Lourdes López-Pérez; María Dolores Olvera-Lobo

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2016

https://doi.org/10.25969/mediarep/11955

Veröffentlichungsversion / published version
Sammelbandbeitrag / collection article

**Empfohlene Zitierung / Suggested Citation:**
López-Pérez, Lourdes; Olvera-Lobo, María Dolores: Social Media as Channels for the Public Communication of Science: The Case of Spanish Research Centers and Public Universities. In: Kathrin Knautz, Katsiaryna S. Baran (Hg.): *Facets of Facebook: Use and Users.* Berlin: de Gruyter 2016, S. 241–264. DOI: https://doi.org/10.25969/mediarep/11955.

Lourdes López-Pérez*, María Dolores Olvera-Lobo

# Chapter 9. Social Media as Channels for the Public Communication of Science: The Case of Spanish Research Centers and Public Universities

**Abstract:** Currently, the Web is valued as a key channel in the informal teaching of science. Despite that, studies on using social media's tools for the public communication of science are still scarce. The objective of our research is to analyze how Spanish research centers and public universities used Facebook, Twitter, and YouTube to communicate their scientific results to society. Three aspects were assessed: presence (if these institutions registered a profile on social media), connectivity (followers on their public profiles), and intensity (this latter element referred to the number of publications registered on their profile during a one-month period for three consecutive years).

The methodology includes the design of an ad hoc checklist, making it possible to compile and analyze data relating to the three above-mentioned aspects. The analysis was carried out in December 2012, 2013, and 2014. From among the principal results, note that the presence of the analyzed Spanish research centers and public universities by way of channels specializing in disseminating science on these three social media websites remains incipient. Nevertheless, the general tendency is for such institutions to use these channels to disseminate their scientific production to the general public. Approximately one-third of the centers analyzed do make use of Facebook and Twitter to transmit knowledge specializing in science; approximately one-sixth do the same on YouTube.

**Keywords:** Scientific Communication, Digital press, Science Journalism, Social Media, Facebook, Twitter, Youtube.

***Corresponding Author: Lourdes López-Pérez**, Departamento de Información y Comunicación. Universidad de Universidad de Granada, Spain, lourdeslopez@correo.ugr.es
**María Dolores Olvera-Lobo**, Unidad Asociada Grupo SCImago, Madrid, Departamento de Información y Comunicación, Universidad de Granada. Spain, molvera@ugr.es

## Introduction

The emergence of the Web has returned science to the public sphere by opening a channel of interactive communication allowing for disintermediation in the conversation between scientists and society. Given the current sharp decline in scientific vocations in Europe (European Commission, 2012), social media is offered as the most prominent way to bring science closer to digital natives (Prensky, 2001). Prior to 1998, academics had not focused their studies on the Web as a channel for disseminating scientific knowledge (Eveland & Dunwoody, 1998). Its capacity to generate debate and discussion about scientific issues, however, has encouraged researchers, chiefly British and American (Delborne et al., 2011; Triunfol, 2004) to fix their attention on this source of knowledge exchange.

Currently, the Web is valued as a key channel in the informal learning of science (Eveland & Dunwoody, 1998; Lederbogen & Trebbe, 2003; Weilgod & Treise, 2004) due to its capacity to transform the process of understanding from passive memorization to active involvement (Weilgod & Treise, 2004). The research objective offered in this chapter is to study an analysis of how Spanish research centers of Consejo Superior de Investigaciones Científicas and public universities used Facebook, Twitter, and YouTube and other tools such as web logs (blogs) or news channels to communicate their scientific results to society. Essentially, three aspects have been assessed: use of the tools (if these institutions registered a profile on social media), connectivity (followers on their public profiles), and intensity (this latter element refers to the number of publications registered on a university's profile during a one-month period for three consecutive years). The methodology used includes the design of an ad hoc checklist, making it possible to compile and analyze data relating to these three aspects.

## Social Media and the Dawn of the Digital Age

Tim Berners Lee has observed the emergence of the Web in the 1990s changed the way people communicate and exchange information (Pinger, 2015). It has evolved as a living universe in which the survivors have been the fittest and best adapted to the profound change introduced by this new media (Asensi, 2013). This process of survival has been defined as "digital Darwinism" (Schwartz, 1999) and has been accentuated starting with the change from Web 1.0 to social media (or Web 2.0). During the earliest period, the Web functioned as a reading vehicle, a digital forum where information prevailed and communication was one-way. It has evolved into a socialization platform (Turkle et al., 2006), which holds a vast

store of knowledge deriving from the large amount of research and innovation produced through the talent, imagination, audacity, and intelligence of the network's users (Flores, 2009).

Castells (2001) states that with social media, the Web has globalized and encompassed the planet. Others go even further (Sáez-Vacas, 2004) and point to the emergence of the social web as the start of the digital age and of the universal digital network. The social media concept began in a brainstorming session between O'Reilly and MediaLive International in 2004 (O'Reilly, 2007). The bursting of the technological bubble and the collapse of the dotcoms in the autumn of 2001 led the companies that had survived to raise the possibility of a crucial change in the direction of the Web. With that possibility, it made sense to issue a call to action such as that entailed by social media. The response was positive, and in 2004, the social media concept began to claim an identity of its own at the *Web 2.0 Conference*. Only 18 months later, the term *social media* had become rooted in society, as observed by 9.5 million Google hits (O'Reilly, 2007).

O'Reilly (2007) gave definition to social media with the establishment of seven constituent principles: the Web as a platform, the harnessing of collective intelligence, the management of databases as a basic competence, the end of the software release cycle, the search for simplicity, software above the level of a single device, and rich user experiences. Cobo-Romaní and Pardo-Kuklinski (2007) distill these seven principles even further; they perceive them as forming an architecture of participation, intercreativity, collective intelligence, and intelligent multitudes.

Other, more simplistic definitions of social media that – while agreeing on the difficulty of putting limits on such a mutable concept – explain it by starting with three basic values: interaction, participation, and exchange. Furthermore, and in contrast to Web 1.0, social media is characterized by the services it offers rather than by the software employed, and its platforms include all the devices that can be connected to the Web, instead of only personal computers (Chen, Yen, & Hwang, 2012).

Thus, with social media, the Web was transformed into an open universe of ideas (Acord & Harley, 2013), which generated a new public space (Castells, 2001; Middaugh & Kahne, 2013; Papacharissi, 2002) for citizen participation. The idea of the network converted into a social space has also been influenced by Fumero and Genís (2007) who value its capacity to create a true society of information, communication, and knowledge.

It is a mass phenomenon (Flores, 2009) that has brought about a revolution in the field of communication (Mansell, 2002; McChesney, 2007), a space where speaker and receiver exchange roles and participate in a mutual dialog (Kiousis, 2002). In this regard, Castells (2001) speaks of the appearance of a new concept

associated with social media, "mass auto-communication": *auto* because an individual can generate the message, define the receivers, select the content, and choose the channel, and *mass* because it reaches a global audience.

Interactivity and the exchange of information are part of social media's nature as mentioned above. Interactivity describes the essence of this new media, wherein communication is a dynamic process, Also, it can be defined as the degree to which a communication technology can create a mediated environment in which participants can communicate (one-to-one, one-to-many, and many-to-many), both synchronously and asynchronously, and participate in reciprocal message exchanges (third-order dependency) (Kiousis, 2002). McMillan and Downes (2000) highlight the same concept when referring to interactivity as the possibility an individual can perform the roles of speaker and receiver simultaneously. It is participation encouraged by the possibility of producing content, whether individual (blogs) or shared (wikis), generating tags to catalogue different content, and personalizing sources of information (Alonso, Lafuente, & Rodríguez, 2008).

Christakis and Fowler (2010) broaden the definition of the concept and assert that, thanks to the Web, interacting with others is translated into enormity (referring to the vast number of people who can be reached), communality (sharing information and contributing to collective efforts), specificity (an increase in the particularity of the ties that can be formed), and virtuality (in the sense a person can have two identities – one online and another offline).

For his part, Cover (2006) insists audiences' inhabit active and creative roles. To illustrate, he draws an analogy between the function currently served by the Web and that of the theater in ancient Greece. In both scenarios, the user is an active party, with a capacity to transform the message and give it new meaning. Thus, we arrive at the creative audience of whom Castells (2001) speaks when referring to the new mass communication media whereby the dialog is horizontal. In effect, the speaker-channel-receiver process ceases to be vertical and transforms into a circle in which all roles become interchangeable, and a person finds not one but rather multiple channels, which favors information exchange (Castells, 2001).

## Tools of Social Media

Social media offers tools that can be grouped around four areas (Cobo-Romaní & Pardo-Kuklinski, 2007): 1) social media sites, 2) tools for generating content, 3) social and intelligent organization of the information, and 4) applications and

services. At the same time, we find simpler classifications (Fumero & Genís, 2007) that synthesize social media tools around three areas: 1) blogs, 2) social media sites, and 3) applications, including proposals (Flores, 2009) that emphasize only social networks and blogs as the principal symbols of sociability.

## Social Networks

This area includes tools that facilitate configuring communities and social exchange. With them, the Web is a means to consume information, but also a way to communicate, to entertain, to share experiences, content, and values, or to remain up-to-date with current information (Java et al., 2007).

In Spain, social media erupted in 2008 but did not consolidate until 2010, the year in which such sites began to form part of day-to-day use of the network and became another tool for communication. Currently, such sites rank third among the services most popular with web users, at 61.2%, behind email and instant messaging (*Asociación para la Investigación de Medios de Comunicación*, 2014).

Of the multiple social media that exist in the Web 2.0 universe (e.g., Messenger, Tuenti, Twitter, YouTube, Skype, MySpace, Flickr, Badoo, Google Plus, and LinkedIn, among others), Facebook has achieved the greatest success. This social media site created by Marc Zuckerberg in 2004 is the second most-popular site in the world, behind only Google in the rankings of Alexa (2014) and Comscore (2014). It has more than 1.3 billion users in the world (ABC Tecnología, 2014) and 18 million in Spain (Comscore, 2014), making it in both Spain and internationally, the website with the second largest audience, close behind Google.

In the context of specialist social media, YouTube has secured the highest level of social acceptance. It is the third most-visited site in the world behind Facebook (Comscore, 2014). YouTube was created by Steve Chen, Chad Hurley, and Jawed Karim in 2005, and it is the most-visited website in Spain with more than 20 million users (*Asociación de Investigación de Medios*, 2014).

The microblogging network Twitter, founded by Jack Dorsey and Evan Williams in 2006, is notable for the important role it has played in social movements and cultural transformations over the past decade. It is one of the 10 most-popular sites on the Web and saw its definitive expansion following the June 2009 election in Iran. After the news blackout ordered by the Iranian government, Twitter became the main source of information inside and outside of Iran. It already has more than 220 million users throughout the world, and reaches 10 million followers in Spain (Comscore, 2014).

Since its inception, Twitter has stolen the limelight from blogs, which had been one of the most important communication tools of social media. Twitter dic-

tates a more condensed means of communication (Java et al., 2007) and attracts more users than blogs because its use requires less of a time investment In addition, tweets are more active because they cannot exceed 140 characters, forcing authors to choose words carefully to rapidly update content at frequent intervals. This is in contrast to the more typically measured composition of a weekly or even monthly posting schedule, which in general has applied to blogs or longer-form web posts.

## Content: Blogs

This area consists of the tools that favor online reading and writing, as well as the distribution and exchange thereof. The blog, shortened from *web log*, is the tool par excellence of social media (Fumero & Genís, 2007). Blogs quickly became a key element of online culture and are considered as a chief element of knowledge exchange (Chen, Yen, & Hwang, 2012). With a popular subject, a blog can attract attention and exercise considerable influence on society. Notable examples of topics that found blog audiences include the "war against terrorism" after 11 September 2011, arguments concerning the war in Iraq, and the 2004 U.S. Presidential election (Hsu & Lin, 2006).

The success of blogs is due to several factors, for example, they are easy to use, they involve little or no cost, they are interactive, they put a human face to organizations, and they combine qualities of credibility, immediacy, directness, and "infectiousness." Furthermore, blogs are unobtrusive, can be consulted by any level of the public readership, bestow authority and influence, allow for reaching audiences who have abandoned other media, create community, contribute to increase an organization's network visibility, reinforce organizational culture, and can help keep communication flowing in times of institutional crisis.

This has boosted the development of what is known as *blog culture*, the most remarkable facets of which are the wish and the desire to share ideas and experiences (Fumero & Genís, 2007), the growing importance of knowing what others are thinking, the culture of speed, and the need for knowledge. In addition to blogs, other tools that can be integrated in the area of content management and creation are wikis, is a website which allows collaborative modification of its content and structure directly from the web browser, applications for photographs and videos, calendars, and online spreadsheets, among others.

### Social and Intelligent Organization of Information

This label includes tools and resources used to tag, syndicate (distribute content), and index information and resources available on the Web, thus facilitating arrangement and storage. Readers for Really Simple Syndication (RSS), Atom (text editor), RDF (Resource Description Framework), OPML (Outline Processor Markup Language), and the search engines as well as the bookmarks of favorites created to store, tag, and share links are deemed tools for the intelligent organization of information.

### Applications and Services

These are resources created to offer end-user services with added value; they encompass such tools as project management (used for managing and team-working), WebTop (offering the same functionalities as a desktop including information management, feeds or news readers, and communication channels), web storage (both free and at cost), and music players.

## The Web: New Portals for Scientific Communication

Prior to 1998, academics had not focused their studies on the Web as a channel for disseminating scientific knowledge (Byrne et al., 2002; Eveland & Dunwoody, 1998). Its capacity to generate debate and discussion about scientific issues, however, has encouraged writers, chiefly British and American (Delborne et al., 2011; Triunfol, 2004) to turn their attention toward this source to study its potential to function as an inexhaustible of knowledge for the multitudes (Shirky, 2010).

Scholars of public communication in science, such as Weilgod (2001), assure us that for various reasons, the Web has radically changed the relationships between the actors in communicating scientific awareness and understanding. First, the Web allows scientists and their organizations to communicate directly with their audiences. Furthermore, it eliminates time and space restrictions inherent to traditional media. At the same time, it combines the in-depth capacity of the published press with opportunities to interact and communicate with users via social media. Finally, it facilitates instantaneous communication one to one, one to many, many to one, and many to many.

Thus, the Web has returned science to the public sphere. After more than a century of isolation, scientists are back before the public. This time, the process does not involve mere spectators who attend the presentation of science, but rather includes active agents who can learn, evaluate, assess, share, participate, and decide (Brossard & Schefeule, 2013).

The social web has allowed for disintermediating public communication in science, reviving the ideal of the democratization of knowledge, bringing down the scientist from an inaccessible ivory tower and into an agora open to citizens (Baron, 2010; López-Pérez & Olvera-Lobo, 2015; Olvera-Lobo & López-Pérez, 2013a, 2013b, 2014). In the past decade, many writers have listed the possibilities offered by the Web for a communication of science that is not only public, but also academic. In short, the shockwave from the network has permeated the entire research and development system, from brainstorming to scientific production, passing, of course, through assessment and dissemination.

Valued as key channels for informally learning science (Eveland & Dunwoody, 1998; Lederbogen & Trebbe, 2000; Weilgod & Treise, 2004), scientific websites can transform the process of understanding from one of passive memorization to active involvement (Weilgod & Treise, 2004). In this regard, while young people use the Web mainly for entertainment (Ferguson & Perse, 2000), they occasionally do search it to obtain additional information for their academic tasks. Thus, what at first functions as an educational resource can later become a repeat-visit site, provided it is adapted to digital natives' concerns and forms of communication (Weilgod & Treise, 2004).

The Web is put forward as a means to accelerate the urgent need for dialog between scientists and the public (Lederbogen & Trebbe, 2000) and as having the capacity to eliminate belief in the magical abilities of scientists, while achieving greater public support for research through knowledge and mutual trust. Science websites thus constitute important tools in curbing scientific illiteracy, promoting positive attitudes toward science, and fostering scientific vocations (Ebersol, 2000). In this sense, the frontier between professional communication and conversation with the public has been made much more permeable by the Web, facilitating society's access to a course previously private and favoring the "disintermediation" of science (Trench, 2008).

Mainstream media are not the only parties responsible for the scientific culture and education of citizens. Now, researchers and public institutions can accept more easily roles in taking the conversation about science into the public sphere (Batts, Anthis, & Smith, 2008; López-Pérez & Olvera-Lobo, 2015; Olvera-Lobo & López-Pérez, 2013a, 2013b, 2014). Nevertheless, they must do so in an open and accessible way. Although it is true that on the Web, what goes on behind the scenes in science and discovery remains to be revealed, all too often

the process of scientific production is presented as a dialog encrypted in the specialist language of the experts, continuing to be inaccessible to the layperson.

Specifically, results from comparable papers in Germany and Poland (Jaskowska, 2004; Lederbogen & Trebbe, 2003) conclude the majority of universities and research centers use websites more to promote themselves before professional and commercial audiences than to share information with different social groups. Yet it is essential that scientific organizations use their websites to communicate science to every member of the public. A notable example can be observed in the approach taken by the U.S. Aeronautics and Space Administration (NASA) (http://www.nasa.gov) and its channels that are specialized, depending on toward which segment of the public the information is aimed – general society, educators, and the media (Weilgod & Treise, 2004).

## The Potential of Social Networks: Twitter and Facebook

As opposed to the numerous papers focusing on blogs and their dual function as means of communication inter pares and between scientists and society, we found few references to the other worthy tools of social media. Studies analyzing the role of social media sites, such as Facebook and Twitter, concerning the democratization of scientific knowledge (Kouper, 2010; Waters, 2000) are scarce. Indeed, the meager existing scientific literature concentrates principally on Twitter's potential to improve social communication of health-related subjects. In this regard, writers such as Hawn (2009) note the ease with which this microblogging network can be accessed and used, making it a vital channel not only for dissemination but also for citizen participation and the evaluation of research in the health field.

From the point of view of both user and producer of content, microblogging facilitates rapid, daily publication, and requires only a few minutes from the user to read or consume the message. In contrast, the extended temporality of blogs may require greater effort on the user's part and thus can reduce their ability to attract a wider public audience. The microblogging site Twitter contributes to increasing the visibility of scientific production (Shuai, Pepe y Bolen, 2012). It has demonstrated considerable capacity as a loudspeaker for disseminating information and knowledge among experts, such that communication through Twitter makes it up to 11 times more likely that an article will be citedT (Shuai, Pepe y Bolen 2012).

In the Spanish case, research into evaluating the Web as a channel for public communication in science has centered on the public itself and the ways its members use the network to inform themselves about the discipline. To date, academic studies undertaken in this field have not addressed how or whether Spanish scientists are using social media tools to explain their research results to citizens.

However, data obtained from the *Encuestas de Percepción Social de la Ciencia y la Tecnología* [Social Perception of Science and Technology Surveys] (*Fundación Española de la Ciencia y la Tecnología*, 2011; 2013) emphasize the value of social media and its tools in communicating science to youth, most of whom – some 75 % in 2010 and around 84 % in 2012 – turn to the Web to inform themselves about science and technology (Vázquez, 2013). Regarding the channels most often accessed to gain information about science through the digital universe, the observed influence of social networks, blogs, and specialist media has increased, while the impact of generalist media has decreased.

This is beneficial for not only the young but also the population in general, whose members point to the Web as their primary source of scientific information. Some 40.9 % of respondents in the 2012 *Encuesta de Percepción Social de la Ciencia y la Tecnología* turn to the Web to learn about the latest advances in research, compared with 31 % who prefer television, which is far removed from the general information dailies turned to by 7.9 % of citizens. As with young people between 14 and 25 years of age, the penetration of social networks, blogs, and specialist media has increased, while that of generalist media has declined.

Thus it appears reasonable to assert that social media and its tools must present themselves as an absolutely essential way for public institutions to communicate their scientific results to citizens (Moreno, 2013). Doing so could also lead to overcoming one of the chief handicaps various writers point out when discussing the possibility of using the Web to publicly communicating scientific information: namely, the lack of expert vetting that determines the veracity of opinions and assessments about the research being presented (Moreno, 2013; Vázquez, 2013).

## Materials and Methods

The larger part of Spanish scientific production is carried out in public research centers integrated into the public universities and the *Consejo Superior de Investigaciones Científicas* [CSIC]. To extract results from the state sector grouping, we selected the 132 research centers, institutes, and units that make up the CSIC and

the 50 public universities that provide education in the different regions of Spain (Ministerio de Educación, Cultura y Deporte, 2012).

The choice of public universities meets our interest in homogenizing the study subject and avoiding any biases that might be brought about by the manifest differences between public and private universities. At the same time, we consider it is public universities that, by their very name, should uphold the greater social responsibility in everything referring to publicly communication scientific knowledge. The selection of public universities corresponds to the selection established by the Ministry of Education, Culture, and Sport (2012).

The analysis was carried out over three periods: from 1 to 31 December 2012, 2013, and 2014. The same month in three different years was chosen to determine the development undergone by the centers in the preceding 12 months as well as to use in analyzing any future trends that might be deduced.

## Methodology

The analysis was performed with regard to the prior design of an ad hoc checklist and was structured around three areas of analysis: tool use, connectivity, and intensity (see Table 1).

**Table 1:** Ad Hoc Checklist to Analyze CSIC Research Centers and Public Universities.

**General information**

| | |
|---|---|
| Name | |
| Scientific subject | |
| Date of analysis | |
| URL of site | |

**Web 2.0 tools**

**Content**

| | | |
|---|---|---|
| Blogs | Yes | No |
| | Nº | |
| Monthly posts | Nº | |
| Dissemination channel News channel | Yes | No |
| Monthly news items | Nº | |

**Social networks**

Use

| | | |
|---|---|---|
| Facebook | Yes | No |
| | Nº | |
| Twitter | Yes | No |
| | Nº | |
| Youtube | Yes | No |
| | Nº | |

Connectivity

| | Number of followers |
|---|---|
| Facebook | |
| Twitter | |

Intensity

| | Number of followers |
|---|---|
| Facebook | |
| Youtube | |
| Twitter | |

| | Research areas |
|---|---|
| News channels | |

Dissemination of research

| | | |
|---|---|---|
| Facebook | Yes | No |
| | Nº | |
| Twitter | Yes | No |
| | Nº | |
| Youtube | Yes | No |
| | Nº | |

**Intelligent organisation of information**

| | | |
|---|---|---|
| RSS channel | Yes | No |
| Applications or services | Yes | No |

The tools studied were blogs and news channels; the social media sites Facebook, Twitter, and YouTube; and content syndication channels and other applications (apps) that include video and audio players, among others types. In this regard, it is important to note that profiles dedicated exclusively to scientific dissemination were those chosen for our analysis.

Connectivity has been evaluated by quantifying the number of followers of the two social media sites Facebook and Twitter, which takes into account an indicator of communication effectiveness. In other words: a bigger audience leads to greater effectiveness.

Regarding intensity, this refers to the number of publications available on the social media sites Twitter, Facebook, and YouTube. This area includes quantifying the number of publications destined specifically to disseminate research accomplished by the center. As with connectivity, this value also allows us to infer effectiveness: the greater the number of publications that communicate the research undertaken by the centers, the more effective is the channel and the greater the impact it can have on society.

# Results

## Public Universities

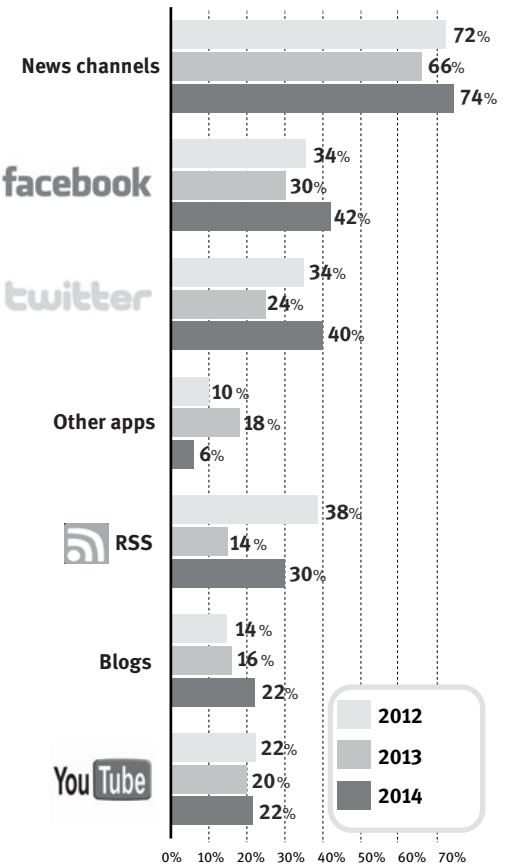
**Use of tools.** Spanish public universities are aware of the Internet's importance as a means of disseminating science: 70 % of them have a channel specifically for disseminating scientific knowledge, a value that was consistent across the three periods we analyzed.

News channels are the tool most widely used by universities, and the least used are other apps and blogs. Although the percentage of centers using the latter – which is considered one of the main channels of dissemination – is low for the three periods analyzed, it is interesting to highlight the progressive trend in its use since 2012, when only 14 % used it, and observing its rise to 22 % in 2014.

*This increase is significant because it shows the tendency of universities to consider this tool as an effective means of making their research work* publicly *available*. This general trend is upward in terms of social media tool use if we examine data from 2012 and 2014. On the other hand, 2013 was a bad year for universities, as they made less use of all of the channels studied with respect to the previous year. This trend changes significantly in 2014, particularly on networks such as Twitter, which went from being used by 34 % of universities in 2013, to 40 % in

2014. It is difficult to explain why it happened but we can speculate that this situation it should be a result of the economical crisis that Spain is suffering currently.

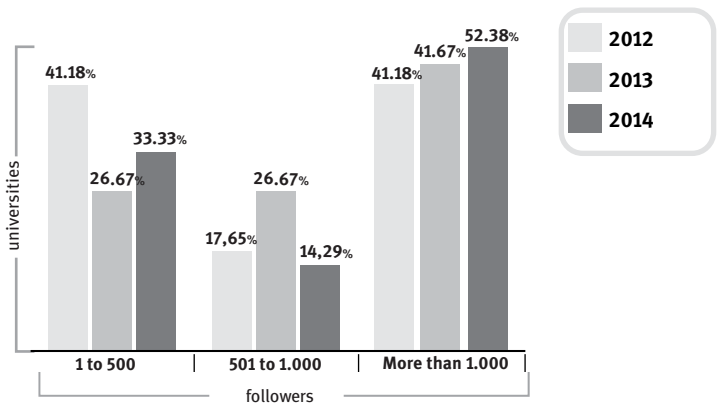
Of participants, 42 % also use Facebook, and YouTube remained at around 20 % over those three years. This shows that, despite the economic crisis affecting the Research, Deployment and Innovation system, universities are starting to realize these channels' importance in bringing the universities' work closer to the general public and, above all, to young people in particular. The latter are, after all, a university's target audience (see Graph 1).



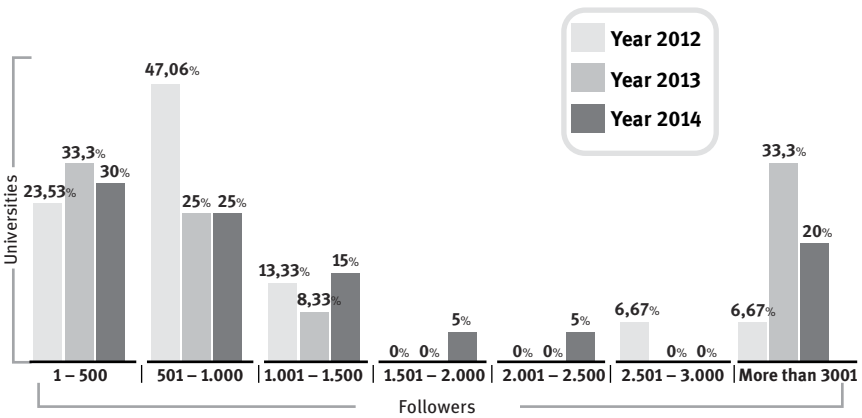

**Graph 1:** Use of Social Media Tools in Spanish Public Universities.

**Connectivity and intensity.** Although it is true the majority have a greater presence on Web 2.0, this presence is not effective if we take into account data on connectivity and intensity. More than a third of universities have fewer than 500 followers each Facebook and Twitter. Although the remainder, approximately 70 %,

exceed this number, none has more than 10,000 followers on both Facebook and Twitter in the three years analyzed. This could indicate that, although university faculty and staff may avail themselves of these tools, they are not creating effective outreach strategies that attract the public. In this regard, it is important to point out the difficulty of finding social profiles dedicated to popularizing science on the universities' websites. They were not provided on the homepage in any of the cases, and many of them could not be located, even on pages devoted to university research. We were compelled to look in other subsections, such as the Office for the Publication of Research Results or the Scientific Culture department to find them.




**Graph 2:** Evolution of the Number of Spanish Public Universities According to Facebook Connectivity.



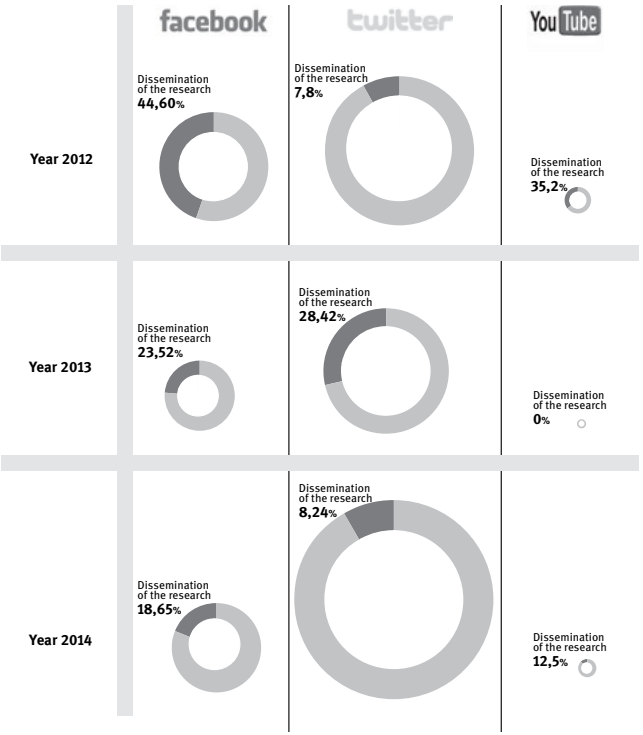

**Graph 3:** Evolution of the Number of Spanish Public Universities According to Twitter Connectivity.

Such a *lack of visibility undoubtedly makes increasing the number of followers* a challenge, *as most of the time*, *users* must execute *a selective search to* locate *these profiles*. Making the effort to maintain a Web 2.0 presence and to feed the various channels is of little use if nothing is then done to ensure people know they exist. One of the main advantages of social media is their ability to reach a large section of a heterogeneous audience simply and directly. If this cannot be achieved, it makes little sense to expend resources to create channels at all.

Furthermore, it should also be noted that, although these channels are specifically for scientific outreach, the percentage of research results being published is very low across all available tools (López-Pérez & Olvera-Lobo, 2015; Olvera-Lobo & López-Pérez, 2013a, 2013b, 2014). News channels barely exceed 30 %: on Facebook, the share is around 20 %, and on Twitter, it varies between 10 % and 30 % (see Graph 4). In the case of YouTube, the result is the same, both in terms of content publishing in general, and of specific information on the research carried out in particular. This may be due to the complexity and quantity of resources necessary to create audiovisual content.

We found that public universities are not harnessing the communication potential of social media tools to make their research work public. Rather, they use them to highlight outreach activities, such as congresses and conferences. Finally, while they work on outreach, they do not explain what scientific results are being obtained via the expenditure of public funds. This is a critical process not only for gaining public support but also because doing so might encourage the development of R&D&I, and, as public institutions, they are obligated to keep society informed.

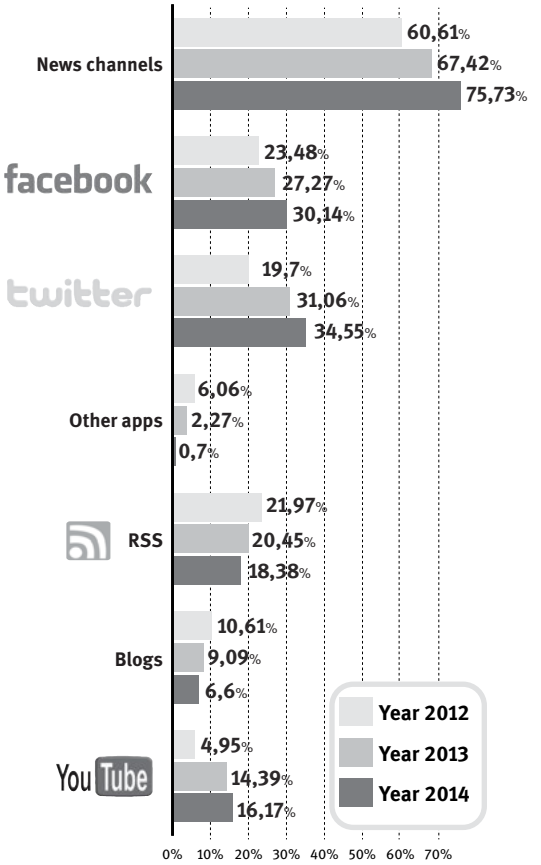
Biology and biomedicine are the subjects most often featured. Universities pay attention to topics of the greatest interest to society – in this case, health. In other words, we could state that in some way, the universities themselves are contributing to this "medicalization" of scientific information by giving more prominence to this area over others. Finally, we want to note universities in Andalusia and Madrid are those most often using Web 2.0 tools to broadcast scientific content to society at large, and to the younger generations in particular.




**Graph 4:** Dissemination Intensity of Spanish Public Universities' Research on the SNSs Facebook, Twitter, and YouTube.

## CSIC Research Centers

**Use of tools.** The general trend in the case of Consejo Superior de Investigaciones Científicas centers is positive in terms of the use of Web 2.0 tools (López-Pérez & Olvera-Lobo, 2015; Olvera-Lobo & López-Pérez, 2013a, 2013b, 2014). This points to a promising future and is indicative of the growing interest that CSIC centers are showing in publicly communicating scientific discoveries. In fact, in 2014, more than one-third of centers had both Facebook and Twitter profiles, and 78.7 % had news channels. However, the use of blogs is still very uncommon (see Graph 5). The constant updates this resource requires, along with the effort to make content more complete and complex, may be slowing this tool's growth.



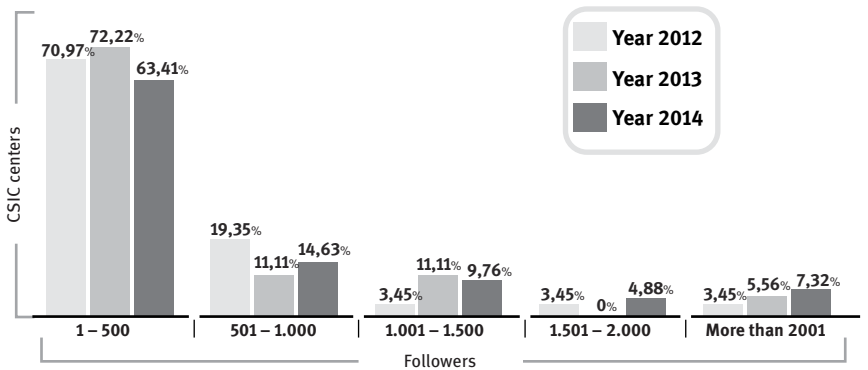

**Graph 5:** Use of Social Media Tools by CSIC Centers in Spain.

It should be noted that CSIC has had an institutional blog since 2014, which it publishes in the digital edition of the *20 Minutos* newspaper. In addition, it has listed the personal blogs of Council researchers – a total of 25 – on its website (www.csic.es) since the end of 2013. This demonstrates the Council's interest in this tool.

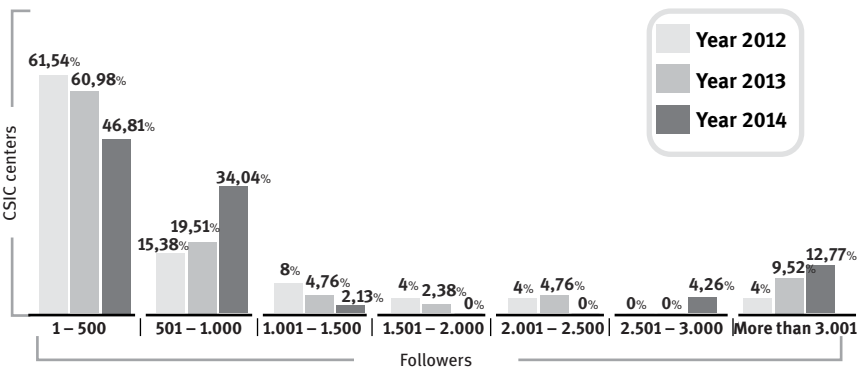
Moreover, we should also add the institutional profiles of the Consejo Superior de Investigaciones Científicas as an organization. It has two Facebook profiles, one general and another specifically for outreach, along with two Twitter profiles. It also has both a YouTube and a news channel. The profiles of the CSIC Delegation in Andalusia and the Casa de las Ciencias [House of Science] museum in Seville on both networks are noteworthy as well.

**Connectivity and intensity.** Although the trend in tool use is an upward one, connectivity continues to be very low. Many of the CSIC Centers have less than

500 followers on both Twitter and Facebook 500 followers in Facebook and Twitter (see Graphs 6 and 7). These values remained constant over the three years analyzed despite the passing of time, which undoubtedly helps to increase the number of users. This may suggest, as in the case of the universities, a lack of an outreach strategy for these profiles. In many cases, their lack of visibility on the centers' homepages and websites may also be having an effect. They are often placed in subsections or spaces users may find tedious to locate, such as at the bottom of a web page.



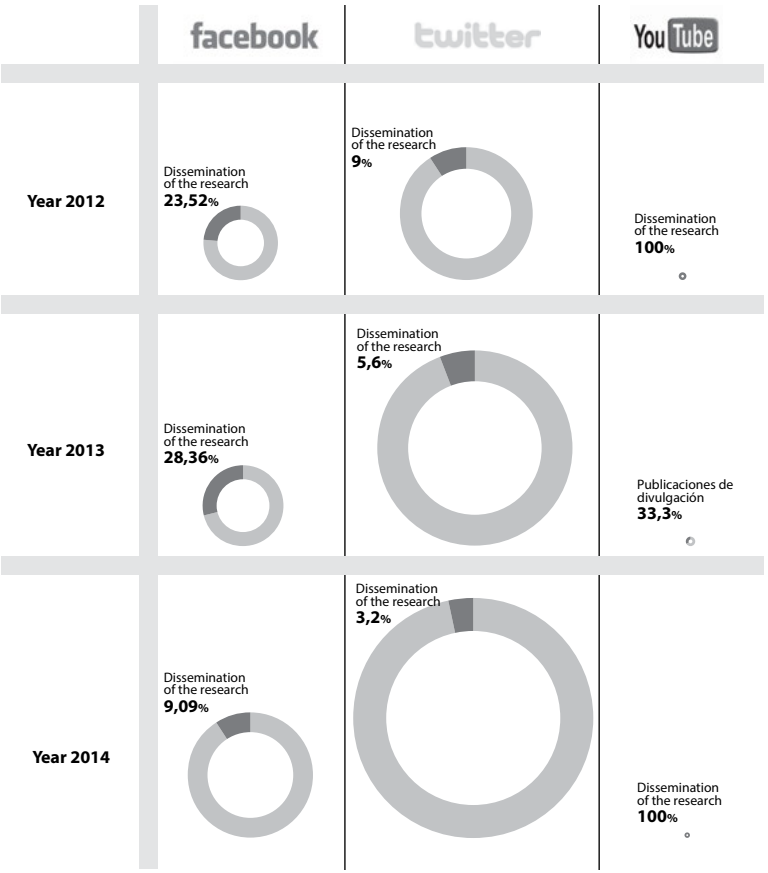

**Graph 6:** Evolution of the Number of CSIC Centers According to Facebook Connectivity.




**Graph 7:** Evolution of the Number of CSIC Centers According to Twitter Connectivity.

Furthermore, the lack of followers may also suggest that, although the centers are increasing their presence on Web 2.0, doing so may be aimed more at attracting experts in the same field than the wider public. In any case, having a presence is of little use if it has no effect. In this regard, the Senior Scientific Research Council

is already helping to publicize these profiles by including on its website a section entitled "Social Networks," which publishes links to the centers' social profiles.




**Graph 8:** Dissemination Intensity of CSIC Centers' Research.

This strategy will undoubtedly help attract followers, but the centers themselves must consolidate their presence on Web 2.0 with more effective communication strategies. In many cases, this lack of interest is due to resource shortages and even a lack of responsibility in disseminating scientific results. Although the number of followers is increasing, the centers' social network profiles face another handicap: their scant use of these tools to publish scientific results. As explained in our results, over the three-year period of our analysis, comments aimed at disseminating research barely account for 10 % of the total (see Graph 8). Therefore, the initial objective of these new channels, which may be to allow

centers to fulfill their social responsibility of informing the public where public funding is being invested, is not being met. Rather, the sites are being used to advertise congresses, conferences, outreach activities, and the like, as we have observed occurring with the universities.

In sum, it appears universities have not yet moved away from the concept of public communication of science as a one-way dialog. It continues to be treated in the traditional manner: experts teaching a lay audience about science, instead of using their discipline to create a dialog in which they relate what they are doing, so their public can participate in the process and assess progress. Regarding those sub-disciplines exhibiting the highest level of Web 2.0 presence, centers whose work belongs to the areas of the physical sciences and technologies show the most interest in using these tools, followed by those in environmental and natural resources, and biology and biomedicine. This accords with what we learned about universities. In any event, future trends must aim at increasing not only the use of the tools, but also the connectivity and intensity of comments aimed at disseminating research results.

## Discussion and Conclusions

The results we obtained regarding social media tool use unfortunately paint a somewhat colorless picture for the public communication of science in Spain. Although public universities and research centers are starting to positively exploit the Web's potential to establish a "dialog" with the public, this process has not been as productive as it could be – either in terms of interactivity (due to the low connectivity shown by social network profiles), or in disseminating scientific results, which account for a small fraction of published content.

While a tendency toward using these tools is on the rise, the effectiveness of the communication they enable has remained low despite the number of years that have passed. This calls into question specifically how centers and universities are exploiting this important channel's potential. It thus leads to recommendations and strategies for public universities to focus their efforts more intently on achieving one of the objectives for which they were originally conceived and designed: none other than ensuring the importance of scientific culture and awakening society's interest in general, and young people's in particular, in science.

Although it is not our study's purpose to make recommendations, we would like to suggest some strategies that can be implemented immediately and easily. The main one is to make specialist profiles for scientific outreach visible on the

homepages of centers and universities. This simple action certainly would help increase connectivity.

As the Consejo Superior de Investigaciones Científicas has done, Spanish public universities should gather and register the science blogs created by their researchers on their websites. To give these blogs credibility, both CSIC centers and universities could create universal designs identifying the institution supporting the published content. This would not only help manage the information that reaches the public, but also create reliable information sources for scientific journalists to use and to which they could cite and track back on their own websites.

Concerning those disciplines figuring most prominently in Web 2.0 communication channels, centers in the areas of physical sciences and technologies exhibit the greatest interest in using these tools, followed by centers in the areas of environmental and natural resources, and biology and biomedicine. These are, in short, disciplinary areas repeated at the universities and research centers. One wonders whether society is more interested in these subject areas than in others and whether universities thus make greater efforts in communicating their research in science because they know a willing audience awaits; or is it the opposite effect at work: Has the effort to communicate caused society to be more interested in these subjects?

In any event, following our analysis, we believe it is clear that aiming not only to increase tool usage, but also to raise connectivity and intensity of the comments – both of which work in tandem to disseminate research results – ought to be a primary goal for any future such efforts, for both universities and research centers.

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