Internet users are shaking the tree of science

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The growing participation of citizens in producing information and knowledge on the internet has reached the doors of science. Many of the social networks deployed on the internet and promoters of blogs are not only voracious consumers of information generated by scientific and technological communities but they more and more frequently assume a leading role in processing and distributing this information. Now the tide is turning: citizens are starting to intervene in the process of research via the internet. Scientists themselves are laying the foundations with a series of initiatives that are opening up laboratories to the internet. At present it is difficult to assess the huge possibilities that are opening up with this gentle tumbling down of the old walls that had preserved the scientific community from "contamination" on the part of amateurs or those lacking experience in the mysteries of scientific research. Citizens now not only contemplate the tree of science or receive and consume its fruit but have also started to shake it, from the internet, to intervene in its growth and its diversification.

Keywords

Social networks, science, technology, laboratory, internet, network, computing, biology, audiovisual, research, blog, citizens.

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Can science be carried out on the internet? Can a laboratory be opened up in virtual space and experiments be carried out via the web and even notable advances be achieved in scientific journals? In this case, are we talking about laboratories open to internet users, without the need to examine professional credentials? Or, as has happened up to now, must science be delimited by a strict boundary built up on the professional credit of researchers and the rigour of scientific method for the scientific community to accept their discoveries? In other words, can (and must) science have the talent of citizens expressed on the internet as another reference of research? If the answer is yes, how can this be achieved? In which fields? How can the results of their work be validated?

These are some of the questions that appear more and more frequently in scientific symposiums and conferences. Research centres and firms, both in the public and private sector, are starting to understand that the tools of the internet, not only the machinery and programs but the very possibility of creating internet networks, open the doors behind which no-one as yet knows what the scenery is like that's awaiting us on the other side. Science arrives at these questions following the trail of technology. As already established years ago by Herbert Simon, "the technological method", based on the popular saying "if it doesn't work, change a part or give it a kick", does not seem to resemble the scientific method at all. Its way of progressing, even in the most complex terrains, is the most experimental and open. The popularity of "Do it yourself" testifies to this chasm that separates technology from science. For this reason, among others, numerous fields of technology have enjoyed the benefits of network teamwork on the internet, beyond canonical institutions and the weight of academia.

Perhaps the best and clearest exponent is the development of machinery and programs. Among the first "working

groups" noted on the internet were, logically, hackers. Intruding into computer systems allowed them to study their architecture, to detect errors and propose solutions that, in many cases, were not only related to pieces of programs or encoding systems but also to the fixed parts of computers (plaques, connections, switches, etc.). This pioneering activity evolved towards veritable experimental laboratories on the web where people discussed, worked, shared and, the most important of all, arrived at solutions. To thousands of solutions in correspondence with the thousands of problems that were caused (and are caused and will be caused) by computer technology.

Teams of engineers and amateurs

This is how legendary lists arose, such as that of the Internet Engineering Task Force (IETF), a group of voluntary engineers that has safeguarded the health of the internet for the last three decades. Their discussions and agreements have encouraged the development of many of the parts that go to make up the backbone of the internet, from computer protocols to the organisation of traffic between servers and routers. The online technological laboratory has diversified into numerous paths, aimed at emerging problems for which the industry has not had the necessary time or very often the necessary resources to attempt to sort out. Sometimes the difficulty lies in the very nature of these problems, which cannot always be tackled from the traditional orientations of polytechnics or IT engineering firms.

The most popular outcome of these virtual laboratories is perhaps that of the operating system Linux, developed by dozens of engineers and amateurs, who gradually assemble parts, check that they work, communicate any errors detected and then get back to the drawing board in order to modify them. The speed of the "online manufacturer-online user-online manufacturer" loop, without any intermediaries, has become one of the low-cost paradigms that has established a strong foothold in some activities of the economy outside the internet. In the background, the main drive for these activities has always been the free exchange of ideas for the mutual benefit of participants.

Along the way, technologists, experts or amateurs, have learned two fundamental things to achieve their goals, also by the trial and error method: to organise themselves in order to work online and to design virtual spaces capable of recording ("remembering") their exchanges. Both aspects are related to overcoming what is a distinctive feature of online groupwork: its temporary nature, sometimes not very structured and without the supports (even when digital) on which to cement continuity. The success of these sections is uneven but they constitute the foundation for the possibility of research and innovation via the internet. Undoubtedly organisation is the key issue, the mother of all sciences on the internet. It is a first step that involves, even though this may not be the intention, innovating what has been done to date. And this is the case because, on the internet, it is users that construct the organisation based on their objectives and their work methodology, on the potential users/interactors and the technological platform used which, in turn, structures the virtual space where the exchanges are carried out and organised (in differing degrees), be they localised, disperse, open or closed.

In other words, it is users (be they individuals, groups, companies, institutions, governments, etc.) that fix the operational rules, the structure of the virtual space where they work, how exchanges are recorded and organised, whether there should only be their own contributions and/or those from outsiders, whether to synthesise or not the activity recorded in this space, being able to consult all the material, modify it, modulate it or redistribute it, etc. All this entails one of the most phenomenal deployments of talent, ingenuity and innovation and also one of the most ignored by the online society or, to be more precise, by the society of virtual social networks. Especially (but not only) because the people who manage to design and materialise these organisations are usually people who have not gone to any business school or do not have the qualifications that would be required in any other sphere in the physical world in order to do a similar job (if possible), but they often have a degree of flexibility and resources that are hard to find among those considered to be experts. This is another of the keys to the success of online technological laboratory networks.

Science's turn

But science is another matter. There's a good reason why we talk of the *scientific community*, which conveys an idea more befitting a brotherhood, with its codes and votes,

hallowed as much by the particularities of its activity as by tradition. The scientific method has consecrated a way of accepting the advances of science that constitutes a funnel with a very narrow exit: discoveries are first published in renowned journals providing the arbiters (specialists in the field in question) approve the articles and, afterwards, these must be reproduced by their peers. In this equation there isn't much room for the social disquisitions that have gradually formed a substantial part of technological research on the internet. With the "do it yourself" of science we are talking of more serious things, from the complex environment of laboratories to the thorny procession for publishing research findings in renowned journals.

But, notwithstanding this, the scientific community is moving and... expanding. The discussions at the end of the last century in which the scientific community became involved concerning the validity of the system of arbiters and renowned journals in order to sanction a scientific advance don't make sense today. The possibilities offered by the internet from the point of view of publishing and communicating have stirred up the status quo. Today there are numerous repositories on the internet, public and private, where scientists deposit abstracts or complete articles on their work and that, for the rest of their peers, are starting to have the same validity as articles published in renowned scientific journals. This is a growing trend and one that is being confirmed, to a great extent, by the potential of initiatives such as the Public Library Of Science, where people are starting to reflect, in a more reliable way than ever, on the complexity and diversity of scientific activity the world over. However, as many people claim, the truth is that the scientific community's fundamental codes have remained intact in spite of the hurricane of the internet. Or have they?

Well, no. Quite the opposite. Contrary to its appearance of anarchy, its redundant or what many call "excess information" (have they ever entered a library?) or its "lack of organisation", the internet is the only space where everything resides, from sublime stupidity to the most extraordinary talent, according to whoever is judging. In other words, like life itself, only that now it is displayed in an environment that is, in principle, visible to everyone and, in principle, always organised according to the objectives of the person promoting the production of information and interaction. Within this context, the challenge of the talent expressed in many of these networks, not only that of individual talent but of talent embodied in collaborative networking, must soon come knocking at the doors of the scientific community.

In just a few years we have witnessed (and been involved in) a notable change in discourse. Before, what stood out (and stands out and will stand out) was concern for the "social communication of science via the internet". However, in the blink of an eye (in just 10 years), what previously had been confined primarily to the traditional media or to the communication offices of corporate bodies or public bodies related to science, has today become an important part in the communication activity of any organisation dedicated to science and research, be it public or private, and whether it performs this activity with greater or lesser success. Moreover, dozens of thousands of internet sites amplify this communication via blogs, specialist pages or various corporate strategies, which have taken on a leading role in the social communication of science.

It has been these very initiatives by internet users, seen as individuals and groups interested in the development of science, in its applications and in debates on scientific policy, that is one of the most innovative aspects of the communication of science on the internet, as they have breached institutional walls to show us, first, research and its findings and, afterwards, the protagonists and, finally, the institutions or companies where the work is being carried out. Here there is an orientation that must be followed given the avalanche of institutional information on the internet that comes in the opposite way: first, the institutions and firms, afterwards the scientists and their work and, finally, the findings of their work in the field of science (although there is always less of this than there should be).

The visual tree of science

Now, in addition to the social communication of science via the internet, people are also starting to think that the internet has sufficient plasticity to be used even to promote and develop certain research online. In this case, *plasticity* means the possibility of organising virtual environments with the adequate tools in order to permit a flow of ideas capable of becoming direct actions and results in the field of scientific research.

Scientists themselves are showing us the way. The rise in digital audiovisual communication on the internet has stimulated the nerve endings of innovation in many of these scientists. Armed with a camera, a script, music and a lot of ingenuity, short films are starting to appear on the internet explaining what they do, how they do it and the results obtained. Access to these materials is open and free and, in passing, the authors take the audiovisual productions with them to scientific congresses and transform the traditional talk into a kind of "live and recorded" performance in which they show their work and the results they are achieving to colleagues. Some of these scientists have even achieved a well-deserved reputation for this way of presenting their research, such as Kota Miura, a Japanese biologist from the European Molecular Biology Laboratory (EMBL, Heidelberg).

One of the most interesting and curious examples of this new trend is that of bioclip.com, where short audiovisuals are shown, focusing primarily on molecular and cellular biology, a field where, added to its complexity, are the technological structures required to obtain the elements that go to make up the research. Moreover, at bioclip.com there are also tools to "manufacture" films. Some scientists have designed ingenuous and innovative videos where music plays a leading role while we see, for example, the result of a sweep by an electronic microscope for cellular structures invisible to the human eye, or contemplate the moment when a virus takes up residence in an organism and starts to reproduce, or how a macrophage acts, or cell division in a tumour. The layman, the internet user, is not only a spectator of this live science but, within the limitations in each case, also "learns" how to do it.

Along these lines, in less than two years and to some degree because of the appearance of YouTube, the internet has filled up with sites where the boundary between the scientific community and social community is staring to blur in the name of a relationship based not only on the protection of accredited professionalism but on the open expression of an unexpected collective talent. From the pioneers of a couple of years ago, we have gone on to a growing number of internet sites offering this blurry intermediate phase between tradition and innovation in how science is carried out.

GEOSET, Vega Science Trust, TSN, Athena Web, jove.com and scivee.tv are some of the firms that occasionally form part of recognised research centres, such as TechTV and MIT. As in many cases regarding creation related to the society of knowledge, Spain is still on the starting blocks in this field. The TV broadcasts undertaken by some universities aim for a "marketing effect" rather than the dissemination of knowledge produced by research. But there are some initiatives that undoubtedly will become leaders in this new trend, such as recerca.tv and particularly Investiga la investigació, both in Catalonia.

In this incipient phase it's easy to confuse, mix or overstate the technological aspects compared with those of organisation, i.e. base the progression of the discourse on the services provided by the technologies of the time, such as wikis or blogs, rather than the capacity to organise innovative environments on the internet where collaboration and exchange are possible, as well as the recording of this activity in organised files (historical, chronological), the summarising of all exchanges and contributions in documents that express much more than simple interactions (knowledge history) and, last but not least, their distillation into products of knowledge, new strategies and alliances, the opening up of new fields of research and even new fields of knowledge. From this point of view, technology is the substrata where this organisation is deployed and where the "manufacture" of its products is possible.

Of course, this entails a slight modification in the traditional structures of the scientific community, in how it thinks and acts and in its public representation on the internet, which, in turn, involves transforming work routines to a certain extent; in other words, making them virtual. At heart, we are talking about constructing and professionalising the virtual laboratory with teams that, in this case, not only hang from the tree of science but also from that climbing plant that is the transition stage between scientific objectives and how these are materialised in the field of social virtual networks. And we are also talking about delimiting this laboratory via specific work methodologies and projecting it via the fruits generated by the activity carried out here. One of the best-known examples of this gigantic leap, unthinkable until just three years ago, is what is called "network economies of scale". In this case, the common ground has been promoted, on the one hand, by corporate bodies known throughout the market, such as Procter&Gamble, Chrysler

and Boeing and, on the other hand, by the appearance of intermediate entities responsible for organising the virtual laboratory, such as InnoCentive, created by the pharmaceutical firm Elly Lily, or Ninesigma.

In these cases, where corporations have advanced due particularly to their financial muscle, the relationship between supply and demand, between needs and solutions is formulated as a question, which is what will mobilise talent on the internet. The intermediate entity organises the virtual space, establishes the work methodology and determines how goals will be achieved which, depending on the case, may conclude in a patent and therefore repay the effort with different types of remuneration. All this means reversing a part of internet culture, namely that which aims for mutual benefit via open collaboration. But it persists in the public scientific community, which depends on contributors and on millions of internet users moved by impulses and motivations impossible to classify and categorise. When all is said and done, this benefit may take many forms, especially on the internet, and does not only exist when based on a pecuniary tradition.

In any case, the different dynamics of the public and private sectors can be measured by their respective capacity to remove obstacles when emerging objectives appear unexpectedly. In the case of the public sector, there is a notable tendency to discover new trenches when old walls are brought down. In any case, it will not be easy to combat the "network conspiracy" because, as can be seen throughout the internet, it already forms part of the scientific community itself, of the new generations and of the everyday demonstration that certain apparently awkward problems become procedural issues when tackled via collective work as a network in a highly organised and suitably managed virtual environment. In other words, in what we might call the most advanced version of social networks.

Moreover, bloggers are present along the way. At the end of August 2008, the magazine *Nature* invited the so-called "blogger scientific community" around the world to a great gathering in London. One of the most notable questions on the agenda was: "Can blogs contribute to scientific research and to the career of researchers?". Apart from themselves, scientists, bloggers or not, millions of internet users, bloggers or not, are awaiting the answer to this question with the belief that, whatever the arguments for or against, many of them will form part of the scientific adventure and not only as passive receivers of information but as participants and, at least we hope, key characters.

Links consulted

A selection of scientific audiovisual websites and experimental science websites on the internet, directories for this kind of website and sites mentioned in the article:

Internet Engineering Task Force
<http://www.ietf.org/>

Ninesigma
<http://www.ietf.org/>

Innocentive
<http://www.innocentive.com>

Vega Science Trust
<http://www.vega.org.uk>

Athena Web
<http://www.athenaweb.com/>

Bioclips
<http://www.bioclips.com/>

Universitat Politècnica de Catalunya. Canal UPC
<http://www.canalupc.tv/>

Canal U
<http://www.canal-u.education.fr/index.php/canalu>

Universitat Autònoma de Barcelona – UAB Divulga
<http://www.uab.es/servlet/Satellite?cid=1096482312445&pagename=UABDivulga%2FPage%2FTemplatePageLlistatVideos#>

Directory of scientific video channels of the Generalitat de Catalunya
<http://www10.gencat.net/dursi/AppJava/links.jsp?area=2&idcat=4545&sub1=6&su>

Geoset
<http://www.geoset.info/>

Investiga la investigació
<http://www.investigalainvestigacio.cat/>

Journal of Visualised Experiments
<http://www.jove.com/>

Live Science
<http://www.livescience.com/>

Madrimasd
<http://www.madrimasd.org/cienciaysociedad/mediateca/default.asp>

Un minut de ciència
<http://edu365.cat/eso/muds/ciencies/minut_de_ciencia/index.htm>

MIT Open Course Ware
<http://ocw.mit.edu/OcwWeb/Physics/8-01Physics-IFall1999/VideoLectures/index.htm>

MIT. TechTV
<http://techtv.mit.edu/>

Nano
<http://www.nano2hybrids.net/>

NASA
<http://www.nasa.gov/multimedia/nasatv/index.html>

Recerca en Acció
<http://www.recercaenaccio.cat/agaur_reac/AppJava/ca/videos.jsp>

Research TV
<http://www.research-tv.com/>

Royal Society TV
<http://royalsociety.tv/dpx_live/dpx.php?dpxuser=dpx_v12>

Si.es.tv
<http://www.sies.tv>

Science Hack
<http://sciencehack.com/>

Steve Spanglers Science
<http://www.stevespanglerscience.com/video/>

Scivee TV
<http://www.scivee.tv/>

Science.Gouv.fr. Tele Science
<http://www.science.gouv.fr/index.php?qcms=telescience>

The Science Network
<http://thesciencenetwork.org/>

Canal del Institut Català de Paleoecologia Humana i Evolució Social
<http://es.youtube.com/user/iphesvideos>

Ciencia en la cocina
<http://www.weshow.com/es/p/16144/ciencia_en_la_cocina>

University of California. Berkeley
<http://es.youtube.com/ucberkeley>

Nature. Congreso de blogs científicos
<http://tinyurl.com/2fl52o>

PLOS Public Library of Science
<http://www.plos.org/>

iscience.server
<http://iscience.eu/>