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About the Internet and the diffusion of science

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Abstract

In this work interesting ideas about the diffusion of science through internet are presented. Starting with an introduction about the Internet and its positive and negative aspects, we consider the impact on scientific results, the popularization of science, the utilization of the Internet as a resource for scientific information and in relation to academic publishing. We conclude by discussing an example of internet research focused on the unification process in science, considered from a pedagogical point of view, as a tool for both adults and children

Keywords: Internet, research, methodology, science, information, truth, popularization, education.

Introduction

The Internet (a word composed from Latin *inter* and English *net*) is the largest worldwide network of computers; its users exceeded 3 billion on June 30, 2014, with a world growth of 741% in the 2000-2014 period (Figure 1).

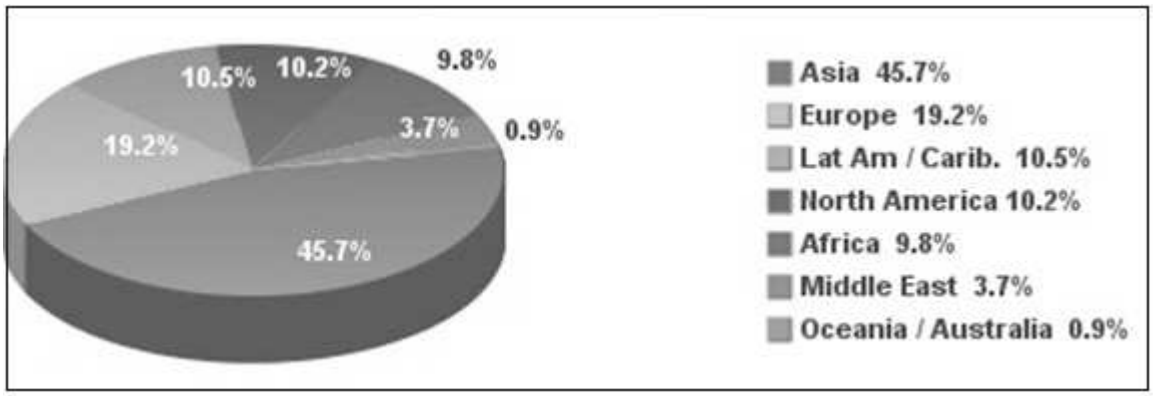

Fig. 1. Internet users in the world, distibuted by world region, at June 30, 2014.
Source: *Internet Users in the World. Distribution by Worl Regions – 2014 Q4*. Retrived from: http://www.internetworldstats.com/stats.htm.

The Internet was born around 1960, according to a project of the Department of Defense of the United States of America at the end of the *cold war*; around 1990 it was made available for civil use, first in universities and then for home users. The structure of the internet is not uniform but branched; it is very fast, but often it is connected to slower subnets, the *intranets*, such as the LAN which connects several computers in a limited number. The first browser was *Mosaic* in 1993, enabling a revolution in the way of conducting research and communication on the network, giving birth to the *World Wide Web* (WWW) (see: Peter, 2010; Personal History/ Biography: the Birth of the Internet, 2015; An anecdotal history of the people and communities that brought about the Internet and the Web, 2014).

Like any innovations in the human history, the discovery of the Internet determined general favorable and unfavorable consequences.

Internet addiction disorder (IAD), also called *problematic Internet use* (PIU), *compulsive Internet use* (CIU), *Internet overuse*, *problematic computer use*, *pathological computer use*, *iDisorder*, reflect a general statement about excessive computer use, which interferes with daily life, and includes:

1) *cyber-relational addiction*: users get involved from online relations, often considering virtual friends more important than real ones or the family;

2) *net gaming*, i.e. online addiction comprising pathological gambling and compulsive shopping;

3) *cognitive overload:* given the enormous amount of available data, users spend too much time managing and finding information on the Internet leading to decline in work performance and everyday life (Meerkerk, Van Den Eijnden, Vermulst, & Garretsen, 2009; Rosen, 2012; Byun, Ruffini, Mills, Douglas, Niang, Stepchenkova, Ki Lee, Loutfi, Lee, Atallah, & Blanton, 2009; Cheng, &Yee-lam Li, 2014).

What leads a user to move from normal use of the web to excess can be affected by items such as a *pre-existing psychopathology* (existing dependencies, depression, obsessive-compulsive disorder, bipolar disorder), a *risk behaviour* (personal tendency to excess), *adverse events in personal life* (leading to use of the Internet as an outlet), *proper characteristics of internet* (anonymity, sense of omnipotence).

In the following we will focus in particular on internet use in relation to scientific results, popularization of science, considering existing controversial aspects.

The Internet, scientific results, public opinion, controversial aspects

The relation between print and online journalism has from long time been at the center of an international debate, central for the evolution of modern society and connected to scientific publications. A focusing question concerns scientists who publish their research on *personal blogs*, rather than waiting for the publication of their final results in scientific journals.

This possibility is a subject of debate, since the seriousness of scientific research is guaranteed only by the mechanism of the so-called *peer review*. Through

scientific articles, people present usually their theoretical or experimental work; the evaluation is always a subjective exercise, and time and numbers of modern publications do not allow the verification of experiments.

It must however be ensured that authors have described in detail the experiments, the level of reproducibility, and the conclusions must derive from data, i.e. the basic principles of scientific method must be followed. This method, used by all scientific journals, is in some aspects misleading and not objective, but it is one of the best ways found by the scientific community for ensuring a high quality of work. Unfortunately fraud, favouritism, and vexation among groups are possible.

Currently journals are increasingly read on the internet and the need for printed journals is declining, because publishers are putting online the older volumes too. The use of the internet accelerates the process of peer review, decreasing the time between the submission of an article for publication and its publication, with subsequent fast availability for the community.

The easiness of communication through the internet is however affecting this kind of mechanism. The daily publication of (pseudo)-scientific results on personal blogs is changing the system of peer review, if it is not properly clarified the boundary line between the process of diffusion of a work and its real scientific value is threatened. The decision to make available to the community personal works before publishing is not new; the past is full of announcements of great discoveries that have afterwards proven to be hoaxes.

In addition to personal blogs there are also many *forums*, where it is possible to add personal scientific works. Some of them are held in considerable credit by the scientific community. For physics, as an example, especially for high-energy physics, there is very well known site *arXiv* (see: website arXiv, 2015), where the *preprints*, results of own research, can appear for debates before publishing. Nevertheless this type of service offers opportunities and risks, for two main reasons:

1. submission can be removed upon a notice from moderators, who determine if they are appropriate or unappropriate for arXiv. But these moderators are *volunteers*, not referees, and provide no feedback nor reviews for their decisions (Figure 2). In negative cases, they suggest finding another forum.

[moderation #13] arXiv: submit/11 removed
arXiv Moderation [moderation@arxiv.org]

Your submission has been removed upon a notice from our moderators, who determined it to be inappropriate for arXiv. Please note that our volunteer moderators are not referees and provide no feedback nor reviews with their decisions. Please find another forum.

Please do not resubmit this paper without contacting moderation and obtaining a positive response. Resubmission of removed papers may result in suspension of submission privileges.

For more information on our moderation policies see:

http://arxiv.org/help/moderation

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arXiv moderation

Fig. 2. A reply mail from ArXiv moderation service, with some personal data cancelled for privacy reasons.
Source: website arXiv, 2015.

Therefore a real professional seriousness about the correct evaluation of the work goes down; the risk is that people who have already inserted works, maybe thanks to *famous co-authors*, can continue to use the forum without problems; on the contrary, those who start inserting works, expecially without noted co-authors, could also see refused important pieces of work, which will be then published in listed international journals.

2. the publication of works already published in *high-impact factor journals* weakens the process based on merit. There is an entire industry, the *bibliometrics* (see: Bibliometrix, 2015; Meyer, 2015) believing that the evaluation of the importance of a scientist consists in the count of high I.F. journal articles and counting all citations. Highly cited papers often contain popular concepts or methods, but an academic work guided mainly by citation statistics or papers in high-I.F. journals get better results.

Reinhard Werner, professor of theoretical physics at the Leibniz University in Hannover, Germany, has cited the example of *Physical Review Letters* (PRL), when it has been separated from *Physical Review*, for allowing speedier publication of short papers. Many authors shorten their work to stay under PRL's page limit, rendering in this way papers less readable and less useful (Werner, 2015).

Therefore, publishing the results of research only on blogs, without undergoing the scrutiny of the international community, can undermine the credibility of a rigorous check system and create confusion between serious and unreliable results, *but only if* the peer review process is honest and not biased, which is not always true.

If publications are the true reference point for measuring the quality of scientific discoveries, the internet can allow a way for a better spreading of own research. This can be useful also both to make citizens aware of what is actually financed, and to sensitize on the importance of research investments. Internet search engines can provide researchers with inexhaustible sources of information, but they cannot determine whether the content can be trusted, even if most notably there are the increases in plagiarism and piracy of intellectual property.

The Internet as resource for diffusion of scientific knowledge

The Internet has impacted all industries in ways we could not imagine three decades ago. During the last 15 years we have seen the transition from hard copy to electronic files and the more recent emergence of networked science. In relation to the diffusion of scientific knowledge, particularly at popular level, some interesting points are to be underlined:

a) hundreds of millions of people worldwide rely on the internet as a *primary source* for news and information about science. For users with broadband access at home, internet and TV are similarly popular as sources of scientific news and information, and the internet is the first for young users.
b) The Internet is the source to which people turn to first if they need information about a *particular scientific topic*. Many of those, who obtain online scientific information, use other online information to verify the reliability of scientific information.
c) *Convenience* plays an important role in attracting people to the internet for science information. Asked why people look for science news and informa-

tion on the internet, users replied:

- they are turning to the internet for science information because it is convenient;
- they believe that this information is more accurate than other sources;
- information available online and not elsewhere.

d) People looking for news and science information on the internet believe that scientific research has a positive impact on society.

e) Users who sought scientific information online, say they have high levels of science understanding and have a good idea of what it means to study something scientifically; they describe themselves as *very* or *quite* informed about new scientific discoveries.

f) Many internet users say they get information on a *specific topic* only by using the internet.

g) *Search engines* are far and away the most important source for starting a scientific search and for getting more information about a specific topic.

h) Half of USA internet users have used a website specializing in scientific contents, like national geographic.com (see: nationalgeographic.com/), usgs.gov (US government site for Earth-science information) (see: http://www.usgs.gov/), nasa.gov (see: http://www.nasa.gov/), The Smithsonian Institution website (institute of education and research with connection to an important museum, administered and funded by the US government) (see: http://www.sciencemag.org/), sciencemag.org (see: http://www.sciencemag.org/), nature.com (see: http://www.nature.com/).

This suggests that online scientific resources play an important role in attracting people to scientific knowledge (see: Lawrence, & Lee Giles, 1998; Björk, 2004; Bozeman, & Rogers, 2002; website Science and Engineering indicators 2014, 2015; Public's Knowledge of Science and Technology, 2015) (Figure 3).

40 million Americans rely on the internet as their primary source for news and information about science.
For home broadband users, the internet and television are equally popular as sources for science news and information – and the internet leads the way for young broadband users.
The internet is the source to which people would turn first if they need information on a specific scientific topic.
The internet is a research tool for 87% of online users. That translates to 128 million adults.
Consumers of online science information are fact-checkers of scientific claims. Sometimes they use the internet for this, other times they use offline sources.
Convenience plays a large role in drawing people to the internet for science information.
Happenstance also plays a role in users' experience with online science resources. Two-thirds of internet users say they have come upon news and information about science when they went online for another reason.
Those who seek out science news or information on the internet are more likely than others to believe that scientific pursuits have a positive impact on society.
Internet users who have sought science information online are more likely to report that they have higher levels of understanding of science.
Between 40% and 50% of internet users say they get information about a specific topic using the internet or through email.
Search engines are far and away the most popular source for beginning science research among users who say they would turn first to the internet to get more information about a specific topic.
Half of all internet users have been to a website which specializes in scientific content.
Fully 59% of Americans have been to a science museum in the past year
Science websites and science museums may serve effectively as portals to one another.

Fig. 3. Internet as resource of science informations: a summary of a statistics research in USA
Source: Horrigan, 2006.

An example: string theory for kids (and clever adults)

As a pedagogical example, an online search was made for information about the unified theories of Nature, possibly with a simple approach, and even directed to children. There are several interesting sites, among which the choice went to the following: "String Theory for Kids (and Clever Adults). String theory explained for kids, teens, and even adults" (String Theory for Kids [and Clever Adults], 2015).

It consists of eight chapters, explaining with non-math-technical language, but clear and complete level the historical path that led to the current string theories, credited as one of the existing most important ways of the current unification in physics. Chapters concern: What Is String Theory, Classical Physics, Relativity, Quantum Mechanics, String Theory, Cosmology, Speculations, Tying Up Loose Strings.

The introduction is comprehensive and articulated; it shows the main basic concepts:

"What does it mean to explain everything? We would know how the universe began and where it is going. A theory of everything would explain everything, would understand all the forces and all types of matter", "Science explores the wonders of the universe we cannot directly see" (String Theory for Kids [and Clever Adults], 2015).

The process of the strings study as the elementary constituents of the universe is introduced: "The electron microscope can detect individual atoms. Is there anything smaller? Atoms are made of elementary particles… Elementary particles contain strings. The strings of string theory are the smallest things that can exist in the universe", "Since strings are as small as anything can be, they cannot have any internal parts and we have found the most basic thing in the universe" (String Theory for Kids [and Clever Adults], 2015).

The historical path is considered, starting from *Myths and Creation Stories*, with the birth of physics even through astronomy: "Science started about 2000 years ago with the first tries at biology, astronomy, and medicine. Science was confused with magic and witchcraft and religion opposed it. The first physical science was astronomy…" (String Theory for Kids [and Clever Adults], 2015).

Classical physics is considered: "Classical physics began with machines and mechanics, the science of motion. This included the motions of the planets and stars. Classical physics is the period 1700-1900" (String Theory for Kids [and Clever Adults], 2015).

The *Newton's Law of Gravitation*, *Electricity and Magnetism*, the role of *Math* are introduced: "The universe seems to follow mathematical rules" (String Theory for Kids [and Clever Adults], 2015), arriving to the two pillars of modern physics, i.e. *Relativity* and *Quantum Mechanics*. It is underlined that "the uncertainty principle of quantum mechanics, as fundamental fact of quantum mechanics, states that we can never know exactly the position and velocity of a particle" (String Theory for Kids [and Clever Adults], 2015). "Quantum mechanics' equations for the motion of elementary particles are equations for a wave". The wave

only predicts *the probability* of finding a particle here or there.

About *String theory*: "…quantum mechanics required accepting some bizarre new ideas: particle-waves, quanta, observers affecting reality, and uncertainty built into the world. String theory is going to make these seem ordinary". "Physicists realized that many of the problems in high-energy physics came from regarding particles as points. Many calculations of particle properties gave infinity".

"Remember that from now on *elementary particles* means *elementary strings*". Surprises: "The first complication is just the change from points in quantum mechanics to string. A point has no size, no direction, it looks the same, completely spatially symmetric. Strings break that symmetry. A string has length. The length can point in a particular direction" (String Theory for Kids [and Clever Adults], 2015).

In relation to *hidden dimensions*: "The only way to make strings move was if space had ten dimensions. This is a very new thing. The details of these extra-dimensions determine the elementary particles and forces and all the rest" (String Theory for Kids [and Clever Adults], 2015). Figures 4, 5.

There is also a part which considers problems related to string theory; in particular:

a) "What experiments confirm string theory?"
b) "String theory is the way to determine elementary particles properties, but there are several hard problems to solve".
c) "Physicists do not even know the complete set of equations".
d) "Some of the equations have not been solved except approximately".

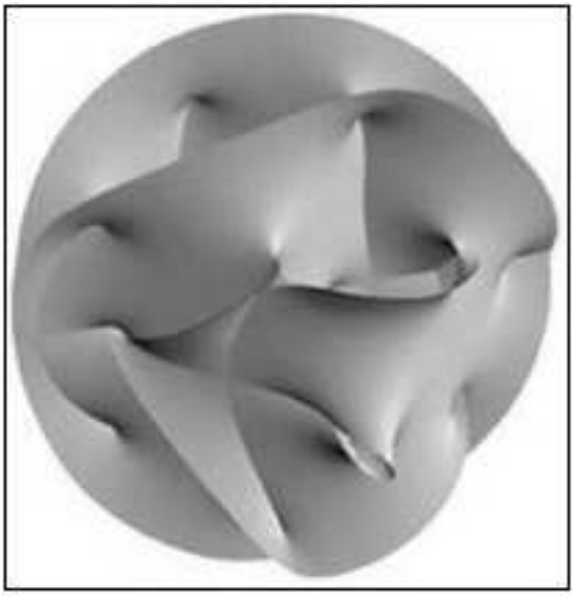

Fig. 4. An attempt to show what the curled-up dimensions look like; this is 2-dimensional views of a 6(7)-dimensional space.

Source: String Theory for Kids [and Clever Adults], 2015.

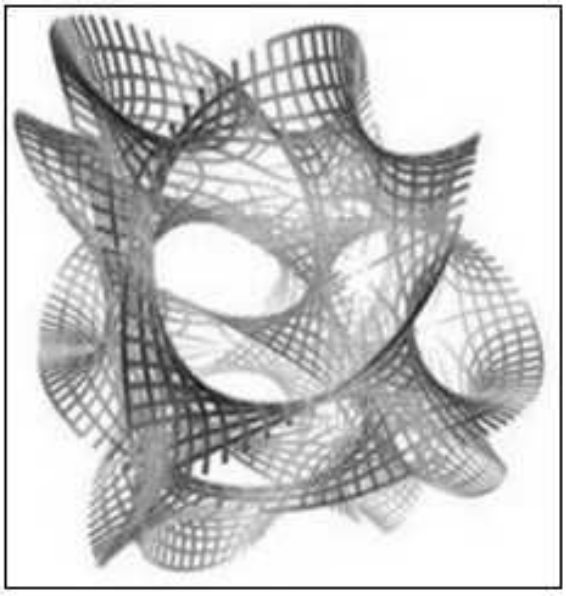

Fig 5. Another attempt to show the extra-dimensions.

Source: String Theory for Kids [and Clever Adults], 2015.

e) "We do not know the exact shape of the hidden dimensions" (String Theory for Kids [and Clever Adults], 2015).

The site ends with a *string theory summary* and with interesting considerations about:

- *Cosmology*: "The most striking thing about the universe is that it is mostly empty space. There is a lot of space between the stars and even more between galaxies. Even on the atomic and sub-atomic scales, we found next to nothing and a whole lot of empty space" (String Theory for Kids [and Clever Adults], 2015).
- *Black Holes*: "They are black because gravity near the hole is so strong that nothing can escape, not even light
- *Dark Matter*
- *Dark Energy*
- *Speculations*
- *Cosmic Strings*
- *What Is Space*
- *Wormholes*: "These are distortions and tears of spacetime that could allow for travel faster than light, or even travel through time"
- *Loop Quantum Gravity*: "In the sub-atomic world, everything is quantized. Why not space and time?"
- *What Is Time*: "What is time? Why is there time? Why do we know the past but not the future? Did time have a beginning? Will it end?"
- *Many Universes*: "String theory allows many different universes. These universes can be very different from ours"
- *Intelligent Design*: "String theory has stirred up the debate about intelligent design. Evolution of life requires a very small range of values for some of the physical universe's physics constants, the nineteen numbers of quantum mechanics", "In string theory, the shape of the curly hidden dimensions sets the values of the constants", "This means our universe was specially designed for life, for us", "This universe works for us because if it did not, we would not be here" (String Theory for Kids [and Clever Adults], 2015).

Conclusions

As all discoveries and achievements of humanity, the Internet is a valuable and powerful tool, but it requires a proper use. It presents not only positive, but also negative aspects, and it can become a tool of bad information.

In relation to science, an increasing number of people in the world rely on the Internet for information, for confirmations, for spreading their research and making it available to the community. If carefully used, through adequate and reliable search, the Internet is certainly an appropriate tool for making available fascinating and complex scientific questions of modern research to all, also children, old and low cultural level people, and people with disabilities.

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