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

# Communication as intermediation for socio-technical innovation

**Cees Leeuwis and Noelle Aarts**

**Abstract**

The academic interest in 'science and technology communication' has evolved from different societal domains and fields of application, giving rise to different scholarly traditions. This contribution introduces current issues and agendas in a field that has its origin at the interface of (agricultural) innovation studies, rural development sociology and the communication sciences. The paper starts with a brief sketch of the history of the field. When compared to earlier approaches, current thinking about 'communication, innovation and development' pays greater attention to limitations in the potential of orchestrating change and innovation in pre-planned directions, and to political and institutional dimensions of both communication and innovation. In relation to this, new lines of questioning are discussed. The article ends with a reflection on the usefulness of the thinking from different historical periods today. It is argued that approaches to science and technology communication need to be matched with the level of complexity of the issue at hand.

**Keywords**

History of public communication of science; Science communication in the developing world; Science communication: theory and models

## Different strands of enlightenment thinking

As is the case with other niches in 'science and technology communication', the early thinking about 'communication, innovation and rural development' was firmly rooted in enlightenment thinking. Two strands of thinking were especially influential. The first relates to work on the adoption and diffusion of innovations, starting with the famous study of Ryan and Gross [1943] on the diffusion of hybrid seed corn in Iowa, and with the seminal synthesis book of Everett Rogers [1962]. Here the focus was on understanding the role of (sources of) information, media and change agents at different stages in the adoption process, which was conceptualised largely as a process of individual decision-making and behaviour change [see also Van den Ban, 1974]. This kind of thinking became institutionalised in a lively field of research and practice called 'agricultural extension' [Adams, 1982; Benor and Harrison, 1977; Swanson, 1984; Van den Ban and Hawkins, 1988], which had clear affinity with simultaneously emerging fields such as health promotion and environmental education. Clearly these fields are still very much

alive today, and knowledge about processes of decision-making and behaviour change have become ever more sophisticated, for example at the intersection between communication sciences and social psychology [see e.g. Bartholomew et al., 2011; Nijland et al., 2013].

Another influential mode of enlightenment thinking — albeit quite different in orientation — is reflected in Paolo Freire's book 'The pedagogy of the oppressed' [1972]. Here the concern was with the role of communication, education and learning in supporting the freedom, emancipation and liberation of marginal groups in post-colonial Latin America. These ideas about popular education and enlightenment have affinity with the practice of Folk High Schools in Northern Europe which emerged from 1844 onwards [Bhattacharya, 2010].

In terms of their conceptualisation of communication, both traditions mentioned arguably start implicitly from an 'objective' or 'sender-oriented' model [Leeuwis and Aarts, 2011]. They were concerned with the best way of transferring specific 'enlightenment messages' (as defined by for example an agricultural extension organization), whereby 'noise' [Shannon and Weaver, 1949] and 'information loss' was to be prevented [Shingi and Mody, 1976].

## Interaction and participation in knowledge systems: science versus indigenous knowledge

The 1980–2005 period was characterised by a critical questioning of the kinds of enlightenment messages that senders transferred. It was realized that knowledge, technologies and policies advocated were frequently inappropriate, and did insufficiently anticipate the life-worlds of receivers. Assumptions made by agricultural scientists about farmers goals, rationales and needs, for example, often did not match with the diverse cultural values, agro-ecological conditions and household compositions that characterise farming communities. Thus, the intellectual journey has continued with considerable interest in topics such as the interaction between scientific and local/indigenous knowledge systems, targeting in communication planning and participatory approaches to technology design and development communication [Huesca, 2008]. The initial emphasis on 'advisor-client' communication was replaced by an emphasis on feedback loops among a wider set of actors that needed to be involved in processes of knowledge, technology and policy development [Röling, 1988; Van Woerkum, 1997]. This is for example reflected in work on 'agricultural knowledge and information systems [Röling and Engel, 1991; Klerkx, Van Mierlo and Leeuwis, 2012].

Arguably, this period is characterised by a lot of attention towards interaction, feedback loops, communication and knowledge processes among stakeholders at a relatively local level, a relatively strong belief in the possibility of planning and orchestrating change based on consensus and mutual understanding, and with limited attention to the more socio-political aspects of innovation and change that were initially emphasized by Freire. Again, models developed in this period still prove their usefulness today, for example in participatory approaches to community health promotion [Wagemakers et al., 2010], interactive approaches to policy formulation [Aarts, Van Woerkum and Vermunt, 2007; Aarts and Leeuwis, 2010] and consultation of citizens/users in setting science and technology agenda's [Klerkx and Leeuwis, 2008a].

In this period, there is more emphasis on 'subjective' and 'receiver-oriented' models of communication [Dervin, 1981; Leeuwis and Aarts, 2011] which assume that senders and receivers are likely to live in different worlds (i.e. had different backgrounds, interests and experiences) that affect the interpretation and/or acceptance of messages. Anticipating pre-existing knowledge and frames of reference, as well as active processes of sense-making were seen as a core task in both 'top-down' and 'bottom-up' processes of intervention.

## Complexity and mutual shaping of technology and society

In recent years, there is increased recognition that societal problems (e.g. climate change, poverty or obesity) arise from a complex web of interactions, and that there are limitations in the potential of orchestrating change and innovation in pre-planned directions. Moreover, innovation is seen to have political and institutional dimensions [Geels, 2002; Arkesteijn, Van Mierlo and Leeuwis, 2015]. In relation to this, there is greater attention towards the role of everyday communication in processes of self-organisation in relation to life-science issues, to the micro-politics involved in communicative exchanges, and to how communication processes in networks (including those around science and technology) shape societal developments at macro level. Thus, science and technology communication is seen as a force in shaping developments in society [Aarts, 2015], which goes far beyond the earlier focus on advisor-client relations or local level innovation and policy networks. Below, we will further elaborate and detail this perspective with emphasis on three interrelated developments, and new lines of questioning that arise from this. We first discuss the greater attention to institutional dimensions of innovation and how this is associated with more emphasis on processes of everyday communication. A second development is the emergence of a broader professional field of innovation intermediation. The third development relates to calls for more responsible governance of science and technology, based on improved dialogue.

### *Everyday communication and the institutional dimensions of technological change*

First, it has become clear that technical innovation requires and/or goes along with changes in the formal and informal 'rules of the game' in society, and that innovation is essentially about change in socio-technical configurations [Bijker and Law, 1992; Leeuwis, 2013]. A shift towards sustainability through decentralised energy webs, for example, not only requires new technology and infrastructure, but also new forms of organisation among 'prosumers' (i.e. citizens who are no longer only energy consumers, but who also produce energy through e.g. solar panels that are connected to the grid), new contractual arrangements between 'prosumers' and energy companies, new cultural norms, as well as changes in energy legislation and policy. In other words, innovation includes social and institutional innovation.

Moreover, it is increasingly recognized that at any point in time we witness newly proposed socio-technical configurations that compete with each other, and with the dominant socio-technical 'regime' in a dynamic selection environment [Geels, 2002; Rotmans, Kemp and Asselt, 2001]. Those supporting alternatives to the currently still dominant fossil fuel technologies (for example wind energy, bio-fuels, hydrogen, solar systems, etc) do not only have to deal with powerful lobbies that

wish to maintain the status-quo, but can also weaken each other in the struggle for survival and success.

An implication of the above is that innovation involves multiple technical and social changes that somehow take place more or less simultaneously in a network of interdependent stakeholders [Leeuwis and Van den Ban, 2004]. In such networks there is often no central party who is in a position to effectively steer and control others. Studies indicate that the success of change initiatives (e.g. wind energy) in competition with others and the existing order depends on (a) the extent to which learning about technical and social dimensions of the innovation contributes to the emergence of mature and well-adapted solutions, and (b) on the strength of network building and coalition formation around a promising technologies [Smits and Kuhlmann, 2004; Hommels, Peters and Bijker, 2007; Van Mierlo, 2012]. While such processes may well be supported by professional communication activities (see below) it is also clear that everyday communication among citizens plays a key role in the building or undermining of support for innovation. That is: whether or not wind energy becomes a success depends to a degree on how prospective users and citizens frame and talk about several aspects of the issue at home, in public spaces and/or on the internet and social media. In such conversations fossil fuels may be represented as a problem (or not), and windmills may be framed as an enrichment of our landscapes, or as the opposite. Such everyday conversations matter, as they may strengthen or weaken discourse coalitions [Hajer and Laws, 2006] in favour of alternative socio-technical futures. Phrased differently, we could say that such everyday conversations are a key element in processes of self-organisation, i.e. the emergence of new societal orders in the absence of central steering and control [Leeuwis and Aarts, 2011]. Such new orders emerge from chains of interaction across time and space.

This perspective on change and innovation gives rise to new research questions related to the role of communication in processes of learning, network building and coalition formation, including questions on how discourses and everyday communication influence the success or failure of new configurations in the competition with others. This may be studied through making so-called 'innovation histories' [Von Hippel, 1988] with specific emphasis on identifying critical moments of stagnation or breakthrough in the innovation process, and how these are linked to network dynamics, communication among stakeholders and the development of frames and discourse coalitions in and around change initiatives [see e.g. Klerkx, Aarts and Leeuwis, 2010; Elzen et al., 2011; Elzen, Van Mierlo and Leeuwis, 2012; Schut, Leeuwis and van Paassen, 2010]. Insights gained from such historical trajectories may subsequently inform practices by those who aim to support innovation in society.

### *The efficacy of new forms of innovation intermediation*

In connection with the above we have seen a considerable broadening of forms of professional communication in support of innovation. Besides the classic intermediaries that were to support individual decision-making (e.g. agricultural extension agents, advisors, etc.) we have seen that network building, mediation, coalition formation, advocacy, knowledge brokerage and facilitation of learning have become important tasks of new style 'innovation intermediaries' [Howells,

2006; Van Lente et al., 2003]. Howells [2006] has defined 'innovation intermediaries' as: "an organization or body that acts as an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations." [Howells, 2006, p. 720]. Many such organisations that strongly rely on professional communication have emerged within agricultural innovation systems [Klerkx and Leeuwis, 2008b], a development which was also stimulated by processes of privatisation and state-withdrawal [Sumberg and Thompson, 2012] in both the North and South [Klerkx, Hall and Leeuwis, 2009; Kilelu et al., 2011].

At the same time, the increased availability of ICT and mobile technologies poses new opportunities for innovation intermediation and communicative service delivery, as well as new possibilities for involving citizens in research processes. The latter may take various forms, including decentralised data collection by citizens at the request of scientists, greater involvement of stakeholders in setting research agenda's (e.g. through web-based consultations), or the collaborative analysis and interpretation of data generated through 'citizen science' to address specific problems [Jalbert and Kinchy, 2016]. Farmers may, for example, use a virtual platform to monitor the spread of agricultural pests and diseases, and use this information to enhance individual and collective decision making.

This has led to new questions related to the potential and limitations of classic and new innovation intermediaries in supporting technical and institutional innovation in society. This includes studies on how the identity and positioning of intermediaries affects their legitimacy and performance [Klerkx and Leeuwis, 2009]. Moreover, there are numerous studies on the effectiveness of and/or the dynamics within new modalities and methods for innovation intermediation, such as innovation platforms, research for development platforms and public private partnerships [Horton, Prain and Thiele, 2009; Smits, Moriarty and Sijbesma, 2007; Kilelu, Klerkx and Leeuwis, 2013; Schut et al., 2016]. In addition, we witness interest in studying alternative 'business models' for the funding and delivery of regular and ICT-based communicative services, and in assessing the contribution of different forms and levels of 'citizen science' [Haklay, 2013] to societal decision-making and problem solving.

### *Dialogue, reflexivity and responsible research and innovation*

In light of the realization that emerging technologies can shape society in numerous intended and unintended ways, there is increased attention for the establishment of forms of governance in science and technology that ensure legitimacy of decisions that are taken in this realm. This is especially so in relation to emerging technological opportunities that are seen from the outset as having major transformative potential, such as genetic modification, nanotechnology and synthetic biology. In relation to this scholars have proposed essentially communicative process designs for 'improving the conversation between today and tomorrow' [Macnagthen, 2016]. One such design is the framework for responsible innovation [Von Schomberg, 2011; Stilgoe, Owen and Macnaghten,

2013] which systematically addresses questions about the likely or possible impacts of the product, the management of the innovation process and the purpose of an innovation. Moreover, the framework proposes that process designs for research and innovation governance should ensure (a) anticipation of potential consequences of the innovation, (b) inclusion of all affected parties and viewpoints, (c) responsiveness to changing societal demands and concerns and (d) reflexivity on values and assumptions underlying design choices. The latter issue of reflexivity, also lies at the centre of newly developed approaches for enhancing learning in processes of societal transformation (for example Reflexive Monitoring in Action, see Van Mierlo et al. [2010]). Such approaches demand effective bridging and dialogue between stakeholders and communities with widely diverging life-worlds, values, experiences, expertise and schemes of interpretation [Aarts, 2015].

The emergence of new dialogical governance approaches leads to questions regarding the ways in which such methods and approaches are operationalised and enacted in specific contexts, and whether and how this contributes to greater legitimacy and agreement around emerging technologies. In addition, it leads to renewed interests in the communicative mechanisms and processes that prevent or stimulate the emergence of true dialogue [Aarts, 2015].

This current period of thinking in the field of 'communication, innovation and rural development' is characterised by an 'interaction' or 'construction' model of communication [Te Molder, 1995; Leeuwis and Aarts, 2011] which emphasises the importance of the relational and political context in shaping communicative exchanges. In this model, senders and receivers are seen to strategically propose and construct meanings in order to pursue relational goals and other interests in the interaction with others [Te Molder and Potter, 2005; Dewulf et al., 2009]. Moreover, micro-level communicative exchanges are regarded as potentially reinforcing or undermining macro level discourses, which implies that citizens and media are regarded as having 'conversational responsibility' [Aarts, 2015].

## Final reflection

We have sketched a brief history of a field of study that started as 'agricultural extension' studies, and which emerged at the interface between (agricultural) innovation studies, rural development sociology and the communication sciences. This field can be regarded as a specific niche within 'science and technology communication'. The thinking in this niche has co-evolved with general developments in the thinking about communication, and is also strongly influenced by developments in innovation and transition studies. While our chronological description captures important shifts in theory and practice over time, this should not be taken to mean that preceding modes of thinking and intervention have disappeared and/or become irrelevant. On the contrary. Enlightenment models of science and technology communication are still very much alive today, and they are still of relevance in specific settings. Similarly, participatory approaches continue to inspire many practitioners, and deserve further study and investigation. What we see in essence is that the field has evolved along with the kinds of problems and challenges that were seen to exist in agriculture and rural development, giving rise to various forms of 'science and technology communication' ranging from dissemination of research findings, involving societal stakeholders in setting agenda's for research and joint learning,

various forms of citizen science and/or active experimentation with (and coalition formation around) new solutions in society (action research) in an effort to replace dominant socio-technical configurations.

When choosing an approach to science and technology communication, it is important to consider that different kinds of thinking and practice are suitable for different kinds of problem settings. Several authors have argued that problem situations can vary in their level of complexity depending on the extent to which parties involved agree on problem definitions and goals to be achieved and the extent to which there exists uncertainty about how the system at hand functions and may be influenced [e.g. Jasanoff, 1990; Funtowicz and Ravetz, 1993; Hisschemöller and Hoppe, 1995]. A third dimension of complexity has been added by Arkesteijn, Van Mierlo and Leeuwis [2015] and includes the degree of stability in the problematic context, as related to e.g. path dependencies and the strength of vested interests and dominant coalitions [see also Urry, 2004]. Arguably, communicative enlightenment approaches may be relevant to relatively simple situations where users and change agents agree on the goals to be achieved, where cognitive and cultural differences are small, and where change can be predicted and achieved through individual behaviour change. In situations where agreement on goals or consensus overlap may be achieved, and where cognitive and cultural differences are significant, it may be useful to use participatory approaches and make use of innovation intermediaries to 'learn the way out' of the problem situation. When situations are characterised by conflict, highly uncertain dynamics and/or strong rigidities in the system, it becomes pertinent to use communicative strategies as a vehicle for putting pressure on the system (e.g. through the formation of discourse coalitions and advocacy) and work towards feelings of mutual dependency and power balance. This is an important pre-condition for achieving integrative negotiation and productive conflict management [Pruitt and Carnevale, 1993; Aarts, 1998; Leeuwis, 2000] and arguably also for fostering commitment to true dialogue and responsible innovation. However, experiences with the communicative support of innovation in domains like agriculture, natural resource management and life-sciences, suggest that policy-makers and other change agents tend to under-estimate rather than over-estimate the complexity of the problematic context at hand. Hence, investing in forms of diagnostic research before choosing a communication strategy remains essential.

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## Authors

Cees Leeuwis is professor of Knowledge, Technology and Innovation. He studies processes of socio-technical innovation and transformation in networks, collaboration between different disciplines, research for development policy, the functioning of innovation support systems and the role of innovation platforms, communication, extension and brokers therein.
He works in many domains, including sustainable agriculture, natural resources management, poverty related diseases and inclusive value chains.
E-mail: cees.leeuwis@wur.nl.

Noelle Aarts studies inter-human processes and communication for creating space for change, in governmental organizations, NGOs, and commercial companies. She has published on topics such as discourse and framing, conflict and negotiation, communication of organizations, dealing with ambivalence, network-building and self-organization.
In addition to her personal chair at Wageningen University Noelle has an extraordinary chair 'Strategic Communication' at the University of Amsterdam.
E-mail: noelle.aarts@wur.nl.

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