry can have an impact on understanding the mobilization dynamics of, and the construction of, ignorance. A first example of the former is a study of ignorance dynamics involving innovation policy experts (Davies, 2011). Roberts and Armitage (2008) broach the potential role of ignorance in creativity and innovation. An example of the latter is normative social scientific inquiry to help shape societal dialogue on the need for, and the direction of, social innovation research (Howaldt and Schwarz, 2010; Phipps *et al*., 2012). These examples direct attention to the high value of ignorance in research. Identifying, structuring and evaluating problems in ways that allow their solution are therefore as important – arguably more important – than finding solutions. In essence, 'we must know what we do not know before we can effectively solve any problem' or else 'poorly posed questions divert energy, resources, and ideas' (Root-Bernstein, 2003, p.170). The role of brokers, government funding partners, civil society and industry stakeholders, and funders is critical to understanding sometimes competing goals. More important, however, is paying attention to the dynamics of what remains invisible as latent non-knowledge, and what becomes visible as active non-knowledge.

Social scientific or natural scientific ignorance identified at the outset of research projects is highly valued when mobilized by actors. For example, policymakers value ignorance when they engage in project selection and funding. The review exercise is composed of competing scientific ignorance claims, all vying for funding in an ignorance economy (High, 2012, pp.122–23). Civil society stakeholder groups also value and mobilize ignorance (though perhaps not overtly). They do so by (co)producing ignorance (sometimes in collaboration with science) on behalf of their membership in the hope that this will eventually lead to knowledge production. Civil society health-related organizations are prime examples of such actors constructing active non-knowledge through lobbying and sometimes even privately funded research programmes.

Additional examples of research and dialogue in processes between steps 1 or 2 in Figure 2 (implicitly, not explicitly) include 'undone science' (Frickel and Vincent, 2007; Frickel *et al*., 2010), the use of foresight (Carvalho *et al*., 2010), social

participation in ethics committees (Kelly, 2003; Felt *et al*., 2009; Danielson, 2010; Carvalho *et al*., 2010) and forbidden knowledge (Kempner *et al*., 2011). These studies essentially (though not exclusively or explicitly) explore the ignorance mobilization processes at the core of scientific inquiry that precede knowledge mobilization processes. Such research typically involves processes from ignorance to latent non-knowledge or to active non-knowledge. Kempner *et al.* (2011), for example, focus on the former in considering forbidden knowledge.

In contrast, research on active non-knowledge to new knowledge, or new to existing knowledge processes (mostly steps 5 or 6), such as technology assessments (Dryzek and Tucker, 2008; van Merkerk and Smits, 2008), might have less impact on (or ability to counter) new knowledge momentum reaching the policy environment, application or commercial goals once it is conceived. Momentum arises from the accumulation and harmonization of physical artefacts and the increased social capital involved (see Hughes, 1983; Erikson, 1994). Understanding the degree of social participation in policymaking, proximity to and potential for co-construction of knowledge or ignorance with science actors, and level of involvement in the transformation from steps 1 or 2 are a few of the many variables that could inform science research and innovation.

The relationship and potential tension between knowledge and ignorance mobilization dynamics on the right side of the model is worthy of attention. Actors outside science who wish to apply or use scientific knowledge will typically engage in knowledge mobilization. Actors who wish to engage in innovation to explore new research problems, on the other hand, will typically mobilize more ignorance than knowledge. An example would be higher ignorance mobilization than knowledge mobilization in a basic research laboratory in the biological sciences. Although more prevalent, ignorance mobilization remains in tension with knowledge mobilization in the laboratory, in part because of policies favouring applied and commercialization goals for research that is partially publicly funded (Gaudet *et al*., 2012).

In addition, the conceptualization developed here, dynamically linking knowledge mobilization with ignorance mobilization in science research and innovation, can be a critical bridge to understanding the Toyota Lean Production System. Ignorance mobilization lies at the heart of its business innovation model and continual learning philosophy with real-world experiments outside the confines of a laboratory. The employee is purposefully immersed in real-world experimentation with clearly delineated parameters. These foster learning and experimenting in order to reach a target condition. A target condition is understood here as what needs to be done, a hypothetical process to reach a future state or 'a description of a process operating in a way – in a pattern – required to achieve the desired outcome' (Rother, 2010, p.103). As the employee is placed in situations where current knowledge no longer applies, the employee must therefore potentially face 'knowledge thresholds' (Rother, 2013, p.7), which is the active non-knowledge mobilization encountered at step 5. Such dynamics emulate in laboratory experiments real-world experimentation (Gross 2010b; Overdevest *et al*., 2010).

Rother (2010, pp.136–37) states that 'experimentation, discovery, and learning' dynamics reflect a scientific approach where target conditions are akin to hypothesis testing. He concludes that 'deliberating over correct answers beyond your knowledge threshold is ineffective. You need to experiment' (Rother, 2013, p.7). This captures the essence of a scientific approach. He explores numerous (mostly) factory examples where such dynamics led to business innovation. Within this scientific approach,

problems become sources of process improvement and learning (mobilizing active non-knowledge). These dynamics also hark back to Root-Bernstein (2003), who advocates knowing what we do not know (ignorance) as a core task in attempting to solve any problem. Finally, the model proposed here does not lock in temporal considerations to a linear concept of knowledge or ignorance from (co)production to (co)use. The model's temporal sensitivity offers the potential to achieve greater understanding of complex issues with multiple synchronous and asynchronous layers of knowledge and ignorance mobilization processes – in short, a tango.

Conclusion

This paper outlines a notion of knowledge mobilization dynamically in tango with ignorance mobilization in science research. An underlying argument is that knowledge mobilization science policy agendas in such countries as Canada and the United Kingdom fail to capture a critical element of science and innovation – ignorance mobilization. The paper's main argument is that knowledge mobilization must be conceptualized as linked with ignorance mobilization in the study of science research and innovation. The conceptualization hinges on a definition and an approach. Knowledge mobilization and ignorance mobilization are defined, respectively, as the use of justified beliefs (knowledge) or the limits and borders of knowing (ignorance) towards the achievement of goals (social, cultural, political, professional and economic goals). The approach is one that looks at the processes and dynamics of how academic scientific knowledge or ignorance is (co)produced, transmitted, received, evaluated, managed and integrated into existing knowledge and ignorance.

Two models capture the essence of the conceptualization with respect to impact and interaction. The first model portrays multiple actors involved in knowledge and ignorance (co)production and (co)use contexts. The second maps out knowledge and ignorance dynamics. The latter illustrates how actors can mobilize knowledge or ignorance at any given step in the model to reach multiple, and potentially conflicting goals. It also highlights the tension between knowledge and ignorance mobilization and differential mobilization practices for the actors involved.

The knowledge and ignorance mobilization concept allows social scientists (and other actors in science and innovation) to capture the complexity of knowledge and ignorance mobilization ecosystems. Mobilization and its impact includes consideration of use, goals, actors and institutions that (co)produce knowledge and ignorance, issues of power, the importance of context and of fungibility, transferability (linked with receptivity or absorptive capacity) and property rights. As a result, value no longer resides solely in knowledge, but also in ignorance mobilization. By focusing attention on ignorance, researchers also heed Firestein's (2012, p.44) caution that 'if ignorance, even more than data, is what propels science, then it requires the same degree of care and thought that one accords data'. Perhaps Firestein's (a neuroscientist) understanding of ignorance tends to reflect science as discovery as opposed to science as culture with socially constructed knowledge and ignorance. Nonetheless, his caution draws attention to ignorance of ignorance in science.

Of particular interest in the proposed knowledge and ignorance research impact interactive model is the potential for multi-level analysis – at the researcher, research unit or collaborative science network levels. This opens up opportunities for comparative analysis where comparative sites and indicators can hold inner-unit/network and outer-unit/network validity, extending to multiple science research investigations.

For governmental organizations promoting knowledge mobilization, most notably in research and in innovation collaborative research networks, the ability to measure impact and network configurations that could further enhance research impact is a valuable tool. For social scientists, an important consideration will be the ability to map out inclusionary and exclusionary dynamics of ignorance in relation to knowledge in science and innovation with an eye for multiple actor involvement and impact considerations. In addition, conceptually integrating the institution of science in the research impact interactive model gives institutional considerations a prominent role while acknowledging the complexity of agent–structure constraints and opportunities in science research.

Finally, it would appear that the conceptualization developed here dynamically linking knowledge mobilization with ignorance mobilization is relevant not only for science research and innovation, but also for business research and innovation. Ignorance mobilization lies at the heart of the Toyota Lean Production System business innovation model and continual learning philosophy. Business appears to have harnessed an understanding of the knowledge and ignorance mobilization tango practised in science research and innovation.

Acknowledgements

Notes

1. The terms 'knowledge' and 'ignorance' are used in this paper; they refer to knowledge claims and ignorance claims – socially constructed knowledge and ignorance.
2. The upstream–downstream metaphor is used only as a starting point. The dialectic interplay between knowledge and ignorance mobilization precludes maintaining such a simplistic relationship.
3. Scholarship on knowledge mobilization is nascent, developing predominantly in the areas of education, social sciences and health (see Amara *et al.*, 2004; Bennet and Bennet, 2007; Davies *et al.*, 2008; Evans, 2010a, 2010b; Lehoux *et al.*, 2010; Greenhalgh and Wieringa, 2011; Fenwick and Farrell, 2012). Hellstrom (2012) contributes insightful empirically founded insights on evaluating epistemic capacity in research networks. Although his theoretical framework does not explicitly relate to epistemic mobilization, his epistemic capacity framework implies knowledge and ignorance mobilization dynamics.

4. For an extensive review of multiple understandings of ignorance see sociologyofigno-rance.com, which draws attention to the interdisciplinary study of ignorance from a sociological perspective.
5. 'Prions are unprecedented infectious pathogens that cause a group of invariably fatal neurodegenerative diseases by an entirely novel mechanism. Prion diseases may present as genetic, infectious, or sporadic disorders, all of which involve modification of the prion protein (PrP). Bovine spongiform encephalopathy (BSE), scrapie of sheep, and Creutzfeldt–Jakob disease (CJD) of humans are among the most notable prion diseases' (Prusiner, 1998, p.13363). In wild elk and deer, the prion pathogen causes chronic wasting disease (CWD) (Wong *et al.*, 2011, p.74). Prior to Prusiner's (1995) research, it was generally understood that conveyers for transmissible disease had to contain genetic material (i.e. viruses).

References

Amara, N. *et al.* (2004) 'New evidence on instrumental, conceptual, and symbolic utilization of university research in government agencies', *Science Communication*, 26, pp.75–106.

Bains, W. (2009) 'Leadership and innovation. How consensus management blocks genuine innovation', *Bioscience Hypotheses*, 2, 5, pp.277–281.

Bammer, G. and Smithson, M. (2009) 'Introduction' in Bammer, G. and Smithson, M. (eds.) *Uncertainty and Risk: Multidisciplinary Perspectives*, Earthscan, Sterling, VA, pp.3–12.

Bennet, A. and Bennet, D. (2007) *Knowledge Mobilization in the Social Sciences and Humanities: Moving from Research to Action*, MQI Press, Marlinton, VA.

Bielak, A. and deGraaf, S. (2011) 'The role of K* in strengthening science–policy integration', *CSPC* – Ottawa, Ontario, 17 November 2011, pp.1–23.

Burke, P. (2000) *A Social History of Knowledge: From Gutenberg to Diderot*, Polity Press, Malden, MA.

Canadian Institutes of Health Research (CIHR) (2012) *Knowledge Translation & Commercialization*, available from http://www.cihr-irsc.gc.ca/e/29529.html [accessed January 2012].

Carter, P. *et al.* (2013) 'Mobilising the experiential knowledge of clinicians, patients and carers for applied health-care research', *Contemporary Social Science: Journal of the Academy of Social Sciences*, DOI:10.1080/21582041.2013.767468.

Carvalho, M., *et al.* (2010) 'Between scientists and public: reframing public participation in science through bioethics', paper presented at *IAMCR Conference*, *Communication and Citizenship*, Braga, Portugal.

Cress, D.M. and Snow, D.A. (1996) 'Mobilization at the margins: resources, benefactors, and the viability of homeless social movement organizations', *American Sociological Review*, 61, pp.1089–109.

Danielson, P. (2010) 'A collaborative platform for experiments in ethics and technology' in Ibo, P. and Godlberg, D. (eds.) *Philosophy of Engineering and Technology, Philosophy and Engineering: An Emerging Agenda*, Springer, Dordrecht, Netherlands, pp.239–52.

Davies, H. *et al.* (2008) 'Why "knowledge transfer" is misconceived for applied social research', *Journal of Health Services Research & Policy*, 13, pp.188–90.

Davies, W. (2011) 'Knowing the unknowable: the epistemological authority of innovation policy experts', *Social Epistemology*, 25, pp.401–21.

Dryzek, J.S. and Tucker, A. (2008) ''Deliberative innovation to different effect: consensus conferences in Denmark, France, and the United States', *Public Administration Review*, 68, pp.864–76.

Edwards, B. and McCarthy, J.D. (2004) 'Resources and social movement mobilization' in Snow, D.A., Soule, S.A. and Kriesi, H. (eds.) *The Blackwell Companion to Social Movements*, Blackwell Publishing, Malden, MA, pp.116–52.

Elissalde, J. and Renaud, L. (2010) 'Les démarches de circulation des connaissances : mobilisation et valorisation des connaissances' in Renaud, L. (ed.) *Les médias et la santé: de l'émergence à l'appropriation des normes sociales*, Presses de l'Université du Québec, Québec, pp.409–29.

Erikson, K. (1994) *A New Species of Trouble: The Human Experience of Modern Disasters*, W.W. Norton, New York.

Evans, J. (2010a) 'Industry collaboration, scientific sharing, and the dissemination of knowledge', *Social Studies of Science*, 40, pp.757–91.

Evans, J.A. (2010b) 'Industry induces academic science to know less about more', *American Journal of Sociology*, 116, pp.389–452.

Expert Panel on Science Performance and Research Funding (2012) *Informing Research Choices: Indicators and Judgment – The Expert Panel on Science Performance and Research Funding*, Council of Canadian Academies, Ottawa, pp.1–142.

Felt, U. *et al.* (2009) 'Unruly ethics: on the difficulties of a bottom-up approach to ethics in the field of genomics', *Public Understanding of Science*, 18, pp.354–71.

Fenwick, T. and Farrell, L. (eds.) (2012) *Knowledge Mobilization and Educational Research*, Routledge, New York.

Firestein S. (2012) *Ignorance: How it Drives Science*, Oxford University Press, New York.

Frickel, S., *et al.* (2010) 'Undone science: charting social movement and civil society challenges to research agenda setting', *Science, Technology, & Human Values*, 35, pp.444–73.

Frickel, S. and Vincent, M.B. (2007) 'Hurricane Katrina, contamination, and the unintended organization of ignorance', *Technology in Society*, 29, pp.181–88.

Gaudet, J. *et al.* (2012) 'Ignorance is power: science in practice epistemic mobilization dynamics', paper presented at the Canadian Sociological Association (CSA) 2012 Conference in Kitchener-Waterloo, 28 May–2 June 2012, p.24.

Godin, B. (2009) 'The value of science: changing conceptions of scientific productivity, 1869 to *circa* 1970', *Studies of Science*, 48, pp.547–86.

Greenhalgh, T. and Wieringa, S. (2011) 'Is it time to drop the "knowledge translation" metaphor? A critical literature review', *Journal of the Royal Society of Medicine*, 104, pp.501–509.

Gross, M. (2007) 'The unknown in process: dynamic connections of ignorance, non-knowledge and related concepts', *Current Sociology*, 55, pp.742–59.

Gross, M. (2010a) *Ignorance and Surprise: Science, Society and Ecological Design*, The MIT Press, Cambridge, MA.

Gross, M. (2010b) 'The public proceduralization of contingency: Bruno Latour and the formation of collective experiments', *Social Epistemology*, 24, pp.63–74.

Grossetti, M. (2004) *Sociologie de l'imprévisible: Dynamique de l'activité et des formes socials*, PUF, Paris.

Halliwell, J. and Smith, W. (2011) 'Paradox and potential: trends in science policy and practice in Canada and New Zealand', *Prometheus*: *Critical Studies in Innovation*, 29, pp.373–91.

Hart, A. *et al.* (2013) 'Mobilising knowledge in community–university partnerships: what does a community of practice approach contribute?' *Contemporary Social Science: Journal of the Academy of Social Sciences*. DOI: 10.1080/21582041.2013.767470.

Hellstrom, T. (2012) 'Epistemic capacity in research environments: a framework for process evaluation', *Prometheus*, 30, pp.395–409.

Hess, D. (2010) 'Social movements, publics, and scientists', Invited Plenary Lecture, Japanese Society for Science and Technology Studies, Tokyo.

High, C. (2012) 'Between knowing and being: ignorance in anthropology and Amazonian shamanism' in High, C., Kelly, A.H. and Mair, J. (eds.) *The Anthropology of Ignorance: An Ethnographic Approach*, Palgrave MacMillan, New York, pp.119–35.

High, C. *et al.* (2012) 'Introduction: making ignorance an ethnographic object' in High, C., Kelly, A.H. and Mair, J. (eds) *The Anthropology of Ignorance: An Ethnographic Approach*, Palgrave MacMillan, New York, pp.1–32.

Howaldt, J. and Schwarz, M. (2010) 'Social innovation: concepts, research fields and international trends' in Henning, K. and Hees, F. (eds) *Studies for Innovation in a Modern Working Environment - International Monitoring,* vol. 5, Eigenverlag, Aachen.

Hughes, T.P. (1983) 'Introduction' *in Networks of Power: Electrification in Western Society 1880–1930*, John Hopkins University Press, Baltimore, MD, pp.1–17.

Kapczynski, A. (2008) 'The access to knowledge mobilization and the new politics of intellectual property', *Yale Law Journal*, 117, pp.804–85.

Karner, S. *et al.* (2011) *Knowledge Brokerage in Communities of Practice: Synthesis Report on Literature Review*, FoodLinks, Graz, Austria.

Kelly, S.E. (2003) 'Public bioethics and publics: consensus, boundaries, and participation in biomedical science policy', *Science, Technology & Human Values*, 28, pp.339–64.

Kempner, J. *et al.* (2011) 'Forbidden knowledge: public controversy and the production of nonknowledge', *Sociological Forum*, 26, pp.475–500.

Lehoux, P. *et al.* (2010) 'Exploring the conundrum of the new knowledge production regime: an ethnographic case study on the governance and outcomes of a science/policy network in genetics', *Science and Public Policy*, 37, pp.737–50.

Levin, B. (2008) *Thinking About Knowledge Mobilization: A Discussion Paper Prepared at the Research of the Canadian Council on Learning and the Social Sciences and Humanities Research Council*, Canadian Council on Learning, Toronto, ON.

Levin, B. and Cooper, A. (2012) 'Theory, research and practice in mobilizing research knowledge in education' in Fenwick, T. and Farrell, L. (eds.) *Knowledge Mobilization and Educational Research*, Routledge, New York, pp.17–29.

Lopez, J. (2009) 'Par-delà l'éthique: vers une sociologie des pratiques éthiques contemporaines', *Cahiers de Recherche Sociologique*, 48, pp.27–44.

Luhmann, N. (1993) *Risk: A Sociological Theory*, Transaction Publishers, Piscataway, NJ.

Luhmann, N. (1998) *Writing Science: Observations on Modernity*, Stanford University Press, Stanford, CA.

McCarthy, J.D. and Zald, M.N. (2001) 'The enduring vitality of the resource mobilization theory of social movements' in Turner, J.H. (ed.) *Handbook of Sociological Theory*, Kluwer Academic/Plenum Publishers, New York, pp.533–65.

McGoey, L. (2012a) 'The logic of strategic ignorance', *British Journal of Sociology*, 63, pp.533–76.

McGoey, L. (2012b) 'Strategic unknowns: towards a sociology of ignorance', *Economy and Society*, 41, pp.1–16.

Merton, R.K. (1987) 'Three fragments from a sociologist's notebooks: establishing the phenomenon, specified ignorance, and strategic research materials', *Annual Review of Sociology*, 13, pp.1–28.

Moore, W. and Tumin, M. (1949) 'Some social functions of ignorance', *American Sociological Review*, 14, pp.787–96.

Networks of Centres of Excellence (NCE) (2012) *Mobilization Initiative Overview*, available from http://www.nce-rce.gc.ca/NCESecretariatPrograms-ProgrammesSecretariatRCE/NCEKM-RCEMC/Index_eng.asp [accessed January 2012].

Nugus, P. *et al.* (2012) 'The politics of action research: "If you don't like the way things are going, get off the bus"', *Social Science & Medicine*, 75, pp.1946–1953.

Nutley, S.M. *et al.* (2007) *Using Evidence: How Research Can Inform Public Services*, The Policy Press, Bristol.

Overdevest, C. *et al.* (2010) 'The experimental turn in environmental sociology: pragmatism and new forms of governance' in Gross, M. and Heinrichs, H. (eds) *Environmental Sociology: European Perspectives and Interdisciplinary Challenges*, Springer, New York, pp.279–294.

Peters, L.S. (2010) *The Big World Experiment: The Mobilization of Social Capital in Migrant Communities*, Universiteit van Amsterdam, Amsterdam.

Phipps, D. *et al.* (2012) 'Applying social sciences research for public benefit using knowledge mobilization and social media' in Lopez-Varela, M. (ed.) *Social Sciences and Humanities – Applications and Theories*, In Tech, Rijeka, pp.167–196.

Provencal, J. (2009) 'Extending the reach of research as a public good: moving beyond the paradox of "zero-sum language games"', *Public Understanding of Science*, 1, pp.1–16.

Prusiner, S.B. (1995) 'The prion diseases', *Scientific American*, 272, pp.30–37.

Prusiner, S.B. (1998) 'Prions', *Proceedings of the National Academy of Sciences*, 95, pp.13363–83.

Ravetz, J.R. (1987) 'Usable Knowledge, Usable Ignorance: Incomplete Science with Policy Implications', *Knowledge: Creation, Diffusion, Utilization*, 9, pp.87–116. DOI:10.1177/107554708700900104.

Roberts, J. (2013) 'Organizational ignorance: towards a managerial perspective on the unknown', *Management Learning*, 44, pp.215–236. DOI:10.1177/1350507612443208.

Roberts, J. and Armitage, J. (2008) 'The ignorance economy', *Prometheus*, 26, pp.335–54.

Root-Bernstein, R. (2003) 'Problem generation and innovation' in Shavinina, L.V. (ed.) *The International Handbook on Innovation*, Elsevier Science, Oxford, pp.170–79.

Rother, M. (2010) *Toyota Kata: Managing People for Improvement, Adaptiveness, and Superior Results*, McGraw Hill, New York.

Rother, M. (2013) *Improvement Kata Handbook v. 17*

Scott, J. and Marshall, G. (1994) *Oxford Dictionary of Sociology*, Oxford University Press, New York.

Shaxson, L. (2010) 'Improving the impact of development research through better research communications and uptake', Background paper for the AusAID, DFID and UKCDS funded workshop, London, 29–30 November, pp.1–22.

Simmel, G. (1906) 'The sociology of secrecy and of secret societies', *American Journal of Sociology*, 11, pp.441–98.

Smithson, M. (1985) 'Toward a social theory of ignorance', *Journal of the Theory of Social Behaviour*, 15, pp.151–72.

Smithson, M. (2009) 'The many faces and masks of uncertainty' in Bammer, G. and Smithson, M. (eds.) *Uncertainty and Risk: Multidisciplinary Perspectives*, Earthscan, Sterling, VA, pp.13–25.

Social Sciences and Humanities Research Council of Canada (SSHRC) (2007) *Knowledge Mobilization Strategy: 2009–11*, available from http://www.sshrc-crsh.gc.ca/about-au_sujet/publications/KMbPI_FinalE.pdf [accessed January 2012].

Sullivan, S. and Tuana, N. (2007) 'Introduction' in Sullivan, S. and Tuana, N. (eds) *Race and Epistemologies of Ignorance*, State University of New York Press, Albany, NY, pp.1–10.

van Merkerk, R.O. and Smits, R.E.H.M. (2008) 'Tailoring CTA for emerging technologies', *Technological Forecasting & Social Change*, 75, pp.312–33.

Whitley, R. (1984) *The Intellectual and Social Organization of the Sciences*, Clarendon Press, Oxford.

Williams, H.C. (2013) 'Epidemiology of human atopic dermatitis – seven areas of notable progress and seven areas of notable ignorance', *Veterinary Dermatology*, 24, pp.3–e2.

Wong, M. *et al.* (2011) 'Prionet Canada: a network of centres of excellence for research on prion diseases – ongoing and future research directions', *Journal of Toxicology and Environmental Health, Part A*, 74, pp.73–87.