Impact of Ibero-American science and technology in Twitter

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Abstract
Introduction. The information published on the Internet is surrounded by a turbulence that makes it unquantifiable. Therefore, the analysis of this ocean of information requires its breakdown into specific areas and categories. In this sense, the dissemination of information on science and technology through Twitter is the object of this research study. **Method**. The objective is to determine the importance acquired by social networks in the dissemination of science and technology information and their influence in the democratisation of information. The study is based on social network analysis, which allows us to visualise through graphs each of the connections and communities that exist in these entities. **Results**. The study took into account the analysis of the Twitter accounts of 31 Ibero-American organisations in order to identify the kinds of information they disseminate and to determine whether these organisations perform their main function: the dissemination of science and technology generated by scientific institutions and researchers. **Conclusions**. There is a growing use of Twitter as a source of science and technology information, according to indicators of quality, quantity, and the use of resources such as: links, images, text, video, etc. Twitter is used by Ibero-American organisations according to the possibilities of the content they generate. The use of Twitter by these institutions is progressive, but their content is purely institutional.

Keywords
Twitter, Social Network Analysis, Science and Technology, Ibero-America.

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1. Introduction

The network of networks, the Internet, "reflects people's ability to transcend institutional rules, overcome bureaucratic barriers and subvert the established values in the process of creation of a new world" (Castells, 2001). Since 40 years ago, after ceasing to be exclusive to military actions, the Internet has been evolving and reaching more users, becoming part of unimaginable processes in society.

Manuel Castells (2003: 17) defines the Internet as "a medium of communication that, for the first time, enables communication from many to many in a chosen time and on a global scale". The author warns that the influence of the Internet transcends the number of its users, i.e., what matters is the quality of the use. While the Internet is a set of networks of interconnected nodes [1] that efficiently link the information shared by users, the relative importance of a node does not lie on its special features, but on its capacity to contribute to the effectiveness of the network to achieve its goals, defined by the values and interests that are programmed in the networks (...). Nodes exist and function exclusively as components of networks. The network is the unit, not the node (2003, p. 45).

According to Fritjof Capra (1996: 100) the relationship between a network and life forms is glaring: "the network is a pattern that is common to all life. Wherever we see life, we see networks"; the formation of networks is present since the beginning of humankind (formations of clans). To understand this statement, we have to identify the three fundamental traits that make the work of a networking efficient (as an organisation), and whish also constitute the basis for the development of technology: flexibility, adaptability and self-reconfiguration capacity.

According to Trejo Delarbre (2006: 219), the Information Society leads to one of the implacable tensions between consumers and citizens; since there is a counter-position that shows open participation and acceptance of the network. Having said that, some corporations see the Information Society as the anchor to think, feel and act as consumers. In contrast, others corporations consider that there is an open, participatory and heterogeneous nature that projects the citizen within the information society. Undoubtedly, what is experienced in the networks is, in principle, a nomad society that wanders from one site to another, never settling in one place, because the sense of journey across the cyberspace lies in the possibility of constant and rushed movement.

Three conditions must be met in order to set a growing pace in technological processes, specifically on the Internet: *first*, the network architecture must be open, decentralised, freely distributed and multidirectional in its interactivity; *second*, all communication protocols and their development must be open, freely distributed and subject to change (which depends on its creator), and *third*, the institutions that manage the network must be in accordance with the principles of transparency and cooperation that are inherent to the Internet. In this way, the contribution of users is crucial in the production of content (understood, as texts, images, applications, etc.), since they adapt it to their own uses and values and, in turn, can transform technology (Castells, 2001: 11)

In order for these conditions to be met, it is essential that there are better forms of access to the Internet (infrastructure, costs, education, culture, policies, etc.) in the various regions of the world and especially in Latin America. Its expansion around the world is unmeasurable. While in early 2000 only few countries had open access, research shows that there has been growth in certain continents, such as Africa, with 28.6%, and Latin America and the Caribbean, whose connectivity annually grows 55.9% (Table 1).

Table 1. Use of the Internet worldwide

CONTINENT	Population	Users	Penetration (%)	Users (%)
Africa	1,158,355,663	330,965,359	28.6%	**9.8%**
Asia	4,032,466,882	1,622,084,293	40.2%	**48.2%**
Europe	821,555,904	604,147,280	73.5%	**18.0%**
Middle East	236,137,235	123,172,132	52.2%	**3.7%**
North America	357,178,284	313,867,363	87.9%	**9.3%**
Latin America / Caribbean	617,049,712	344,824,199	55.9%	**10.2%**
Oceania Australia	37,158,563	27,200,530	73.2%	**0.8%**
World total	**7,259,902,243**	**3,366,261,156**	**46.4%**	**100.0%**

Source: Authors' own creation with data from http://www.internetworldstats.com/, updated on 30 November 2015 and revised in April 2016.

Sociologist Giddens (2009) quotes Lilley (2004) who pointed out that since the appearance of information technologies, lax and relatively informal connections acquired greater prominence in the organisation of society, facilitating the creation of networks of individuals, and more effective and global groups and organisations. Taking into account that the Internet is open to traditional media (press, radio, TV), industrial, financial and commercial companies, and to advertising, leisure, and governments, international crime, schools, churches, research centres, private citizens, etc., the role social networks play in the dissemination of good and evil has promoted the creation of new strategies to address social problems.

Figure 1. Internet penetration in Latin America
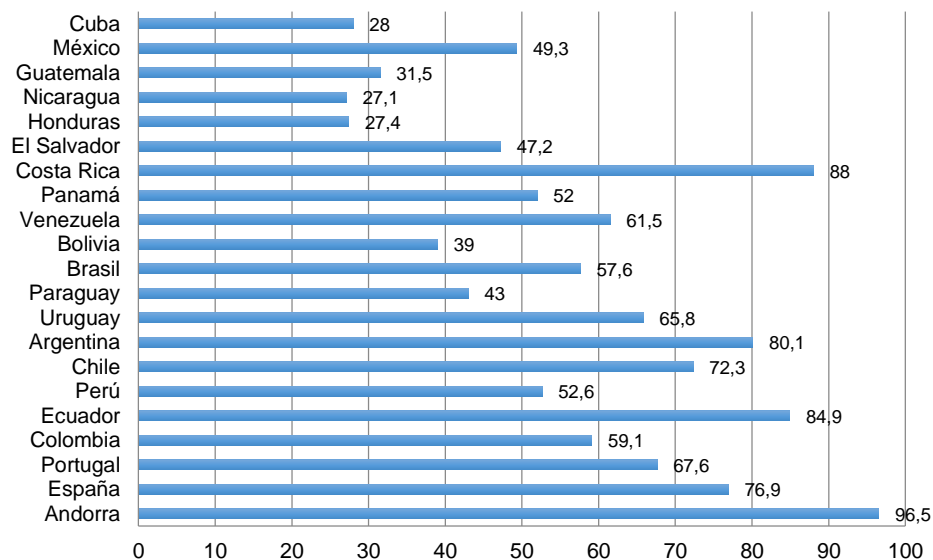
Source: Authors' own creation with data from http://www.internetworldstats.com/, last updated on 30 November, 2015.

Anglo-Saxon scholars have used Twitter to measure the impact [2] of a diversity of publications [3]: political, economic, social [4], academic [5], sentimental [6], etc. The analysis of data through Twitter involves a high number of participation (tweets, retweets, favourites) and interaction. The analysis of Twitter does not focus on small sectors, but on a great group during certain periods.

For data collection we took as reference the Ibero-American General Secretariat (2014), which is defined as "an association of free, sovereign and equal nations, capable of helping build a future based on democracy and development, while maintaining a shared ethnic, cultural and linguistic diversity. The Ibero-American Community is composed of 22 Spanish and Portuguese speaking countries of Latin America and the Iberian Peninsula, which altogether represent, on average, 10% of the planet in territorial, demographic and economic terms".

Through the study of Twitter accounts specialised in science and technology (S&T) of Latin American we can analyse and determine how Twitter [7] can be used to disseminate S&T information. In the region, there are few studies in this field. The research evaluates the level, scope and type of scientific and technological information that is transmitted or not by Ibero-American entities focused on R&D.

This study is based on the analysis of one of the most important microblogging services in these last eight years, Twitter. Many have seen great potential in this tool because it allows greater democratisation of communication; thanks to the opportunity of participation, access and immediacy in the reception and transmission of information in 140 characters, thus fulfilling the communication process.

1.1. Web 2.0 and social networks
1.1.2. The social web

The Web becomes important for the sectors dedicated to technological research, looking for the possibility of a shift in the terms of use, techniques and access. For this reason, the Web 2.0 is designed to be used by anyone. Blogs, wikis, social networks [8] and other tools, promote the participation and collaboration of users who simply share their life through texts, photos, videos, and even their favourite websites. In itself, the social web is a revolution of business related to computers industry, as a consequence of the arrival and evolution of the Internet as a platform.

The conception of the Web 2.0 is surrounded by significant points of interest, such as control of contents [9] by the user, consumer, producer or prosumer [10] of contents. With the advent of the Social Web or Web 2.0, promoted by O´Reilly [11] and his team in 2004 [12], also emerges [13] the questioning of the the real WWW (World Wide Web) and its involvement with the society and particular with the Internet user. The difference lies in the participation of users, either through the contribution of their knowledge, their active involvement through social networks, or through their building of an "architecture of participation" (Cobo Romaní & Pardo Kuklinski, 2007)

O'Reilly's theory of participation is based on authors who developed concepts around the idea of open knowledge: Inter-creativity (Berners-Lee, 1996); collective intelligence (Levy, 2004); smart mobs (Rheingold, 2002); the wisdom of crowds (Surowiecki, 2004) and architecture of participation (O'Reilly, 2005). In this way, O'Reilly showed that participation is manifested in several areas of human life.

Cobo and Pardo Kuklinski (2007, p. 63) propose four main lines to best consolidate the resources immersed in the Web:

1. *Social Networking*: refers to all the tools designed to create spaces that facilitate the creation of communities and forms of social exchange. Since their expansion they became known as the "new public square" [14], where communicative agents gather to discuss diverse issues related to their common interests.

2. *Contents:* these are determined by tools that promote online reading and writing, distribution and exchange. In a near future, content will change, depending on the platform for which it will be identified: computer, mobile phone, tablet.

3. *Social and intelligent organisation of information:* Tools and resources to tag, organise, and index information, which facilitates the ordering and storage of information and other resources available on the net.

4. *Applications and services (mashup):* these are determined by various tools, software, online platforms and more resources created to offer added value to the end user.

Social networks, content, collective intelligence and their applications evolve along with the needs of users, who are the ones present in the technological atmosphere. Along the lines of Cobo Romaní & Pardo Kuklinski (2007, p. 110), Leandro Zanoni (2008, p. 21) argues that "beyond technical advances, the main difference of this new Internet, with respect to the previous one, is that every human being today is an essential part of the information society. Users abandon their passive role towards content and uses the network to provide and share contents. Communities and interaction within social networks resulted in a resounding change of paradigm".

1.1.3. Social networks

The actor-network theory formulated by Bruno Latour (1993), John Law and Michael Callon, who considered that a company (community or organisation) is not composed only of their physical structure and workforce, goes beyond and proposes it is a conjunction of elements interconnected as a network of actors. "The popular myth says that networks are powerful, global, fast and cheap (...) is not necessarily true. Our networks can be frustrating, expensive, and unreliable connections that interfere with useful work" (1995, p. 231). The transformation of the media and of the way people have been gradually empowered, is manifested itself in the creation of technologies focused on improving communication. Proof of this are the tools and applications that have emerged as a result of the boom 2.0 [15]. As we have seen, they let users generate content and community around networks (technical as structure and physical as background) with diverse functionalities.

For Hansen, Shneiderman & Smith (2010: 11), social media and new technologies of collaboration are one of the wonders of our time, a technological development without precedents that support social interaction; generating new forms of work, leisure, and learning, leaving an undeniable mark on all levels. It is a network of millions of people weaving connections with email, Twitter, SMS, photos, podcasts, video, blogs, wikis, virtual reality games and social networking sites like Facebook and MySpace, which are used to connect with the world and especially with their acquaintances. Currently, access to these tools is occurring more and more through mobile devices.

Castells points out that information is the key ingredient of social organisation, and the flows of message and images from some networks to others constitute the basic fibre of the current social structure (2002: 514). Without information (understood as content) it is impossible to sustain one-way nor two-way interaction between people. In this sense, Armand Mattelart argues that the discourses that accompany the information society have risen the principle of clean slate to the status of law (2007: 178).

The formation of communities or cyber-communities is present in the network. Christakis & Fowler (2010: 26-27) define them "as a group of people who are much more interconnected with each other than with other groups of people connected in other parts of the network. Communities are defined by structural connections and not necessarily by any particular feature that can connect their members with each other. In other words, a social network is an organised group of people forming two types of elements: human beings and connections between them. These evolve organically from the natural tendency of all people to establish relationships and to make few or many friends, to have a big or small family and to work in places where dull or cosy relationships are established."

1.1.4. Microblogging: Twitter

Among the web services and tools offered in recent years, one that was launched in 2014 became one of the most popular and a symbol of immediacy: the microblogging network Twitter. *The digiactive guide to twitter for activism* defines this service as: "a microblogging service that enables its users to publish short messages, up to 140 characters in length, on a personalised news feed..." (Jungherr, 2009)

The use of mobile devices plays a valuable role in immediacy. These devices are used to send texts, images, videos and reports from the scene. López and Otero (2007, p. 9) indicate "that despite the new channels and the increased offer, users remain in need of qualitative information in a scenario characterised by an abundance of information products that are not always what they demand". This is why the use of tools 2.0 has become of great help and an opportunity for their users to engage in communication, business or leisure. Instant messaging (Gtalk, MSN, Yahoo Messenger); networks: (Facebook, Hi5) and microblogging networks (Twitter) enable people to obtain news immediately, and to have facilitated communication between organisations, journalists, editors and sources of information, among others.

Microblogging sites, such as Twitter, create interesting and varied structures of social networks. The most obvious network is the one created by "*follows*" and "*followed by"*. Unlike Facebook, these relations are potentially directed: you can follow people that you do not follow you and vice versa. This is in contrast to the non-directed links present on Facebook and LinkedIn (Hansen, Shneiderman & Smith, 2010: 23)

1.1.4.1. The anatomy of a tweet

According to its creators, Twitter [16] is a microblogging service that helps people create and share ideas and information instantly. It is the easiest way to follow the trends, stories and news. In addition, it allows users to keep in touch with people who are not close: friends, family, co-workers, etc. In order to understand the role of Twitter and specifically of a Tweet [17], it is important to identify the elements that comprise it: A) *Tweet*: a message, of up to 140 characters in length, sent through Twitter; B) *Tweet, tweeting, tweeted*: to post a message via a *Tweet*.

Figure 2. The anatomy of a tweet
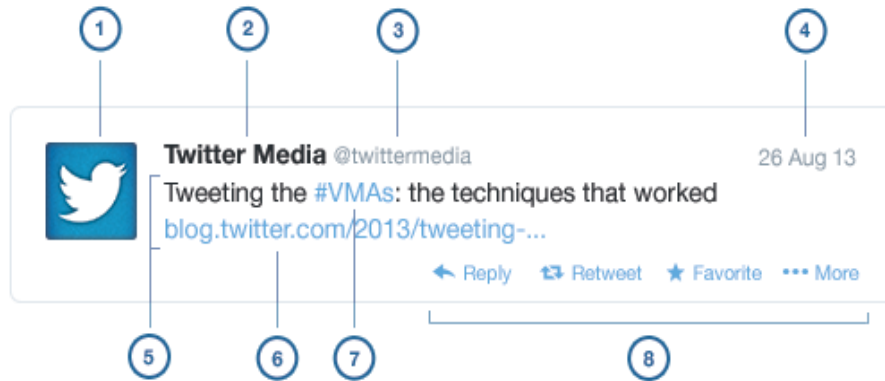
1. User's Twitter avatar: Personal image or avatar uploaded to the Twitter profile.

2. Tweeter's name: The name or nickname of the account. You can use a real name or other information

3. Twitter username/handle: the @username is the only identity disclosed by Twitter. Usernames cannot be repeated.

4. Time/date of tweet: indicates when the tweet was sent. When the date/time is clicked on, the user is taken to a unique web page where the tweet stands alone.

5. Tweet text: one tweet cannot exceed 140 characters in length, the right length for an idea, a title, an observation or an opinion.

6. Shortened URL: allows users to post links to other web sites, articles, photos, videos, or gifs

7. Hashtags: the hashtag is a word or phrase with the symbol # at the beginning. For example: #science. This symbol turns the word into a link, making it easy to find and to follow a conversation on that topic.

8. Tweet options: allow users to reply a tweet, retweet and mark a tweet as favourite.

2. Methods

The objective is to identify and analyse the Twitter accounts of science and technology institutions in Latin America. Social Network Analysis is used for this purpose. The initial hypothesis is that the use of Twitter is growing as a source of science and technology information, and that his can be determined by such indicators as: quality, quantity and resources such as links and images. A second hypothesis is that S&T profiles are characterised by one-way communication.

2.1. Quantitative analysis

It is based on two basic concepts: the case or unit of analysis, and the variable or feature susceptible to acquire different modalities.

2.1.1. Social network analysis

Social Network Analysis is used to determine how persons, entities, organisations or institutions relate. This technique allows for the visualisation of complex sets of relationships through graphs or sociograms, and for the exact calculation of the size, shape and density of the network as a whole, and the positions of each element inside them. (Hansen, Shneiderman, & Smith, 2010: 32)

Figure 3. Types of social networks
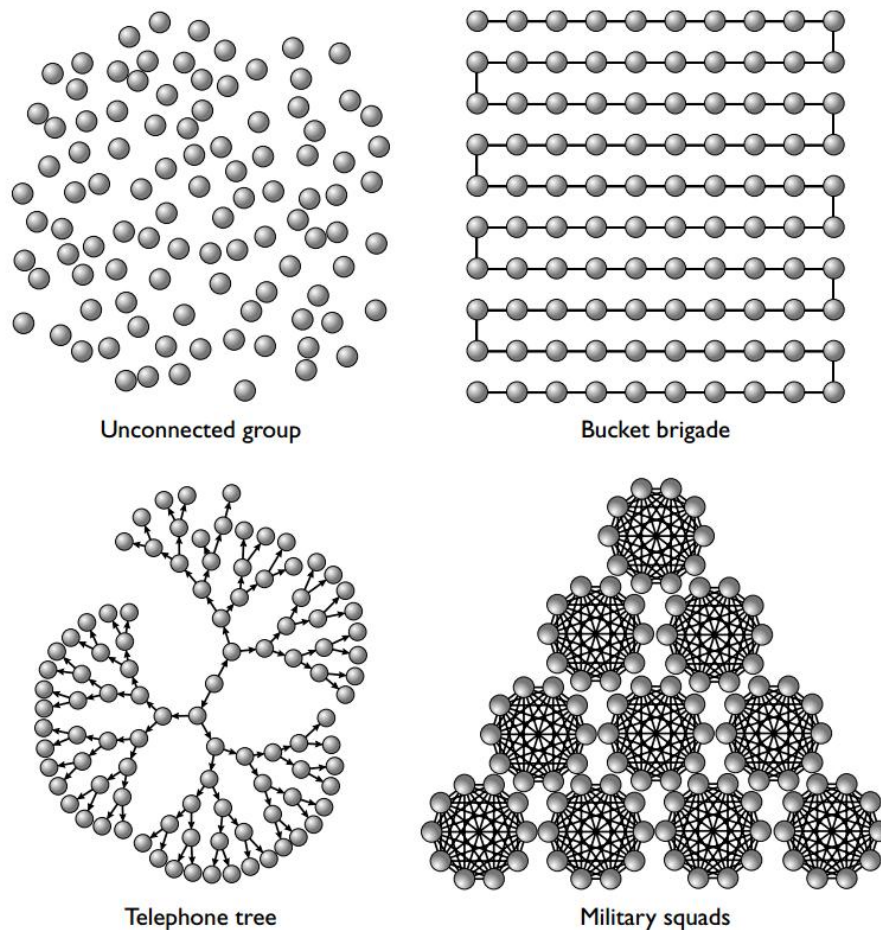
Source: Christakis, N. A., & Fowler, J. H. (2010). *Connected: The surprising power of our social networks and how they shape our lives].* Madrid: Taurus **[18]**.

For Alonso Berrocal, Figuerola & Zazo (2010: 3), the analysis of graph structures has been used occasionally to improve the quality of web searches. It has also been used for the classification of websites based on the elements of the pages that are pointed out by a specific page: to display information or to carry out web mining.

The growth of web applications and access to mobile devices has made connections between networks more visible. In this sense, social network analysis helps in the exploration and visualisation of patterns within the connections, specifically connections between people in order to identify the characteristic features of a community.

Researchers Hansen, Shneiderman & Smith (2010: 32) claim that networks are "collections of things and their relationships to one another. The "things" that are connected are called nodes, vertices, entities. The connections between the vertices are called edges, ties and links. Social networks are formed "whenever people interact, directly or indirectly, with other people, institutions, and artifacts".

Social network analysis has multiple applications in the most diverse fields. It is used to improve the efficiency of the organisational structure of enterprises, the successful development of new products, the analysis of disease transmission, spread of computer viruses, the analysis of the behaviour of communities, the study of social capital, among others. Graphically, a social network is represented by graphs. The nodes of the graph correspond to the actors; and the links between them show the relationships or flows between nodes. Links are usually assigned a weight which is the force or importance of the relationship (Navarro Sánchez & Salazar Fernández, 2007: 70).

2.2. Techniques
2.2.1. Data extraction

Data extraction was carried out between 15 May and 4 June, 2014, from the API [19] of Twitter, and with the use of NodeXL [20], a software that allows importing data through a complement in an Excel spreadsheet and their graphic representation. The imported data corresponded to the official accounts of Ibero-American science and technology institutions, with a range of 200 followers and a level of 1.5, i.e., the followers who relate with one another were also studied.

2.2.2. Population sampling

The sampling stage consists of the selection of the data that will be subjected to analysis. "In this context the concepts of population (or universe) and sample are relevant. The population is the set of messages susceptible to be studied in accordance with the objectives of the research" (Igartua, 2006: 211). The sample is part of the population that is selected, measured, observed and analysed.

The sample is composed of 22 Latin American countries. A total of 31 organisations are responsible for promoting science and technology in the different countries of the region. Some of them have more than one organisation. Cuba and Portugal do not have account on the microblogging network.

The criteria that were taken into account to select the sample are:

- Exclusively Latin American countries.
- Science and technology institutions that have been created by Governments
- Ibero-American non-governmental science and technology agencies.
- Entities that have a Twitter profile.

Table 2. Latin American science and technology institutions on Twitter

Latin America				
Nº	Accounts	Entity	URL	Country
1	**mcti**	Ministry of the Popular Power for science, technology and innovation.	https://twitter.com/mcti/	https://twitter.com/mcti/
2	Ministerio_TIC	Colombia: Ministry of information and communications technologies	https://twitter.com/Ministerio_TIC	https://twitter.com/Ministerio_TIC
3	Colciencias	Administrative department of science, technology and innovation. COLCIENCIAS	https://twitter.com/Colciencias	https://twitter.com/Colciencias
4	EduSuperiorEc	Secretary of higher education, science, technology and innovation	https://twitter.com/EduSuperiorEc	https://twitter.com/EduSuperiorEc
5	concytecperu	National Council of science, technology and technological innovation	https://twitter.com/concytecperu	https://twitter.com/concytecperu
6	minedubol	Ministry of education of Bolivia [21]	https://twitter.com/minedubol	https://twitter.com/minedubol
7	portalinovacao	Innovation website, ascribed to the Ministry of science, technology and innovation [22]	https://twitter.com/portalinovacao	https://twitter.com/portalinovacao https://twitter.com/CNPq https://twitter.com/consecti https://twitter.com/SBPC
8	CNPq_Oficial	Nacional Council of Scientific and Technological development (CNPq), agency of the Ministry of Science, Technology and Innovation (MCTI).	https://twitter.com/CNPq	
9	consecti	News website of the National Council of State departments for Science, Technology and Innovation (Consecti)	https://twitter.com/consecti	
10	SBPC	Brazilian Society for the Progress of Science	https://twitter.com/SBPC	
11	conacytparaguay	National Council of Science and Technology	https://twitter.com/conacytparaguay	https://twitter.com/conacytparaguay
12	ClubesdeCiencia	Department of Scientific Culture (DCC) [23]	https://twitter.com/ClubesdeCiencia	https://twitter.com/ClubesdeCiencia
13	RedCLARA	Latin American cooperation for advanced networks	https://twitter.com/RedCLARA	https://twitter.com/RedCLARA

14	min_ciencia	Ministry of Science, Technology and Productive Innovation of the Nation	https://twitter.com/min_ciencia	https://twitter.com/min_ciencia
15	Mineduc	Ministry of Education of Chile [24]	https://twitter.com/Mineduc o	https://twitter.com/Mineduc o
16	DatosCientific	Scientific Data [25]	https://twitter.com/DatosCientific	

Europe				
N°	Accounts	Entity	Link	Country
17	FECYT_Ciencia	Spanish Foundation for Science and Technology, FECYT	https://twitter.com/FECYT_Ciencia	
18	programa_cyted	Ibero-American Programme for Science and Technology for development (CYTED)	https://twitter.com/programa_cyted	Spain
19	GovernAndorra	Government of Andorra [26]	https://twitter.com/GovernAndorra	Andorra

Central America				
N°	Accounts	Entity	Link	Country
20	Conacyt_MX	National Council for Science and Technology, CONACYT	https://twitter.com/Conacyt_MX	
21	mexicocyt	Mexico Science and Technology [27]	https://twitter.com/mexicocyt	Mexico
22	CienciayTecMx	Science and Technology in Mexico, of the System of Public Research centres, CONACYT	https://twitter.com/CienciayTecMx	
23	CONICIT_CR	National Council for Scientific and Technological Research, CONICIT	https://twitter.com/CONICIT_CR	
24	micittcr	Ministry of Science, Technology and Telecommunications	https://twitter.com/micittcr	Costa Rica
25	InnovandoCR	National Innovation Website	https://twitter.com/InnovandoCR	
26	NCONACYT	National Council of Science and Technology	https://twitter.com/NCONACYT	El Salvador
27	senacytgt	National Department of Science and Technology	https://twitter.com/senacytgt	Guatemala
28	CONICYT	Nicaraguan Council of Science and Technology, CONICYT [28]	https://twitter.com/CONICYT	Nicaragua
29	senacyt	National Department of Science, Technology and Innovation, SENACYT	https://twitter.com/senacyt	Panama

Ibero-American organisations				
N°	Accounts	Entity	Link	Location
30	EspacioOEI	Organisation of Ibero-American States	http://twitter.com/EspacioOEI	Latin America
31	CienciadelaOEI	Science of the Organisation of Ibero-American States	http://twitter.com/cienciadelaoei	Latin America

Source: Authors' own creation

3. Analysis of results
3.1. Content of tweets

Wordle **[29]** was used to analyse and visualise the content of the extracted data, creating a cloud of tags or keywords used in the tweets, which were collected by means of social network analysis, in order to understand and find the middle point of the message that authors/readers convey through their information and opinion.

The generation of community and conversation that occurs through the tweets created a mixture of ideas shared by the producers and consumers of information. The research shows that the central theme is "science", followed by "technology", "innovation" and "education", "calls" (Figure 4), which creates a unifying thread in the narrative of science and technology.

Figure 4. Content collected from all the Twitter profiles

Source: Authors' own creation. Tag cloud with the most commonly used words in tweets. http://www.wordle.net/create/.

The previous cloud captures the essence, in words, of the message and ideas that the institutions send to their followers through the use of Twitter.

Depending on the context and circumstances in which the dynamics of topics evolves, the content of tweets tries to explain or review certain information: seminars, calls, projects, etc. Content with scientific character is rarely disseminated: articles, discoveries, etc. The words "science" and "technology" appear in a large percentage of tweets because they use these as tags even if they may not be related to the content of the post.

Figure 5. Most commonly-used words in the science and technology accounts in Twitter
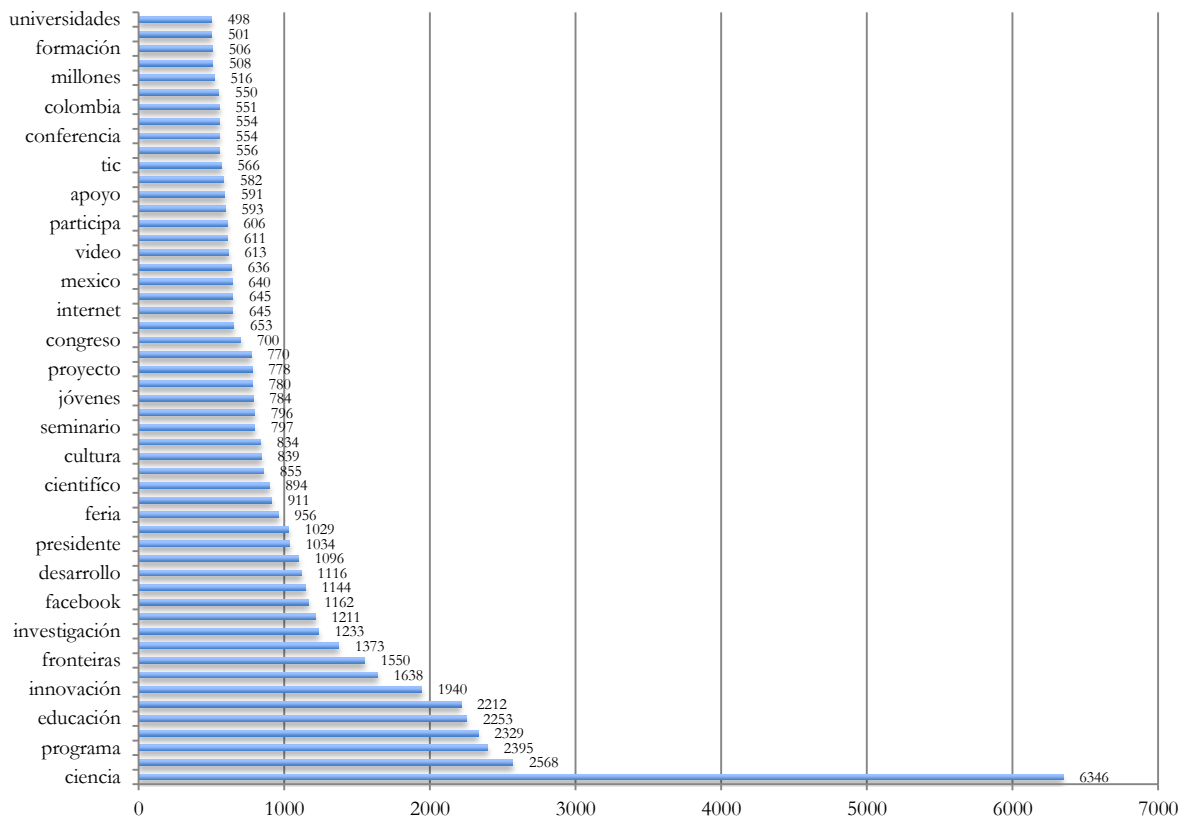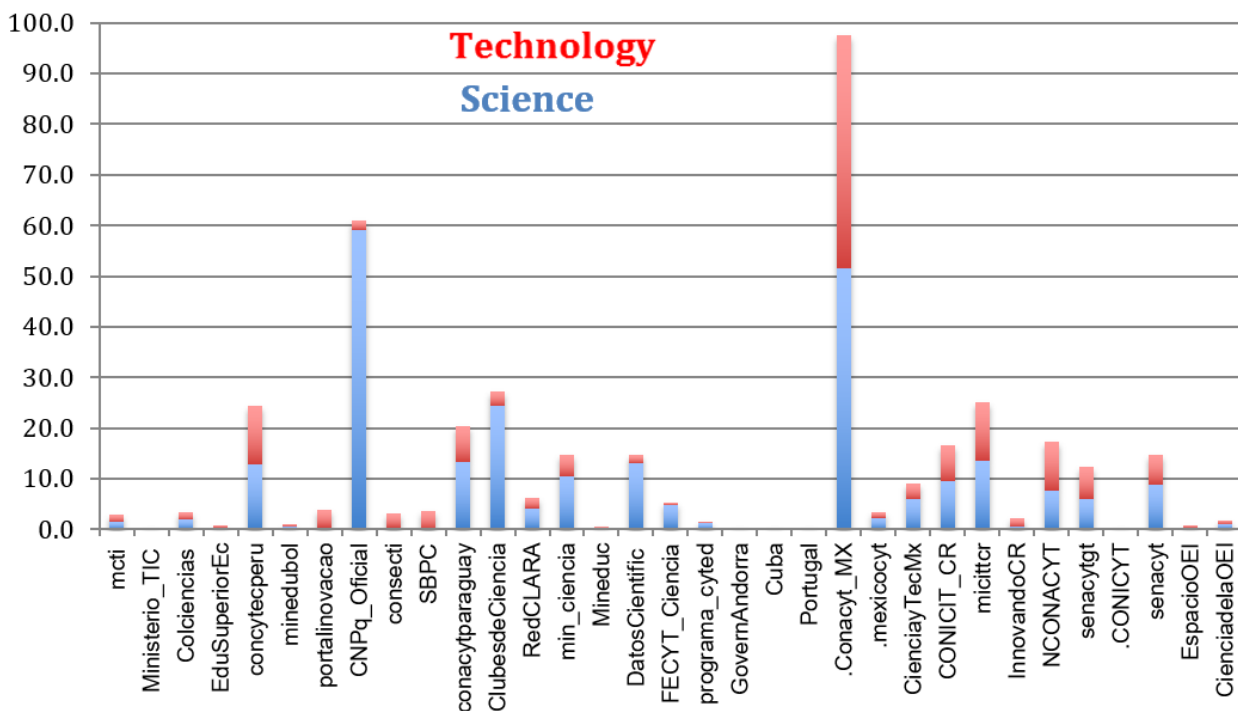

Source: Authors' own creation.

Table 3. Words on S&T and number of tweets published

Entity	N of Science	N of Technology	Total N of tweets	% of Science	% of Technology
mcti	395	307	24,337	1.6	1.3
Ministerio_TIC	1	108	46,005	0.0	0.2
Colciencias	103	80	5,262	2.0	1.5
EduSuperiorEc	62	54	17,435	0.4	0.3
concytecperu	270	240	2,087	12.9	11.5
minedubol	21	4	3,458	0.6	0.1
portalinovacao	15	117	3,488	0.4	3.4
CNPq_Oficial	**1,521**	**47**	**2,575**	**59.1**	**1.8**
consecti	29	215	7,410	0.4	2.9
SBPC	1	26	727	0.1	3.6
conacytparaguay	**64**	**35**	**483**	**13.3**	**7.2**
ClubesdeCiencia	**1,000**	**122**	**4,109**	**24.3**	**3.0**
RedCLARA	69	39	1,720	4.0	2.3
min_ciencia	**468**	**198**	**4,497**	**10.4**	**4.4**
Mineduc	6	18	5,406	0.1	0.3
DatosCientific	**35**	**4**	**265**	**13.2**	**1.5**
FECYT_Ciencia	416	29	8,627	4.8	0.3

programa_cyted	3	1	252	1.2	0.4
GovernAndorra	0	1	4,196	0.0	0.0
Cuba	0	0	0	0.0	0.0
Portugal	0	0	0	0.0	0.0
Conacyt_MX	**127**	**113**	**246**	**51.6**	**45.9**
mexicocyt	112	59	4,850	2.3	1.2
CienciayTecMx	47	24	791	5.9	3.0
CONICIT_CR	33	24	344	9.6	7.0
micittcr	**293**	**246**	**2,144**	**13.7**	**11.5**
InnovandoCR	4	10	625	0.6	1.6
NCONACYT	4	5	52	7.7	9.6
senacytgt	31	34	522	5.9	6.5
.CONICYT	0	0	7	0.0	0.0
senacyt	99	66	1,120	8.8	5.9
EspacioOEI	265	152	58,705	0.5	0.3
CienciadelaOEI	360	169	31,841	1.1	0.5

Source: Authors' own creation.

Figure 3 Use of the words "Science" and "technology" in tweets

Source: Authors' own creation.

The analysis of the Twitter accounts of each institution and in relation to the previous figure shows that the use of the terms S&T with respect to the total number of tweets posted by agencies is minimum. Cnpq_oficial (Brazil), Conacyt (Paraguay), Clubes de Ciencia (Uruguay), Conacyt (Mexico), Micitt (Costa Rica) and Datos Científicos (Chile) use the terms "Science and technology" in their content more than the other institutions, demonstrating that they do use their Twitter account, to some extent, to disseminate scientific content.

3.2. Connections between networks

To understand social network analysis, it is necessary to discuss two components that enable the interpretation and visualisation of data through graphs: vertices and edges. Hansen, Shneiderman & Smith (2010: 34) defines them as:

- *Vertices.* also called nodes, agents, entities or items. They often represent people or social structures such as: work groups, teams, organisations, institutions, states, and even countries. They can also represent the content of web pages, tags of keywords and videos; even places or physical or virtual events. In this case, they represent the Twitter accounts of the Latin American science and technology institutions and their followers.

- *Edges.* Also known as links, connections and relationships, they are the building blocks of networks. An edge connects two vertices together. These can represent many types of relationships such as proximity, collaboration, kinship, friendship, trade associations, citations, investments, hyperlinks, operations and shared attributes.

3.2.1. Degree centrality

Centrality measures allow us to identify which nodes are the most central, most important, most powerful or most prestigious. Centrality measures are a good approach to the analysis of web graphs, allowing us to evaluate the actual dimensions of prestige and power (Alonso Berrocal, 2014)

The degree of centrality reflects the total number of connections associated with a vertex.

- *Degree centrality.* It includes the most active actors, i.e. those who have a greater number of links in the network.
- *Degree of proximity.* In this case, the centrality is measured in relation to the distance between two nodes. The closer they are, the easier communication and interaction between them is.
- *Betweenness centrality.* measures the control an actor has on the information flowing in the network. The fact that it is a medium of communication between two people can influence and even exercise a strong control in the flow of relationships and interactions among others.
- *Eigenvector Centrality.* refers to a node/actor that has few yet very important or beneficial connections, or connections that are widely developed with third actors. This adds extra value to the node and turns it into the central element of the network (Hansen, Shneiderman & Smith, 2010: 40-41)

In the graphs, the nodes are represented by points (·) and these in turn represent the accounts of science and technology institutions and their followers. The edges are represented by lines (--------) which join the nodes at the centre or between them. Table 4 is the graphical representation of each of the Twitter accounts of the science and technology institutions.
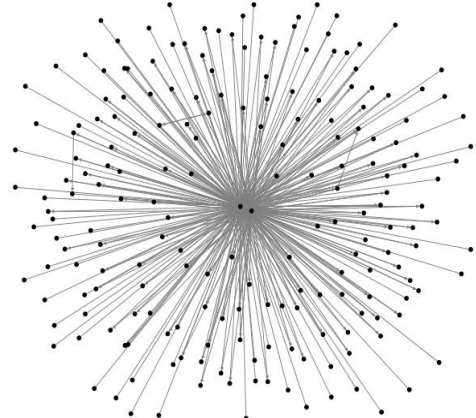
Table 4. Graphs of the Twitter accounts of the Ibero-American science and technology entities
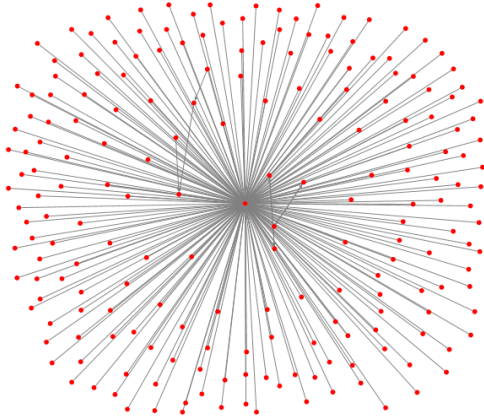
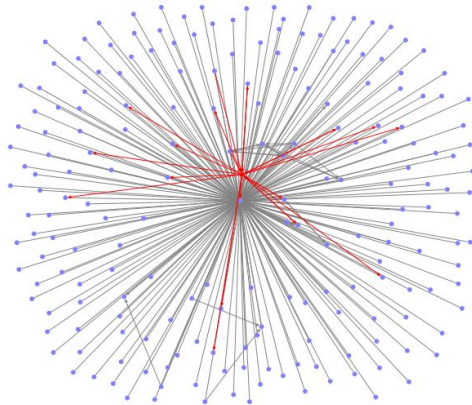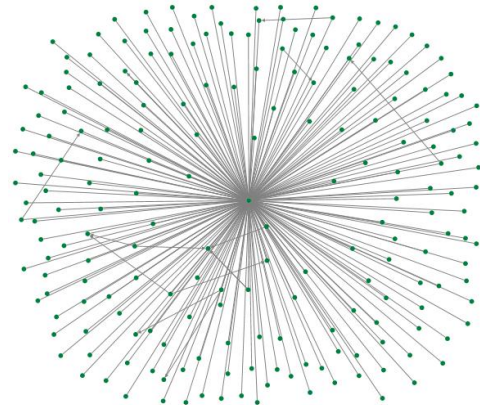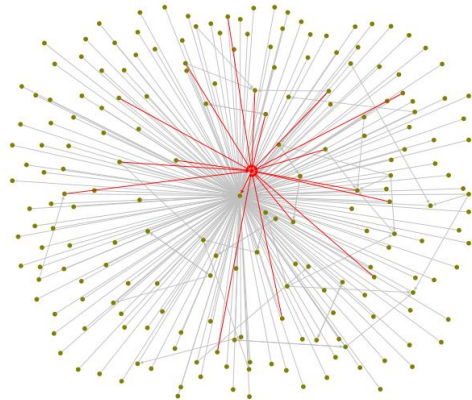|	
1. @mcti, Venezuela	**2. Ministerio_TIC**
In this network actor @*mcti* plays a clearly central role as it is connected with all the nodes, which need to pass through it (central node) to connect with others. About 7 nodes have mutual connections.	The network @*Ministerio_TIC* plays a clearly central role as it is connected with all the nodes, which need to pass through it (central node) to connect with others. Eight nodes have mutual connections.
3. Colciencias	**4. EduSuperiorEc**
Network with *a degree of proximity*, which is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.	The network is 100% central, with connections between the nodes that have to go through the central node, @*EduSuperiorEC*, to access other nodes.
5. concytecperu	**6. minedubol**
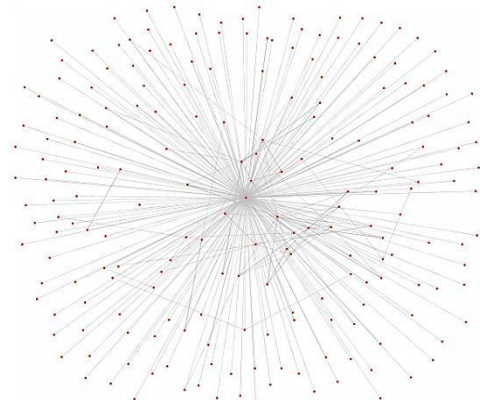
Betweenness centrality. The fact that it is a channel of communication between two people can influence, and even exercise strong control in the flow of relationships and interactions. In this case *@concytecperu* and another node (red lines) that exerts direct connection with other members of the network.
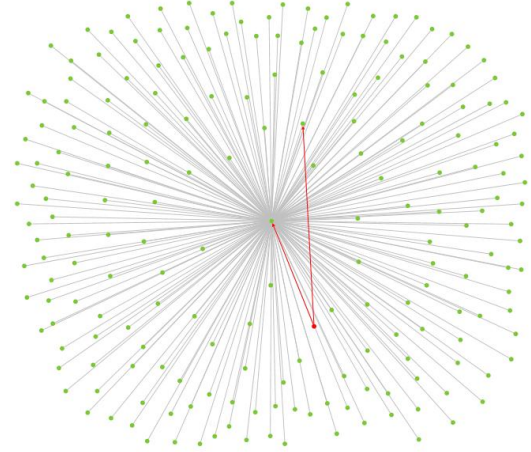
The network has a degree of proximity between nodes that have become its followers. In this case, the centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.

7. portalinovacao
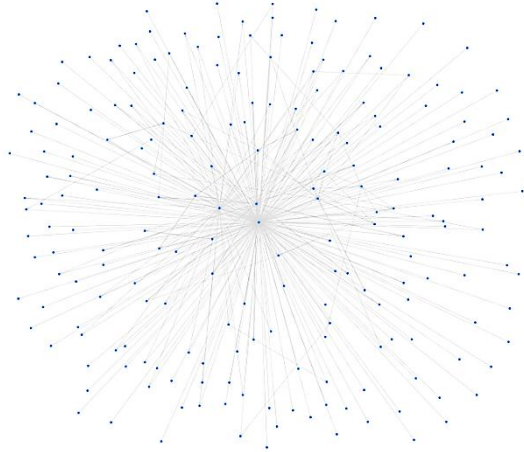
This network has a degree of proximity between the nodes that have become its followers. In this case, the centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.

8. CNPq_Oficial

The case of @CNPq_Oficial is characteristic of a network with a degree centrality, which includes the most active actors, i.e. those that have a greater number of links in the network. Moreover, there is proximity between nodes, which facilitates communication between members.

9. consecti
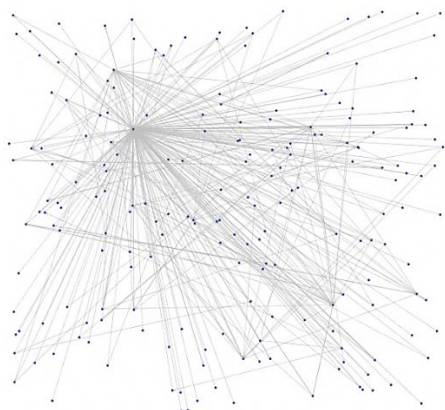
The degree centrality is based on the number of connections associated with a vertex. In *@consecti* there is evidence of betweenness centrality. The fact it is a communication channel between two members can influence and exercise strong control in the flow of relations.

10. SBPC
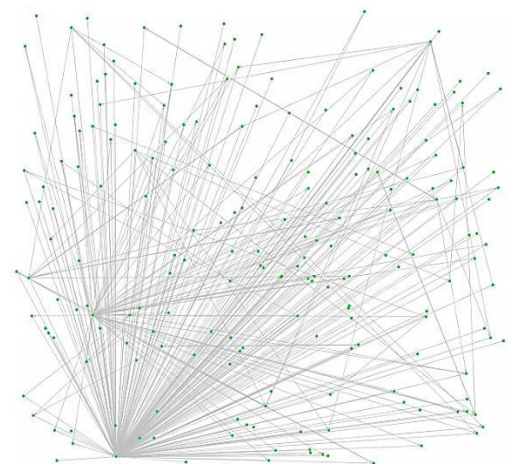
Like with *@consecti*, *betweenness centrality* is evident in *@SBPC*. The fact it is a communication channel between two members can influence and exercise strong control in the flow of relations.

11. conacytparaguay
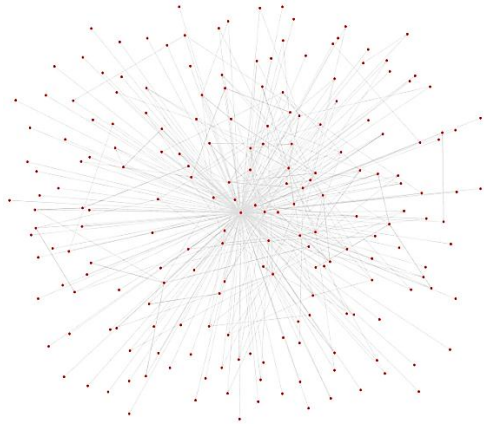
The degree centrality and proximity of the nodes with the central actor results in a better flow of communication and closeness. At the same time, the connection between followers of @conacytparaguay achieves synergy in the network.

12. ClubesdeCiencia
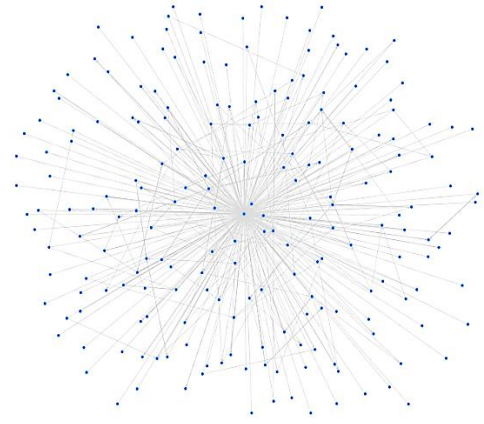
Similar to network no. 11, whose degree centrality and proximity of nodes with the central actor results in a flow of communication and closeness. At the same time, the connection between the followers of @ClubesdeCiencia accomplishes association in the network.
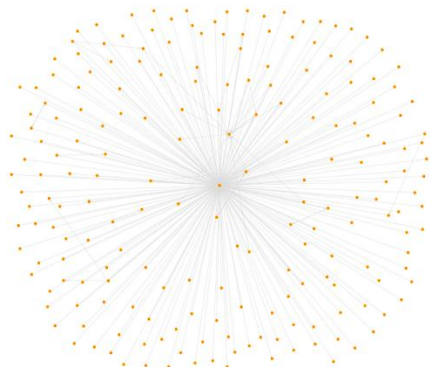
13. RedCLARA
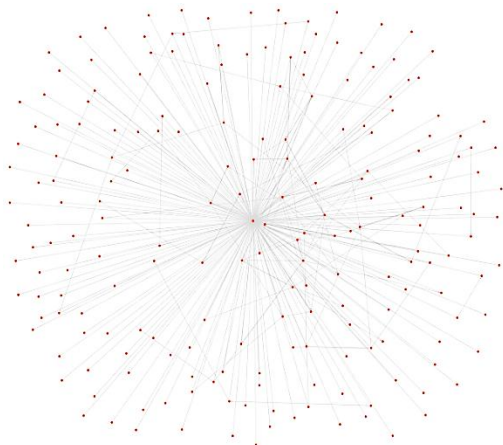
@RedCLARA has a degree of proximity between nodes that have become its followers. In this case, the centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.
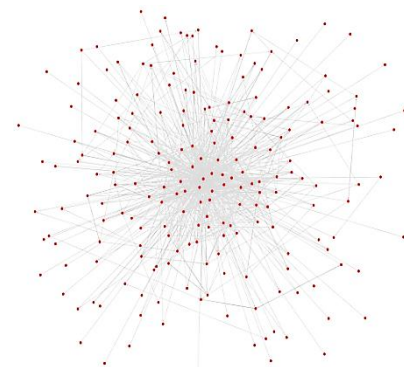
14. min_ciencia
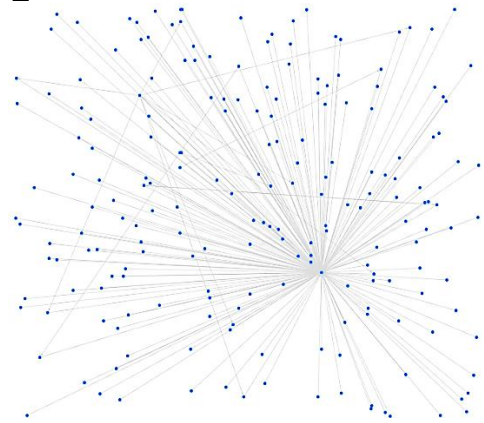
This network that has a degree of proximity between nodes that have become its followers. In this case, centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.

15. Mineduc

16. DatosCientific

@*Mineduc* plays a clearly central role as it connected with all the nodes, which need to pass through it (central node) to connect with others. About 20 nodes have mutual connections.

The degree of eigenvector centrality refers to a node that has few yet very important or beneficial connections, and connections widely developed with third actors. This adds extra value to the node and turns it into a central element of the network

17. FECYT_Ciencia
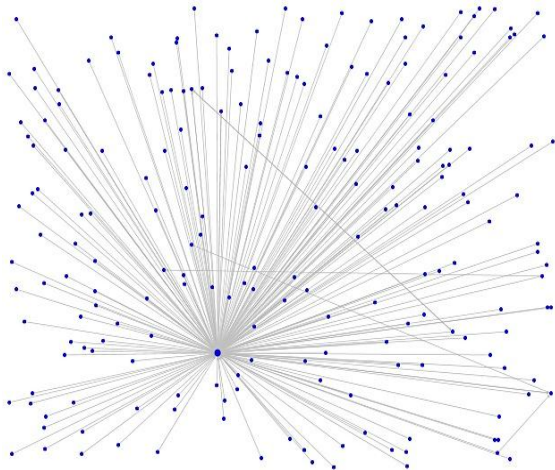
This network that has a degree of proximity between nodes that have become its followers. In this case, centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.
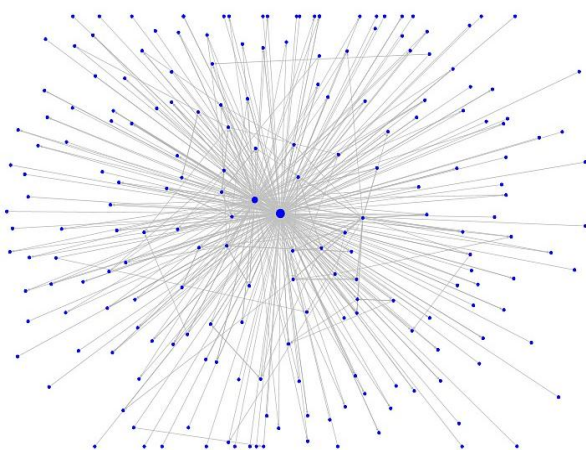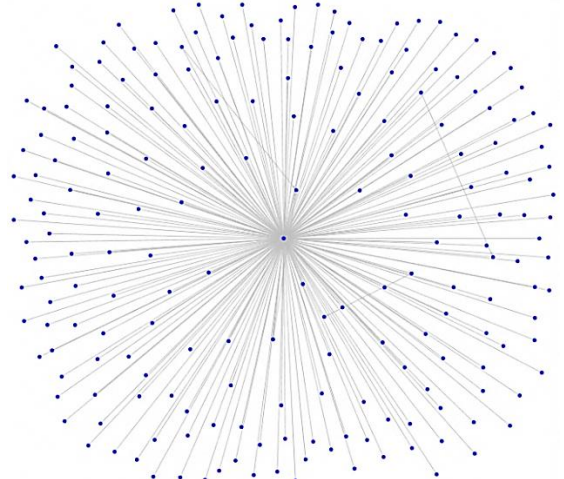
18. programa_cyted
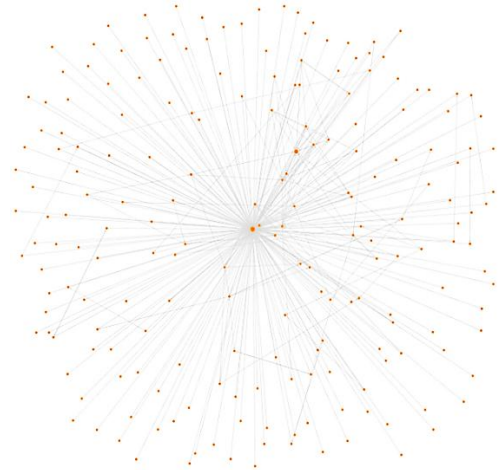
This network that has a degree of proximity between nodes that have become its followers. In this case, centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.

19. GovernAndorra

The fact that it is a communication channel between two members can influence and exercise strong control in the flow of relations. In this case @*GovernAndorra* and another node (blue dot with less volume) that exerts direct connection with other members.

20. Conacyt_MX

As it has been constant in the previous accounts, the network @Conacyt_MX is 100% centric, with connections between the nodes that would not have to go through the central node to access other nodes.

21. mexicocyt

@Mexicocyt is a network 100% centric, with connections between the nodes that would not have to go through the central node to access other nodes.

22. CienciayTecMx

This network has a degree of proximity between the nodes that have become its followers. In this case, centrality is measured in relation to the distance between two nodes. The closer two players are, the easier communication and interaction between them is.

23. CONICIT_CR

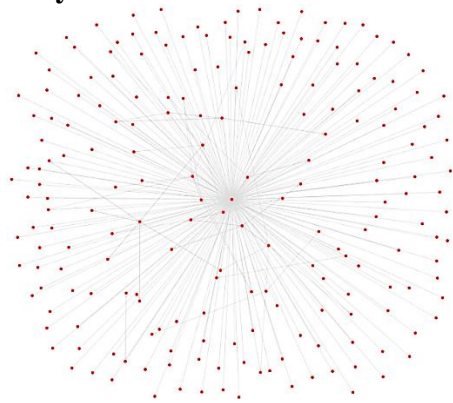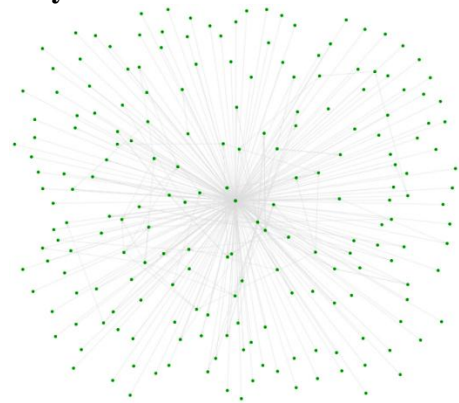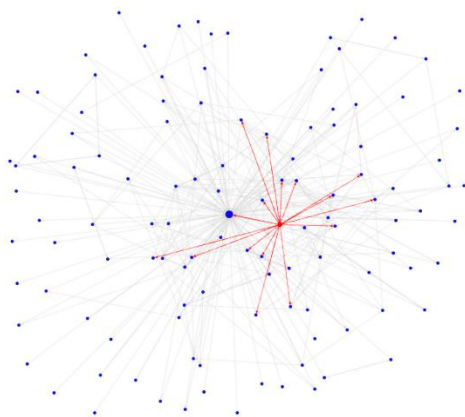
The network's connections have a degree of proximity between its members. While it is 100% centric, there are actors (red lines) that intertwine and, above all, communicate with each other. It ceases to be only a medium to become a communicative body.

24. micittcr
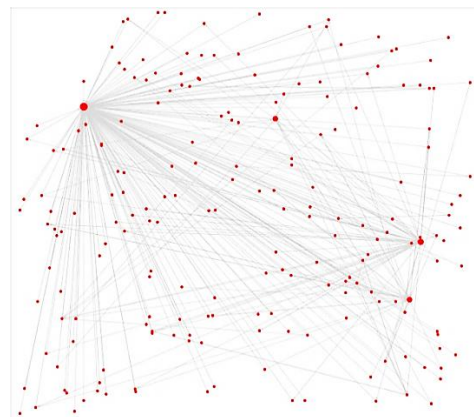
There are 4 central nodes, which are linked with one another to communicate with other members of the network. We can say that there is two-way communication. Members follow the main node, @micittcr, and this in turn also follows them, and there is reciprocity even between the nodes.

25. InnovandoCR
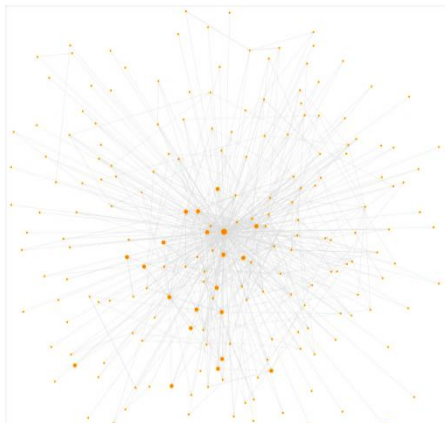
26. NCONACYT
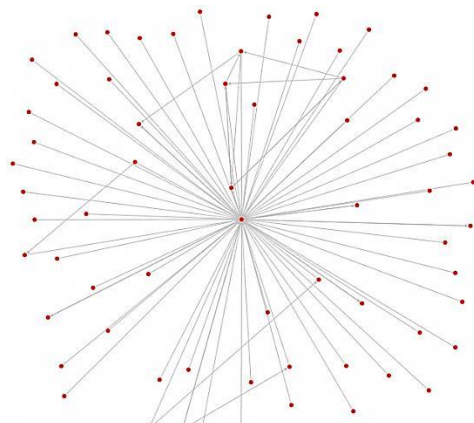
There is evidence of several key players, which are linked with one another to communicate with other members of the network. We can say that there is two-way communication and reciprocity between nodes.

27. senacytgt
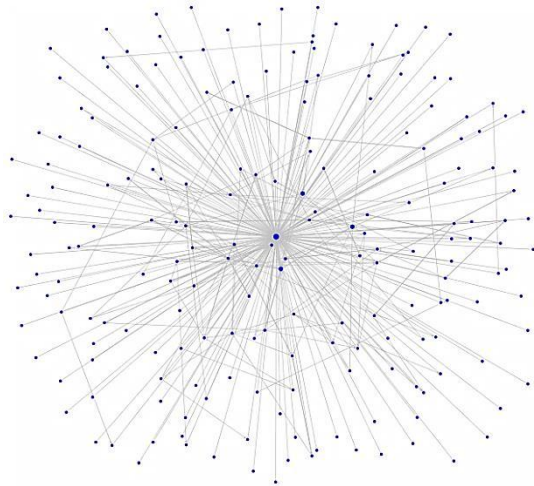
The central actor is linked to other nodes, and these in turn are linked with one another, to communicate with the other members of the network. We can say that there is two-way communication.

This network is 100% centric with certain actors that follow each other. @NCONACYT controls communication between members, most of which will have to go through it to have contact with other nodes involved in the network.

28. CONICYT
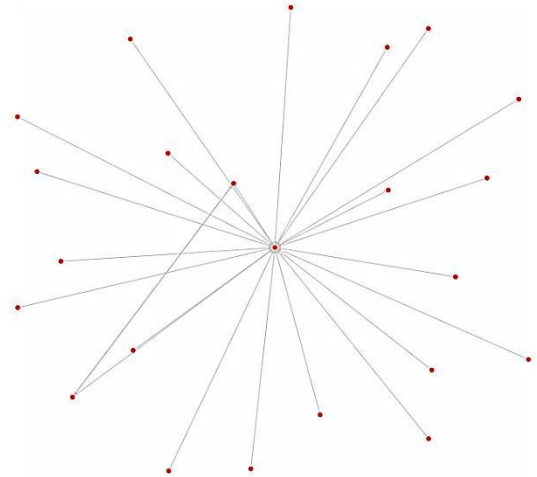
This network has few connections and centrality in its entirety. Three nodes have relationships with one another. In terms of communication, @CONICYT directs the information entirely.
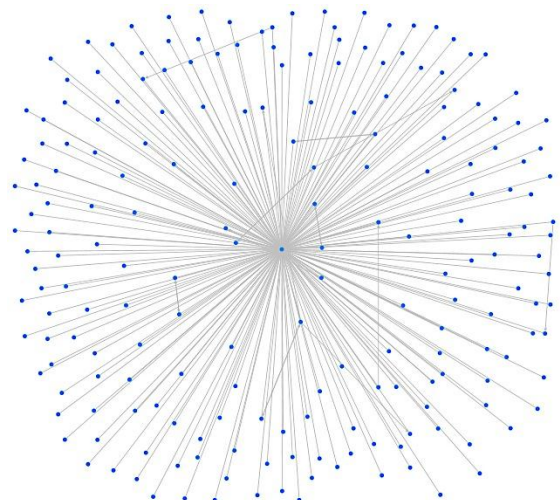
29. senacyt

This network has betweenness centrality. As it is a communication channel between two people, it can influence and even exercise strong control in the flow of relationships and interactions. In this case @concytecperu and other nearby nodes that have direct connection with other members of the network.

30. EspacioOEI

This network is 100% centric, with connections between the nodes that would have to go through the central node, @EspacioOEI, to access other nodes. There are few two-way connections between the members of the network. There are approximately 20 connected actors.

31. CienciadelaOEI
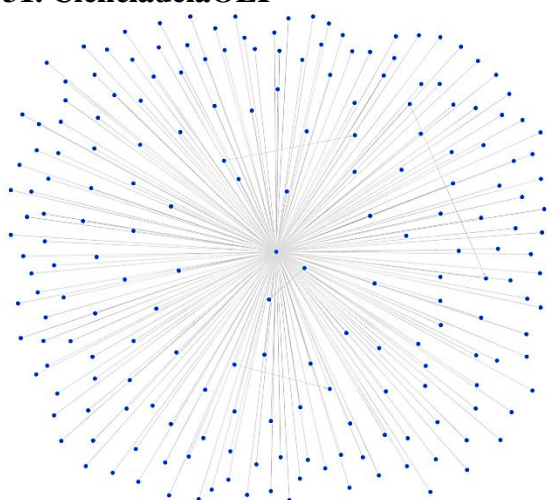
@CienciadelaOEI is a centric network, with connections between the nodes that would have to go through the central node to access other nodes.

In conclusion: In the previous 31 graphs, a node (which is located in the centre representing the Twitter profile of the S&T institution) plays the central role as it is the only one connected with everyone else. In some cases, it means that the rest of the nodes has to go through it to connect with other entities. This kind of central nodes have significant power and prestige within their network. The nodes of followers that connect with one another are located in the accounts: @Colciencias; @Concytecperu; @Minedubol; *Brasil: @Portalinovacao, @Consecti, @SBPC;* @ConacytParaguay; Uruguay: @ClubesdeCiencia, @RedClara; Chile: @Min_ciencia, @DatosCientific; @Programacyted; @GovernAndorra; @MexicoCyT; @CienciayTecMx; *Costa Rica: @CONICIT_CR, @Micittcr, @InnovandoCR*; @Senacytgt; @Senacyt. This shows that there are other representative profiles within the networks. In the specific case of Brazil, the account of one of the followers, @PPFEnergia, is connected with several nodes of the network, and is the direct link towards the accounts of the S&T institutions. **[30]**

Source: Authors' own creation, with NodeXL

Table 5. Networks' in-degree, out-degree and betweenness

N°	Label	In-degree*	Out-degree**	Betweenness***	Modularity Class
1	mcti	200	0	0.0	0
2	ministerio_tic	200	1	6.47E+10	1
3	colciencias	200	1	6.79E+09	2
4	edusuperiorec	200	1	1.30E+10	3
5	concytecperu	200	0	0.0	4
6	minedubol	200	4	2.75E+11	5
7	portalinovacao	200	0	0.0000	7
8	cnpq_oficial	200	0	0.0000	6
9	consecti	200	8	9.25E+10	7
10	sbpc	200	0	0.0	7
11	conacytparaguay	200	0	0.0	8
12	clubesdeciencia	200	50	0.0017	9
13	redclara	200	4	1.07E+12	10
14	min_ciencia	200	0	0.0000	11
15	mineduc	200	0	0.0000	12
16	datoscientific	200	49	0,0011	13
17	fecyt_ciencia	200	2	5.77E+10	14
18	programa_cyted	200	0	0.0	15
19	governandorra	200	48	6.97E+11	16
20	conacyt_mx	200	0	0.0	17

21	mexicocyt	200	0	0.0	18
22	cienciaytecmx	200	26	0.0010	18
23	micittcr	200	2	7.63E+11	20
24	innovandocr	200	10	0.0013	19
25	senacytgt	200	0	0.0000	21
26	espacioooei	200	0	0.0000	23
27	cienciadelaoei	200	0	0.0000	23
28	senacyt	199	0	0.0000	22
29	conicit_cr	115	2	3.00E+12	19
30	nconacyt	65	7	3.27E+11	15
31	conicyt	22	0	0.0000	15

In-degree: number of links that point to a given node. It identifies the most prestigious node of the network. **O**ut-degree*: number of links started from a node. It identifies the social activity of a node, as well as its ability to access the rest of the nodes. ***Betweenness*: indicates the extent to what a node is in an intermediate position in the geodesic path between the other two nodes. **Source:** Authors' own creation.

Table 6. Out-degree of other accounts

NO.	Account @	Value
1	PPFEnergia	131
2	solotara	111
3	andorranespreso	91
4	clubesdeciencia	50
5	datoscientific	49
6	*governandorra	48
7	SerCientifico	41
8	UDICostaRica	41
9	ILUniversity	29
10	Encuentros2014	27
11	DePosgrado	26
12	cienciaytecmx	26
13	laugalera13	26
14	Nutrisport_and	22
15	inovacaopratica	21
16	ZaidaClaure	20
17	explorarm	20
18	explorasp	19
19	joseigcaballero	18
20	fonade	16

*The Government of Andorra has an interesting peculiarity. It is a governmental account that does not discusses science and technology, but the relationship or betweenness that exists within this community is high. **Source:** Authors' own creation.

The information extracted from the Twitter accounts and their followers has been so far presented separately, so the following table unifies the 31 individual graphs in a single one to identify the relationships existing between all the accounts (Figure 6).

Figure 6. Communities' betweenness
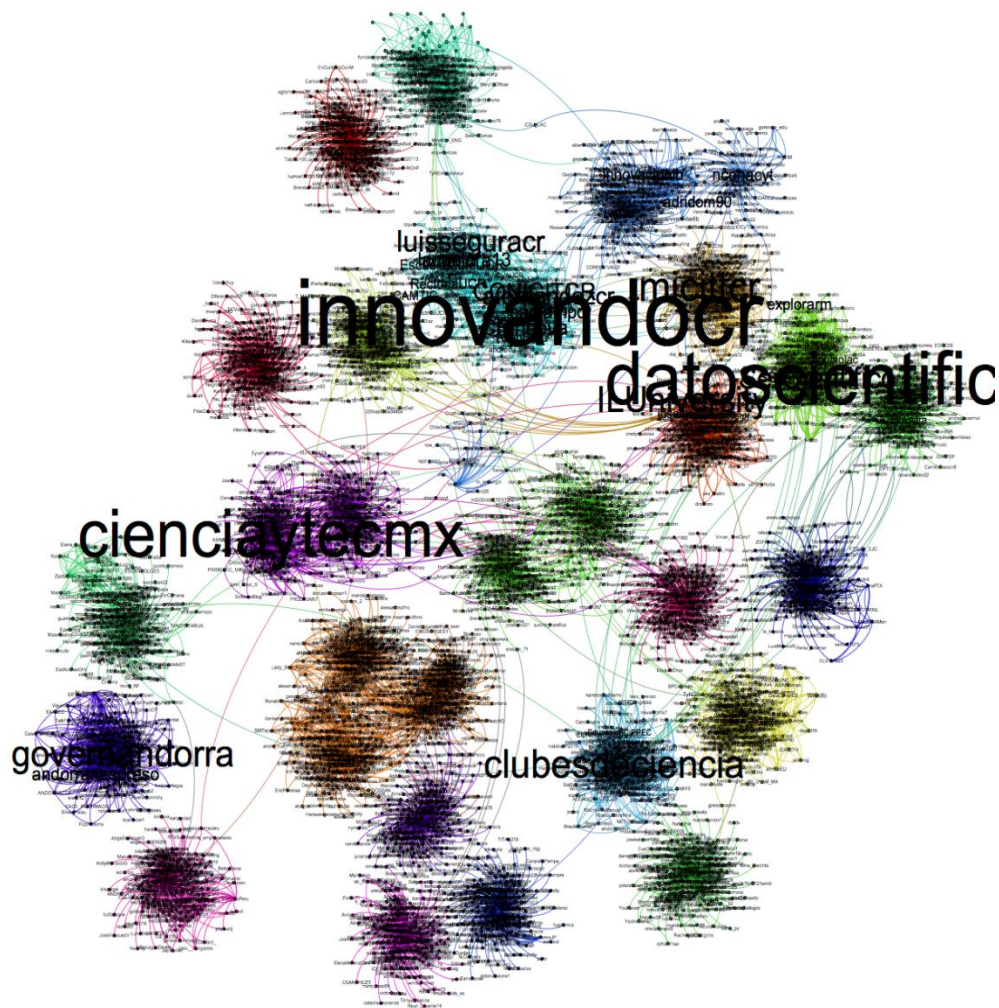
*The degree of betweenness indicates to what extent a node is in an intermediate position between the rest of the nodes. Nodes with higher rates have great power to control the most optimal information flows. In addition, it focuses on the control of communication that one actor has other nodes, which allows it to mediate their communication process. **Source:** Authors' own creation with NodeXL.

In the context of networks, speaking of a community refers to the set of nodes (official accounts and their followers) of the network that are more densely connected with one another than with the rest of the network. The previous figure shows the communities with a strong correlation between them. Nodes with a high value (dominant tag) have a great deal of power, because they control the flows of information.

4. Conclusions

In conclusion we can point out that the study of social networks has experienced a boom in recent years. Researchers focused on this area have made efforts to analyse the physical and virtual connections of people and organisations. In doing so, they have discovered features that allow us to understand the information they disseminate and, above all, the role played by users in this process.

Research has shown that better-connected people play a key role in a network, since they disseminate information more efficiently in their circles. This is of particular interest when it comes to the spread of gossip and even the transmission of diseases.

The research study achieved its objective of analysing the Twitter accounts of the Latin American science and technology institutions, which allowed us to identify the entities that focus on this issue and the types of content disseminated through their official accounts.

In relation to the hypothesis, we can mention that indeed there is a growing use of Twitter as a source of information on science and technology, based on quality and quantity indicators and the use of resources such as, links and images. Twitter is used by Ibero-American organisations according to the possibilities of the content they generate. The use of Twitter by these institutions is progressive.

During the development of this study, we requested information to the official accounts but there was no much response, which demonstrates that they follow a one-way communication model and do not complete the communication process as such: because there is no feedback. This can occur for two reasons: they do not have person responsible for the management of social networks, known as *Community Manager*, or they just created the Twitter account to have a presence on the web and publish contents.

Twitter can be used to disseminate science and technology information and this actually occurs in a small proportion of the analysed accounts. Therefore, it is necessary for S&T institutions that disseminate scientific communication through the Internet to do so with a clear, conversational and dynamic language; with rich content that is accompanied by digital resources (video, audio) and hypertext. It is clear that Twitter is characterised by its immediacy, but the character limit of its messages (140) should not be an impediment to communicate scientific and technological content in a creative way.

The Twitter accounts of science and technology institutions meet the anatomy of the networking site, i.e., they contain text, in the way of a headline, links and *tags* (keywords). There are cases in which some Twitter accounts are connected to Facebook accounts and so when the latter type of accounts is updated, the former type of accounts is automatically updated.

The degree of betweenness between the accounts and their followers grants importance to the roles that an actor can play. The fact that actors can sign in and communicate can influence and even exercise strong control in the flow of relationships and interactions. In this sense, there is a slight relationship between the accounts and their networks. For this reason, a future lines of research must be social network analysis in relation to the formation of communities, given that the study confirmed that there is an extrinsic relation between the institutional profiles/accounts.

5. Notes

1. Node: is a term used in the field of large computers (*mainframes*) and refers to the intersection of communication links, rather than specific devices. Rábago, J. F. (2010). *Redes locales.* Madrid: ANAYA.

2. See: Cataldi, M., Caro, L. D., & Schifanella, C.
   http://www.di.unito.it/~dicaro/papers/twitter2010.pdf

3. See: Kumar, S., Morstatter, F., & Liu, H.
   http://tweettracker.fulton.asu.edu/tda/TwitterDataAnalytics.pdf

4. See: Thelwall, M., Haustein, S., Larivière, V., & Sugimoto, C.
   http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0064841

5. See: Thelwall, M., Tsou, A., Weingart, S., Holmberg, K., & Haustein, S.
   http://cybermetrics.cindoc.csic.es/articles/v17i1p1.pdf

6. See: Thelwall, M., Buckley, K., & Paltoglou, G. *Sentiment in Twitter events*. Journal of the American Society for Information Science and Technology, 406- 418.

7. See: http://www.twitter.com

8. Among the virtual communities that are connected with each other and maintain constant communication between people related to certain topics of interest are: Facebook, Myspace, Hi5, Twitter, Second Life.

9. See: Governor, J., Nickull, D., & Hinchcliffe, D. *O'Reilly Media*:
   http://oreilly.com/pub/a/web2/excerpts/web2-architectures/chapter-3.html?page=3

10. Alvin Toffler was the first to use this term in his book *"The Third Wave"*

11. See: O'Reilly Media: http://oreilly.com/

12. See: W. 2.0: http://www.web2summit.com/

13. See: O'Reilly radar: http://radar.oreilly.com/archives/2005/10/web-20-compact-definition.html

14. See: TVN: http://www.24horas.cl/videosRegiones.aspx?id=52431&idRegion=5

15. The boom 2.0 gave way to the emergence of new applications that are the basis of the so-called Social Web, such as wikis and blogs, as all as the structuration of social networks; easy-to-use formats that do not require knowledge iin programming in html and php for instance.

16. Twitter (18 June 2015). *Anatomy of a Tweet*. Retrieved from twitter.com: https://media.twitter.com/best-practice/anatomy-of-a-tweet

17. *Tuit*, a word used in Spanish as a translation of *tweet*.

18. "Four different ways to connect one hundred people. Each circle ("node") represents a person, and each line ("tie") a relationship between two people. Lines with arrows indicate a directed relationship; in the telephone tree, one person calls another. Otherwise, ties are mutual: in the bucket brigade, full and empty buckets travel in both directions; in military squads, the connections between the soldiers are all two-way". (Christakis & Fowler, 2010, p. 26)

19. Application Programming Interface.

20. See: NodeXL: http://nodexl.codeplex.com

21. The account of the Vice Ministry of Science and Technology was not located.

22. The Ministry does not have an official Twitter account.

23. Attached to the Direction of Innovation, Science and Technology for Development (DICyT), of the Ministry of Education and Culture (MEC). The Uruguayan Ministry does not have a Twitter account.

24. In Chile, according to the review, there is no institution in charge of science and technology. The closest thing is the Ministry of Education or the National Commission of Scientific and Technological Research (CONICYT), but its Twitter account is closed

(https://twitter.com/DTP_Conicyt). There is a Science and Technology Council but it is not present in social networks.

25. It is an initiative of the CONICYT, which seeks to develop an open access policy for scientific information and research data.

26. There is not a single institution dedicated to science and technology, according to the report issued by CYTED (http://segib.org/upload/CYTED.pdf). So only the account of the Government is available for this purpose.

27. Dissemination of the System of Public Research Centres (CPI) of the CONACYT in Mexico and partner institutions.

28. Attached to the Vice-Presidency of the Republic of Nicaragua.

29. See Wordle: http://www.wordle.net

30. *Assessoria em Desenvolvimento de Negócios de Energia. - Medição e Verificação - Eficiência Energética - Energia Renovável - Lubrificação de Alto Desempenho*. The account has more than 23 thousand followers. https://twitter.com/PPFEnergia

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