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ARTICLE

Social Trust in Emerging Technologies: The Challenge to Incorporate Fundamentally Different Perspectives in Public Engagement

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ABSTRACT

The social construction of emerging science and technology systems requires extensive dialogue between diverse stakeholders, each with historically-diverse scientific, political and historical points of view. Public-engagement in debates about novel technologies has received substantial coverage within science communication studies but the origin of opposing positions regarding controversial science and technology developments has received little coverage. This work uses the juxtaposition between scientific and historical origins as a tool to explain the roots of different perceptions of emerging technologies in various sectors, with nanotechnologies as an empirical example.

KEYWORDS: Nanotechnology, science perception, social and technical, NGOs.

Introduction

Science and technology (S&T) advances are not isolated from society; to the contrary, they hold great social relevance. Lewenstein (2005, p. 6) notes that S&T only exists in a social context and we cannot understand its development without understanding both the socially-produced context and the scientific and technological conditions that help shape society. Consequently, any significant technological project is also a social project (Andreev & Butyrin, 2011) and requires the support of different sectors to succeed.

Social-acceptance and uptake of a new technological system is not solely dependent on S&T education or making people feel like they have a voice in the discussion; it involves engaging people meaningfully in development decisions regarding the wise use of technology (Priest, 2012, p. 9). But society is far from homogeneous; it is a complex network of sectors and actors; when it comes to the social issues related to a technological system, stakeholders emerge with a wide variety of interests and needs. Hence, as Priest (2012) suggests, the best thing to do — both as a democratic practice and as a tool to manage a new technology — is from the beginning to bring a broad spectrum of the members of society on board as partners in the thinking through of the wisdom of new technologies. In this line of thought, we find a growing trend to incorporate different social sectors into the processes of science production and its public communication. This appeared as a way to legitimize advances related to S&T (Barben et al., 2008; Bubela et al., 2009; David, 2008; Einsiedel, 2008; McCormick, 2009).

Science perception studies point out that people do not resort only to technical information in order to make sense of an emerging technology. In fact, they use cognitive shortcuts that come from values, religious beliefs or ideologies (Ho, 2008; Nisbet & Scheufele, 2009; Macnaghten et al., 2015), or they turn to trust (or lack thereof) in agents that promote such technology. And it is precisely this, in the question of trust, where the historical experience of stakeholders becomes a highly relevant issue.

The argument in this article transcends a discussion of individual-level perspectives of S&T advances. Instead, we are interested in organized civil society with collective historical backgrounds — such as non-governmental organizations (NGOs), labor unions or consumer associations.

This article uses the case of nanotechnology to highlight that social stakeholders draw on different histories for their perception of emerging S&T. While enterprises, researchers, and government base their perception mainly on technical facts and formal scientific results, NGOs and trade unions base their perception on social relations, such as past experience with the actors that introduce and manage new technologies.

Changes in the perception of scientific and technological innovations

Public communication of science work could be considered as old as modern science,[1] but it is from the Second World War that upstream communication of S&T (especially in the United States and Europe) grew in importance, in the spirit of creating a more democratic world (Lewenstein, 2016). Science popularization activities could be considered the first step towards a social discussion of S&T, by making people and organizations aware of an important issue; then, on a deeper level, there is a process of public incorporation into organized processes of state-promoted consultation (through agencies); and finally, in what is called upstream participation or upstream engagement (Selin & Hudson, 2010; Priest, 2012), social actors have a real opportunity to shape the future of emerging S&T. These three distinct levels of communication represent the main mechanisms for public discussion of S&T.

The analysis of the public communication of S&T has evolved greatly over the last two decades. A transition has occurred from a point of clear distinction between the communicator and the public, to a point where people are actively involved in the elaboration and process of communication (Einsiedel, 2008, p. 175; Gross, 1994 pp. 5-6), blurring the boundaries between these agents. Decade-long transitions include institutional changes in the science communication and decision processes (such as the creation of public forums, public consultation), which has resulted in social disputes and a challenge to corporations –chemical, pharmaceutical, and military- against environmentalist and pacifist NGOs; it has also resulted in disputes that led to legislation change (e.g. the empirical evidence against junk science controversy and the Daubert case) (Golan, 2004).

The legal use of the concept of "scientific evidence", now widely spread over the most diverse of legal bodies, has been a victory for corporations over social movements. First, because in

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[1]Just as Galileo Galilei is considered the father of modern science his book “Dialogues concerning the two chief world systems” (1632) is widely considered the first public communication of science effort.

areas such as human health or the environment it is very difficult to determine a cause-effect relationship from a product or chemical element, due to the enormous number of variables that come into play; so that scientific evidence that restricts testing to only a few variables can hardly be considered responsible (Brown & Grossman, 2015a, 2015b). Second, because the legal concept of scientific evidence and the process of evidence-gathering is tied to a series of pre-established techniques and instruments; these necessary techniques, together with the equipment and methods they require, have been promoted and controlled by the large chemical corporations and international organizations. Consequently, laboratories and procedures are restricted to the well-known *Good Laboratory Practices*, which are not necessarily the best ones — in many cases they are obsolete because they require delayed multiparty agreements to correct themselves, and more commonly they reduce the variables to predetermined criteria, making it extremely difficult to explore novelty (Cornwall, 2017; Latham, 2016; Zimmerman & Anastas, 2015). Third, because the concept of scientific evidence restricts the "scientific" to the realm of the physical-natural sciences. As a counterweight of the scientific evidence concept, the precautionary principle has emerged and expanded during the 1990s which does recognize historical experience and demands action before the necessary scientific evidence is gathered, provided there is sufficient evidence of a causal relationship (EEA, 2002, 2013). This legal concept is the instrument that social organizations use to claim rights and is based on historical experience rather than on laboratory results. However, the history of this concept has always been based on defensive position, against the hegemonic weight of the concept of scientific evidence, and legislation is not always clear on how and at what time to use one or the other criterion.

Elzinga and Jameson (1995) tell us that controversial developments in S&T have been greatly influenced by public debates which have forced many changes in policy; clearly, promoters of public communication of science endeavors play a key role in establishing the “conceptual frameworks” for the discussion about emerging technologies. In this context, “the politics of science becomes a rhetorical struggle over the ways science and technology are interpreted, the worldviews and associated metaphors that give rise to alternative visions for the organization of knowledge" (Elzinga & Jameson, 1995, p. 574).

The evolution of S&T has resulted in models that incorporate the lay public as an active agent in the construction of emergent S&T systems. This is clear in the analysis of public communication of S&T, which reveals a transition from the deficit paradigm to the interactive (or dialogue) model and associated public engagement with S&T (Durant, 1999; Bubela et al., 2009; Bensaude-Vincent, 2012).

Public engagement with S&T has brought changes both in content and form. Changes in content have occurred because cutting-edge research is no longer limited to what experts consider of interest (Lock, 2011; Scheufele, 2014). Instead, it incorporates the concerns of the public; for example, ethical issues on the social impacts of health and environmental risks. This has enabled people to participate in a meaningful way and furthermore, it can involve other social issues of great importance (e.g. labor changes, power struggles or S&T divides). Also, it has been historically established that there are social sectors that can understand a scientific matter beyond the expert domain, as has happened in the case of patients and their illnesses (Epstein, 1998).

There can be changes in form because the structure of the discourse, and the discussion itself, changes with the incorporation of the experiences of users or consumers of a new S&T product (Fischer et al., 2013). This incorporation can be performed through mechanisms to enhance social participation in the construction of S&T, or, in other words, through ways that consider the point of view of social sectors that were previously passive (Lock, 2011; Macnaghten et al., 2015). Now S&T is not restricted to experts, nor extended only to government or enterprises, but includes all kinds of actors and social organizations that, with their activities, influence the development of S&T.

This change means the traditional border between science and popularization tends to disappear. Some authors view it as a sign of democratization in S&T (Durant, 1999; Priest, 2012; Lewenstein, 2016), while others suggest it could be a mechanism to control citizens in times of globalization (Thorpe & Gregory, 2010). In any case, public engagement is regarded by its growing community of supporters as a big step in getting different social sectors involved in the advance and legitimization of S&T.

Science and technology are involved in permanent processes of social construction, at the intersection of politics, values and expert knowledge (Nisbet & Scheufele, 2009). It is not about an elitist perspective created in the community of experts that replicates homogeneously throughout the rest of society, but about knowledge that is re-created in a characteristic way depending on the agents involved. For instance, if we take the case of the nanoparticle version of an insecticide: the perception is going to differ between businesses who sell it, researchers that dig into its chemical properties, workers involved in its production, farmers who use it, or consumers that eat vegetables sprayed with it. The same technology entails a different meaning (and causes for concern) in every context and, at the same time, meets different expectations and demands. Consequently, in the political domain, there is a broader cultural assessment of S&T related choices and also a variety of specific perspectives of various groups in society (Elzinga & Jameson, 1995).

Making sense of emerging technologies

Different interests are not incumbent to a certain emerging technology; they relate to deeper issues in the relationship among science, technology, and society. Several challenges and dilemmas presented by novel technologies do not have a scientific answer (Scheufele, 2014). It is necessary to elevate the discussion and practice from a conception of S&T as a problem solver, to one where social participation defines how and for what S&T must be developed; that is, to move from a technical to a socio-political conception.

Historically, in deficit-model type conceptions, ignorance was seen as the root of social conflict over science because it was believed once citizens understood through research the scientific aspects of the controversy, the problem should "go away" (Nisbet & Scheufele, 2009). But the process is not that simple: understanding how people make sense of emerging technologies involves several other issues, depending on the social sectors in question. Facing new technologies, stakeholders base their perception on different facts. Governments, enterprises, and academies, for example, usually relate technological risks to technical facts, to issues that can be laboratory-confirmed. Social organizations, by contrast, base their assessments less on expert explanations and more on media portrayal, political awareness, technology background (Selin & Hudson, 2010), and their historical experience with the major stakeholders involved.

Lee et al. (2005) highlight that trust is a key aspect of affective relations with S&T and it can influence the public acceptance of new technologies. Also, according to Priest (1995) and Robbins (2001), public trust in the management of technology-related risks can be more important than beliefs in the advantages of a specific technology. Therefore, corporations with a proven history of introducing toxic chemicals into the market will not be trusted with new products, no matter what the results of scientific research show.[2] As Kyle & Dodds (2008, p. 86) put it, concerns about the potential risks and misuses of novel technologies, and hence their acceptability, are socially and culturally shaped.

Both groups, with government, corporations, and academics on one side, and NGOs and trade unions on the other, consider their views objective; and both are correct, although based on a different premise: both use legitimate evidence, but one side supports its claims with scientific data and the other with historical background. Each one forms the foundation for a narrative that will guide the discussion in public communication of emerging S&T — a narrative that will seek to represent the socio-technical dynamics at play (Macnaghten et al., 2015).

There are conflicting frameworks, each representing different interpretive schemes. They influence how people make sense of emerging issues by communicating what is at stake

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[2]There is abundant information on cases where commercially available products end up being harmful to health and the environment; these cases represent the base for consumers' and workers' mistrust in technical arguments as well as in the actors that promote them; see, for example, European Environmental Agency (EEA, 2002, 2013).

in a particular debate and by explaining why the matter is important (McCormick, 2009; Nisbet & Scheufele, 2009; Berube et al., 2010; Scheufele, 2014). The distinction between what can be called a technocentric approach and a socio-centric approach is therefore crucial to understand the complexities of the modern technoscience communication debate.

An empirical case: Nanotechnologies

Nanotecnologies represent a useful example case for our analysis, given that they have developed under the public eye like no other system before. From "There's plenty of room at the bottom", the famous lecture by Richard Feynman; to "Engines of Creation", the popular book by Eric Drexler and the National Nanotechnology Initiative in the United States (and many strategies that followed in other countries), the "nano wave" has been increasingly advertised. But, curiously, up until 2000 the social debate about nanotechnolgies seemed limited to the value of investing in them.

As Bell (2009, p. 32) points out, nanotechnologies were not an immediately obvious topic for debate because of their very low level of public awareness and the lack of widespread burning public issues. Even after decades of promotion, they remain essentially invisible for most people, not least because their novel properties are at the nanoscale (a millionth of a millimeter). Also, so far, efforts to build large-scale social opposition against nanotechnology development have not been successful as happened with genetically modified organisms (Bawa & Anilakumar, 2013; Fischer et al., 2013). People's emotional reactions do not seem to stem from nanotechnologies' intrinsic properties but are influenced, at least in part, by their experiences and perceptions of previous scientific controversies (Lee et al., 2005, p. 262). And the same thing is seen when we look at the perception of organized sectors, such as labor unions.

IUF is the International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations, which brings together 12 million members of 365 trade unions from 122 countries around. In its 25th Congress, in Geneva in 2007, the IUF presented the first worldwide declaration on nanotechnologies made by a labor union. This document calls for a public debate, warning that nanotechnological products are entering the market before civil society gets an opportunity to evaluate their economic, environmental and human health implications; it also points out that decisions on technologies that could trigger substantive changes in society should not be left only in the hand of experts.

In a presentation given by the labor union,[3] the speaker opened with the notion that the research and introduction of nanotechnological products to the market, and the discussion about them, is promoted by chemical corporations such as Monsanto, Syngenta, and Dow Chemical. Next, he made references to how these companies have been, and continue to be, responsible for both the death and occupational diseases of global producers and workers. The labor union has historical experience of political struggle which has taught them not to trust such corporations. This mistrust is independent of a specific technology. Social relations established by these corporations with workers have created historical experience, which has substantial weight in the perception of new technologies. The union does not make judgments about technical facts, but bases opinion on the past behavior of agents promoting the use of a new technology, that is, opinion built on social relations. This involves a shift in the focus of analysis from the intrinsic technical hazards of technologies to who produces them and who introduces them into the market.

Nisbet and Scheufele (2009) make a case in point when they highlight how some NGOs question the introduction of carbon nanotubes based on historical experience with asbestos. This does not mean that workers or consumers do not know the objective material conditions of a product or process and their advantages or their physical-biological hazards — but this is not the only issue at stake. Social relations are as important as technical issues for social

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[3]International Workshop “Nanotechnology, Workers´ health, Food and impact on Society and the Environment”, Fundacentro/IIEP/Diesse/Renanosoma, October 3-4, 2007, Sao Paulo, Brazil.

organizations and NGOs[4]. Such perspective presents a sharp contrast to scientists, enterprises and many governments that for the most part take technical content and properties as the only focus.

Social relations are those established among people in the process of production; while technical relations are established between people and things, which for them are instruments, devices, or any kind of means of production. It should be noted that this distinction is a mental abstraction: in reality, a worker establishes social relations with the capitalist and, at the same time, develops technical relations with machinery, supplies, and raw materials.

The dichotomy between technical and social relations was used in the 1960s and 1970s by critics of education programs who, following authors such as Gorz (1976) or Althusser (2008), claimed that teaching to improve skills (technical relations) was not neutral; it reproduces social relations of hierarchy, authority, power or control (Avis, 1981). The same dichotomy has been used to analyze the difficulties of skilled and specialized workers in creating trade unions when new technologies are introduced in the labor process (e.g. lean production, toyotism system) (Parker, 2015; Parker & Slaughter, 1988). Finally, the duality was also used by the philosopher Sánchez Vázquez (1984) to explain the difference in the object of study of physical-natural sciences (technical relations) compared to that of social sciences (social relations), which sheds light on the different perceptions that the various kinds of stakeholders have with regard to S&T.

When we turn to the analysis of Public Communication of Science and Technology practice, there is a clear distinction regarding the technical and social content in the discussion, depending on the type of agent that promotes the communication strategy. García-Guerrero & Foladori (2015) studied the

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[4]Note: The distinction between social relations and technical relations, developed by Karl Marx, represents a useful theoretical tool to understand the dilemma we just presented.

frames[5] used by relevant strategies for the public communication of nanotechnologies (PCN) in different countries, finding that — for the most part — PCN is performed by technical specialists that do not discuss the social issues related to the emerging technologies.

We are working on a framework that considers the relation different stakeholders establish with emerging technologies, so it is also relevant to ponder their influence (or lack thereof) on strategies that promote the PCN. We can ask how the products of said strategies frame the discussion for different social sectors. For that, we performed a study on PCN books.

The study intends to establish the centrality of social or technical issues in the discourse of different stakeholders when performing public communication of nanotechnologies. We selected 16 public communication of nanotechnologies books that were published in 8 different countries, although several cases have a regional or global reach. Three documents were published by government agencies, four came from commercial publishers, three originated in universities and the rest (6) were developed by other social organizations. Table 1 summarizes the data obtained.

We used content analysis as a method to classify the books according to their content of social and technical issues about nanotechnologies, with the following criteria: the level of social discussion of a book is high if it comprises more than 40% of the document; a medium level considers between 20% and 40% of the discussion space; the level is low from 1% to 20%; and it is absent if there is no social discussion at all. The same applies to the levels of technical discussion.

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[5]Considered here as interpretative storylines that communicate what is at stake in a societal debate and why the issue matters (Nisbet & Scheufele, 2009).

Table 1: Centrality of technical or social issues in public communication of nanotechnology books

Strategy	**Institution**	**Country or region**	**Technical**	**Social**
Nanociencia y nanotecnología	Spanish Foundation for Science and Technology (FECYT)	Spain	High	Low
Nanociencia y nanotecnología	Economic Culture Fund (FCE) and National Council for S&T (CONACYT)	Mexico	High	Absent
Understanding nanotechnology	Scientific American	United States	High	Absent
The Big Down	ETC Group	England	High	High
Way too little	Friends of Earth	Australia	High	High
ETUC 2nd Resolution on Nanotechnologies and Nanomaterials	European Trade Union Confederation	Europe	Medium	High
IUF Resolution on Nanotechnologies	International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations	World wide	Medium	High
Implicaciones sociales y ambientales del desarrollo de las nanotecnologías en América Latina y el Caribe	Latin American Nanotechnology and Society Network	Mexico and Brasil	High	High
Understanding the nanotechnology revolution	Wiley-VCH	Germany	High	Low
Una revolución en miniatura	Valencia University	Spain	High	Low
Nanotechnology: new promises, new dangers	University of Chicago Press	United States	Medium	High
Nanofuture: what's next for nanotechnology?	Prometheus Books	United States	High	Absent

Nanotechnology for dummies	Wiley Publishing Inc.	United States	High	Medium
La nanotecnología	Superior Council for Scientific Research	Spain	High	Medium
Hablemos de nanociencia	National Autonomous University of Mexico	Mexico	High	Absent
Radical Abundance	Foresight Institute	United States	Medium	Low

Source: Own elaboration with data from García-Guerrero & Foladori (2015) and García-Guerrero (2016)

Data shows that most books (12, which represent 75%) provide a high level of technical content, while only 4 have a medium level for this kind of discussion; there were no cases with low or absent technical discussion. For social organizations, we found that half of them offer a high level of technical discussion, with the other half providing a medium level.

On the other hand, data indicates that only six documents offer a high level of discussion about social issues in their narrative, with five of them coming from social organizations. Two books have a medium level of social discussion; four cases offer a low level and the last four do not provide any social discussion at all. In the last scenario, with absent social discussion, the cases come from commercial publishers, government agencies and universities.

Documents created with the participation of academic and government institutions, and even most commercial publishers, show a high degree of trust in technical issues: they highlight the advantages of nanotechnologies as scientific *facts*, to promote support and social adoption, and in very few cases they get into a solid discussion of risks that are usually labeled as *possible*.

In contrast, social organizations' communication strategies seem concerned with offering a solid technical base to understand the fundamentals of nanotechnologies; and it is only after this technical foundation that they discuss the social issues considered of interest.

Notably, there is a fundamental difference between stakeholders in terms of openness and trust. Social organizations take time and effort to assimilate and discuss technical aspects, while government agencies, enterprises, and researchers in basic sciences, are not willing to go into social discussion. NGOs accept scientific results but question the motivations and socio-economic practices that lead to the creation and development of novel technologies. Companies and scientists, on the other hand, trust the results of technical facts and discard the contributions of socio-historical issues related to the agents involved. For many social organizations, this situation translates into the idea that, while they were not considered in the definition of the technological route, they nonetheless have to assume the risks inherent in the new advances (Joly & Kaufmann, 2008, p. 227).

This situation presents a fundamental imbalance that erodes the trust of social organizations towards the stakeholders that propose and define the advance of an emerging technology. This lack of recognition regarding the legitimacy of historical evidence, and poor attention to past experiences, suggests the possibility of them being repeated.

Conclusions

In this article, we introduce the distinction between the technical and/or the social issues in the public communication of S&T, and their centrality in the perception of emerging technologies, using nanotechnologies as a case example.

The place occupied by the actors in relation to new technologies differs, and from there arises a different perception of their virtues and implications. Entrepreneurs and scientists base their perception on the technical relationship they have with new technologies and products, while workers, outside the scientific-technical knowledge of the processes, are interested in the effects of the product and the background of the companies that manufacture them.

The conventional approach in the discussion of emerging technologies, promoted by enterprises, most governmental agencies, and academic institutions, is based on the discussion of scientific facts. On the other side, NGOs and trade unions, although worried about scientific facts, add social knowledge of stakeholders' past behavior as a key variable in assessing the implications of new technologies. Historical experience relating to past introductions of technologies by corporations with harmful consequences is considered of equal relevance to laboratory-measured risk results.

Social organizations claim that the role of stakeholders in risks from past technologies is excluded by regulators from discussions on new technologies, hence historical experience is absent from technology assessment.

Instead of making the best of the valuable historical experience to enrich the public engagement with emerging technologies, the experience of NGOs and labor unions is neglected. Organizations that intend to participate in the construction of new technologies thus suffer an implicit disqualification as their stance, which could translate into opposition and rejection to promoters of new technologies, is excluded.

The analysis of an empirical case of perception of nanotechnologies by an international trade union shows that the necessary trust for a public engagement with S&T demands the recognition of historical experience of the role of stakeholders as significant evidence and a fundamental component to consider in the construction of emerging S&T.

On the other hand, in the content analysis of 16 public-communication-of- nanotechnologies books, we find a latent struggle between stakeholders. Strategies promoted by social organizations seem to involve discussion-promotion, mainly as an effort to get their concerns addressed; they seek to be part of the construction process of emerging technologies. The other stakeholders, government, researchers, and private efforts, appear more interested in spreading their own perspective and getting society to accept nanotechnologies as they are.

Here we find what might be our most important conclusion: the study of the public-communication-of-nanotechnologies books showed a latent political struggle between different stakeholders. Strategies promoted by scientists, government officials and the private sector, frame nanotechnologies as principally something that we should take advantage of, but as something that experts have already built; possible new developments are mentioned but within the domain of a specialized community. Books published by social organizations are more of a call to get people to discuss the issues (risks and benefits) that arise with the new technologies and, beyond that, act in an organized way to achieve a bigger role for society in the development of nanotechnologies.

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