JCOM

SCIENCE COMMUNICATION AND INNOVATION: ZOOMING OUT FOR MICRO-LEVEL INSIGHTS CLOSE TO REALITY

Science communication for uncertain science and innovation

Maarten C. A. van der Sanden and Steven M. Flipse

Abstract

Differences in viewpoints between science and society, like in for example the HPV-vaccination debate, should be considered from a socio-technical system perspective, and not solely from a boundary perspective between the lay public, medical doctors and scientists. Recent developments in the HPV-vaccination case show how the debate concerning uncertainty amongst scientists and the lay audience is mostly focussed on the improvement of understanding of lay people about why vaccination is important. This boundary thinking leads to the idea that once the boundary is crossed, the problem is solved. However, such 'bug-fixing' and technocentric boundary thinking is not leading to sustainable resolutions. We view science communication as a key aspect of the socio-technical system of scientific, technological and innovation development, in which the vaccine and its corresponding immunisation program are socially constructed. A process of construction that takes place all the way from the fuzzy front-end of their scientific conception until the marketing back-end. The authority, legitimacy and therefore the license to operate of scientists, engineers and policy makers are discussed, primarily at this boundary, but develops during the whole process of innovation. During upstream processes, professional roles and according behaviour are also defined.

In this commentary we state that the development of science communication strategies should also start upstream, and that the 'bug-fixes' of improved listening to (and not by) the lay audience, could be become a more sustainable solution to the HPV-debate if this process of listening by experts considers the socio-technical system of vaccination as a whole. One of the outcomes might be that the dialogue between scientists, policy makers and the lay audience is about the various possible scenarios that deal with inherent scientific and societal uncertainty in which the inevitable uncertainty of science becomes more explicit. It is not known according whether this will lead to more profound interactions, however we would like to explore this possibility a bit more from an uncertain innovation process point of view. This could clear the way for a process of co-inquiry into ideas concerning shared responsibility and accountability. The latter means that the focus in the debate is more balanced and concerns the social network, and is not purely focussed on the betterment of

understanding by the lay audience. Moreover, in this way we consider communication and interaction between actors not as a means of crossing any boundaries (since that may be impossible), but as a means to perturb a status quo or equilibrium within a network of actors. This makes apparent boundaries more explicit and discussable. Methods of interaction, e.g. based on concepts like midstream modulation, may lead to another discourse and give way to new dynamics in this social system.

Keywords Public engagement with science and technology; Science and policy-making; Science communication: theory and models

Uncertain science in an uncertain world: HPV-vaccination debate revival

Lips [2011] quotes the science philosopher Philip Kitcher, who says that the ideal collaboration between science and politics involves societal and political deliberation, scientific advice and political decision making [Kitcher, 2001]. This ideal way of interaction between science and politics entails that normative decision making is separated from scientific deliberation. This leads to a decision making process that is bounded by normative frames and realistic epistemology [Lips, 2011]. However, by definition this ideal process does not occur in reality. Scientific development is not a value-free enterprise, as described by many science philosophers, such as Latour [1988]. And that becomes even more apparent in complex social scientific issues like decision making in the case of HPV vaccination [Lips, 2011]. The issue is, as said, that scientists deal with concurrent results of scientific research, that entail uncertainty, and that do not always lead to answers, but to more questions. E.g., the HPV tests are executed with girls and women older than 12 years, whereas the vaccination is given at the age of 12. Other uncertainties are about the sustainability of the preservation of the vaccine [ibid.]. Remarkably, medical researchers and doctors tend to ignore this uncertainty when the lay audience is stressing the same or other uncertainties.

This results in an HPV-vaccination discourse — which has recently revived in the Netherlands — that is about the fact that some parents are resistant to vaccinating their children, since they are convinced of, supported by other scientific evidence, serious negative side effects of this vaccination. Some scientists and medical doctors responded by continuing to explain that most of the scientific literature is pointing in a different direction and that vaccination is safe. Or even more strongly, some have called parents keeping their children away from the vaccination program a serious health threat for society [Kouwenhoven and Voormolen, 2016; Köhler, 2016]. The discussion on 'facts' and 'opinions' from both sides seem to be not of any use to better or further the discussion. Since all this does not take into account the idea that innovation and scientific development is intrinsically uncertain, starting from its early development all the way to its market introduction at the back-end, solely considering boundary thinking — as supposed and executed by Dutch medical staff, entailing improved listening in order to figure out where the contradictory thoughts and ideas come from — may be a nice and sometimes effective idea, but unfortunately fails to solve the problem because it's focus is too restricted. We feel that there are opportunities to better consider its systemic focus.

In this commentary we will first elaborate on the idea that if one wants to develop sustainable solutions, a detailed focus on the boundaries between scientists, policy

makers and lay audience is needed (the parts), but the social system of socio-technical development should also be taken into account (the whole). The practical implication of this 'system thinking' is that the focus of the debate is not on facts and opinions, but on various scenarios of implementing vaccination that take into account uncertainties that emerge throughout the whole process. This kind of thinking, as we will state, frees-up the debate in search for new dynamics in debates like the one on HPV vaccination.

Micro-social order

There is no news in saying that scientific and technological developments, and innovation processes, are inherently uncertain. Also within the social sciences and humanities voices state that talking about the *process* of science and technological development, and the related beliefs, failures, dreams and ideas of those involved upstream, should get attention [Flipse, van der Sanden and Osseweijer, 2014; van der Sanden, 2000]. In the realm of science communication research on engagement and dialogue, various roles of scientists and engineers are partly influenced by scientific uncertainties. Therefore scientists' and engineers' communication with policy makers and the lay audience is often researched as one can read in the by Gilbert and Stocklmayer [2013] edited book on *Communication and Engagement with Science and Technology*, or more recently Davies' and Horst's [2016] book on *Science Communication, Culture, Identity and Citizenship*.

Leeuwis and Aarts [2011, p. 27] write: 'meaningful innovation is dependent on changes in discourses, representations and storylines that are mobilized by interacting social actors'. These social actors include all the actors involved from the start (upstream) to the end (downstream). Concerning the HPV vaccination, this includes scientists, the pharmaceutical industry, medical doctors and the lay audience. These all have different positions and roles in this socio-technical system. Leeuwis & Aarts mention that insights in the micro-social order of collaboration between these actors in which e.g. uncertainties are discussed, are important to understand science and technology developments. Therefore, it may be the case that the critical stage in the process of HPV-vaccination — from a science communication perspective — is not only at the level of the audience but also at the levels of the numerous meetings of professionals at meeting tables throughout the world during which their professional roles and identities are constructed in a collaborative process [Wenger, 2000].

One of these micro-social order aspects is 'silence' in conversation. Along with others [Krippendorff, 2008; Fonseca, 2002; Ford, 1999], Verouden, van der Sanden and Aarts [2016, p. 93] state: 'despite the importance of verbal exchanges, it is widely recognized that people's behaviour is not only shaped by what they talk about, but also by that about which they stay silent'. It might happen that even professionals do not really understand what is going on, or are not used to thinking about various important relevant downstream aspects. This may be inherent to the process of scientific research, and hence people keep silent. And so, technology is pushed further, but not always deliberately and frequently unconsciously. So, a downstream dialogue between scientists, medical doctors and the lay audience has a further downstream future in resulting social interactions, which includes elements of the micro-social order in the network between these actors. But this dialogue also has its upstream fundaments in the history of its research.

Dilemmas

This mentioned uncertainty becomes clear in the various descriptions of known dilemmas in innovation processes. And one might imagine that these dilemmas are not always extensively discussed throughout the innovation process. Consider the Collingridge [1980] dilemma, that describes a so called double-bind problem in which there is an information problem and a power problem. The information problem entails that impacts (of new technology, authors) cannot be easily predicted until the technology is extensively developed (or even and widely used). The power problem is about the difficulties in control or change once the technology has become entrenched in society. Yet, another dilemma is described by Christensen [2002], the innovator's dilemma. This dilemma in short is about how improvements of the products or services from incumbent companies do not keep pace with what customers or the markets expect. This leads to questions about how executives can simultaneously do what is right for the near-term health of their established business, while also focussing adequate resources on the new, disruptive technologies that ultimately could lead to their downfall. In the case of the HPV vaccination implementation program this means: do we invest in implementing the vaccination program now, or do we need to wait and put resources into further research on the uncertainties that still exist? Importantly, these dilemmas should be discussed, and actors should decide consciously on what to do within collaborative networks, i.e scientists, policy makers and the lay audience. So, within this micro-social order, as Kleinman [2006, p. 235] describes: "one of our eyes is open to dangers of the world and the uncertainty of our human condition; the other is closed, so that we do not see or feel these things, so that we can go on with our lives".

System thinking supports thinking about this dilemma in a much broader way, while not missing out on the details. System thinking does not lead to solutions directly, but opens the way to many more scenarios being considered. Therefore, in our opinion, 'system thinking' and 'scenario thinking' are two conceptual ways of thinking that can help to develop, or rather design, science communication processes as part of innovation processes, and that simultaneously take into account uncertainty, history and future of scientific and technological development. More specific 'midstream modulation' of innovation processes supports scientists, engineers, business developers to establish mutual understanding about e.g. uncertainties and develop a common language to efficiently work together [Flipse et al., 2014]. This shared language, in which uncertainties are made explicit, can support system thinking and scenario thinking for all stakeholders involved. This can lead to a dialogue on shared responsibility and accountability, supporting and shaping further co-development of e.g. a vaccination program. As Flipse et al. [2014, p. 137] write: '*This notion of social responsible innovation goes beyond communication strategies for market introduction or assessing societal impacts of technology. The real value of 'making music' together is in its collaborative performance, in its harmonium [. . .] collaboration requires an active trial and error attitude, and only practice makes perfect*'.

Uncertainty, system thinking, scenario thinking enabled by midstream modulations

These are professional challenges within the realm of science and scientific development, which are opaque, ill-defined and ill-structured [Rittel and Webber, 1973]. We need to deal with such uncertain science in an uncertain world, as Pollack [2003, p. 2] writes: 'the topic of global change illustrates both the scientific complexities and the uncertainties, and the difficulties people and nations have in formulating rational policy addressing the many facets of a changing climate on Earth.' He describes four aspects of uncertainty which all also have to do with science communication: 1) uncertainty is always with us and can never be fully eliminated; 2) decisions are made in the absence of certainty; 3) predicting the long-term future is a perilous business; 4) uncertainty far from being a barrier to progress, is actually a strong stimulus for, and an important ingredient of, creativity. The latter makes all this quite challenging, since it implies we should embrace uncertainty in science communication, instead of excluding it [van der Sanden, 2008].

As an example, the advice given by de National Health Council concerning HPV vaccination is not solely based on scientific research. The process of advice is to been seen as a constructive process, in which uncertainties (in line with Pollack's aforementioned ideas, authors) are weighted, in which political issues suffice and stakeholders aim for consensus [Lips, 2011]: the choice for one answer will inevitably lead to a politicization of the scientific institute that advises. This shield of scientific decision making is called 'stealth issue advocacy' by Pielke [2007, p. 63]: '*A great danger for both science and politics occurs when members of the scientific community itself participate in the politicization of science [. . .] In the resulting media contest between competing authorities, it is not possible to tell whether science or politics is speaking. We then lose both the power of science and the credibility of democratic process*'.

Innovation processes are often described as occurring within dynamic social systems in which the niche (local level of innovation processes, e.g. incubators), regime (rules and practices shared amongst scientists, engineers, business people, users, policy makers) and landscape (external environment of processes and factors that influence both regimes and niches, including aspects such as, oil prices, cultural and normative values) are dynamically intertwined and time dependent [Markard and Truffer, 2008; Geels and Schot, 2007]. So when professionals design science communication strategies, one should not only focus at the back-end of innovation — i.e. the interaction with the lay audience and improved listening — but also travel upstream in the innovation process in which scientists, policy makers and others are dealing with similarly difficult substance and nature of arguments. What is lacking in the discussion on e.g. HPV vaccination is this overall picture of the innovation process in which identities and professional behaviour are changing over time. From a system perspective [Bailey, 1994; Banathy, 1996; Mitchell, 2009; Markard and Truffer, 2008; Geels and Schot, 2007] one should have an understanding of this development of vaccination until the very end. As the authors wrote earlier in this journal [van der Sanden and Flipse, 2015], that if one wants to understand public engagement or participation, the collaboration between scientists and their scientific partners, and its dynamic properties should also be taken into consideration. Namely, as we can learn from corporate communication [van Riel and Fombrun, 2007], the identity of scientists and their values and needs as partners of co-creation on the level of public engagement and participation, is partly based on the values and needs of scientists on the level of collaboration with their scientific peers [van der Sanden and Osseweijer, 2011]. Scientists, industrial

researchers, university and governmental policy makers on science and technology and the public all co-exist, collaborate and co-create on various levels, adopting various roles within the socio-technical system of science and technology development. Science communication is a distributed system-element within such a socio-technical system in which each actor has a communicative role, function and tasks, that need to be stimulated, supported and trained. This kind of science communication supports stakeholders in the socio-technical system to solve real-world issues that are complex and dynamic from the perspective of multidisciplinary collaboration, in all stages of science and innovation.

Returning to the HPV case, we see that reflection in the daily practice of the debate can be quite hard. Researchers and medical doctors apply communication strategies such as listening, and try to understand where misconceptions come from. But to reflect on their own role as researchers or medical doctors, and to actively use the outcomes of such reflection in their communication with the lay audience — i.e. anticipate in the formulation of their research questions about future implications — is immensely difficult. That is not merely based on resistance, but probably also on a lack of insights into the fact that more information to the public does not lead to more understanding let alone acceptance [Wynne, 2008, Elephants in the room]. They may not recognize the vaccination regime as an interlinked socio-technical system in which interlinked uncertainties and interlinked communication occurs. We may also see this as a social learning process in which engagement, imagination and alignment are important fundamentals for learning together [Wenger, 2000]. This entails the adoption of a trial-and-error approach, of bringing vaccination programs to ill-defined, ill-structured, social practices. This trial and error needs to be facilitated.

Mid-stream

Clarifying which processes are relevant to consider, and what good directions for solutions might be, is one thing, but how to bring this all to practice? How to better and further the debate? Scenario thinking, in order to get a grip on the complexity of the HPV vaccination debate, enhanced through facilitated communication and interaction based on concepts like midstream modulation to support reflecting on one's own (changing) role, can lead to more comprehensive thoughts on responsibility and accountability.

In the process of midstream modulation [Fisher, Mahajan and Mitcham, 2006; Flipse, van der Sanden and Osseweijer, 2014] a social scientist embedded in the execution of scientific research encourages 'natural scientists and engineers' to actively broaden their deliberations on social and ethical aspects. For the process of HPV vaccination, this could concern an innovation process that doesn't only merely deal with uncertainty concerning HPV-vaccination, but also a process in which uncertainty may lead to creativity, following Pollack's idea. This may help them to focus not only on the boundaries between science and lay audience, but also to understand their innovation pathway from a system perspective.

The outcome of these reflections could be used as input for scenarios concerning the future implementation of HPV-vaccination program. Scenarios are amongst, as Schoemaker [1995] writes, the many tools a manager can use for strategic planning, and scenario thinking stands out for its ability to capture a whole range of possibilities in rich detail. By identifying basic trends and uncertainties a manager

(or scientist, engineer, policy maker) can construct a series of scenarios that will help to compensate for the usual errors in decision making, including e.g. overconfidence and tunnel vision. These scenarios are of course also based on scientific uncertainty and normative politics. However, 'there is a difference', as described by Pielke, 'between providing a single option and providing a broader set of options, particularly if the latter reflects a range of valued outcomes' [Pielke, 2007, p. 142]. Moreover, presenting various scenarios more clearly shows that there is uncertainty, and where these uncertainties may be. Then, as Lips says [2011, p. 91]: frontstage behaviour is aligned with backstage decision making and avoids 'stealth issue advocacy'. Now one can see that only listening at the boundary between science and a lay audience is too simple, and even when scientists are concerned, not a wise thing to do, both form the viewpoint of the scientist and from that of the lay audience. However, talking about shared and different responsibilities and the accountability that emerges from the innovation system, in which uncertainties became clear through scenarios, based on the reflections by the scientists, makes sense. Than we cut through complexity in the HPV vaccination debate. According to our opinion that is what science communication aims are about in responsible research and innovation: imagination, collaboration, deliberation and decision making, supported by methods like midstream modulation, system thinking and scenario thinking. That keeps us away from solely 'bug-fix'-oriented boundary thinking and leads to communication and interaction between actors, not as a means of crossing any boundaries (since that may be impossible), but as a means to perturb a status quo or equilibrium within a network of actors. This makes apparent boundaries more explicit and discussable and nudges stakeholders and their relations in the socio-technical network of HPV-vaccination.

References

Bailey, K. H. (1994). Sociology and the new systems theory: toward a theoretical synthesis. New York, U.S.A.: State University of New York Press.

Banathy, B. H. (1996). Designing social systems in a changing world. New York, U.S.A.: Plenum Press.

Christensen, C. M. (2002). The innovator's dilemma. Harvard, U.S.A.: Harvard Business School Press.

Collingridge, D. (1980). The Social Control of Technology. New York, U.S.A.: St. Martin's Press; London, U.K.: Pinter.

Davies, S. R. and Horst, M. (2016). Science Communication: culture, identity and citizenship. London, New York and Shanghai: Palgrave Macmillan. DOI: 10.1057/978-1-137-50366-4.

Fisher, E., Mahajan, R. L. and Mitcham, C. (2006). 'Midstream Modulation of Technology: Governance From Within'. *Bulletin of Science, Technology & Society* 26 (6), pp. 485–496. DOI: 10.1177/0270467606295402.

Flipse, S. M., van der Sanden, M. C. A. and Osseweijer, P. (March 2014). 'Setting up spaces for collaboration in industry between researchers from the natural and social sciences'. *Science and Engineering Ethics* 20 (1), pp. 7–22. DOI: 10.1007/s11948-013-9434-7. PMID: 23467918.

Flipse, S. M., van der Sanden, M. C. A., Radstake, M., De Winde, J. H. and Osseweijer, P. (2014). 'The DNA of socially responsible innovation: Social and natural scientists need to establish mutual understanding and a common language to efficiently work together'. *EMBO reports* 15 (2), pp. 134–137. DOI: 10.1002/embr.201337949.

Fonseca, J. (2002). Complexity and innovation in organizations. London, U.K.: Routledge.
Ford, J. D. (1999). 'Organizational change as shifting conversations'. *Journal of Organizational Change Management* 12 (6), pp. 480–500. DOI: 10.1108/09534819910300855.
Geels, F. W. and Schot, J. (2007). 'Typology of sociotechnical transition pathways'. *Research Policy* 36 (3), pp. 399–417. DOI: 10.1016/j.respol.2007.01.003.
Gilbert, J. K. and Stocklmayer, S. M. (2013). Communication and engagement with science and technology. Issues and dilemmas. New York, U.S.A.: Routledge.
Kitcher, P. (2001). Science, truth and democracy. New York, U.S.A.: Oxford University Press.
Kleinman, A. (2006). What really matters. Living a moral life amidst uncertainty and danger. New York, U.S.A.: Oxford University Press.
Köhler, W. (26th November 2016). 'Redders van vele mensenlevens'. *NRC Handelsblad*, W4–W5.
Kouwenhoven, A. and Voormolen, S. (18th November 2016). 'Vijf vragen over vaccineren. Nee, uw kind krijgt geen autisme van vaccinaties'. *NRC Handelsblad*, p. 5.
Krippendorff, K. (2008). 'Social Organizations as Reconstitutable Networks of Conversation'. *Cybernetics and Human Knowing* 15 (3–4), pp. 149–161.
Latour, B. (1988). Science in action. Cambridge, MA, U.S.A.: Harvard University Press.
Leeuwis, C. and Aarts, N. (2011). 'Rethinking Communication in Innovation Processes: Creating Space for Change in Complex Systems'. *The Journal of Agricultural Education and Extension* 17 (1), pp. 21–36. DOI: 10.1080/1389224X.2011.536344.
Lips, P. (2011). 'Over de grens van wetenschap: de vaccinatie tegen baarmoederhalskanker'. In: Onzekerheid troef. Het betwiste gezag van de wetenschap. Ed. by H. Dijstelbloem and R. Hagendijk. Amsterdam, Netherlands: Van Gennep.
Markard, J. and Truffer, B. (2008). 'Technological innovation systems and the multi-level perspective: Towards an integrated framework'. *Research Policy* 37 (4), pp. 596–615. DOI: 10.1016/j.respol.2008.01.004.
Mitchell, M. (2009). Complexity a guided tour. New York, U.S.A.: Oxford University Press.
Pielke, R. A. J. (2007). The Honest Broker. Cambridge, U.S.A.: Cambridge University Press.
Pollack, H. N. (2003). Uncertain Science...Uncertain World. New York, U.S.A.: Cambridge University Press.
Rittel, H. W. J. and Webber, M. M. (1973). 'Dilemmas in a general theory of planning'. *Policy Sciences* 4 (2), pp. 155–169. DOI: 10.1007/BF01405730.
Schoemaker, P. J. H. (1995). 'Scenario planning: a tool for strategic thinking'. *Sloan Management Review* Winter 1995, pp. 25–40.
van der Sanden, M. C. A. (2000). 'Het zweet, de lach en de traan van wetenschap'. *Natuur & Techniek Wetenschapsmagazine* 68 (10), pp. 65–68.
— (2008). 'Towards effecticve biomedical science communication. A composite theoretical framework making biomedical science communication on predictive DNA diagnostics understandable and manageable'. Doctorate Thesis. Amsterdam Free University.
van der Sanden, M. C. A. and Flipse, S. M. (2015). 'A cybernetic dream: how a crisis in social sciences leads us to a Communication for Innovation-Laboratory'. *JCOM* 14 (01), Y01. URL: https://jcom.sissa.it/archive/14/01/JCOM_1401_2015_Y01.

van der Sanden, M. C. A. and Osseweijer, P. (2011). 'Effectively embedding science communication in academia: a second paradigm shift'. In: Successful Science Communication. Telling It Like it is. Ed. by D. J. Bennett, D. J. and R. C. Jennings. Cambridge, U.K.: Cambridge University Press.
van Riel, C. B. M. and Fombrun, C. J. (2007). Essentials of corporate communication: implementing practices for effective reputation management. New York, U.S.A.: Routledge.
Verouden, N. W., van der Sanden, M. C. A. and Aarts, N. M. N. C. (2016). 'Engineers at the patien's bedside. The case of silence in inter-institutional educational innovation'. In: The Silences of Science: Gaps and Pauses in the Communication of Science. Ed. by F. Mellor and S. Webster. New York, U.S.A.: Routledge.
Wenger, E. (2000). 'Communities of practice and social learning systems'. *Organization* 7 (2), pp. 225–246.
Wynne, B. (2008). 'Elephants in the rooms where publics encounter "science"?: A response to Darrin Durant, "Accounting for expertise: Wynne and the autonomy of the lay public"'. *Public Understanding of Science* 17 (1), pp. 21–33. DOI: 10.1177/0963662507085162.

Authors

Maarten C. A. van der Sanden, Ph.D. is an associate professor of science communication at the Delft University of Technology, The Netherlands. He specializes in the social design of science communication processes and its supporting tools for scientists and science communication practitioners, from a social systems perspective. He teaches social systems and design courses in both MSc and BSc programs and is a member of communities of practice in science communication and corporate communication.
E-mail: M.C.A.vanderSanden@tudelft.nl.

Steven M. Flipse, Ph.D. is an assistant professor of science communication at the Delft University of Technology, The Netherlands. He specializes in science communication and innovation from a responsible research and innovation perspective. He develops and designs supportive tools for scientists and science communication practitioners involved in innovation processes. He teaches science marketing and innovation classes in both MSc, BSc and Postgraduate programs.
E-mail: s.m.flipse@tudelft.nl.

How to cite

van der Sanden, M. C. A. and Flipse, S. M. (2016). 'Science communication for uncertain science and innovation'. *JCOM* 15 (06), C05.

ISSN 1824-2049. Published by SISSA Medialab. jcom.sissa.it