# Systems of Innovation are Systems of Mediation: A discussion of the critical role of science communication in innovation and knowledge-based development

Working Paper

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## Summary

This discussion paper highlights the critical role of science communication, not as an 'add-on' topic to bring about the acceptance of science, but as a process which guides the processes of innovation and knowledge-based development. It argues that people do not passively adopt science for homogeneous activities; rather, scientific knowledge and technologies are adapted to the everyday lives of very different communities and vice versa. If one wishes to design processes to support and respond to innovation and knowledge based-development without excluding certain groups of people, it is not enough to say that science is applied in society, nor that technologies impact on society. Rather, what needs to be recognised is that it is through the efforts of science communication activities that scientific knowledge and technologies are made meaningful to the everyday lives of very different communities. It is therefore through the support of science communication activities that socio-economic and political systems may give rise to, and may be influenced by, the patterns of use and adaptation of technologies by different communities of interest. The paper ends with a discussion of the policy objectives of the Office of Science and Technology (OST) and the Department for International Development (DFID) in the UK, and the kinds of science communication policies that might fulfil those objectives.

## 1. Introduction

Science communication is often regarded as an ‘add-on’ topic by science policymakers, somehow disconnected from the more serious business of supporting innovation, and through this, wealth creation and social well-being. This short paper aims to show how the support of innovation and knowledge based-development rely fundamentally on the activities of science communication. Science communication activities are important, but not as a means to bring about support and acceptance of innovation and development. Rather, they guide the processes that create and determine the practical influence of new technologies on the everyday lives of different communities around the world.

By charting our changing understanding of the nature of innovation, international development and science communication, this paper highlights the relationships that exist between these processes. It is argued that innovation, knowledge-based development and science communication are, in fact, interdependent parts of the same process. The policy implications of this perspective will be different in different national and international contexts. However, as a starting point, this paper discusses the implications of this systemic perspective on innovation and knowledge-based development for UK Government policy. This discussion is made with reference to the aims and objectives of the Office of Science and Technology and the Department for International Development in the UK.

## 2. Changing Perspectives on Science Communication

At the 2000 DFID/UNESCO International Workshop on Science Communication in London, Prof. John Durant discussed two perspectives on the science communication process: the *deficit model* and the *democratic model*. These are illustrated in Table 1. In essence, the deficit model of science communication sees the principal problem to be addressed as the 'public ignorance or misunderstanding of the facts, theories and processes of science'. It is therefore a linear model. According to this model, the 'outputs' of science are seen to require public acceptance which is managed by science communication activities, which insert 'understanding' into a bewildered public. The democratic model, on the other hand, sees that the principal problem to be addressed as the public's lack of confidence in the decisions being made on its behalf about science and technology. Durant describes this as essentially a two-way process, with the possibility of ‘feedback loops’ between two communities - scientists and non-scientists. 'For advocates of the democratic model the solution to the problem lies not in one-way communication from scientists to non-scientists, but rather in open dialogue and consensus-building between the two communities' (Durant 2000).

Although Durant says that the deficit model may be helpful in certain circumstances, he also says that it has received much criticism. 'It blames the public for dislocations in the science-society relationship; it ignores the extent to which mis-matches between the professional and popular perceptions may result from active and perfectly rational processes of issue re-definition or re-framing in particular contexts; and it inspires a great deal of unproductive or even counter-productive one-way communication between science and a sceptical public.' (Durant 200). This is of particular concern as most of the science communication activity in Europe is currently organised around the deficit model (Durant 2000).

**Table 1: Changing Perspectives on Science Communication**

| **If science communication is seen as . . .** | **Practitioners and policy-makers act to. . .** | **The result can be . . .** |
|---|---|---|
| Addressing public ignorance or misunderstanding of the facts, theories and processes of science. The **deficit model** or the **'public understanding of science'.** | Stimulate more and better one-way communication with the public about science and risk assessment. | A great deal of unproductive or even counter-productive one-way communication between science and a sceptical public (Durant 2000). |
| Addressing the public's lack of confidence in the decisions being made on its behalf about science and technology. The **democratic** model of science communication. | Stimulate open dialogue and consensus-building between scientists and non-scientists. | Processes which address mis-matches between the professional and popular perceptions which may result from active and perfectly rational processes of issue re-definition or re-framing in particular contexts. |

Source: Adapted from Durant (2000)

## 3. Changing Perspectives on Innovation

Science communication is not alone in being (mistakenly) seen as a linear, sequential process. After all, those who first studied technological change saw innovation in exactly the same way. For these analysts and policymakers, innovation was the result of a linear sequence of events which channelled scientific results to their 'implementation' in the society/the marketplace. Such a perspective has long been discredited. For example, the last column of Table 2 illustrates the particularly negative effects of this early view of the innovation process. It also shows more complex perspectives on innovation that have been put forward over time.

**Table 2: Changing Perspectives on Innovation**

| **If innovation is seen as . . .** | **The idea is known as . . .** | **Practitioners and policy makers act to . . .** | **The result can be. . . .** |
|---|---|---|---|
| . . .the result of a linear process which channels R&D to the marketplace. | The first generation 'linear model' of innovation or technology-push | Simply fund more scientific understanding R&D | Scientific results and technologies which fail to meet user needs, innovations which fail to harness scientific and technological developments outside the disciplinary/firm boundary. |
| . . . the result of activities which 'pull' market needs from the R&D laboratory. | The second generation model, market-pull | Simply fund more market understanding: do more marketing on consumer needs | Relatively poor capabilities in science and technology, which discourage innovation, innovations which fail to meet future needs. |
| . . . the result of technology push/market pull combinations with feedback loops. R&D and marketing are more in balance. | The third generation model of innovation: the Coupling model | Encourage 2-way interaction between R&D and marketing | Innovations which fail to harness scientific and technological developments outside the disciplinary/firm boundary, innovations which fail to meet future needs, or the current needs of those who do not participate in the R&D/marketing interactions. |
| . . . the result of collaborations with suppliers, leading edge customers and between teams. | The Fourth/Fifth Generation Integrated Systems Integration and Networking models | Use ICTs (simulations, etc), collaborations between R&D and manufacturing and suppliers and customers. | the same as above, although effects are limited to developments outside the disciplinary/supply chain boundary. Similar danger of ignoring the needs of the future and communities excluded from the development process. |

Source: Based on and adapted from Rothwell 1992 and Tidd, Bessant and Pavitt 1997

For example, those who see innovation as the result of process which push technologies to the market (the linear model) are in danger of encouraging the production of new knowledge and technologies which do not meet user needs (Tidd, Bessant and Pavitt 1997: 31). Those who see innovation as the result of a two-way interchange between R&D and marketing (the coupling model) risk creating innovations which fail to harness scientific and technological developments beyond the firm/discipline/country boundary, which do not meet future needs, and which exclude or do not meet the needs of those who do not participate in the R&D/marketing interactions (See Table 2).

More recently, empirical research into the factors associated with successful innovation has established that 'understanding user needs, good communication and effective collaboration' tend to be strongly associated with success, taking the market pull/technology push debate 'to a qualitatively different level.' (Coombs, Saviotti and Walsh 1987: 101/102). Innovation has grown to be seen not as a sequence of events, but as a process (Lundvall 1992: 9), 'where interaction is the critical element'. (Tidd, Bessant and Pavitt 1997: 29). At the heart of the question of how to support innovation is therefore an understanding of how these interactions take place.

Such ideas culminated in the National Systems of Innovation approach, where innovation is not seen as an 'isolated act', nor (simply) as a transferable process. Rather, the influence of technological development on everyday lives -and vice-versa - is seen to be a product of the way in which science and technology choices are made effective and are implemented in particular contexts. Since the ability to make such choices is enabled and constrained through processes of technological and institutional learning and policy-making (for example, the systems which affect literacy rates, the disciplinary structure of education or the available infrastructural support for communication via the internet), innovation is seen as embedded in the socio-economic and political systems which support it.

The national system of innovation approach holds that efforts to support innovation require an understanding of the environment in which these socio-economic contexts are experienced. From this perspective, the idea of 'technology transfer' is seen in a new light, as the contexts of application influence the way knowledge and technologies influence everyday lives. In their use, technologies are not transferred: they are translated from one context to another.

This approach sees technological development as being influenced by the state of the main institutions (e.g. universities, industry, government departments) their competencies, and the incentives and pressures to which these institutions have to respond. Of particular importance is the strength, not just of the different institutions, but also of the links between them (See Freeman and Soete 1997).

Particularly with regards to development activities, (but so too in a national context) there is growing recognition of the need to recognise 'the technology user as a creative contributor to the innovation process' (Mansell and Wehn 1998 ; 50). In other words, following Silverstone and Hirsch (1992: 1-2), users do not passively adopt scientific results or technologies for homogeneous activities; rather the innovation process involves the adaptation of science and technology to everyday lives and vice versa.

This means that users need to see meaning new scientific knowledge, to have the capabilities and confidence to use technologies for their own purposes, to have a voice when the use of these technologies excludes or introduces hardship, and to have the skills and capabilities to participate in the innovation process as such technologies are created. This requires that every community in the world has the power and means to communicate with all of the other groups (scientists, governments, industry, other local communities) who influence this process via economic, social or economic processes. Communication mechanisms which help these communities exchange knowledge on a national level can be used to support national systems of innovation. For example, in the UK, ‘Foresight’ activities have been successful in bringing academic and industrial communities together, to interact in ways that encourage people who live and work in very different context to see meaning in the work of others; to recognise potential sources of innovation and to adapt new knowledge and new technologies to their different everyday experiences. But to support knowledge-based development, governments, scientists, firms and other communities will all need to exchange knowledge on a local, global level. 'There has to be an understanding of what local people want and what local people are already doing.' (Appleton and Jeans 1991:49)

**4. Changing Perspectives on International Development**

Just as science communication and innovation were once seen as simple linear processes, the relationship between international development and science was once seen to involve as a simple, 'technology-push' process which solved a scientific 'deficit'. For example, Cooper notes,

*During the 1960s it was easy to make rather facile prescriptions about the kinds of scientific and technical institutions which were needed in the underdeveloped countries, and about the kinds of scientific activity they should do. . . And if, in the interests of development it was necessary to strengthen scientific and technological capability, the thing could be done quite easily: all that was required was to endow a few good research institutes, and to train the appropriate number of scientists to do the research* (Cooper 1973 : 1).

At this time, science-led development was simply a matter of introducing 'a bit more science and technology' into developing countries, and so to 'solve the problem of underdevelopment' (Cooper 1973:2). In later years, policymakers and academics took a more analytical approach in their thinking about science, technology and development, asking, for the first time, 'how all-round dependence on technologies from the advanced countries' might affect 'economic and social development' (Cooper 1973 : 1). The idea that science and technology were a force for good, and only good, was abandoned in favour of a perspective in which 'the underdeveloped countries' were seen to need to 'be as much concerned to defend themselves against the effects of science, as to 'use' it for their own internal development' (Cooper 1973 : 2). This was necessary as even appropriate technologies could have 'unanticipated negative results, because the consequences of introducing them into particular types of economic and social organization' are frequently unforeseen (Cooper 1973: 15).

Another perspective on development, which might be termed 'market-led development' takes the standpoint that industry is best placed to form 'the primary means of co- ordination with a limited role for governments to facilitate this co-ordination process.' (Mansell and Wehn 1998: 260). Participation by other groups, 'such as citizens groups, women's groups, non-governmental organizations, and labour organisations are involved mainly through their representation in the political processes that underlie regulation and government programmes' (Mansell and Wehn 1998: 260).

Although market-led development is said to play a 'very important role in countering the bureaucratic inertia and inefficiency of many governments' (Mansell and Wehn 1998: 260). They have also been severely criticised for failing to address the problems that international development activities aim to address: poverty, disease, the protection of the environment, and the alleviation of hardship. This is because of the very different objectives of international development organisations and industry. If 'the purpose of industry is to provide goods to create wealth' (Masanjia 1991 : 59) then the 'capabilities of markets are limited. . . they deliver co-ordination solutions that do not address important social objectives. . . and cannot always be relied upon to deliver the financial, technological and social resources necessary for building innovative knowledge societies' Mansell and Wehn (1998; 260).

Particularly with regards to the environmental effects of new technologies, some development authors argue that there is a growing recognition across the world that citizens should play a role in informing and shaping policy. Such political mechanisms, in effect, constitute a democratic perspective on development which, it is argued, currently suffers from a failure to initiate or link up with 'broader processes of policy change - including connections to conventional forms of democratic representation' (Holmes and Scoones 2000:1).

**Table 3: Changing Perspectives on International Development**

| **If development is seen as/the idea might be expressed as . . .** | **Practitioners and policy-makers act to** | **The result can be . . .** |
|---|---|---|
| Efforts which address the underdevelopment of science and technology as part of the general condition of 'underdevelopment' (Cooper 1973 : 1)<br><br>**Science-led development** | Introduce more science and technology into developing countries. | Scientific results and technologies which fail to meet local needs, innovations which fail to harness or develop local expertise and knowledge, development activities which ignore the effects of (sometimes perfectly rational) processes of issue re-definition or re-framing in particular contexts, |

| | | |
|---|---|---|
| **or 'technology push'** | | developments which ignore the negative effects of science and technology. |
| Efforts which use market as a means of providing co-ordination for development. **Market-led development.** | Bring industry and development stakeholders - local communities, governments - together for 2-way communication. | Stakeholder involvement generally occurs after most of the technological decisions have been made and the basis for learning have been established. Development serves industrial objectives instead of local social needs. (Mansell and Wehn 1998: 260) Activities fail to harness or develop local expertise and knowledge. |
| Efforts which use government machinery as a means of stimulating discussion of technology-related issues. **Democratic Policy Development**. | Bring local communities and policymakers together to form technology-related policy for 2-way communication. | To date, stakeholder involvement generally occurs after most of the technological decisions have been made and the basis for learning have been established (Mansell and Wehn 1998: 260). Activities serve - and are seen to serve - political ends rather than local social needs. 'One-off' initiatives fail to maintain involvement. Activities fail to harness or develop local expertise and knowledge. Local communities are not part of the innovation process. |

Source: Constructed using Cooper (1973), Holmes and Scoones (2000) Mansell and Wehn (1998)

Unfortunately, in practice, this approach is not without its problems. Currently the degree of community involvement 'varies, and generally occurs after most of the significant technological decisions have been made and after the education and training curricula that provide a basis for learning have been established' (Mansell and Wehn 1998: 260). Because these deliberate communication mechanisms are conceived and implemented as 'one-off events, their considerable potentials for transforming environmental policy processes goes unrealised' (Holmes and Scoones 2000:1). Table 3 illustrates these different perspectives on the development process, and their likely effects on the process of international development.

**5. Science Communication, Innovation and Knowledge-Based Development as Systems of Mediation**

Mansell and Wehn argue that a new development model is emerging which recognises many of the deficiencies of market-led development model. 'New partnerships are being forged within developing countries between public sector organisations and the business sector. . . Governments and firms are working more closely with users in their local communities to create a greater awareness of the possible contributions' of new technologies 'to their activities'. (Mansell and Wehn 1998: 260). This new model of development involves local communities both in the political decision-making process, and in the innovation process itself. 'If user-producer interaction is essential to the innovation process, then there is a need for a growing presence of [users as] creative producers in developing countries' (Mansell and Wehn 1998 : 50).

Talero and Gaudette (1995) see this new model in terms of a 'stakeholder' approach, which focuses on partnerships among stakeholders in the very process of development. But like the national systems of innovation approach, the essential element of knowledge-based development are not activities which address the needs of any one community or group (although the participation of all communities is important) but of the strength of the links between them.

Knowledge-based development requires communication between governments, industrial groups, non-governmental organisations and local communities of interest. Since each of these 'audiences' has a different set of skills and experiences, and different levels and types of understanding, exchanges of knowledge between these groups are not facilitated by the exchange of homogeneous information. They need to be mediated by science communicators, so that the science-related knowledge is made meaningful to the everyday lives and experiences of these different groups. User involvement in innovation and knowledge-based development means that science Communication is at the heart of both processes. Government support to science communication, innovation and knowledge-based development requires a systemic approach to policy-making that addresses the needs of all three processes.

## 6. Policies for Systems of Mediation: Towards New Science Communication Policies for Innovation and Development

'Democratic' approaches to science communication, government policymaking and international development need to aim to involve local communities in the processes of innovation - to meet economic and/or social needs. However, at present, the involvement of local communities is sought too far down the line in the policy-making process, and hence rarely involve these communities in process of innovation at all. This should be of concern as innovations need to be 'designed and articulated not just in the formal corridors of power but in the everyday interventions and experiences of . . . technology producers and users' (Silverstone and Mansell 1996 ; 225). To illustrate this, the remainder of this paper examines current UK Government policy on science communication, asking, 'Does current UK policy on science communication support systems of innovation/mediation? Or do real policy mechanisms simply reflect linear models of science communication, innovation and international development?'

### 6.1 Science Communication and Innovation:

National UK policy

The role of the OST is to 'maintain and develop excellence in UK science, engineering and technology and to maximise their contribution to sustainable wealth creation and quality of life in the UK' (OST 2000a). 'In taking a broad view of national needs, he [The Secretary of State for Trade and Industry] aims to strengthen the UK's science and technology capabilities and to maximise their contribution to sustainable growth and quality of life in the UK' (OST 2000b).

The Office of Science and Technology appears to be wrestling with different models of the science communication process. On the one hand, it claims to see citizens as part of the innovation process: 'Consumers play a vital role in the cycle of innovation. Consumers do not stand at the end of the scientific pipeline passively waiting to consume new products. They are agents in the process of innovation. Innovations only succeed when they are taken up by consumers, who in the process of using a new product often discover or even create uses for it that the original inventors never deemed possible' (OST 2000c).

Such a perspective would need a 'systems of mediation' approach to science communication. However, a closer inspection of the 2000 White Paper on science reveals that science communication is seen not as part of a mediated innovation process, but under the old 'deficit' model of the 'public understanding of science', where problems between science and society are attributed to the public's capacity to assess risk and the incorporation of scientific advice.

Indeed, people are conceived not as citizens or members of different communities, but as 'consumers'. The White Paper says that 'Public satisfaction feeds the cycle because public support underpins investment in the basic science that fuels the innovation process.' It also says, 'The Government's role is to work on both sides of this equation of benefit and risk that consumers make. That means adopting policies that promote and spread benefits as widely and quickly as possible, while also assuring consumers that the highest possible standards of safety are being adhered to. That is why the 1999 Consumer White Paper placed consumers at the heart of policy making' (OST 2000c).

Further evidence of the deficit model is found in later parts of the White Paper, where Government policy to 'encourage the cycle of innovation needs to address consumers' because 'Public trust is vital to innovation'. The paper appears to take a more democratic view with respect to 'public involvement' which is needed so that people have 'a confident relationship with science'. This is said to require 'plenty of opportunities for them to learn about recent scientific developments and to debate their value'.

Such statements may address issues concerning high-profile public debates, but what of the processes which create and determine the practical influence of new technologies on the everyday lives of different communities? What mechanisms exist to allow communities to respond to technological change - which may exclude them, or introduce suffering or hardship? Safe technologies may still exclude some social groups. Without the participation of those groups in the very process of innovation, their needs cannot be addressed.

The dialogue between scientists, policymakers and different communities of interest requires more than initiatives which 'help scientists understand how to communicate their work.' (OST 2000c) It also requires incentives for them to do so. As Mansell and Wehn (1998) note, 'Investment in the accumulation of technology and skills does not guarantee that strategies for building innovative 'knowledge societies' will be effective or coherent. . . It is necessary to create 'virtuous circles' of positive reinforcement and incentives for the participation of actors to maintain their commitment'. These processes of reinforcement require effective co-ordination mechanisms'. Science communication and the support of science communication mechanisms is not an add-on topic but an essential part of innovation policy. Systems of innovation are systems of mediation.

**6.2 Science Communication and Development:**

UK International Development Policy

The DFID's specific objectives are to promote: sustainable livelihoods, better education, health and opportunities for poor people and the protection and better management of the natural and physical environment (DFID 2000). It recognises that 'New knowledge, if it is to influence development, must be shared in relevant and accessible form to maximise the chance of it being used' (DFID 2000b).

If science and technology are to be used to create sustainable livelihoods, better education, health and opportunities for poor people and the protection and better management of the natural and physical environment, then socio-economic and political systems need to be designed to address the needs of very different communities of interest - governments, firms, NGOs, local communities, scientists - which are influenced by, and need to respond to, these technological developments. This requires knowledge exchange between these very different groups of people. Such exchanges cannot take place unless scientific and technological developments are made meaningful to policymakers, industrialists, the urban and rural poor, as well as the more well-off communities in the developing world. Since all these communities are best reached using different languages, different media, different metaphors and different means of expression, the processes that create and determine the practical influence of new technologies on the everyday lives of different communities around the world are the processes of mediation employed by science communicators of every kind.

Exploring these and similar issues, the DFID Knowledge Unit aims to 'enhance the use of knowledge by DFID and others in support of the elimination of poverty' (DFID 2000c). If the DFID believes that the development process relies fundamentally on knowledge being 'effectively disseminated to the right people and institutions' (DFID 2000b) then the support of international science communication mechanisms is not an add-on topic, but an essential part of the support of international development. Science communication policies are development policies. Systems of development are systems of mediation.

## 7. Conclusions

Although the support of science communication, innovation and international development are often seen as separate activities, they are, in fact, all part of the same process - the support of systems of mediation. For governments who wish to guide the processes that create, direct and respond to scientific and technological change so that they create real and practical benefits for their communities of interest, attention needs to be paid, not just to the main institutions, incentives and pressures that are felt by those involved in the innovation process, but also to the links between them.

It is not just scientists, but also industrialists, policymakers, non-governmental organisations and local communities around the world who determine the ways in which new scientific knowledge and new technologies are adapted to everyday lives and vice versa. Therefore, an essential part of the innovation process - and the process of international development - are the actors who facilitate exchanges of knowledge between them. This is the work of science communicators. By using particular languages, approaches, media, metaphors and cultural reference points, it is science communicators who bring science to life, allowing communities all over the world to give meaning to new developments, giving them the opportunity to respond to technological change.

This is increasingly important in a world where technologies do not only alleviate poverty, or improve health, but also introduce hardship, suffering and social exclusion. Furthermore, as rapid technological change and scientific advance have created techniques, products and applications which have the power to affect the everyday lives of people on a global scale, the communities which have an interest in technological development are no longer local. They are global.

Science communication activities which are carried out on a national basis, may, if perceived as systems of mediated innovation - dialogues between scientists, industrialists, policymakers and many different publics - produce competitive advantage for individual countries. But sustainable knowledge-based development has to address the requirement for a global dialogue to steer the process of scientific and technological advance, not just for the creation of wealth by industry, but for the good of communities all over the world. It is also needed so that the use of technologies (e.g. genetic modification, cloning) does not fall between the policy gaps of individual countries.

Such dialogues cannot be guided by national systems of mediation alone. International systems are therefore needed so that communities all over the world may participate as creative contributors to the innovation process, and so that they can adapt of science and technology to their everyday lives and vice versa. There is therefore a need to develop science communication capability - and indeed, science communication policy capability- globally, with particular reference to the needs of the developing world so that those involved in science communication activities can further their own local activities using professional development, infrastructure and capacity building, networking and research.

Through such activities will people in all communities throughout the world be able to see meaning in new scientific knowledge; to have the capability and confidence to use technologies to develop more sustainable livelihoods, better education, health and opportunities for poor people, a protected and better managed natural and physical environment, or a voice when the use of new technologies exclude or introduce hardship and the skills and capabilities to participate in the innovation process as such technologies are created.

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