Physics Communication. From Past to Future

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Abstract: At present, the perception of a widespread anti-scientific attitude of society is denied by less superficial analysis of the communication market. In contrast to the general crisis, especially in the cultural sector, the attendance at science museums, the conspicuous number of informative scientific books, the relevance of various initiatives on scientific themes in television, cinema and theatre, demonstrate how much this land is fertile and how much the society is curious of science. The steps of the scientific communication will be retraced till the present day, through examples that clarify goals, methods and strategies, and how these have changed depending on the historical eras through the changes in the relationship between “scientist” and society. Who, how, what: these are some of the questions to be asked to avoid to simplify the problem of public communication of science, no more optional, but necessary, in era of the so-called post-academic science. In particular it will be emphasized the importance of the history of science, rich of anecdotes and experiences that could help to restore the fracture between humanistic and scientific culture and to understand how the start and evolution of scientific thought and theories have permeated the history of the humanity.

Keywords: Science communication, Science history, Physics dissemination.

1. Introduction

Knowledge is a cumulative good: its use by anyone, instead of diminishing, grows it. It is a not rival good: its use by anyone does not prevent or limit the use by another. Thus it is undeniable that the rate at which knowledge increases is related with the extension of its communication.

In 1531 Cornelius Agrippa invented a device for projecting points on the surface of the Moon, so that anyone could read even at long distance. Lunar writing dreamed by Agrippa was one among various extravagant expedients proposed in the sixteenth and seventeenth centuries to facilitate communication. Tubes were designed to amplify the human voice, techniques to transport secretly letters underwater, etc.

2. Invention of printing and scientific communication

The invention of printing was considered by many people as the true engine of scientific progress. As reported by Gorman (2002), Kepler speaks in glowing terms and writes:

> With the advent of printing the books had a much wide dissemination. Every year, especially since 1563, the number of papers published in each field is greater than those produced in the thousand years before. Thanks to them, today a new theology and a new law have been created. The followers of Paracelsus have re-established the medicine and the Copernican astronomy. I really believe that finally the world is alive, more than before, and that the stimuli of these extraordinary conjunctions did not act in vain (Gorman 2002, pp. 277-278).

It is significant that many of the crucial years of the Scientific Revolution correspond to dates of milestone publications: in 1543 the *De humani corporis fabrica* of Andrea Vesalius and the *De revolutionibus orbium coelestium* of Nicolaus Copernicus; in 1610 the *Sidereus nuncius* of Galileo Galilei and in 1687 and Sir Isaac Newton's *Principia*.

Printed words for the first time assumed a fundamental importance for European science when the astronomer Johann Müller of Königsberg, known as Regiomontanus, opened his printing office in Nuremberg in 1471, in order to publish technical and scientific books, considered not economically convenient for Nuremberg printers and required skilled artisans to insert correctly diagrams xylographed in written texts. As first editor of the astronomical and mathematics literature, Regiomontanus wanted to offer to its readers texts and manuals free of typographical errors. The lack of specific knowledge of the printers would have had disastrous consequences for scientific publications, and not a few works circulated in Europe in incorrect versions compared to the original ones. In this regards, as reported by Gorman (2002), the teacher of Kepler, the great Danish astronomer Tycho Brahe wrote:

> The art of printing was invented less than a hundred and fifty years ago; and in the long time that preceded it, many things, especially the numbers, could be wrong due to the fact that they had been rewritten many times. But the error occurs easily also in printing, especially in this field, unless you use a very careful proofreader (Gorman 2002, pp. 71-72).

The risk of incorrect printing of technical texts brought some of the richest natural philosophers, including Tycho himself, to acquire, in addition to their study places or private laboratories, its own printing office. But they were just exceptions.

3. Illustrations and instruments in support of printed books

If the probability of incurring errors in the printing of the texts was high, the inaccurate reproduction of the illustrations was almost inevitable. The collaboration of artists, designers, engravers, behaved as a result that the most famous European printing offices were transformed into places of lively interaction among artists, philologists, natural philosophers, artisans and printers. But practically, the fact that the production of printed books was a collective process often meant that the authors had limited control on the illustrations that accompanied their books. Moreover, even if the illustrations had undeniable advantage as help in explanation, they determined indirectly less

dissemination of books, because the most richly illustrated books became too much expensive for most of scholars.

The problem became particularly important in case of reproduction of observations made by means of optical instruments such as microscope or telescope. For example Galilei used his knowledge of the clear-dark and other specific pictorial techniques to reproduce with xylography the Moon surface and to represent the different positions of the Jupiter satellites, overcoming the problem to create realistic representations so that his readers did not concentrate on the likelihood graphics, but on topics treated in the text. Reprints of the *Sidereus nuncius* of Galileo were distributed through diplomatic channels of Medici family, together with telescopes, that allowed readers to repeat astronomical observations.

The Scientific Revolution started also thanks to a circulation of particular objects, instruments and especially letters. Jesuits played a crucial role in their missions around the world, they behaved like as scientific communicators, receiving, copying by hand and circulating among scholars letters that treated natural phenomena. These letters were also used to encourage and grant protection, to report on the state of research, to ask for information, otherwise impossible to find, and to give news of the latest publications. The correspondence was also used as a "pre-publication", to affirm the priority or authorship of studies and researches or, at times, to address topics too controversial for print, as in the case of the Galileo Letter to Madame Cristina Grand Duchess of Tuscany.

In 1665 the secretary of the Royal Society, Oldenburg inaugurated the first scientific journal, the *Philosophical Transactions*, which he defined as review of the "current researches, studies and labors of the ingenious people of many parts of the world" (Gorman, 2002). Afterwards similar initiatives follow in France, in Leipzig and Rome.

4. The debate between secrecy and communication of science

While was universally recognized the need for natural philosophers to communicate with each other, not just as easily the need was recognized for dissemination. The history of the scientific dissemination is closely linked to the history of the contrasts between exoteric and esoteric tendencies of the first scholars of the modern age.

The idea that scientific knowledge should be freely shared rather than revealed only to initiates through an obscure language, was controversy reason across the sixteenth and seventeenth centuries. It seemed natural that only an *élite* of people was destined to knowledge, while the most of people was condemned to ignorance and servitude. Even Francis Bacon, describing the community of scientists in the *New Atlantis*, still attributes an important role to secrecy. The inhabitants of the *House of Solomon* consult to decide "which of our inventions, experiences and discoveries we make public, and [of which] we should make solemn promise of secrecy" (Gorman, 2002).

The fear was that a distributed knowledge could make the people aware of their rights and freedoms, that no longer would have accepted to be governed with oppression. In the seventeenth century was born, with revolutionary act, not only

modern science, but also a new concept of communication. It is just this new interpretation of the communication – everything has to be communicated to everyone – to be one of the key factors that enabled the start of the modern science. This is the "dangerous idea" of Galileo: to subtract the knowledge to small *élites* and potentially make it available to everyone. The *Dialogo sopra i massimi sistemi* by Galileo, one of the works which revolutionized not only the scientific culture and not only in Italy, can be considered a scientific text of monumental importance but also an admirable example of scientific communication.

In reconstructing the history of the scientific dissemination, it is important to distinguish between works of practical and technical nature, written in vulgar language for boaters, surveyors, engineers and artisans, that is an audience outside the academies, and works that were deliberately non-technical for more sophisticated readers who had no real need to use those skills, but could treat appropriately the topics in a conversation.

5. The scientific lounges

The start of academies, cafes, collections of curiosity and scientific societies created a new audience for natural philosophy. As reported by Gorman (2002), in France at the end of the seventeenth century, natural philosophy, in addition to music and poetry, it was common topic of elegant conversation in gardens, lounges, cafes and boudoirs. The *Entretiens sur la pluralité des mondes* by Bernard Le Bovier de Fontenelle, published in 1686, became a canonical example of how natural philosophy could be addressed to a refined public. It is a dialogue in which the protagonist tries to explain the structure of the universe to a woman, intelligent but ignorant of philosophy. The *Entretiens*, which represent an idealized version of the conversations that took place in the lounges of Paris, had a great success and more than ten editions in the next fifty years. The real novelty was not so much in the content or structure of the book, but in the social role of the author, the first professional communicator, who was capable to make pleasant the natural philosophy to the aristocratic classes. It also demonstrates that at the end of the seventeenth century, women constituted an important part of the society for which natural philosophy became accessible; afterwards many scientific dissemination works were just written by women.

6. The science show

Furthermore, it is stated, since the sixteenth century, another way of communication, recovered today: the conference show. Bernard de Palissy, a French ceramist became famous also for his public readings of natural history. To listen to his lecture a ticket of one crown was required, a considerable price at that time. Nicolas Lémery (1670), French chemist, arranged a chemical preparation for explosions and built an "artificial volcano" to attract an audience of students, scientists and ladies. Georges Claude (1870-1960, inventor of the neon) installed in the luna park in Paris a stand entitled *Science*. Moreover, to be considered the very popular conferences (1864-1867) held by Louis

Pasteur at the Sorbonne, where the experimental demonstration took the form of a theatre representation. Another example among the best known, is the experiment of Foucault pendulum in the dome of the Pantheon in Paris to demonstrate the rotational motion of the Earth. Science interested nobles, politicians, but also the middle class, owners of lands and mines, in particular for what concerned the technological applications designed to improve performance. But even the workers and peasants were interested to science: when the physicist Silvanus Thompson gave a lesson on electricity in the mine, in Cardiff, the miners organized special trains to participate.

7. The role of newspapers to a large dissemination of scientific knowledge

In the meantime newspapers were born at large-printing. The audience extends further. Large space is reserved to scientific news. Through newspapers the great scientific disputes become accessible to the public: the debate between Huxley (Darwinian) and Bishop Wilberforce arrives on the cartoons of newspapers. Perhaps the first popular scientific article is what in 1752 Benjamin Franklin published in The *Pennsylvania Gazette* on his experiments on lightning and kites. Benjamin Franklin, journalist, printer, scientist and politician, son of a merchant of candles, is incarnation of the spirit of the Enlightenment self-made man. *The chemical history of a candle* (Faraday 1982) was one of the most famous popular articles, transcription of a series of great successful science lessons held by Faraday.

8. Faraday and physics shows

Michael Faraday represents the best example of the effectiveness of the science dissemination. If scientists were limited to communicate with each other, if there were no books or scientific shows, if the son of a smith did not have the right of access to science, we would not have had any Faraday. He, son of a smith, seemed destined to be artisan. Working as young apprentice to a bookbinder, he had the opportunity to read and get an education, particularly in science. He was also enthusiastic spectator of the famous spectacle lectures of Sir Humphry Davy, the most famous chemist of England, of whom he became assistant. Showing his value as investigator, Faraday had a career so brilliant to become more famous than Davy. Born poor and desirous to emancipate, he was very sensitive to the knowledge desire coming from poorly educated people. So, when in 1825 he became the Director of the Laboratory of the Royal Institution in London, one of the first initiatives was to open in the evening to the members of the Institute to perform experiments and demonstrations. These informal meetings soon became systematic and popular as *Friday Night Discourses*, scientific informative lectures with experimental activities. Similarly, he gave start to the *Christmas Lectures*, series of scientific events, every year on a specific theme, which were performed during the Christmas holidays, because primarily addressed to an audience of young people. This tradition is still alive at the Royal Institution. *The chemical history of a candle* was the title of his last and most

famous Christmas Lectures. He used the candle, an everyday object, as a pretext to carry out experiments in chemistry and physics. The candle becomes, in this way, a sort of "universal laboratory" accessible to everyone. "There is no law, according to which any part of this universe is governed, that does not be involved in physical phenomena that occur in a candle". Faraday proposed to participants to his lectures to repeat at home his experiments, so they even could feel the pleasure of scientific discovery. "Who has the fortune to discover a beautiful thing should not hold it hidden to others". He is convinced that anyone can learn if he observes the natural phenomena and plays them through the manipulation of real objects, as himself does: hand, eye and brain.

9. Science museums

It was what Frank Oppenheimer tried to do much later, in 1969, the founder of the Exploratorium in San Francisco. "Explaining the science and technology without the support of facts may look like trying to speak o someone about swim without never put him in the water". It must be arouse the pleasure of discovery! The mission statement of the Exploratorium is an example of a strongly democratic and open approach to science communication: "The mission of the Exploratorium is to create contexts, programs, and tools for innovative learning and exploration, which will help the people of all ages, backgrounds and origins to exploit their innate curiosity to learn about the surrounding". The Exploratorium is an important transition in the history of scientific museology: no longer science museums based on historical collections of instruments and machinery (museums of science and technology or science and industry), but on the communication of scientific concepts through experiments. The hands-on exhibits – that is the objects on which one has to "get their hands" to reproduce phenomena – recall besides a peculiar feature of science, that is its experimental nature. The second innovation is that of a democratic vocation of science and its socialization. The third aspect is related to the aesthetic dimension. The Exploratorium – originated as a "museum of art, science and human perception" – plays an explicit relationship with the visitors from the implicit beauty and elegance of natural phenomena, which represent a kind of "bait" to capture their attention, then towards the understanding of the laws. On this basis, an entire generation of new museums originated or traditional museums were renewed, all over the world. In Italy science museums, in strong contrast with a general decrease of museum visitors and of quality standards, science museums record not only an increase in visitors, but seem more dynamic and with better quality standards, towards greater interactivity. It should be noted, however, the predominant presence of children and young people than adults.

10. Are we in a scientific era today?

In addition to museums, scientific dissemination has landed on television in various formats; we assist to a boom of scientific magazines as of books on the libraries – in particular specific scientific publishing for children and young people. In bookstores today

more than ever one can find a corner dedicated to science and even some books on showcase. On the other hand many daily newspapers no longer have a scientific editing. Often simple reporters take care also of scientific news or, more frequently, the press offices of institutions or research institutes. The "science" of which they speak mostly concerns with health and wellness, or is strictly limited to the launch of sensational scoop.

Moreover, there is science at cinema and theater. In particular, what could possibly be the most immediate heir of the dialogues written by scientists of the sixteenth century, spectacle lectures of the evening appointments of the Royal Institution, what could be the appointed place, the theater, during the years, always less timidly, has ventured to explore science, from different points of view. So Brecht's *Leben des Galilei* (Brecht 1998) and *Copenhagen* by Frayn (2000) inaugurate a trend that could be called ethical, where the relationship between science and society, the definition of freedom and foremost the responsibility of scientific research, are investigated. Alternatively attempts are made of spectacular experiments or dramatizations of the live of individual scientists, genial or strange. An exception is to be considered the very successful theatre representation *Infinities* by Ronconi, written by Barrow (2002), which represents not the phenomena investigated by science, not experiments, not a process to the science, but a pure and abstract concept, the infinity in all its forms, which becomes a viable experienced path of senses. And more recently *ITIS Galilei* by Paolini (2013), who explains Physics concepts trough the life and the work of the scientist.

In addition to the traditional media, science cafes, science festivals, cineclub, week of science, night of the researcher are very frequented events. On the web we see an increasing number of portals, blogs, podcasts, newspapers and online magazines, institutional websites, video on youtube, etc. Moreover there is a proliferation on the web of spontaneous dissemination initiatives from students, children, lovers, enthusiasts. From the web one can learn that sometimes one may even smile or even laugh of the science when one is confident with it, as well as with the general culture. The serious attitude is indicative of strangeness and awe.

11. The rhetoric of the two cultures

Most people have a contradictory behavior, on the one hand they have not confidence in the work of scientists, on the other hand they make confidence more and more on science. In addition, although there is an increasing demand for scientific knowledge, only few enroll in scientific faculties, and the image of the physicist continues to be for the people very far from reality so much that most people do not know absolutely in what the work of the physicist consists. In 1959 the scientist and novelist Charles Percy Snow (2005), during a conference at the University of Cambridge, in a famous talk on the substantial gap between scientists and humanists and bipolarity that characterizes the intellectual life of the Western world, then published in numerous editions and translations, stigmatizes the so-called rhetoric of the two cultures. The bipolar vision of Snow is not only about knowledge produced from the university system. The consequences of the "Great separation" are too heavy for the role of science in society and are reflected, for example,

in the little importance that science plays in the educational system, dominated by the influence of historians, philosophers and writers who often boast of their scientific ignorance. The effect is that even the most of cultured people do not know the most basic scientific concepts.

If in 1949 the historian Herbert Butterfield (1949) described the scientific revolution as "the true origin both of the modern world and of the modern mentality" overcoming "in splendor anything that has happened since the birth of Christianity" reducing "the Renaissance and the Reformation to the status of mere episodes". Why science has not place in the history books? Why textbooks of history still give much more space to popes, poets and leaders rather than Bacon, Pasteur and Einstein? Why are there two histories: one of the humanity and the other one of the science, independent of each other? Because François Rouelle, performing demonstrations of chemistry in the Royal gardens, could count on the presence, among others, Diderot and Rousseau, and Dickens participated in scientific evenings of Faraday, while today does not happen the same?

"Why – Feynman (1988) wondered – no one feels inspired by our present description of the universe? This aspect of the science is not sung by singers, one is reduced to listen not in music or in verse, but in an evening conference. We are not yet in a scientific age". We cannot say to be fully in a scientific era, because today we take yet only an exterior "impression" of the science. Rather, the present is a technological age: the technology permeates deeply our live, to shape our imagination; one lives technology without the problem to communicate it. The scientific knowledge, which is still became social phenomenon involving hundreds of thousands of people in the world, is a knowledge not yet percolated in everyone and it does not emerge spontaneously in the artistic and literary expressions, only with some exceptions. Why we tend to forget that science is culture, not just progress, well-being, care? Why we are not familiar with the science?

12. A lack in the history

To remedy the training deficiencies was developed in the 80s the Public Understanding of Science (PUS) and the communication model called Top-down, a form of transmission of scientific knowledge, translated from specialist language to the everyday simplified language, prepared for an audience generally considered ignorant and homogeneous. However, the most alarming lack is not so much on contents and scientific knowledge (assumption of PUS) but the fact that the scientific "mentality" is not diffused in a society that knows perhaps Newton's laws but continues to maintain an irrational attitude of faith towards science.

Perhaps just the history could play a decisive role, the history of scientific discovery, of the researches, a collective history, made up of teams and not of solitary genius, of winning theories and forgotten theories, of studies and experiments rather than of fatal intuitions. It would perhaps also a useful way to reintroduce in the universal history the missing scientific chapters, in order to understand the influence of science in history and the history on science, let talk and reconcile, a way to contextualize and demystify the science, to give to the scientist profession the

connotation of a true profession, the result of a concrete practice and not of inspiration, and finally to propose a realistic image of science, without special effects and without banalizations, reflecting on the contrary all the complexity of the cognitive process.

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