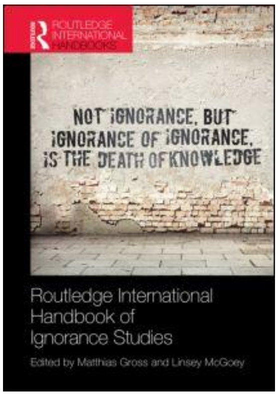

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Unfolding the map

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33

Unfolding the map

Making knowledge and ignorance mobilization dynamics *visible* in science evaluation and policymaking

Joanne Gaudet

> [T]he generation of Experiments being like that of Discourse, where one thing introduceth an hundred more which otherwise would never have been thought of.
>
> *(Grew 1673: A6)*

> [S]ince the faculties of Plants do often lie more recluse; it is best therefore not wholly to acquiesce in such Conjectures as their tastes or other properties may suggest; but to subjoyn Experiment.
>
> *(Grew 1673: 41)*

The main goal in this chapter is to explore how a mapping of knowledge and ignorance mobilization dynamics in science (Gaudet 2013: 11) can play a role in science evaluation and policymaking. The standard science epistemic map – where only knowledge is valued – is thus unfolded, making knowledge *and* ignorance mobilization dynamics more visible. An emphasis on mapping is in keeping with practices by natural scientists who construct visualizations for natural scientific knowledge, making it more visible and thereby hopefully easier to communicate (Gross and Harmon 2014). The starting point for the chapter is not the proposed mapping, however; instead, it is in the seventeenth century with the above quotes from Nehemiah Grew in 1673.

The opening quotes capture the essence of epistemic dynamics in burgeoning scientific experiments[1] in the seventeenth century. The disproportionate (cf., 'one thing introduceth an hundred more') and dynamic interplay between knowledge and what remained unknown (cf., ignorance – 'the faculties of Plants do often lie more recluse', or nescience – 'would never have been thought of') were already evident for experimental natural philosophers (see Anstey 2005; Gaukroger 2006).

Natural philosophy (as the study of nature, Hannam 2010: 6) had then only recently split into speculative natural philosophy and experimental natural philosophy. Speculative natural philosophers did not systematically engage in observation or use experimentation to propose explanations for nature and its phenomena (Anstey 2005: 215). Moreover, the types of entities (ontological considerations) that were offered to support speculative natural philosophy explanations included 'inexplicable occult qualities, substantial forms, virtual extension, sympathies and antipathies' (2005: 221). In contrast, experimental natural philosophers delved into 'the collection and ordering of observations and experimental reports with a view to the development of explanations of natural phenomena based on these observations and experiments' (2005: 215).

What is more, as Johns suggests, is that the success of an experiment for experimental natural philosophers was at least in part tied to its ability to generate further experiments (1998: 470). Success viewed this way meant constructing and valuing new ignorance. Ignorance here refers to the limits and borders of knowing (see Gross 2010: 68). Moreover, ignorance is non-pejorative as what scientists know is not (yet) known in science (see Ivainer and Lenglet 1996; Logan 2009). For a seventeenth-century experimenter, valuable ignorance could thus fuel further experimentation. The *intentional* and *explicit* knowledge and ignorance dynamic practices that natural experimental philosophers engaged in persist in contemporary science in and out of the laboratory (see Bhaskar [1975] 2008: 58; Gross 2010: 30; Latour 2000; Overdevest et al. 2010).

The use of mapping is enlisted here to make scientific knowledge and ignorance dynamics – like those Grew (1673) and his fellow experimental natural philosophers engaged in over three hundred years ago – more visible (see mapping of ignorance typologies in Hess 2010: 5). In addition, mapping can make intentional and unintentional inclusion and exclusion of ignorance more visible. Thus, the underlying argument in the chapter is the following: Although science evaluation and policymaking typically focus on and value scientific knowledge – mapping of, and acknowledgement of – knowledge *and* ignorance mobilization dynamics is crucial to account for scientific practices of valuing ignorance (see Firestein 2012; Davies 2011; Roberts and Armitage 2008). The focus of the chapter is therefore intentionally on epistemic dynamics.

The chapter proceeds in two parts. First, I present mapping for knowledge and ignorance dynamics and their respective mobilization in science (Gaudet 2013: 11). It extends mapping of topologies for knowledge and ignorance developed by Gross (2010: 71). Second, harnessing mapping dynamics, I briefly explore two Canadian cases of science evaluation and policymaking. In the first case, I investigate the Council of Canadian Academies' consideration of expert opinion on knowledge gaps as a potential socio-economic impact indicator for science performance (Expert Panel on Science Performance and Research Funding 2012: 41). The case explicitly acknowledges the role of ignorance in science evaluation. In the second case, my attention turns to a decision by Health Canada, a federal department, to remove some calcitonin-containing drugs off the Canadian market following research on their potential cancer risk (Health Canada 2013b). The change highlights a need for evergreen[2] science policies that take knowledge and ignorance mobilization dynamics in science seriously. By evergreen science policy, I refer to policy that has emergent properties explicitly acknowledging potential new scientific knowledge or ignorance that can lead to a need for change in policy direction. Given that the focus in the chapter is on epistemic dynamics, I only briefly locate the second case within literatures on post-market surveillance and regulatory bodies (i.e., Carpenter 2006; Lexchin 2014). The chapter closes with reflections on the role of mapping in the sociology of scientific knowledge and ignorance.

Mapping knowledge and ignorance mobilization dynamics in science

In Figure 33.1, I present mapping for knowledge and ignorance mobilization dynamics in science (Gaudet 2013: 11) that was originally inspired from knowledge and ignorance topological mapping developed by Gross (2010: 71). Typically, only the top half of the map would retain the explicit attention of policymakers and science evaluators. In contrast, the unfolded mapping in Figure 33.1 attempts to convey scientific practices of dynamic and dialogical knowledge and ignorance construction and mobilization where new knowledge can lead to more ignorance, and ignorance itself can lead to more ignorance (see Smithson 2009: 24; Gross 2010: 173). Before looking at dynamics however, I tend to definitions.

Nescience here is understood as the complete absence of knowledge (Gross 2010: 68) and therefore lies outside of the mapping. Once constructed, however, and frequently in response to surprise, it can lead to ignorance and knowledge (Gross 2010). Surprise is used in the way Simmel (1922) proposed it where it can 'be freed from its psychological and sentimental meaning as a logical category for the relation between different contents' (quoted within Gross 2010: 38). Therefore, 'something is surprising when a pre-existing set of experiences and a horizon of expectation turn out to be inappropriate, since [a given] situation contradicts any anticipation' (2010: 37, my adaptation in brackets). Essentially, a contradiction in anticipation can motivate a researcher to construct new ignorance to account for surprise.

Moreover, in keeping with Gross (2010: 49), knowledge refers to a justified belief connected to purpose (or use), and two sub-types are existing and new knowledge (Gaudet 2013: 5). The broader category of ignorance for its part refers to the borders and the limits of knowing (see Gross 2010: 68). Two ignorance sub-types are active non-knowledge and latent non-knowledge. Active non-knowledge denotes 'the limits and the borders of knowing that are intentionally or unintentionally taken into account for immediate or future planning, theorizing and action' (Gaudet 2013: 5). In contrast, latent non-knowledge is *not* taken into account and therefore not mobilized by actors within or outside of science (examples in Frickel et al. 2010; Kempner et al. 2011). If it is eventually mobilized by actors, it exits latency to be constructed as new active non-knowledge. Finally, knowledge and ignorance mobilization, respectively, refer to the use of justified beliefs or the borders and the limits of knowing towards the achievement of goals (social, cultural, political, professional and economic) (Gaudet 2013: 7). These definitions already convey some relational dynamics, but a closer examination of Figure 33.1 renders their wider range.

Multiple actors including scientists, policymakers, stakeholders, brokers, and funders can engage in knowledge and ignorance mobilization (Gaudet 2013). A quick overview of Figure 33.1 starts with an understanding that linkages are conceptual and can sometimes depict causal relationships. Step numbering is solely for ease of reference to locate processes and dynamics at particular junctures in the model, for example, and do not refer to a sequential process. Existing knowledge, typically in written (print and electronic) cultural archives such as scientific journal articles and books, includes existing written ignorance (not displayed). Lastly, in spite of portraying a one-dimensional diagram, the model attempts to capture complexity and dynamic layers with recursive relationships that create new instances of ignorance or knowledge and their sub-types.

Starting on the left-hand side of Figure 33.1, the two overarching and related epistemic categories are knowledge and ignorance. Respective sub-types link within the overarching categories. As discussed above, for example, new ignorance can *not* be mobilized and therefore remain excluded (and at least temporarily not valued by scientific actors) as latent non-knowledge (step 1). Alternatively, ignorance *can* be mobilized and constructed as valuable active non-knowledge (step 2), active non-knowledge can lead to the construction of new active non-knowledge (step 3), and latent non-knowledge can eventually be constructed as active non-knowledge (step 4). Finally, new knowledge can join existing knowledge (step 6). Between the categories, knowledge can lead to the construction of more ignorance (step 7), active non-knowledge can lead to

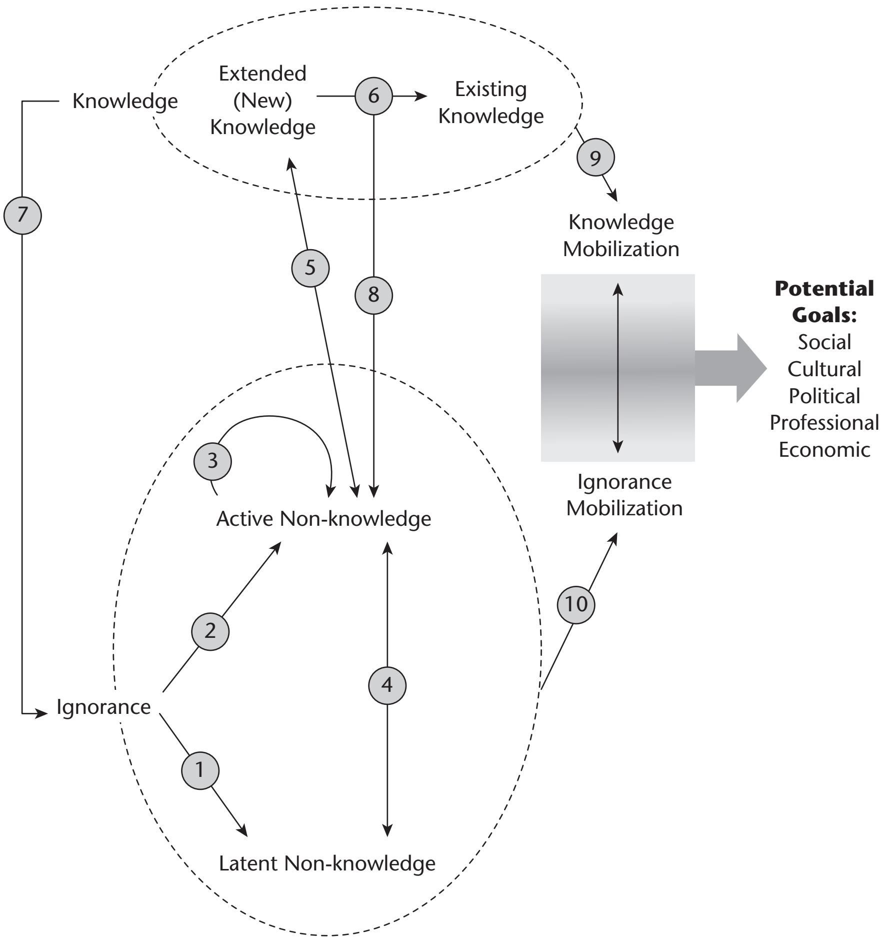

Figure 33.1 Model of knowledge and ignorance mobilization dynamics in science*

Source: Gaudet 2013: 11.

Note: *Numbering is for ease of reference and does not refer to a sequential process. Arrows are conceptual and sometimes depict causal relationships.

the construction of new knowledge (step 5), and judgements on manuscripts in journal editorial peer review (conceptualized between new and existing knowledge) can lead to the construction of new active non-knowledge (step 8).

Finally, the right-hand side of Figure 33.1 focuses on actors, mobilization, and goals. Actor knowledge (step 9) and ignorance (step 10) mobilization dynamics are distinct yet remain in tension and link with potential mobilization goals (i.e., social, cultural, political, professional, and economic). Here I highlight differential mobilization of knowledge and/or ignorance that actors can engage in. By this, I mean that actors can mobilize more or less knowledge and/or ignorance, thus differentially. An example is actors in a basic research laboratory who engaged in higher ignorance mobilization in comparison to lower knowledge mobilization in a biological sciences case study (Gaudet et al. 2012).

A last consideration is that my use of a model such as Figure 33.1 does not mean that I conceptualize knowledge and ignorance exclusively as property. Rather, I advance that competent actors engage in situated mobilization (see Wehling 2006: 87), be they scientists, policymakers, stakeholders, brokers, or funders. Lastly and in keeping with the main argument in the chapter, the overview of dynamics in Figure 33.1 renders scientific knowledge and ignorance dynamics visible and thus potentially useful for science evaluators and policymakers. I use the model to explore two cases, starting with a first case in science evaluation.

Expert opinion on knowledge gaps as a socio-economic impact indicator in science evaluation

The first case focuses on a specific socio-economic impact stemming from scientific activity – 'expert opinion on knowledge gaps' (Expert Panel on Science Performance and Research Funding 2012: 41) – framed in a 'Logic model for the selection of appropriate indicators'. The logic model was part of a project report entitled 'Informing Research Choices: Indicators and Judgment' by the Council of Canadian Academies (the Council). The board members for the Council who oversaw the project included representatives from the Royal Society of Canada, the Canadian Academy of Engineering, the Canadian Academy of Health Sciences, and the Canadian public (2012: ii). The logic model was presented as a 'common policy tool [that] can provide an instructive organizing structure for theoretical linkages between funding and the expected impacts and societal benefits from investing in discovery science' (2012: 40). Socio-economic impact here refers to an assessment of how results obtained from research are more broadly relevant (2012: 40).

The main element of interest in the case, 'expert opinion on knowledge gaps' (2012: 41), was framed as a potential indicator of scientific socio-economic impact in the context of Canada's science and technology strategy (2012: 41). Expert opinion on knowledge gaps is of interest because it explicitly acknowledges potential scientific impact beyond what is known in science.

Referring to Figure 33.1, 'knowledge gaps' can be understood as active non-knowledge or valued ignorance. Constructed as potential socio-economic impact, it is intentionally taken into account for possible future use in planning, theorizing, and action inside or outside of academia. Actors could therefore mobilize this active non-knowledge to construct new knowledge (step 5) or potentially further new active non-knowledge (step 3). Furthermore, 'expert opinion' implies a competent actor (cf., a scientist) to construct a knowledge gap as valuable active non-knowledge. Once constructed, other actors can mobilize the active non-knowledge. For example, a policymaker can mobilize it to inform policy with political, social, and economic goals. Alternatively, a stakeholder or commercial actor could mobilize the active non-knowledge to construct a new research project or commercial venture, thereby meeting professional and economic goals.

For science evaluators, therefore, socio-economic impact in this case refers to emergent properties when it considers the limits and the borders of knowledge. To be sure, knowledge gaps are not a final impact 'product'. Impact instead rests in emergent relational potential for knowledge gaps as valuable active non-knowledge. Made visible in Figure 33.1, emergent relational potential can touch on several potential impact spheres including social, cultural, political, professional, and economic. From a focus on science evaluation in this first case, the second case shifts more specifically to scientific epistemic dynamics and science policy.

Knowledge and ignorance dynamics and evergreen science policies

The second case focuses on post-market surveillance by Health Canada that led to 'changes in the availability and recommended conditions of use of drugs containing calcitonin' (Health Canada 2013b). A Government of Canada federal department, Health Canada's mandate includes health-related policy, legislation, regulation, and activities such as drug approval, and post-market surveillance. The hormone in question, calcitonin, is naturally present in the human body and is known to increase calcium levels in the bones and lower these in the blood (European Medicines Agency 2012: 1). Commercial synthetic forms of the hormone are used in pharmaceutical products. In Canada, synthetic '[c]alcitonin is used as a nasal spray to treat osteoporosis (loss of calcium in bones) [. . .] and as an injection to treat Paget's disease (a chronic bone disorder) and hypercalcemia (high blood calcium)' (Health Canada 2013b).

Especially relevant in the chapter is that initial conditions of use for calcitonin containing products approved nearly 30 years ago by Health Canada (Health Canada 2013a: 4) did not anticipate that long-term use of the products could potentially lead to increased risk of various types of cancer. The unanticipated increased cancer risks are understood in this case as nescience or the complete absence of knowledge (outside of Figure 33.1). As Lexchin (2014) advanced, 'a prolonged period on the market is no guarantee of safety' (Lexchin, 2014: e18). Understood within an epistemic framework, length of market use does not equate with safety, rather knowledge and active non-knowledge remain on 'probation' with respect to potential new ignorance.

Prior to this construction of nescience, active non-knowledge for synthetic calcitonin containing drugs had generally revolved around these drugs' health impact on osteoporosis, Paget's disease, and hypercalcemia. An example is research on nasal calcitonin's ability to increase bone mass density and to lead to reductions in various types of fractures for individuals with osteoporosis. Newly constructed knowledge (step 5 in Figure 33.1) on the topic joined existing knowledge (step 6) (i.e., Tuck and Datta 2007: 530–531).

Once constructed, however, nescience led scientists to produce new active non-knowledge (step 2) on the link between calcitonin products and cancer. Further research helped construct new knowledge (step 5) that joined existing knowledge (step 6) such as a difference in increased risk of cancer for long-term use with higher doses and intranasal use in comparison to short-term use with minimal effective doses through injection and infusion (Health Canada 2013a: 2–3; European Medicines Agency 2012: 2). With this new active non-knowledge, the above active non-knowledge on the drugs' potential health impact for osteoporosis appeared to shift to latent non-knowledge (step 4).

In addition, active non-knowledge on the link between calcitonin products and cancer led to the construction of new active non-knowledge (step 3) pertaining to *how* calcitonin products could potentially lead to certain malignancies (cancers) (see limited scholarship of vitro research on human prostate cancer cell lines in Miacalcin team – Novartis 2013: 63–64). Not all types of cancer (or disease) with a potential link with calcitonin appear to have been considered for further research, however, and remain unstudied as examples of latent non-knowledge (step 1).

As the above dynamics illustrate, post-market surveillance performed by Health Canada and health regulatory agencies around the world (i.e., the European Medicines Agency and the Food and Drug Administration in the United States) at least *implicitly,* if not *explicitly,* acknowledges potential science knowledge and ignorance mobilization dynamics. Surveillance monitors unanticipated or surprising consequences with potential human health impact.

Post-market surveillance therefore constitutes an example of an 'evergreen science policy' process if it explicitly places active non-knowledge and knowledge on 'probation' with respect to potential new knowledge or ignorance. I define evergreen science policy as policies that have emergent properties explicitly acknowledging the potential construction of new epistemic relations as portrayed in Figure 33.1 (cf., new active non-knowledge, new ignorance, or new knowledge). Evergreen policy is therefore flexible and accommodates refinement, development (see Parliament of Canada Standing Committee on Environment and Sustainable Development 2008), or perhaps dissolution in response to the construction of emerging epistemic relations.

For policymakers, the challenge in creating evergreen policies is to convey the potential for change in scientific knowledge and ignorance without appearing to compromise the validity of scientific knowledge framing the policy. Figure 33.1 can support policymakers to perform this task in two ways. First, in Figure 33.1 scientific knowledge and ignorance are not understood in linear and finite relation, but rather explicitly in dynamic and potentially dialogical relations. Validity, therefore, does not rest in knowledge stability, instead it remains probationary to potential anticipated change. Second, policymakers can use Figure 33.1 as a tool to educate stakeholders, partners, funders, and the general public on scientific epistemic practices. By doing so, these actors can see and learn to expect and value change in scientific knowledge and ignorance.

Moreover, a focus on epistemic dynamics here might wrongly convey simplicity in post-market surveillance. Simplicity belies underlying complexity. As Jasanoff argued, regulatory science is complex given that it is performed 'at the margins of existing knowledge' (Jasanoff, 1990: 79) that not only entails knowledge production, but also prediction, involving numerous actors and accountabilities (1990: 77). Research shows that post-market surveillance is fraught with challenges including conflicting institutional relations of power over decision-making, problems with enforcement (Carpenter 2006; Light 2010), and potential increased exposure of users prior to the withdrawals of unsafe drugs (Lexchin 2014: e18). Where post-market surveillance actors can enter an epistemic framework is in how they mobilize, or do not mobilize, new ignorance or knowledge and for which (perhaps conflicting) goals they do so, or not (steps 9 and 10).

Finally, the model can help policymakers and non-scientific actors understand and learn how to engage in the relationship between latent non-knowledge and active non-knowledge (step 4) in science. For example, policymakers wishing to enlist a wider range of non-scientific actors to participate in shaping publicly-funded science and science policy can use the model to illustrate how health issues that matter to citizens, as latent non-knowledge, can eventually be constructed as active scientific non-knowledge. This final consideration is part of wider dynamics on the democratization of science and technology and citizen participation in science policy (i.e., Callon et al. 2001; Kelly 2003; Rask 2008; Selin and Hudson 2010).

Conclusion

I advanced in this chapter that a model of knowledge and ignorance mobilization dynamics in science could play a valuable role in science evaluation and policymaking. In essence, the model represents the unfolding of the typical map focussed on scientific knowledge. In the first case, active non-knowledge was explicitly acknowledged in science evaluation (cf., the Council report). Understood within a model of knowledge and ignorance mobilization dynamics (Figure 33.1), further potential epistemic relations (to new knowledge and/or active non-knowledge) and actor mobilization goals become more visible for science evaluators looking to account for impact as emergence.

In the second case, seeing post-market surveillance of a pharmaceutical product through a model of knowledge and ignorance mobilization dynamics (Figure 33.1) illustrated the multiplicity of new knowledge and ignorance mobilized, or not mobilized in the case of latent non-knowledge. It was also in the second case that I proposed the concept of evergreen policy with emergent properties explicitly acknowledging the potential construction of new epistemic relations. What is more, for policymakers, a model like that in Figure 33.1 could be a useful tool to account for validity in a context of expected change, and as a tool to educate and empower actors outside of science such as stakeholders, partners, funders, and the general public.

To conclude, I explore two implications from the use of a model of knowledge and ignorance mobilization dynamics in science evaluation and policymaking. First, such a model equips science evaluators and policymakers with concepts that reflect dynamic scientific epistemic practices. Second, there are at least two consequences of acknowledging such dynamics. First, scientific knowledge can no longer be conceived of as permanent – it retains potential changing relations with ignorance. Second, active and latent non-knowledge can no longer be conceived of as permanently regarded or disregarded by scientists. Rather, scientific knowledge and active and latent non-knowledge retain expected and ongoing shaped and reshaped relations with knowledge and ignorance and their sub-types. Ultimately, the model highlights relational mobilization dynamics with valuable scientific knowledge and ignorance as was the case for experimental natural philosophers in the seventeenth century. The unfolded map reflects a sociology of knowledge and ignorance.

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Notes

1 I focus on epistemic dynamics. This introductory discussion on experiments is not intended as a history of experimentation that investigates analytical, demonstrative, and synthesis functions in experimentation. An example of such analysis is Shapin and Schaffer's (1985) history of early scientific experimentation. Pickstone (2001), for his part, bemoans the lack of a typology for experimentation and proposes a history of experimentation that draws on biological and medical sciences (2001: Chapter Six).

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