

Focus

What type of Science Communication best suits emerging countries?

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If we wish to attempt an initial analysis of the inquiry on the communication of science in Brazil,^{1, 2} India³ and China⁴ that *JCOM* proposed in its three most recent issues, we should paraphrase Chinese science and science-fiction writer, Yan Wu: even though these three countries are emerging in the fields of economy and science, and are now part of a wide group of communicators, promoting numerous methods to divulge information, they don't yet have a sound theory on the communication of science to the public.

This is not an insignificant problem because according to David Dickson, the director of *SciDev.Net*, democratic dialogue on scientific matters is crucial to modern societies.⁵

However, it is difficult to propose the highest possible level of democratic dialogue on science topics without having a sound theory about the communication of science. In addition, the difficulties increase in those countries where developing economies and systems of science are both new and impetuous, as is the case of Brazil, India and China.

The term "impetuous" is not used here as a concession to rhetoric. Indeed, China's economy has been growing for the past 10-15 years at an annual 10% rate, but public investments in scientific research and technological development are increasing at even twice the speed, nearly 20% annually,⁶ and with immediate results: the publications of Chinese scientists in international magazines increased 20 fold from 1981 to 2003;⁷ while the exportation of high-technology products, in only ten years (1990-2000), went from 5% to nearly 25% of the total amount of exports.⁸ By now, China ranks third in the world with regards to total investments in scientific research and technological development (after the USA and Japan), second with regards to the number of researchers (after the USA), and ranks top in investment growth.

In India and Brazil, growth in terms of the economy and investment in research and scientific productivity is slightly less sustained. In Brazil, but only in the richest regions, such as the state of Sao Paulo, the percentage of the GDP allotted for research funding is nearly equal to that of Italy, while the number of scientific publications increased 4 fold between 1985 and 1999.⁹ India, as Tony Blair reminded the European Parliament at the inauguration of the European Union's English premiership, now confers science degrees to more youth than in the whole of Europe.¹⁰

In other words, to paraphrase *New Scientist*, we could say that China, India and Brazil are or can aspire to be the three new "superpowers of knowledge".¹¹

As a natural consequence these new superpowers of knowledge are experiencing a relationship between science and society that is still uneven and strained (and not necessarily in a negative sense). The speed of development is, in itself, a disturbing factor, while the great disparities regarding income and education within the various sectors of society produce further complications. In the absence of a theory that could provide some kind of guidance, the communication of science in countries with emerging economies proceeds by trial and error while designing dialogue on scientific matters in an environment that is also continuously changing.

Nevertheless, *JCOM's* inquiries have demonstrated that in each of the three countries this designing process follows its own path only in part. Normally, it often inevitably follows a path common to other countries and experiences.

Yan Wu and the communicators from countries with emerging economies rightly express dissatisfaction with the absence of a theory about the communication of science in their countries, but should not complain all that much. The whole world lacks this theory.

Around the world there exist diverse models of the communication of science, some of which, like those in China, India, and even that of Brazil, contain variations defining, regional characteristics and draw from local traditions both ancient and entrenched. With regard to the universal character of science and its communication there should be no difference between cultures: it should be able to adapt to all local cultural models. Indeed, if it is in the public interest that democratic dialogue between science and society be implemented, then not only is it possible, but also desirable for the communication of science to the public to adapt itself to the specific culture of the society in which it operates.¹²

This does not mean dispelling the possibility and legitimacy of aspiring to search for universal invariants within the various models of science communication. Researching valid invariants is necessary not only in Europe, North America and Oceania, which have a similar and, at times, even homologous scientific tradition, but also in Asia, Africa and South America. Invariants are present in models of communication both in countries with a well-developed system of science (the United States, Europe, and Japan) and in those with an emerging system of science such as China, India and Brazil.

David Dickson recently re-proposed a truly universal model of public communication of science based on the concept of “knowledge deficit”, capable of improving democratic dialogue and increasing the efficiency of policy-making surrounding scientific matters, in addition to and perhaps above all, in emerging and/or developing countries.¹³ It isn’t by chance that he re-proposed his model precisely in Beijing where the Working Symposium on “Strategic Issues in Science and Technology Communication”, organized by PCST (Public Communication of Science and Technology),¹⁴ was held the previous June and at the closing of a series of talks on the behavior of communicators of science in Asia’s south-eastern countries before and after the 26 December 2004 tsunami.

Dickson’s idea is that scientific information and communicators of science should allow the different components of society to recover from a knowledge deficit in order to improve democratic dialogue involving scientific facts and render the complex system of political decision-making more efficient.

In essence, it would seem that David Dickson only re-proposes the “deficit model” of communication brought forth a couple of decades ago in the Anglo-Saxon cultural environment. In effect, what Dickson proposes is a prerequisite for the public communication of science and technology, in addition to and above all, in emerging and/or developing countries: the “accurate” communication of knowledge regarding science and technology. Here the adjective accurate takes on a definitive and “rigorous” meaning “strongly linked to facts” and as accepted by the eminent Anglo-Saxon media, facts are (need to be) separate from opinions because if opinions are debatable facts are not.

The prerequisite to which Dickson draws attention, accurate information, can (must) have universal aspirations. It can be proposed, even if with additional side-notes, as an “invariant” among the thousands of models of local communication of science.

It is exactly for this reason that the call for that deficit model, also having been brought forth in the Anglo-Saxon environment and historically having taken on a very precise meaning¹⁵ could appear misleading and, as such, has been subjected to criticism by its own founders.^{16,17} The deficit model is, in fact, historically based on two different yet related declarations of principle:

- the skepticism that the general public often demonstrates towards science is largely based on knowledge deficit;
- by providing “correct” information and recovering its knowledge deficit, the general public realizes that science and technology are a “good thing”.

The deficit model itself, with its two declarations of principle, characterized the first years of the development of the Public Understanding of Science, the cultural movement that was among the first to understand the new role that the public communication of science and technology was taking on during the post-academic era of science.¹⁸ It was also the very first to promote, above all in Great Britain and the United States, a systematic “literacy” campaign for the general public.

This model, as mentioned above, essentially failed because, as David Dickson also points out with great precision, both declarations of principle revealed themselves to be unfounded when the facts were tested:

- the skepticism that the general public often demonstrates towards science is neither always nor primarily based on knowledge deficit; the individual and collective perception of a cultural phenomenon (including science and technology) is complex, an outcome of cognitive and emotional processes that are finely and, at times, inextricably woven;
- it is not entirely true that more information (or greater literacy, if you will) about a cultural phenomenon (including science and technology) means greater support for that cultural phenomenon. A more informed public (or more literate, if you will) can also be more hostile towards science where scientific facts are concerned.

Criticism of the efficiency of the deficit model could also be nurtured by at least two other elements no less important than the first two:

- an instrumental method for the public communication of science and technology (more information in order to obtain more support), which is inherent to the deficit model, often produces a boomerang effect: people grasp the instrumental nature and wariness increases rather than decreases;
- however important systematic and widespread “literacy campaigns” are, they will never manage to have the “firepower” of other sources that compete in the formation of the “public perception” of science and technology. From TV fiction to cinema, from advertising to word of mouth, from figurative art to literature, all of us are exposed to a quantity of messages related to scientific matters that is far superior to the number of messages that can be passed on directly from scientists, science journalists or other professional communicators of science and technology.

The so-called historic deficit model has not worked and still doesn't today because its objectives are not fully shared even by the scientific community and/or professional communicators of science and technology, because its perception of the system of mass communication is naïve, or more than anything else, because an “alphabet” of science doesn't exist and thus, there is no need for “literacy”. Science is a cultural process of great complexity, not reducible to a minimum set of notions. All that is science is a cultural process, a way of thinking, a way of seeing the world. The popularization of scientific culture can not be achieved by transferring a determinate set of notions from “those who know” to “those who don't know”, but by means of a balanced dialogue and common growth of the large groups of cultural participants within various societies: scientists, politicians, managers, bureaucrats, cultural mediators, the general public.

In other words, communication by scientists (varied and, at times, not without contradictions) and by professional communicators of science (also varied and often not without contradictions) compete in the “real world” with other forms of communication of science and technology whether it be to “produce” information, or to vigorously and incessantly reshape the public's individual and collective perception. In every country and culture, the “efficient communication of science” needs to have a different structure. Brazil is not China; China is not India, and in each one of these great nations, the development of the public perception of science and technology follows a different path for structural, historic and cultural reasons.

It is this diversity, whether it is within single systems or among national systems of communication, which renders a sole model of the public communication of science impossible to propose, in spite of the intrinsic, universal nature of scientific culture. The fact that the Earth revolves around the Sun and not the contrary, is scientifically proven and as valid in China as in India, in Brazil as in North America and Europe. However, the most efficient way to enable the general public to benefit from this objective information is found by trial and error, in a different way in each country. It is no wonder that in China, India and Brazil, as in Europe and North America, this process can be, at times, different, similar and even homologous.

In fact, *JCOM*'s inquiries have shown that scientists in emerging countries communicate with the general public by either standard Western methods (for example: high-circulation magazines such as *Ciência e Cultura* in Brazil; television channels such as CCTV-10 in China; India's general or China's thematic Science Days, which are basically similar to the science weeks in Europe; the popular hands on science centers), or by new popularization methods (for example: the *Science Jahtas* in India, with their characteristic processions; science popularization trains in China; India's thematic TV serials), or even

by “extension programs” (not known in Europe, for example, that involve the *favelas* population in Brazil in specific projects).

So, in countries emerging in the fields of economy and science, the models of the communication of science include knowledge deficit, “co-textual”, “lay-knowledge”, and the “output model”, which was tested in China. These differ from didactic and passive top-down models and double-track interactive models. India seems to be the perfect example of a country with a diversity of models which are rooted in a 5,000 year-old history, and is culturally influenced by purely Anglo-Saxon models as a result of English colonialism and post-colonialism as well.

So much diversity was only to be expected. From what has been said, it is of value. However, the problem posed by Dickson remains: as different as efficient methods of communication may be, the information needs to be accurate. In no country, be it developed, emerging, or developing, can I choose one socially desirable method of communication based on information that is not strictly tied to scientific facts and to rigorous source checks. In other words, for the sake of the diversity of the models of communication, I can (I should) say neither that the Sun revolves around the Earth, nor that the Earth revolves around the Sun, but only on odd-numbered days.

There is therefore an invariant, a universal prerequisite for models of the public communication of science: the search for accuracy of information.

Having said this, it poses the question of what exactly “accuracy” of information means. The term lends itself to different interpretations. To state that the Earth revolves around the Sun could seem little accurate to a couple of physicists specialized in general relativity, but sufficiently accurate to two people lacking a specific physics background such as an advertising agent and a housewife in Great Britain or an elementary school teacher and a farmer from India who is still illiterate.

If we wanted to work out a complete theory (and not just find a general model or the invariants of the thousands of existing models), we could look to verify the validity of the kind of “uncertainty principle” that influences the communication of science:

$$\Delta r \cdot \Delta c \geq k$$

where r represents rigor and Δr is the error in relation to the rigorous diffusion of information in every instance of the communication of science; c represents communicability and Δc is the error in relation to the capacity to transmit scientific information in such a way that the interlocutor is able to understand; k represents a constant superior to zero ($k > 0$).

The disparity shows:

- that it is possible to transmit scientific information neither with maximum rigor ($\Delta r = 0$) nor with maximum communicability ($\Delta c = 0$). There is an inevitable level of error in any instance of communication either in terms of rigor ($\Delta r > 0$) or in terms of communicability ($\Delta c > 0$);
- that it is possible to try to minimize Δr and try to communicate with the maximum possible rigor ($\Delta r \rightarrow 0$), but only if the error in relation to communicability increases ($\Delta c \gg 0$). On the contrary, it is possible to increase communicability ($\Delta c \rightarrow 0$), but only at the cost of increasing the error in relation to rigor ($\Delta r \gg 0$).

It is in the realm of this «uncertainty principal» that the problem of “factual reporting”, the search for accuracy and maximum adherence to facts posed by David Dickson, can and should be resolved.

In fact, we could define the problem that the director of *SciDev.Net* poses as “ k minimum”. In each context, finding the least possible k is of general, if not widespread interest. In other words: finding the best possible relationship between rigor and communicability.

Looking back to our astronomy example, let’s imagine that there are two competent physicists of relativity discussing the movements of the Earth and Sun. They can easily delve into the more detailed aspects of general relativity and formalize the communication of information in mathematical terms. In this case, the k in the discussion on the movement of the Earth and Sun can decrease considerably because both interlocutors know the theory and are capable of understanding the mathematic formalism, so the error in relation to both rigor and communicability can indeed be kept to a minimum though not eliminated.

However, if the two that discuss the movement of the Earth and Sun are a relative physicist and a biologist, it is almost certainly necessary that the discussion become qualitative because the biologist has neither command over the theory of relativity nor the mathematical tools necessary to communicate it in a formal manner. In this case k increases significantly though not towards the infinitive. It is worth noting that if the physicist seeks to fill the biologist's knowledge deficit and minimize, as much as possible, the error in relation to the rigor of the information ($\Delta r \rightarrow 0$), in other words, if he speaks to her as if she were an expert in physics, she would not be able to follow, she would be lost in the complexity of physics/mathematics and the inability to communicate between the two would increase to the point of total divergence. The search for the best solution to the minimum k problem, in this case, lies in finding the greatest possible balance between rigor and communicability while consciously allowing for a certain loss of rigor in order to allow the discussion to continue.

Lastly, if two people without a specific scientific education discuss the movement of the Earth and Sun, such as the teacher and the farmer or the advertising agent and the housewife, the risk that k increases and tends towards the infinitive is indeed high. Nevertheless, even in these contexts it is possible (and necessary) to attempt to find a minimum k ; it would be an extremely higher k than in the case of the two relativity physicists, but even in this case, we can search for a k that does not diverge and settles on values significantly far from infinitive.

In essence, if the teacher manages to explain to the farmer that the Earth revolves around the Sun, we would undoubtedly be presented with a diverse and more desirable method of communicating information with respect to the advertising agent, who manages to convince the housewife that the Earth revolves around the Sun on odd-numbered days and that the Sun revolves around the Earth on even-numbered days instead.

In short, finding a solution to the "minimum k problem" is of general interest to society. The uncertainty principal tells us that the solution does not consist of sole concentration on rigor because a barrier of communicability inevitably rises and that the problem allows for different solutions in different contexts.

The k minimum problem is solved by trial and error in each context. Absolute rigor, a perfect language capable of communicating the entire content with maximum rigor, and universal algorithms do not exist.

The solution is essentially empirical because communicability is not reducible to a mere mathematical function; communicability is a complex matter. To be communicative means to express oneself in a language that is accessible to others and it is this language that is often capable of penetrating the hearts of others in addition to the minds of those with whom we speak.

Albert Einstein's 1905 article on the electrodynamics of moving bodies poses a problem regarding the concept of "absolute space" in physics, addressing the mind of the *Annalen der Physik* reader more than the heart.

Pablo Picasso's, *Les Femmes d'Alger*, which he started in 1906 and finished in 1907, poses a problem for the concept of absolute space in the figurative arts as it addresses the heart more than the mind of the observer of the painting.

Galileo Galilei demonstrated that it is possible to penetrate the minds and hearts of the interlocutor while maintaining maximum semantic rigor, ability to communicate, adherence to facts and poetic creativity.

Conclusion, if only for the time being

China, India and Brazil are three great countries that have set out on a path, impetuous at times, towards development both in terms of economy and scientific culture. Thanks to these countries, as well as many others in Latin American and Asia, a historic turning point is occurring in the geopolitics of research. Modern science with the sole and partial exception of Japan, has been until now a transatlantic reality (between Europe, including Russia, and North America), but is becoming an Indo-Pacific reality as well. In other words, it is becoming truly global.

In these countries of new scientific frontiers and emerging economies, a significant system of the public communication of science and technology is also coming about.

This system is characterized by an extraordinary diversity of methods and cultural approaches. This diversity is of value in itself, but also has its defects. The democratic dialogue regarding the scientific matters that it should favor is not (nor could be) well developed yet.

Among the causes of this inadequacy, as David Dickson asserts, is the difficulty in recovering the knowledge deficit. However, there is also a scarce knowledge, common to all communicators of science in the world, of the fact that in addition to knowledge deficit, there is also a “communicability deficit” among men/women of science and even among professionals in the field of the communication of science.

The entirety of these deficits produces undesirable effects: it hinders attempts at improving democratic dialogue involving scientific matters and it makes the political decision-making process less efficient. However, it is an enormous obstacle, above all, to the fulfillment of a project dear to Francis Bacon and that is the foundation of modern science: knowledge of science must not belong to one specific person, but needs to be truly accessible to all so that the benefits that stem from new knowledge of science do not become the exclusive property of one specific person, but must be divulged to the advantage of all mankind.

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