Science Communication 2.0:
The Situation of Spain through Its Public Universities and the Most Widely-Circulated Online Newspapers

Dra. María Dolores Olvera-Lobo, CSIC, Unidad Asociada Grupo SCImago, Madrid. Departamento de Información y Comunicación, Universidad de Granada, Granada, Spain

Lourdes López-Pérez, Departamento de Información y Comunicación, Universidad de Granada, Granada, Spain

ABSTRACT

The level of scientific culture among young Spaniards is one of the lowest in Europe. The media, as spokespersons to the public, and public universities, as the institutions responsible for higher education, are two important parties with the responsibility for changing this situation. This study analyses how both use the Internet and Web 2.0 to promote science. In the case of universities, the results demonstrate the effort they are making to connect science to these tools. 72.9% have a scientific news feed and almost a third have a profile on Facebook and Twitter. However, the role of Spanish science is still irrelevant in online newspapers. Only 35.4% of published information refers to research in Spain.

Keywords: *Digital Journalism, Digital Natives, Internet, Scientific Journalism, Scientific Literacy, Scientific Vocations, Web 2.0, Web Communication 2.0*

INTRODUCTION

The level of scientific culture among young Spaniards is one of the lowest in Europe (Instituto Nacional de Evaluación Educativa, 2013) and registration on scientific courses has fallen in the last decade (Instituto Nacional de Estadísticas, 2010). The future of Spanish R+D+i depends on new generations and demands educated, trained people. The increasing complexity of society and the unstoppable advance of science and technology demand essential scientific literacy from an early age (Nisbet, et al., 2012).

The priorities of European financing programmes for the coming decade (European Commission, 2014) or the strategies for the integration of science and technology in the strengthening of the knowledge community (United Nations Educational Scientific and Cultural Organization, 2014) indicate public involvement in R+D+i as one of their primary objectives.

DOI: 10.4018/irmj.2014070104

The future shows a research system that will assume the responsibility for the public communication of scientific results as one of its integral parts. Spanish science should focus efforts on this approach if it does not want to be left behind in terms of research and lose its position in the international ranking, where it appears as the ninth country in terms of scientific production (Fundación Española para la Ciencia y la Tecnología, 2011).

At the same time, the growth of the Internet as one of the media with the greatest social impact, already close to television (Asociación para la Investigación de Medios, 2013), indicates this channel as the main tool for providing information about science. And it becomes even more important if the target audience are young people, so-called digital natives (Prensky, 2001) due to their dependence on new communication channels (Brigué Sala & Sádaba Chalezquer, 2010).

This study analyses how Spain is dealing with the new priorities established by the European Union as far as scientific communication is concerned. To do this, we analysed the role played by some of the principal agents responsible for this task, namely the media and public universities, because of their dual condition as research centres and higher education institutions for young people.

We prepared two ad-hoc checklists aimed at obtaining specific information from each of the agents. In the case of universities we analysed the use of Web 2.0 tools for the scientific dissemination of research results and the effectiveness of communication using them. In the case of online newspapers the analysed items were mainly focused on discovering the nature of the sources of information used, and the scope of the origin (national or international) of the information published related to scientific news about research carried out in Spain. The analysis period comprised one month, from 1st December to 31st December 2012.

Below we present an overview of state of the art, the methodology used, the results obtained and the conclusions that can be drawn from them.

LITERATURE REVIEW

Web 2.0 and Digital Natives: Uses and Effects. The Emergence of Web 2.0 and a New Social Profile

We have experienced a technological revolution that has altered the way in which knowledge is produced, shared and spread. The emergence of the World Wide Web in the 1990s, pioneered by Tim Berners-Lee, has changed our means of communicating and exchanging information. In barely three decades, the Internet has conquered the communication empire with over 2000 million users/followers across the world. It was born as a living universe in which the most capable and successful have survived. In this way, a digital Darwinism has been produced (Schwartz, 1999), triggering revolutionary transformations in the network of networks: its identity shifting from that of a reading-based Web, where communication is unidirectional, to that of a platform storing a mass of knowledge derived from the immense number of investigations and innovations created by the talent, imagination, audacity, and intelligence of web-users (Flores, 2009).

The concept of Web 2.0 began in a brainstorming session held between O'Reilly and MediaLive International in 2004 (O'Reilly, 2007). The bursting of the technological bubble and the collapse of the dot-coms in fall 2001 led surviving companies to consider the possibility of producing a crucial change of direction for the Web, one in which a call for action could make sense in the way of Web 2.0. Reactions were positive and, in 2004, the Web 2.0 concept began to take on an identity of its own in the *International Conference 2.0.* Just a year and a half later, the term Web 2.0 had taken hold in society; the proof was found in the 9.5 million mentions on Google (O'Reilly, 2007).

O'Reilly (2007) gave further definition to Web 2.0 with the establishment of its constitutive principles. On the one hand, the Web becomes an information platform constantly improved by a community that ceaselessly adds content, a community in which collective intelligence

is harnessed to produce an enormous quantity of highly valuable information. Moreover, free software, and not limited to a single machine; the search for simplicity in the transmission of information; and the creation of a conversational space that provides enriching experiences to its users, all turn Web 2.0 into a peerless agora in securing access to scientific knowledge – and into a solid foundation upon which the system connecting science, technology and society could be constructed. Cobo Romaní and Pardo Kuklinski (2007) summarize these principles into four ideas: namely, a new architecture of participation, inter-creativity, collective intelligence, and the existence of intelligent multitudes.

All of these characteristics establish the Internet as a mass phenomenon (Flores, 2009) and transform the new technologies into an essential infrastructure for daily life (Emurian, 2004); indeed, since the birth of the World Wide Web, its users go online to communicate with others, buy and sell resources, learn and teach, play and entertain themselves (Notley, 2009).

Thus, with the network of networks, not only are technological changes produced, but so are social changes that, as discussed by Christakis & Fowler (2010), modify the very base of society (Burn & Loch, 2001); that is, interaction with the other in various fundamental ways that can be broken down into the concepts of enormity (the large number of people with whom contact can be made), communality (sharing information and contributing to collective efforts), specificity (the particularity of the links that can be formed is increasing), and virtuality (in the sense that one can have two identities, one online and the other offline).

It is a transformation of such magnitude that it produces new sociological profiles altogether, according to their level of involvement with digital culture; thus, we can speak of digital natives, digital immigrants, and the digital illiterate (Prensky, 2001). In this way, we also note the existence of an interactive generation (Brigué Sala & Sádaba Chalezquer, 2010) composed of minors born into a fully operational technology society, and who, from an early age, have had access to technology. This generation is highly equipped, multi-everything, mobilized, emancipated, autonomous, interactive; a generation that entertains itself digitally, that needs to relate to others and that is exposed to new risks.

Uses and Effects

The indispensable role occupied by Web 2.0 and its tools in the lives of young people is, precisely, what has meant that most studies carried out within this field, whether of a national or international scope, are oriented toward studying age, use, frequency, and the impact that social networks, the main symbol of Web 2.0 (Flores, 2009), have on digital natives. After all, young people choose social networks as the primary means of communication and interaction with their environment (Colás et al, 2013).

In the Spanish case, 70% of Internet users between the ages of 10 and 18 have a profile on a social network – an age range that drops further if we consider the fact that access to a personal computer is situated around six years old (Brigué Sala & Sádaba Chalezquer, 2010) . In the case of Andalusia, 71.7% of young people join these networks between 12 and 14 years old (Colás et al., 2013). Although these figures are very striking, they are still far removed from cases like that of Singapore, where the age at which children begin to use social networks lies around six years old and where 99% of young people between six and 24 use this communication tool (Cheok & Zhen, 2011).

Personal interests and relational social needs are the primary causes prompting the use of social networks, both in Spain (Colás et al, 2013; Flores, 2009) and in the international sphere (Notley, 2009).

In the case of university students, such causes are joined by other ones, like the desire to be up-to-date on what happens around them (Gómez et al, 2012). Social networks are essential parts of everyday life to this segment of the public, which confesses to going online multiple times a day and which affirms that using these networks is a routine activity integrated into their daily lives.

Although a certain degree of concern exists with respect to the dangers and risks entailed by social networks for their youngest users, such as problems of social isolation (Jung Lee, 2009), cyberbullying (Brigué Sala & Sádaba Chalezquer, 2010) or psychological vulnerability (Martínez Rodríguez et al, 2011), there is also considerable interest in their beneficial effects.

In this way, social networks are viewed as an important resource for training in terms of both personal and social values (Colás et al, 2013); likewise, students have a positive attitude toward the academic use of social networks, perceiving them as channels with enormous communicative possibilities that must be taken advantage of in the educational context (Gómez et al., 2012). They are valuable in encouraging social inclusion among young people (Notley, 2009); they have a great capacity to influence, which can become deeply advantageous in the educational realm (Flores, 2009); and, without a doubt, they can be extremely influential when it comes to decisions young people make in their own lives (Notley, 2009).

All of the aforementioned points emphasize the leading role played by Web 2.0 in general, and social networks in particular, as a communication channel for the youngest individuals; moreover, they reinforce the idea of what the tools should be for familiarizing this sector of the public with science, as well as the medium for encouraging vocations and advancing scientific culture. This hypothesis becomes still more persuasive when we consult the figures published by the *VI Encuesta de Percepción Social de la Ciencia y la Tecnología* (Fundación Española para la Ciencia y la Tecnología, 2012), a survey on the social perception of science and technology, which defines social networks as the primary source of scientific information for people below 25.

The Digital Press in Web 2.0

The media, entrusted with reconstructing the reality that is visible to society, has not been far from the transformation of the communication process implied by the emergence of the Internet and Web 2.0. Since *El Periódico de Cataluña* published the first online edition of a Spanish print newspaper in 1994, the media has jumped on the bandwagon of new technologies; today, all have an active presence on the Web. Of the different channels in existence, the digital press has had a key role in the history of Spanish cyber-journalism: not only because newspapers were the first to open up to the digital world in the late 1990s – television and the radio joined the Internet nearly five years after the press did – but also because they have the most extensive Internet presence, at 54.6% of the total (Salaverría, 2005).

If the arrival of the World Wide Web in the '90s entailed a journalistic revolution with the appearance of a new medium, the birth of Web 2.0 in 2004 went even farther, changing the very process of communication as it had been understood until then. Thus, the emitter-channel-receiver circuit has become more complex in order to present itself as a multidirectional network in which all emitters are receivers and vice-versa. In this way, the term 'creative audience' emerges (Castells, 2009) to define receptors who are capable of transforming the message and making the most of advantages inherent to this new multi-channel, multimodal environment.

It is an environment where the Spanish digital press has been established just as audience data conveys: the figures place the periodicals www.elmundo.es and www.elpais.es among the ten most widely read in Europe (Cea Esteruelas, 2013). The success of online newspapers runs parallel to the Internet's permeation in Spanish society; digital editions grow at the same pace as the print versions plummet. Readers feel that this new media has enormous advantages as compared to the conventional one: easy access to the news; the personalization of content (RSS); constant information updates; and, most of all, the fact that it is free (Rodríguez-Martínez & Pedraza Jiménez, 2009).

Journalistic businesses are aware of the importance of this new channel, which has now penetrated the medium with the largest audience, television (Asociación de Investigación de

Medios, 2012); practically all Spanish printed newspapers use the tools offered by Web. 2.0 – social networks, blogs, RSS channels, and so forth – to reach their readers.

If, in assessing this reality, we also consider the fact that the press users of the future are so-called digital natives, it seems clear that the online press will gain power and influence over printed newspapers, the radio, and television within just a few years.

In this way, if, to date, the thematic organization of reality had fundamentally fallen to television as the largest mass medium, it is now the digital press that is defining the newsworthiness of current events with an important difference from traditional journalism: readers are an active player in the process of constructing a news story, a process that never truly ends and which responds more than ever to the 'now'.

In this context, digital newspapers become important loudspeakers for Spanish science because of their double role of forming and informing; their ability to generate opinions and ideas about Spanish research in society; and, lastly, their capacity to disseminate messages instantaneously to a mass audience. In this sense, the digital press has managed to link the excellent qualities of three great media by uniting the advantages offered by each one: the attractiveness of the audiovisual image, the instantaneousness of the radio, and the durability and invitation to reflect provided to readers of the printed press.

As a result, it is essential to analyze the role of Spanish science in the agenda of the national periodicals with the largest readership: www.elpais.com, www.elmundo.es, www.abc.es, and www.20minutos.es. Indeed, this agenda shapes society's image of research being conducted in Spain.

Scientific Culture in Spain

Spain returns to the center stage of European science – not, this time, for the quantity or quality of the research conducted, but rather for the level of scientific culture among the population. The results of the 2013 student evaluation program called the Programa Internacional de Evaluación de Alumnos (PISA) place Spanish secondary school students below average for Organisation for Economic Co-operation and Development countries. This position is repeated in statistics published by other international reports, such as the *Estudio Internacional de Cultura Científica,* published by the Fundación BBVA (2012), which names Spanish society as having the least scientific culture of the 11 countries analyzed (10 European and the United States).

According to this same report, 57% of Spanish adults show a low level of scientific knowledge as compared to 22% characterizing the European average, and 46% are not even able to mention a scientist by name. For its part, the *Encuesta de Percepción Social de la Ciencia a Estudiantes de Secundaria* developed by the Fundación Española para la Ciencia y la Tecnología (2011) makes conclusions along these same lines, stating that a majority of the secondary school students surveyed could not name a scientist or a Spanish scientific institution.

In examining the low level of scientific culture, we must also refer to a decrease in vocations among young people, reflected in the drop in student enrollment at the higher levels of experimental sciences between 2000 and 2010, according to the information provided by Estadísticas de la Enseñanza Universitaria (Instituto Nacional de Estadística, 2010).

Although this situation is not exclusive to Spain – in Europe, the number of bachelor's degrees in Mathematics, Sciences, and Technologies has decreased nearly 4% from 2001 to 2010 (European Commission, 2012) – it does contribute to further intensifying the low level of scientific knowledge that Spanish citizens will have in the coming years, and it will widen the gap that already exists in this field between Spain and other European countries. This divide opened up in the eighteenth century during the Enlightenment, when Spain remained isolated from the scientific revolution (Fernández Rañada, 2003), a distance that has continued into our present day in spite of the efforts made by

Spanish political, social, and cultural agents to fundamentally narrow the gap as of the 1990s.

Scientific Culture: A Rough Definition

Dissemination (Calvo Hernando, 2006), the popularization of science (Brossard, 2009), public comprehension of science (Conant, 1951; Macedo-Rouet, 2003), scientific culture (Gingras & Godin, 2000) and the public communication of science (Fayard, 2004) are some of the many terms that relevant literature has employed to define contact between society and scientific knowledge.

Thus, the actions of informing and disseminating are also discussed. Informing refers to journalistic divulgation, a task that journalists ought to develop with the same gravity and significance that it applies to other informative areas (Belenguer Jané, 2003). The second term encompasses a broader universe, entailing any activity related to the explanation and circulation of knowledge, culture, and scientific and technical culture developed beyond the bounds of official instruction or equivalent teachings (Calvo Hernando, 2006).

On other occasions, the concept is simplified and the terms "informing" and "disseminating" are combined (Fayard, 2004). In this case, scientists and journalists play the leading role and it is advocated that the public communication of science must fundamentally seek to connect science and society through many different strategies. In short, the goal is to help society access the changes derived from the evolving role of science and technology.

Other authors go further and offer a deeper approach to this task, coining the term "cultural and technological culture," an expression that defines all means by which individuals and society take ownership of science and technology (Gingras & Godin, 2000), distinguishing three types of appropriation. The first, the means of learning, refers to the formal education implicit in the educational system and not to the informal kind, which includes museums, the media, leisure activities, workshops, and so forth. Next, the means of involvement refers to experts' and scientists' degree of involvement in the dissemination process. And finally, the socio-organizational means refers to dissemination implemented in and from research centers, universities, and other institutions that work with investigation.

In this text, we will use the term "scientific culture," since it implies a broader concept and is ultimately closest to the field of study addressed here.

Scientific Journalism

As previously mentioned, the media is the primary channel through which scientific information reaches society (Moreno, 2010). It plays a fundamental role in promoting scientific culture – not only through its capacity to disseminate scientific knowledge, but also because it generates a public image of science and scientists (Alcíbar, 2004).

In Spain, there is a common impression of science (Fernández-Rañada, 2004) as something dull and incomprehensible that only awakens people's interest or curiosity with star subjects like medicine (Moreno, 2010), the big bang, dinosaurs, the origins of life, the formation of the Earth, and so on (Fernández-Rañada, 2004). As a result, the ways in which the media deals with scientific content is crucial to understanding the image people have of Spanish R+D+i.

Although Spanish journalism in the 1990s showed an incipient interest in scientific subjects, it isn't until early 2000 that supplements, sections, and radio and television programs specialized in science and technology begin to proliferate. Then supplements appear like *Futuro* in *El País*, *Eureka* in *El Mundo,* radio programs like *A hombros de gigantes* on *Radio Nacional de España* or television shows like *Redes*. The emergence of the Internet and the publication of digital editions has not left behind the creation of sections exclusively dedicated to science and technology; the digital publications with the largest readerships in Spain, www.elmundo.es and www.elpais.es, both have one section devoted to science and another to health.

Although the media's interest in science and technology has grown exponentially in recent years, the information it publishes on these fields presents numerous limitations. The first is the very structure of the journalistic message, which establishes certain criteria of newsworthiness that a large amount of science, particularly basic science, does not meet. In this sense, authors like Alcíbar (2004) claim that society turns to the media to familiarize itself with the social and cultural repercussions of scientific discoveries and technological advances. The pedagogical function is not fundamental; rather, it is complementary to scientific journalism.

It is for this reason that journalistic discourse produces a re-contextualization of scientific information (Moreno, 2010). It seeks impressive results that are subsequently presented as apodictic and with a certain dose of spectacle to command the reader's attention. Thus, such journalism displays a positivist image of science as a neutral authority and objective judge of truth (Alcíbar, 2004) – while simultaneously omitting the entire process of the scientific method that lies behind the story.

As Moreno states (2010), a diversion of information and a re-adaptation of the text occurs along the path from a paper to a scientific news story – since, in the news, the key elements for a headline are the papers' conclusions, whereas, for scientists, the methods and discussion are equally important or more so.

The second limitation involves sources of information. Scientists have been very reluctant to divulge their knowledge to journalists, feeling that they present such information in a simplistic, erroneous, and often insufficiently rigorous way (Alcíbar, 2004). In this way, the primary sources of scientific information today are university communication departments and research centers, as well as the press offices of high-impact scientific journals.

One way to resolve the distrust exhibited by scientists toward information professionals could be that researchers take control of disseminating their research and transmit their results directly to society, without intermediaries. In fact, universities and research centers are the most credible entities in the eyes of society (Fundación Española para la Ciencia y la Tecnología, 2010; Treise et al, 2003).

But what are scientists' attitudes in response to scientific dissemination in Spain? The few studies conducted with the aim of understanding scientists' opinions of the transmission of their research to society has spotlighted the existing distance between, on the one hand, the pressure to which they are subjected so that they will participate in this task, and, on the other, the relatively scarce interest they express in doing so – a fracture they justify with the lack of incentives that would compel them to take part in such activities (Martín Sempere & Rey Rocha, 2007). Most researchers feel that, for science-related communication to have greater implications for the public, it is essential for this to be valued in the assessment of scientific activity.

Recognition is a key factor in the scientific world. It is a distinction in and of itself; at the same time, it is also the mechanism by which most of science's rewards are established (Merton, 1977). In Spain, not only is the work of scientific dissemination not rewarded or 'recognized' in the research, but it can also have a negative effect. The general attitude toward participation in dissemination-related events, that those who take part "don't have anything better to do", or that they do it "because they don't have a high enough level to devote themselves to more important activities", is widespread (Martín Sempere & Rey Rocha, 2007).

In this sense, Hendrix and Campbell (2001) state that, often, scientists who dedicate part of their time to talking with the media or the public pay a high price in professional terms. These activities detract precious time from their work – which further emphasizes the importance of institutional backing for these efforts.

Indeed, the pressure to achieve high scientific production quotas explain why young scientists, primarily pre-doctoral scholarship students, participate less in science and technology dissemination activities than more senior scientists (Martín Sempere and Rey Rocha, 2007). As a result, it is easy to understand why it

is sometimes considered that, although circulation is important, dissemination isn't the job of the scientist himself or herself, who, first and foremost, must research and often teach as well (Cuenca, 2002). This is a conviction shared by much of the scientific community, which does not view dissemination as a duty – and which, moreover, states that the task is not scientists' responsibility to begin with.

The Development of Scientific Culture through Web 2.0

Web 2.0 has qualities that facilitate both dissemination and access to scientific and technological development. It is a platform designed to share and distribute information in a quick, simple, and instantaneous way to many people of different ages and social profiles. It constitutes an open space in which the information exchange flows freely and there are no intermediaries in the process of communicating with the receiver. It is portrayed as an agora where science and society may dialogue face-to-face, and where the oft-acclaimed democratization of knowledge may be established (Reig, 2012).

This reality allows scientists themselves to divulge the results of their research without being subjected to standards of newsworthiness or journalistic interest, or to conceptual errors committed by non-specialist professionals. In addition, it is a medium that doesn't require any economic cost or enormous effort by the researchers as compared to other dissemination-related activities that do (science fairs, expositions, conferences, etc.) and which have proven to not be particularly effective, judging, at least, by statistics pertaining to vocations and scientific culture.

Further, the latest information published by the Fundación Española para la Ciencia y la Tecnología in its *Encuesta de Percepción Social de la Ciencia* (2012) places the Internet, for the very first time, above television as the primary source of scientific information. It also elevates the permeation of social networks, blogs and specialized media, while it lowers that of general-interest media on the Internet.

OBJECTIVES

Observing the underlying situation with respect to Spain's low level of scientific culture and to the decrease in scientific vocations among young people has prompted the development of this text. It seeks to analyze how public Spanish universities use the Internet and new Web 2.0 tools to communicate their scientific results to society, as well as to examine whether the digital newspapers with the largest readerships in the country, in their educational role, publish news about scientific results emerging from Spanish universities and research centers.

This general objective is broken down into the following specific ones: *a)* to analyze whether public Spanish universities have specialized channels for circulating their research on Web 2.0, *b)* study the effectiveness of science-related communication undergone by public Spanish universities on Web 2.0 in terms of intensity and connectivity, *c)* define research areas with the dissemination of science playing a more central role, *d)* determine whether Spanish digital newspapers with large readerships have created specific sections for science and technology, *e)* establish the contextual origin (national and international) of the main scientific news stories being published, as well as the source of their information and the research area they refer to, and *f)* determine whether there is an equivalence between the dissemination conducted by universities of their own research and the information published by the major media sources in their science sections.

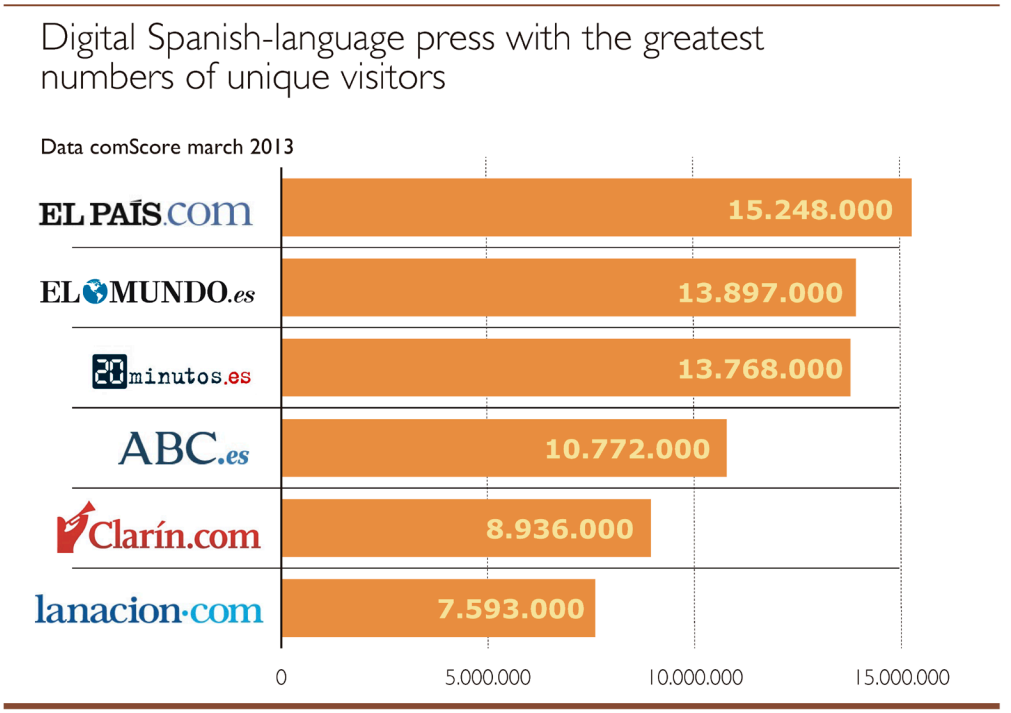
MATERIALS AND METHODS

Study Sample

As a study sample, we have selected the public Spanish universities and the most widely read digital newspapers in the national context. The study period was one month long, from December 1 to December 31, 2012.

To homogenize the sample and avoid the biases that can be prompted by the evident differences that exist, in terms of resources

Figure 1. Digital Spanish-language press with the greatest numbers of unique visitors



and objectives, between public and private universities, we have opted for the public ones. At the same time, we understand that public universities, by their own appointment, have greater social responsibility with respect to scientific communication. The selection of public universities responds to the selection established by Scimago Group in its Ranking of Spanish Universities based on Scopus data (2006-2010) and published in March 2012. This ranking compiles a total of 93 universities, of which 48 are public and 45 private, and is drawn from various scientometric indicators: number of documents published; international collaboration; normalized impact; % of documents published in top-quartile journals according to the ScimagoCIMAGO Journal Rank; and the number of works of excellence published by each institution.

Our analysis has focused on the 47 public universities.

As for the selection of digital newspapers, we have taken the audience data into account as published by the two most relevant companies in audience measurement for digital media: Comscore (2012) and Nielsen (2012). They concur in defining the online newspapers with the largest readerships as online edition of *El Mundo*, *El País*, *ABC* y *20 Minutos*, which complete our study sample.

METHODOLOGY

In the following, we describe the methods we utilized for the analysis developed over the period in question (December 1 to 31, 2012).

A Study of Universities

To analyze how public Spanish universities disseminate the results of their research on Web 2.0, we have designed an evaluation sheet that

includes the four areas of tools defined by Cobo Romaní & Pardo Kulinski (2007):

a. Social networks. The analysis of social networks has centered fundamentally on the level of presence of the universities being studied through specific profiles dedicated to research dissemination on the primary social networks used in Spain: Facebook, Twitter, Tuenti and Youtube.

For our study, it has been important to evaluate not only the aforementioned presence itself, but also the effectiveness of the communication in question; for this reason, we have studied connectivity (the number of followers) and the level of intensity (number of publications or entries).

b. Content-generating tools. Regarding this aspect, we have studied two of the most commonly utilized tools – blogs and news channels – which in some cases are referred to as dissemination channels.
c. Tools used for social and intelligent organization of information. We have analyzed whether the centers have RSS (Really Simple Syndication) channels.
d. Other applications. We have considered other general applications like audio and video players and other services that help circulate the work conducted by these research centers in society.

A Study of the Media

As with the case of the universities, in order to study how the media disseminates Spanish science, we have designed an ad-hoc checklist that comprises the following sections: whether they have created specific sections dedicated to scientific information; the scientific area referenced by the published news stories; the source of information for the story; and the geographic origins of the source (national or international).

The analysis has been conducted by means of daily searches on the media included in the study: namely, www.elpais.es, www.elmundo.es, www.abc.es and www.20minutos.es. From the scientific information discussed in these publications, we have excluded anything from the study that was not related to research dissemination.

The fact of including the source of information responds to the interest in analyzing the extent to which, as Carlos Elías indicated (2008) in *La razón estrangulada*, the media limits itself to publishing only *media science* created by high-impact scientific journals. At the same time, this item allows us to establish correspondence between the dissemination of the research performed by universities and its impact in the media.

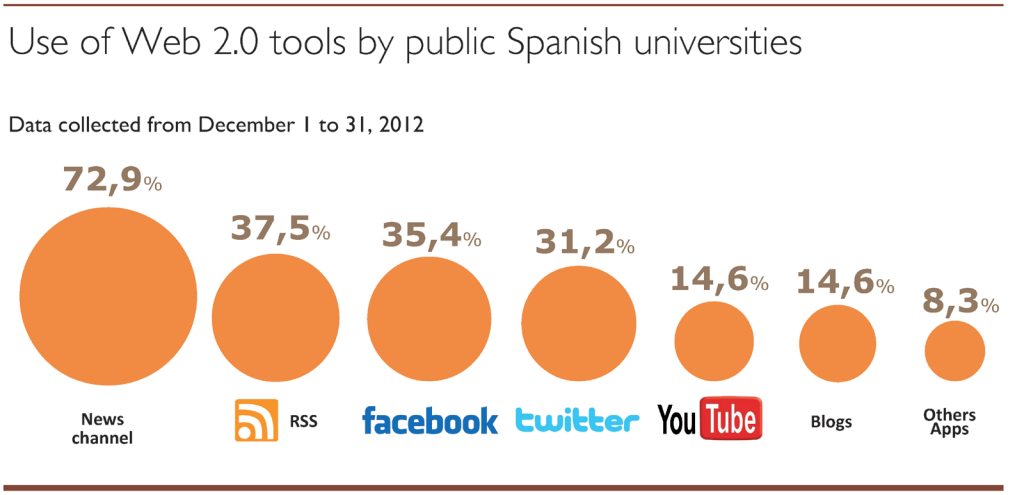
Additionally, including the geographic origins of the research published in the media allows us to observe the role of Spanish research in the Spanish journalistic agenda and the influence of the source's origin on the newsworthiness of scientific work.

RESULTS

Universities and Communication on Science on Web 2.0: Presence in Web 2.0

News channels are the primary tool for scientific communication used by public Spanish universities. Seventy-two point ninety percent have a channel specifically dedicated to scientific dissemination. This figure is followed by content syndication, a medium used by 37.5%, and Facebook, a network in which 35.41% of the universities have profiles specialized in research dissemination. A similar percentage -31,2%-, turns to Twitter to communicate its R+D+i. The figures drop in the case of YouTube, where 14.6% of the centers have a presence, and in the use of blogs, a resource employed by 14.6%. Only 8.33% of the centers use other kinds of applications. On the other hand, it is notable that not a single university has a profile dedicated to scientific dissemination on Tuenti,

Figure 2. Use of Web 2.0 tools by public Spanish universities



the network most followed by the young public (The Cocktail Analysis, 2012).

Connectivity

Of the three social networks analyzed, Twitter presents the highest values of connectivity. The Universidad Nacional a Distancia has the most followers: 3510. Twenty-six point six percent have more than 1000 followers and 73.33% have less than 1000.

As for Facebook, the Universidad Autónoma de Madrid has the most followers, at 3180. Forty-one point seventeen percent of the centers analyzed that have a profile on this network have more than 1000 followers, 17.6% have fewer than 1000, and 35.2% have fewer than 500.

The Universidad de Málaga's YouTube channel has the most views with a total of 24,006. Of the centers that have a presence in this channel, 71.42% have fewer than 10,000 views.

Intensity

The intensity of the communication via the different channels analyzed is not very high, but it is relevant that most of the universities use these tools to disseminate their scientific research. The Universidad Autónoma de Madrid has the most activity on social networks, with 122 posts published during the study period. The Universidad de Huelva has published the most scientific news stories: a total of 30. The Universidad de Granada stands out with respect to the number of tweets, 14, and the Universidad de Córdoba and la Politécnica de Cartagena tie when it comes to YouTube with two videos posted each.

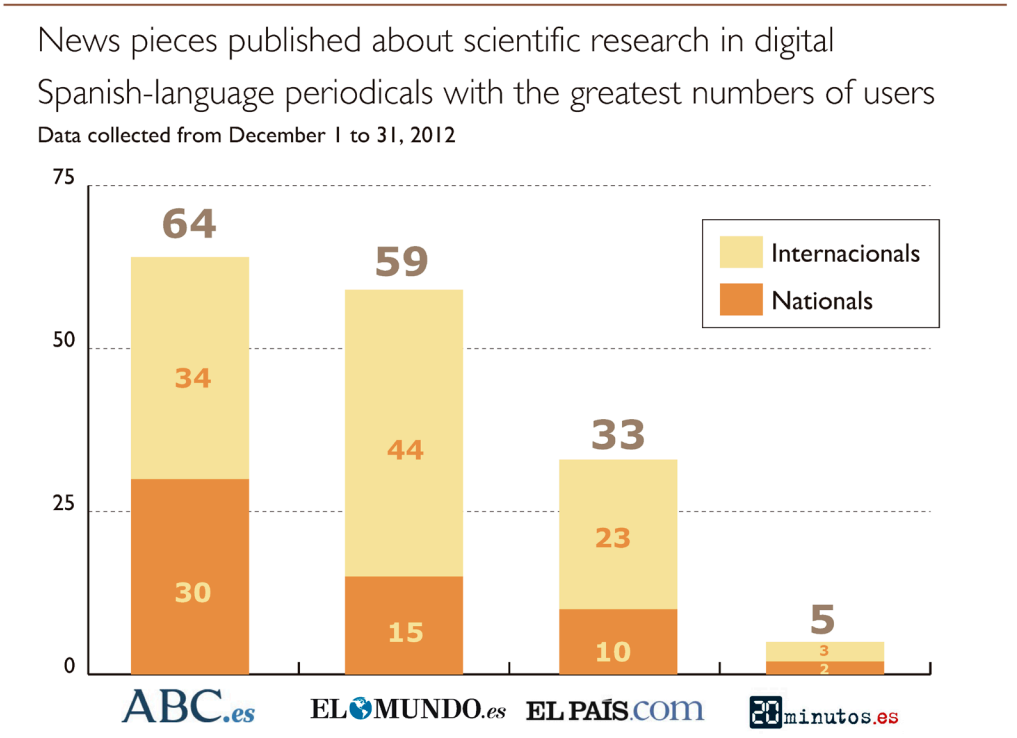
Scientific Areas

Biology and medicine are the areas that appear most frequently in all the channels analyzed. They are followed by social sciences and natural resources on news channels, blogs and Facebook, and physics in the case of Twitter.

The Media and the Dissemination of Science in Digital Editions

The analysis of the research dissemination conducted by the highest-circulation online newspapers corresponds to the same period as the universities: December 1 to 31, 2012.

Figure 3. News pieces published about scientific research in digital Spanish-language periodicals with the greatest numbers of users



Specific Sections and Intensity

The four periodicals analyzed dedicated specific sections to scientific news. Of the four, elmundo.es, abc.es and elpais.es concur on the names of the two sections; that is, Science and Health. While this is visible on the homepage of the first two periodicals, on elpais.es they are integrated as two subsections of the Society area. 20 Minutos has, like the others, a section dedicated to Health and another to Environment.

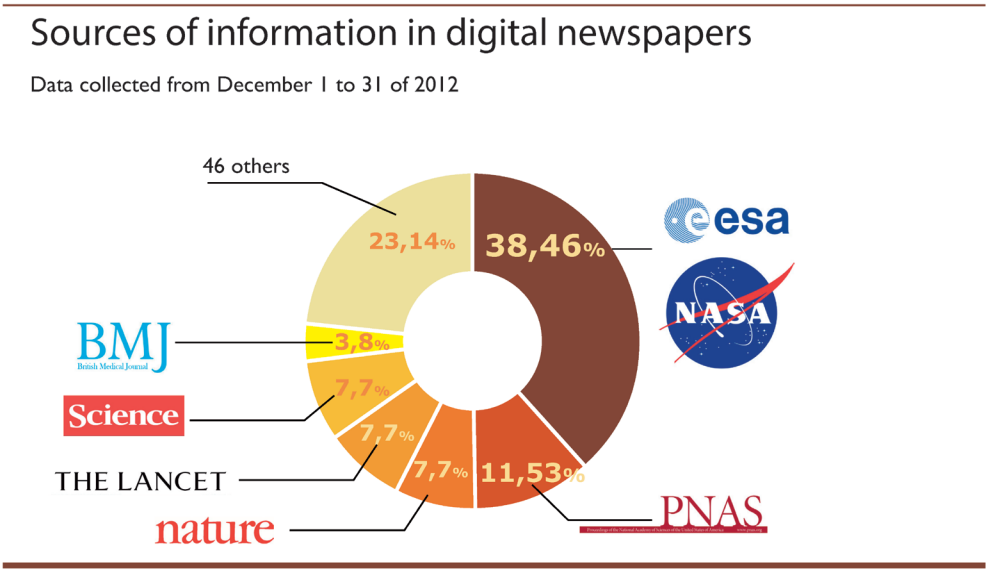
As for intensity, the online newspaper that publishes the most scientific news stories is abc.es with 64, followed by elmundo.es with 59, elpais.es with 33 and, in last place, 20minutos.es with five. If we add up the production of all four periodicals, 161 scientific news stories have been published between December 1 and 31, 2012.

Origins and Sources of Information

All four periodicals predominantly publish research results from international centers and universities: so much so that 64.5% of the news stories make reference to a foreign center or university as compared to 35.40% that mention scientific work developed in Spain.

Scientific journals are the primary source of information for the news. Fully 45.96% indicate a scientific journal as a source. In this respect, we must mention that of the 52 journals mentioned in the news pieces published by the four periodicals, not one is a Spanish-language publication. The journals with the most significant presence are: *Proceedings of the National Academy of Sciences*, *Nature*, *Science* and *British Medical Journal*. The European Space

Figure 4. Sources of information in digital newspapers



Agency (ESA) and the National Aeronautics and Space Administration (NSA) are the second most frequently appearing sources. Of the news stories analyzed, 12.42% refer to these two space agencies.

Scientific Areas

Medicine and biology are at the top of the ranking of scientific news stories. Fifty point thirty-one percent of the publications mention discoveries made in these fields. They are followed by astrophysics, included in the area of sciences and physical technologies, with 22.98%; third place, with 14.28%, goes to the social sciences, primarily represented by archaeology and paleontology.

CONCLUSION

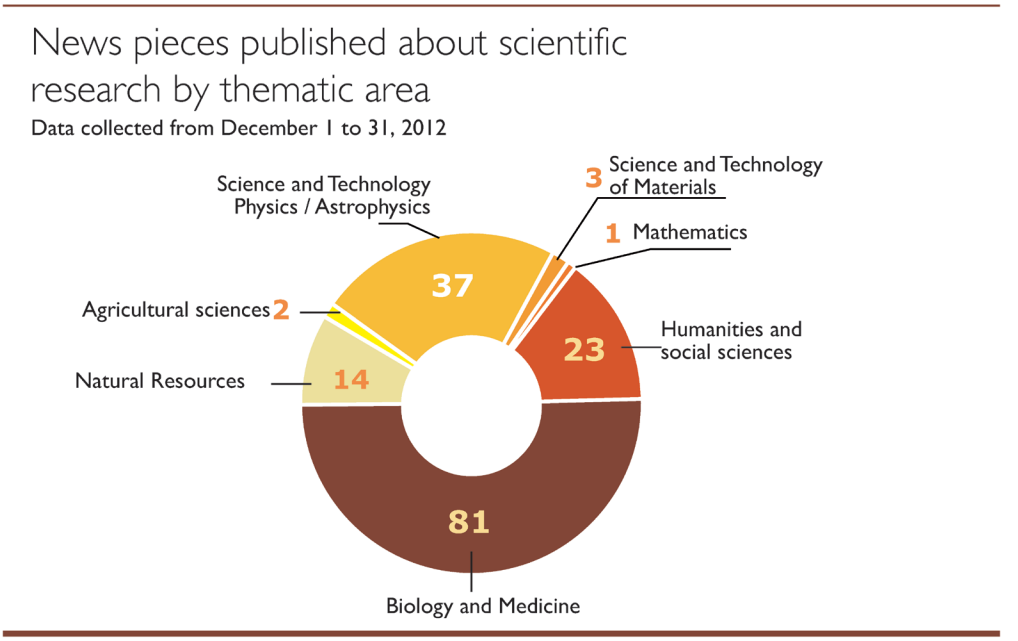
Public Spanish universities are making an effort to use the tools offered by Web 2.0 in order to make their research accessible to the entire public. The data confirm this effort, as 72.9% of the universities have specific channels on their websites for communicating their scientific projects.

The figures are lower when it comes to their presence on social networks, but they indicate the growing interest shown by academic institutions in Web 2.0 as a means of reversing the enrollment drop in science and the decrease of scientific vocations. Of the social networks, Facebook is in first place, with the presence of 35.4% of the centers analyzed.

On the other hand, it is noteworthy that a substantial percentage of the centers that use these communication channels are International Campuses of Excellence. This is a tendency to keep in mind and an item that gives rise to a new research hypothesis that links excellence, with apologies for the redundancy, with international campuses of excellence not only in terms of their research itself, but also in terms of dissemination.

As for the effectiveness of communication, the results indicate that, although the presence in Web 2.0 is significant, the incursion into this channel is relatively recent. None of the universities exceeds 3600 followers on the two most

Figure 5. News pieces published about scientific research by thematic area



popular networks, Twitter and Facebook. The intensity is not high – an average of 10 pieces of information are published during the study period on each one of the channels studied – but it does reflect the general tendency to publish the results of their scientific projects. With respect to the areas with the greatest presence in this information, all channels display the same conclusion: medicine and biology lead the way, followed by physics and natural resources.

Regarding the analysis of the presence of Spanish science in the digital newspapers with the largest readerships, we can say that although Web 2.0 has permitted the establishment of specific sections on scientific information in digital media, it has not altered the handicap that Spanish science had to overcome in the print editions of these media sources in the late 1990s.

In this way, the results show that 45.96% of the news pieces analyzed name a scientific journal as a source. This result resembles the findings published by Carlos Elías (2008) in a study performed in 1998, which concluded that 45% of news stories stemmed from a scientific journal.

This same research observed the absence of Spanish journals in the news pieces analyzed, a reality that reappears in our analysis. The prevalence of three of the world's most prestigious science journals – *Science*, *Nature* and *The Lancet* – is another result obtained both by our analysis and the study conducted in 1998. That said, the data acquired by that study could be more precise, since, while these are the journals with the greatest presence, our study contains more heterogeneity in this sense by including 52 different scientific journals as information sources.

The strong presence of scientific journals in the published information is also reflected in the origins of more media-oriented research; strikingly, only 35.4% of newsworthy scientific results come from Spanish centers or researchers. The absence of news pieces about Spanish centers does not seem to result from a lack of

communication on the part of Spanish universities, since, during the study, they published 236 news stories as compared to the 57 that were allotted space in the four online periodicals analyzed.

As for scientific areas, we can continue speaking about media science (Elías, 2008) with medicine and astrophysics as key players. This tendency is repeated in the information elaborated by the universities, where these two remain the areas that receive most attention.

Thus, with everything previously discussed here, we can say that Spanish universities are beginning to use Web 2.0 tools in order to bring research to society – but that this communication is still incipient and therefore not completely effective. As for digital media, while online periodicals include science in their agendas, they are rendering invisible the scientific work occurring in Spain due to the predominance of international information in their publications.

As an addition to these conclusions, we must also mention the homogeneity of the scientific information present in the media as a whole, which repeatedly turns to magazines like *Science*, *Nature* and *The Lancet* as sources of information.

All of these factors can contribute to the decrease both in vocations and in scientific culture in Spain: by conveying an unreachable image of science that only large international centers with prestige and diffusion can produce.

REFERENCES

Alcíbar, M. (2004). La divulgación mediática de la ciencia y la tecnología como recontextualización discursiva. *Anàlisi*, *31*, 43–70.

Asociación para la investigación de Medios de Comunicación (2013*). Estudio General de Medios*. Madrid: AIMC (2011). http://www.aimc.es/-Datos-EGM-Resumen-General-.html [December, 2013]

Belenguer Jané, M. (2003). Información y divulgación científica: dos conceptos paralelos y complementarios en el periodismo científico, *Estudios sobre el mensaje periodístico*, 9, 43-53.

Brigué Sala, X., & Sádaba Chalezquer, C. (2010). Niños y adolescentes españoles ante las pantallas: Rasgos configuradores de una generación interactiva. *CEE Participación Educativa*, *15*, 86–104.

Brossard, D. (2008). Media, scientific journals and science communication: Examining the construction of scientific controversies. *Public Understanding of Science (Bristol, England)*, *18*(3), 258–274. doi:10.1177/0963662507084398

Burn, J. M., & Loch, K. D. (2001). The societal impact of the world wide web--key challenges for the 21st century. *Information Resources Management Journal*, *14*(4), 4–14. doi:10.4018/irmj.2001100101

Calvo Hernando, M. (2006). Difusión, divulgación y diseminación. <http://www.manuelcalvohernando.es> [April 2012].

Castell, M. (2009). *Comunicación y poder*. Madrid: Alianza Editorial.

Cea, N. (2013). La audiencia de la ciberprensa española en los mercados de habla hispana. *Revista Mediterránea de Comunicación*, *4*(1), 99–115. doi:10.14198/MEDCOM2013.4.1.05

Cheok, A., & Zheng, R. (2011). Singaporean Adolescent's Perceptions of On-line Social Communication: An Exploratory Factor Analysis. *Journal of Educational Computing Research*, *45*(2), 203–221. doi:10.2190/EC.45.2.e

Christakis, N., & Fowler, J. (2010). *Conec-tados. El sorprendente poder de las redes sociales y cómo nos afectan*. Madrid: Taurus.

Cobo Romaní, C., & Pardo Kuklinski, H. (2007). *Planeta web 2.0: Inteligencia colectiva o medios fast food*. Barcelona, DF, México: Grup de Recerca d'Interaccions Digitals de la Universitat de Vic y FLACSO México.

Colás, P. et al (2013). Juventud y redes sociales: Motivaciones y usos preferentes. *Comunicar*, 40 (VXX), 15-23.

Comscore (2012). *El Mercado online español en un vistazo*. http://www.comscore.com/esl/Panorama_Digital/Datos_actuales/El_mercado_online_espanol_en_un_vistazo_-_Noviembre_2012 [Noviembre 2012]

Elías, C. (2008). La razón estrangulada. La crisis de la ciencia en la sociedad contemporánea. Barcelona.

Emurian, H. H. (2004). Fostering citizenship via the Internet1. [II,III,IV]. *Information Resources Management Journal*, *17*(1), I.

European Comission. (2012). *Developing Challenges and Opportunities for Policy at School in Europe: Key Competences* http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/145EN.pdf [September 2013]

Fayard, P. (2004). *La comunicación pública de la ciencia: hacia la sociedad del conocimiento*. México: Dirección General de Divulgación de la Ciencia, Universidad Nacional Autónoma de México.

Fernández-Rañada, A. (2013). *Los muchos rostros de la ciencia*. México: La ciencia/192 para todos.

Flores, J. M. (2009). Nuevos modelos de comunicación, perfiles y tendencias en las redes sociales. *Comunicar*, *35*(XVII), 73–81. doi:10.3916/c33-2009-02-007

Fundación, B. B. V. A. (2012). Estudio Internacional de Cultura Científica. Fundación BBVA. Comprensión de la Ciencia. <http://www.fbbva.es/TLFU/dat/comprension.pdf> [May 2013]

Fundación Española para la Ciencia y la Tecnología. (2011). *Percepción Social de la Ciencia y la Tecnología 2010*. Madrid: Fundación Española para la Ciencia y la Tecnología.

Fundación Española para la Ciencia y la Tecnología. (2012). *Percepción Social de la Ciencia y la Tecnología 2012*. Madrid: Fundación Española para la Ciencia y la Tecnología.

Godin, B., & Gingras, Y. (2000). What is scientific and technological culture and how is it measured? A multidimensional model. *Public Understanding of Science (Bristol, England)*, *9*(1), 43–58. doi:10.1088/0963-6625/9/1/303

Gómez, M. et al (2012). El uso académico de las redes sociales en universitarios. *Comunicar*, 38, (VXIX), 131-138.

Hendrix MJC & Campbell P. (2001). Communicating Science: From the laboratory bench to the breakfast table. *The Anatomical Record (New Anat.)* 265(4):165-167.

Instituto Nacional de Estadística. (2010). *Estadística de Enseñanzas Universitarias*. <http://www.ine.es> [April 2012]

Instituto Nacional de Evaluación Educativa. (2013). *Programa para la Evaluación Internacional de los Alumnos 2012*. http://www.mecd.gob.es/dctm/inee/internacional/pisa2012/pisa2012lineavolumeni.pdf?documentId=0901e72b81786310 [December 2013]

Jung Lee, S. (2009). Online Communication and Adolescent Social Ties: Who benefits more from Internet use? *Journal of Computer-Mediated Communication*, *14*(3), 509–531. doi:10.1111/j.1083-6101.2009.01451.x

Macedo Rouet, M., Rouet, J., Eipstein, I., & Fayard, P. (2003). Effects of Online Reading on Popular Science Comprehension. *Science Communication*, *25*(2), 99–128. doi:10.1177/1075547003259209

Martín Sempere, M. J., & Rey Rocha, J. (2007). *El papel de los científicos en la comunicación social de la ciencia y la tecnología a la sociedad: actitudes, aptitudes e implicaciones*. Madrid: Consejería de Educación de la Comunidad de Madrid.

Martínez, E. et al. (2011). El complejo mundo de la interactividad: Emociones y redes sociales. *Revista Mediterránea*, *2*(1), 189–208.

Merton, R. (1977). *La sociología de la ciencia*. Madrid: Alianza Editorial.

Moreno, C. (2010). La construcción periodística de la ciencia a través de los medios de comunicación social: Hacia una taxonomía de la difusión del conocimiento científico. *Artefactos*, *3*(1), 109–130.

Nielsen 2012. *State of the media: The Social Media Report*. http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2012-Reports/The-Social-Media-Report-2012.pdf (September 2013)

Nisbet, M., Scheufele, D., Shanahan, J., Moy, P., Brossard, D., & Lewenstein, B. V. (2002). Knowledge, reservations, or Promise?: A Media Effects Model for Public Perceptions of Science and Technology. *Communication Research*, *29*(5), 586–608. doi:10.1177/009365002236196

Notley, T. (2009). Young people, Online Networks and Social Inclusion. *Journal of Computer-Mediated Communication*, *44*(4), 1208–1227. doi:10.1111/j.1083-6101.2009.01487.x

O'Reilly, T. (2007). What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software. *International Journal of Digital Economics*, *65*, 17–37.

Prensky, M. (2001). Digital Natives, Digital Inmigrants. MC University Press. 9 (5).

Reig Fernández, D. (2012). *Socionomía ¿Vas a perderte la revolución social?* Barcelona: Ediciones Deusto.

Rodríguez-Martinez, S., & Pedraza, R. (2009). Prensa Digital y Web 2.0. *Hipertext.net*. nº 7 http://www.upf.edu/hipertextnet/numero-7/prensa-digital.html#5 [June 2013].

Salaverría, R. (2005). *Cibermedios. El impacto de Internet en los medios de comunicación en España*. Sevilla: Comunicación Social Ediciones y Publicaciones.

Schwartz, E. (1999). *Digital Darwinism*. New York: Brodway Books.

Scimago Group. (2012) Science Indicators of Spanish HEIs 2006-2010. www.sciamgolab.com/blog/ [April 2013]

Treise, D., Walsh-Childers, K., Weigold, M., & Friedman, M. (2003). Cultivating the Science Internet Audience: Impact of Brand and Domain on Source Credibility for Science Information. *Science Communication*, *24*(3), 309–332. doi:10.1177/1075547002250298

United Nations Educational Scientific and Cultural Organization. (2012). Science and Technologies for Knowledges Societies. What role for UNESCO in 2014-2020? http://www.unesco.org/new/es [January 2014]