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Miscellaneous

Overview of science communication (2017-2022): A thematic and bibliographic analysis

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Abstract

This article presents the results of an integrative of the literature review on science communication. The objective is to know the panorama of R+D+i in science communication during 6 years; for this purpose, the existing literature on scientific communication is analysed in the databases Web of Science (WoS), Scopus and Dialnet, and define the formal dimensions (time frame, categories, fields of knowledge and lines of research) that have shaped the approaches within relevant articles included in the review. This analysis covers the period 2017-2022 and aims to serve as a reference to study the importance of research in scientific communication in different fields of knowledge, as well as to highlight the need for professional scientific communication in the educational, social, cultural, and social fields and professional domains. To do this, a search has been carried out through three databases, WOS (Web of Science), Scopus, and Dialnet by using a series of search criteria related to science communication. From these searches, the pertinent documents have been selected through reading the abstract and the author's keywords, to assess later and determine which category created ad hoc based on research on science communication (educational, social, cultural, and professional domains) belongs to each document and find out which journal has published the most on the object of study during the 2017-2022 period. In a conclusion, the interest is limited to the branches of social sciences in areas such as communication, journalism and information and documentation sciences.

Keywords
Science communication, scientific journals, scientific output, professional scientific communication, integrative review.

1. Introduction

Science communication is an exciting endeavor (Lázaro, 2020) that has transformed in recent years. It has developed rapidly as a field of study, and research in this area has been influenced by various perspectives (Fähnrich, 2021). From this standpoint, many authors have studied numerous definitions and different approaches and methodologies for its study (Akin, 2017;

Anichini & de Cheveigne, 2012; Davies, 2020; Leßmöllmann *et al.*, 2019; Macho Reyes & Bermúdez Vázquez, 2020; Miller, 2008; Negretti *et al.*, 2022; Rauchfleisch & Schäfer, 2018).

For instance, Gerber (2020) considers science communication as a plural endeavor in research and practice. The combination of institutions, techniques, and disciplinary approaches contribute to its diverse nature, which influences the perception that there is no theoretical framework for the study of science communication. In this regard, Ennis & Conforti (2019, p. 5) explain that "the diversity of levels, their complex interactions, the multiple actors and the products at stake can only be defined by specifying the reference framework in each case, leaving general aspects aside."

Despite the plurality in its study, until relatively recently, the development of the field of science communication has been influenced by the so-called "deficit model" (Gregory & Miller, 1998). In this paradigm "that conceives public communication of science and technology as a 'correction process' of a supposed ignorance, disinterest or rejection of science and technology by society" (Rodríguez, 2020, p. 33) three well-studied concepts converge: scientific literacy (Farina, 2020; Gallego Torres, 2020; Gallego Torres & Ballesteros, 2022; Valladares, 2021); public engagement with science; and public understanding of science (Rodríguez, 2020; Schäfer *et al.*, 2020). These terms share the institutional nature of the communication of knowledge generated in laboratories but differ in the aspects that connect science with society, as well as the modes of communication (Fähnrich, 2021b).

For Wagenknecht *et al.* (2021), the mission of "science communication" is to strengthen citizen understanding of scientific processes and principles, but "public understanding of science" and "public awareness of science" must be concerned with increasing public appreciation and acceptance of scientific issues.

Today, changes in citizens' perception of science (FECYT, 2020) and digital transformation have disrupted science communication, blurring the roles of communicators and audiences. Consequently, we have witnessed a more diversified set of actors. These include the media, scientific journalists, researchers, institutions, and citizens, among others. They have become publicly visible through social media, directly affecting public opinion (Schäfer *et al.,* 2020).

New forms of collaboration and interaction have also been established, which greatly facilitate the dialogue between society and science (Hans *et al.*, 2008; Metcalfe *et al.*, 2022; Rasmus Kleis *et al.*, 2020; Revuelta-De-la-Poza, 2019). This new perspective has influenced new models of science communication research based on "dialogue" (Humm *et al.*, 2020). This concept comprises a variety of approaches to science communication (Fähnrich, 2018; Jünger & Fähnrich, 2020; Mede & Schäfer, 2020; Metag & Schäfer, 2017; Thaker, 2020). We highlight studies from a citizen science perspective (Brossard *et al.*, 2005; Cooper, 2016; Mesía-Montenegro, 2021) as well as research that focuses on new media and social networks (Brossard & Scheufele, 2013; Denia, 2021; Lee *et al.*, 2018; Ojeda-Serna & García-Ruiz, 2022; Pérez-Rodríguez *et al.*, 2018; Popov, 2020; Vizcaíno-Verdú *et al.*, 2020; Yuan *et al.*, 2022; Zaragoza & Roca Marín, 2020) or the development of science journalism (Brüggemann *et al.*, 2020; Dunwoody, 2014; Duque & Tejedor, 2020).

1.1. *Science communication: scientific culture and popular science*

In any case, there is a consensus that suggests that scientific education should be the main means to keep society involved in scientific issues (Aguilera Moyano *et al.*, 2012; Cormier *et al.*, 2009; Costa, 2001; Galdón, 1994; Mayor Paredes & Rodríguez Martínez, 2016; Thelwall & Aguillo, 2003). According to Watanabe and Kawamura (2016), it is necessary to build an understanding of the importance of science in culture, and to this end, researchers must promote the acquisition of this scientific culture by society. But it is not only important to educate citizens in the fields of science, it is also relevant for all the actors involved in the process of science communication.

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> Science must become part of culture in order to reach the public in the most efficient way. Indeed, the sciences simply must be reintegrated into mainstream culture since that is where they belong and have always belonged. This will ensure that all citizens can understand and share in the process of change and take advantage of the opportunities of this process (Diviu Miñarro, 2019, p. 98).

According to Sánchez Mora and Macías Nestor (2019), the construction of a scientific culture based on the development of educational and communicative efforts is necessary, and it should work as "social mediation between citizens, institutions and cience-based activities" (Sánchez Mora & Macías Nestor, 2019, p. 1). Definitions of scientific culture usually focus on the description and knowledge of specific contents, hence, most of the tools to locate it focus on the characteristics of scientific knowledge in formal education.

There is research that proposes models of scientific communication and their effects to understand the interest and acquisition of societal scientific knowledge from different perspectives, that of the scientist, universities, educational centers, institutions and the citizen (Anchondo-Granados *et al.*, 2020; Besley *et al.*, 2018; Besley & Dudo, 2017; Figueroa Céspedes *et al.*, 2020; Lima & Giordan, 2021; Martínez Rizo, 2022; Rey Rocha *et al.*, 2019; Urquiza Humara *et al.*, 2020; Zaragoza & Roca Marín, 2020).

For Wu *et al.* (2019), academic output related to the study of science communication has focused on the field of science education. Although most research focuses on science education, these two fields –science education and science communication– converge in their objectives and methods (Baram-Tsabari & Osborne, 2015), but differ in style and setting (Wu *et al.*, 2019). While science communication broadly focuses on public education, which involves not only science education. Science education communicates science more intimately in classrooms and through teachers. Despite this, both disciplines focus on developing scientific literacy and critical thinking, so that citizens can participate in scientific discussions and their social effects (Feinstein, 2015).

One of the formative tools, which allows education and science communication to converge, is "dissemination," defined by Roqueplo (1983), as an activity related to the transfer of knowledge, culture and scientific thought, outside official training programs, but complementing them. It is the means to disseminate scientific knowledge simply to a non-specialized audience. Dissemination, which is more closely linked to non-formal education, involves a process of free choice on the part of the citizen who wishes to learn and obtain new knowledge.

An important aspect of science popularisation is the communication channels, such as books and journals, media such as press, radio and television, social media and science centres. Thanks to these channels, formal and non-formal education converge, as they are sources of information that are also used in the classroom.

Moreover, the dissemination of science goes beyond a mere explanation of scientific phenomena, analytical methods and the formula for solving everyday problems; it is also the main source of information on scientific developments (Olmedo Estrada, 2011). It favors the role of the scientist as the visible face, as a direct and reliable source. Seguí Simarro *et al.* (2015) explain that it is important for researchers to go beyond their scientific work. Their task also requires them to possess a series of skills and abilities that allow them to transmit their knowledge to the public. This author points out that it is both convenient and necessary for scientists to make their work visible for the following reasons:

- To justify the public investment in cience for citizens.
- To demonstrate the need for more funding for science.
- For researchers themselves, to enhance the value of their scientific work, to improve their public image, and to achieve visibility and prestige, "to achieve a professional career [...] that is complete and satisfying" (Seguí Simarro *et al.*, 2015, p. 5).

Science journalism is gaining strength to help the scientific community in the proper dissemination and generation of knowledge. For Fischhoff (2019, p. 7670), "the two worlds

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support each other when they connect, with practitioners helping scientists to identify results that are important to their audiences and scientists helping practitioners to structure those interactions." Science journalism has quickly become the focus of interest, as it plays a major role in science communication (Vallejos Gancedo, 2021). Science journalists contribute to rigorous, high-quality, and accessible information (Cassany *et al.*, 2018).

For Hans (2013) and Diviu Miñsrro (2019), researchers are adapting to mass media communication. They consider the importance of making their research visible in the media and are more prepared to speak out and comply with journalistic demands, but that "they often deeply regret the inaccurate or incomplete coverage of science in the media" (Diviu Miñarro, 2019, p. 98). Researchers continue to feel a sense of risk that their words may be misinterpreted by journalists.

According to the same author, it is necessary to invest in interdisciplinary profiles. For this, academic institutions and the media should devote more efforts and resources to professional growth among science journalists (Diviu Miñarro, 2019). Science journalists must be able to recognize the social importance of scientific research and translate it into the appropriate genre and format to convey scientific information to society as a whole (Ennis & Conforti, 2019). There is a dichotomy in terms of the profile of science journalists. In this sense, Belenguer Jané (2003) noted that there were different conceptions of journalistic work related to science communication:

- Science journalism has the mere function of providing information on scientific activities through the media. In this case, the journalist does not undertake educational functions, which are covered by the researcher/disseminator.
- Science journalism with an educational function. Here, the figure of the science journalist stands out.

Although the second conception would be the "ideal," in Spain, studies such as Cassany *et al.* (2018, p. 11) suggest that "only between 20% and 25% of the science journalists surveyed have an academic degree that combines journalism and science." According to these authors, when professional journalists have a scientific profile, journalistic information about science has an added value. Therefore, it is necessary to emphasize the importance of the national scientific system in journalism degrees (Moreno-Castro & Gómez-Mompart, 2002). This integration can alleviate the deficiencies in science journalism training from the perspective of the R+D+I system (Meneses Fernández & Rivero Abreu, 2017).

In short, the science journalist must be conceived as a source of information and documentation. They must be able to address doubts in a short period of time due to the volatility of the news, but, above all, they must be critical and select the content to be reported, analyzed, and disseminated (Semir & Revuelta, 2017).

> The core of dissemination activities lies in their explanatory effort. Although the public communication of science can be limited to the mere reporting of news, it will only become what we are calling dissemination if it includes –we insist– an explanation. That is, discourse that is organized choosing certain procedures with the aim of helping people know and understand (Semir & Revuelta, 2017, p. 5).

In this context, it is important to highlight the role of universities in dissemination activities (Vivas *et al.*, 2018). Their efforts are mainly focused on the promotion of scientific culture with outreach activities that enable literacy and "societal access and uptake of science and technology-generated knowledge" (Sebastián, 2006, p. 5). To achieve this, researchers rely on a variety of university services such as press offices and, above all, units or services devoted to the dissemination of scientific culture (FECYT, 2021). These are constituted as "a key service to improve citizens' education, culture, and scientific knowledge" (FECYT, 2012, p. 5).

These units are defined as intermediaries between scientists and journalists; their mission is focused on collaboration with the media to make the scientific message more

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understandable. They also advise researchers on matters related to science communication to generate a critical opinion among the general public (FECYT, 2021). Among its outreach activities are proposals such as Science Week, *Pint of Science,* European Researchers' Night, conferences, seminars, workshops, and exhibitions, among others. These are actions that go beyond bringing science closer to the public, by also closing the gap between scientists and the media.

Through these activities, these services favor the visibility of science and the knowledge generated in universities and research centers. They promote the inclusion of scientific topics in the public debate as current issues (González Pedraz *et al.*, 2018).

1.2. *Media and other platforms*

There is a plethora of online platforms dedicated to science education and communication (Farinella, 2018). These arise as a direct reflection of increased public interest in science and technology (FECYT, 2020), and citizens' use of the Internet and social networking sites as a source of information (IABSpain, 2021; INE, 2021). These online media provide new channels for debate and participation, as well as open access to scientific sources, new forms and spaces for communication, and a diversification of the actors involved in scientific communication (Fähnrich, 2021b).

> What was once reserved for scientific meetings, only linked to public discussion through press releases and reports by professional journalists, has now been brought to all people through Internet platforms and applications (Taddicken & Krämer, 2021, p. 2).

In recent years, digital media such as blogs and social networking sites like Facebook, Twitter (Denia, 2021), Youtube (Ojeda-Serna & García-Ruiz, 2022; Vizcaíno-Verdú *et al.*, 2020; Zaragoza & Roca Marín, 2020), Instagram (Chomón-Serna & Busto-Salinas, 2018; Figuero-Benítez *et al.*, 2021) and TikTok (Torres-Toukoumidis *et al.*, 2021) have become meeting places for scientists, journalists, the media and other social actors to talk about science. As new communication channels evolve on the web, the way in which science is communicated has undergone profound changes (Ferreira *et al.*, 2021).

For Boothby *et al.* (2021), the reasons why scientists use these social media to present their work involve the lack of barriers and their immediacy compared to traditional means of communication. Consequently, *old media* have been forced to evolve towards a "*transmedia*" dynamic, where their content can be viewed anytime, anywhere. In this model, the medium adapts to current events to satisfy its audience (Velázquez *et al.*, 2018).

A large majority of citizens used these new media as a source because they offer information beyond scientific journalism and mass media. They allow access to academic and governmental scientific information and to a large amount of new content, generated by the users themselves. Therefore, citizens can be informed about scientific topics and methods through a diversity of sources with varying levels of "expertise" (Taddicken & Krämer, 2021b). This aspect has manifested itself during the pandemic, where the need for information has been paramount for the citizens. According to Masip *et al.* (2020), 78% of them accessed information at a higher rate than before the pandemic.

The communicative context around science communication has aroused an interest in knowing where the field is at present, in all its forms (popularisation of science, scientific culture, informal science education, formal science education and public understanding of science), what is the focus of its studies, and which scientific journals are interested in this discipline. This study aims to show an overview of the current state of science communication as a whole.

This analysis aims to serve as a reference to study the importance of science communication research in different fields of knowledge and to highlight the importance of professional science communication in different fields, such as educational, social, cultural and professional.

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2. Objectives

Based on this context where science communication acquires an essential role in different scenarios, it becomes necessary to know the current situation of science communication research in the period 2017-2022, for this purpose the following specific objectives are proposed:

O1. To analyze existing literature on science communication within the databases: Web of Science (WoS), Scopus, and Dialnet.
O2. Define the formal dimensions for the present study (time frame, categories, fields of knowledge and lines of research) that have shaped the approaches within relevant articles included in the review.

3. Material and Methods

Due to the importance of science communication during the Covid-19 crisis, a two-year period before and after the pandemic (2017-2022) was selected for analysis in this study to see if there were differences in the science communication landscape.

3.1. *Design*

For the selection of the literature, specific search criteria were defined (Table 1). These criteria are related to the categories used to classify the relevant documents (Table 2).

Due to the terminological characteristics and their meaning in different languages, combined searches were carried out in English for WOS and Scopus, and key words in Spanish were used for Dialnet, which is also the database where non-indexed journals that provide relevant documents for this research are indexed.

Table 1. Keywords/search criteria.

Search criteria/keywords
professional communication/ comunicación profesional
professional communication of science/ comunicación profesional de la ciencia
scientific popularization or popularization of science / popularización de la ciencia
scientific journalism/ periodismo científico
science communication/ comunicación científica
public communication of science and technology/ comunicación pública de la ciencia y la tecnología

Source: own elaboration.

3.2. *Procedure*

For this research, a process map (Diagram 1) was developed to define the methodological steps.

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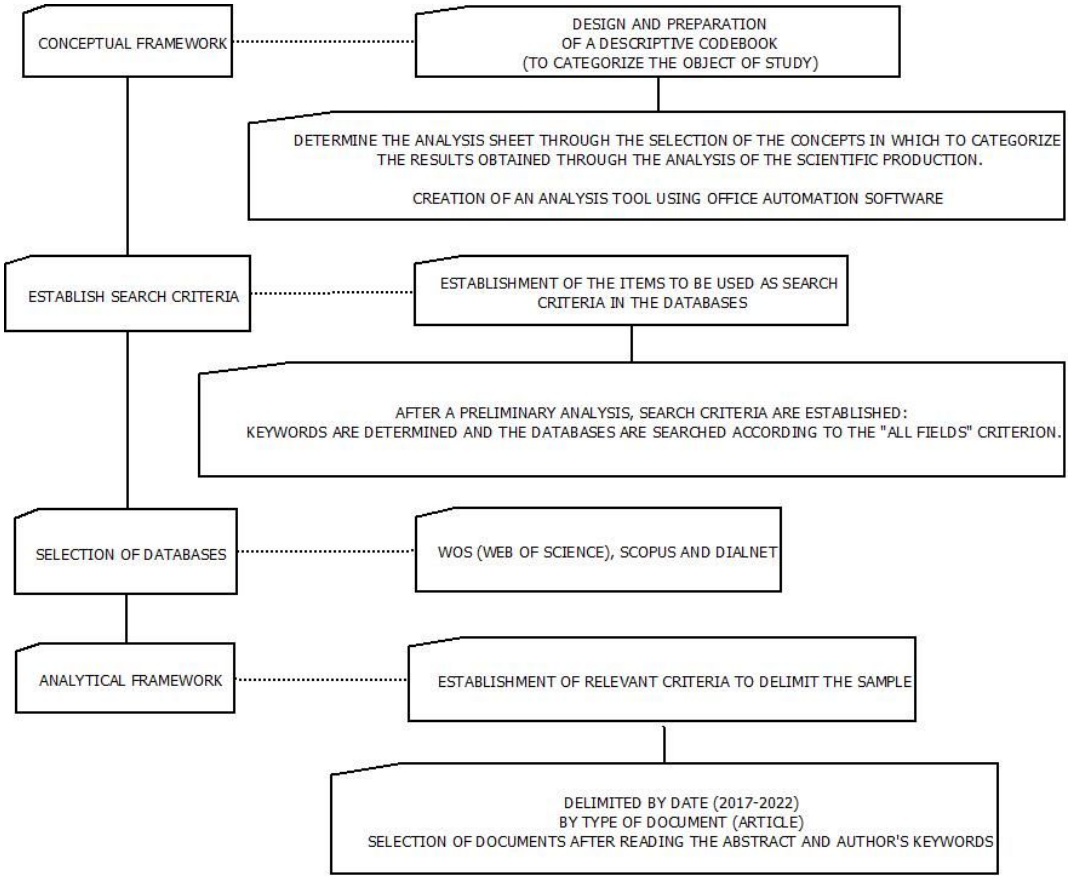
Diagram 1. Process map.



Source: own elaboration.

The WoS, Scopus and Dialnet databases were selected due to their multidisciplinary nature and scientific quality (WoS and Scopus), which are very relevant aspects in this area as they encompass different disciplines. Dialnet allows the inclusion of documentation in Spanish and provides access to research in journals that are less visible (Mateo, 2015).

The results of the search were considered taking into account the following selection criteria:

By type of document “articles.”

By date (2017 to 2022).

By content (keywords and abstract).

A search was carried out on the Dialnet, Web of Science (WoS), and Scopus platforms, using as search criteria in “all fields” those proposed in Table 1, limiting the sample in time (2017-2021) and by document type (article).

Following a qualitative methodology, for the study of the relevance of each article, a series of criteria were applied and developed using a codebook. In this codebook, linked to an office database, the documents obtained in the search have been incorporated. The results are then sorted by title, author and journal, in order to identify duplicates and eliminate them manually. Once eliminated, the relevance and categorisation of the documents was determined, by consensus of the authors, by reading the abstract and the author’s keywords. This categorization has been designed ad hoc in order to group the scientific output according to the aspects of science communication, agreed on the basis of the literature already addressed in the introduction, and determined the possible categories into which the studies related to the subject fall. Thus, a breakdown into 5 general categories was made: training, media,

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outreach activities, other platforms and professional communication. These, in turn, are divided into subcategories, which are detailed in the following table (2, Appendage).

From each document obtained in the different searches, the following aspects were analyzed to respond to the objective:

Scientific output by years, from 2017 to 2022.

The categories for each publication, following the selection criteria (Table 2).

Scientific output by journal.

4. Results

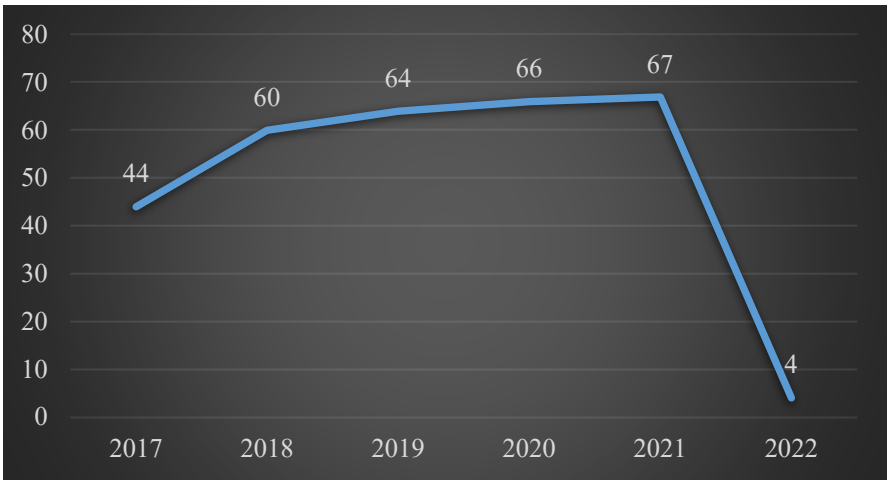
The Office software was used for the analysis of the results and the creation of the graphs. After performing the query in the different databases, a total of 18143 documents were obtained and distributed as follows (Table 3, Appendage).

From these results, duplicate documents were removed and evaluated for their relevance (Table 1), considering the criteria established in Table (2), proceeding to their selection by reading the abstract and the relevance of keywords. The following table (4, Appendage) shows the bibliographic references of the relevant documents, ordered according to the general categories assigned to them.

From the total number of documents obtained, and after the selection process, the following graph (1, Appendage) shows that the relevant documents (305 documents) account for approximately 2% of the total number of documents.

If we analyze the scientific output by time period (Figure 2), the bulk of articles on the subject are published in 2021 (67 papers), although with little difference with respect to the two previous years, 2020 (66 papers), 2019 (64 papers). As for the year 2022, although it has been considered for this study, the output is low because it is still in progress, therefore, the data are not comparable.

Graph 2. Output by year.



Source: own elaboration.

With regard to the output by category (Figure 3), there is a clear interest in publications related to *Training* (108 documents), with a larger volume of documents dealing with *Scientific Literacy* (63 documents). We also found a higher volume of papers dealing with topics related to *Other platforms* (71 documents), with a higher volume of documents dealing with *Social media* (51 documents) Another value to be highlighted is the documents that address the *Treatment of information* (41 documents) in the media (65 documents).

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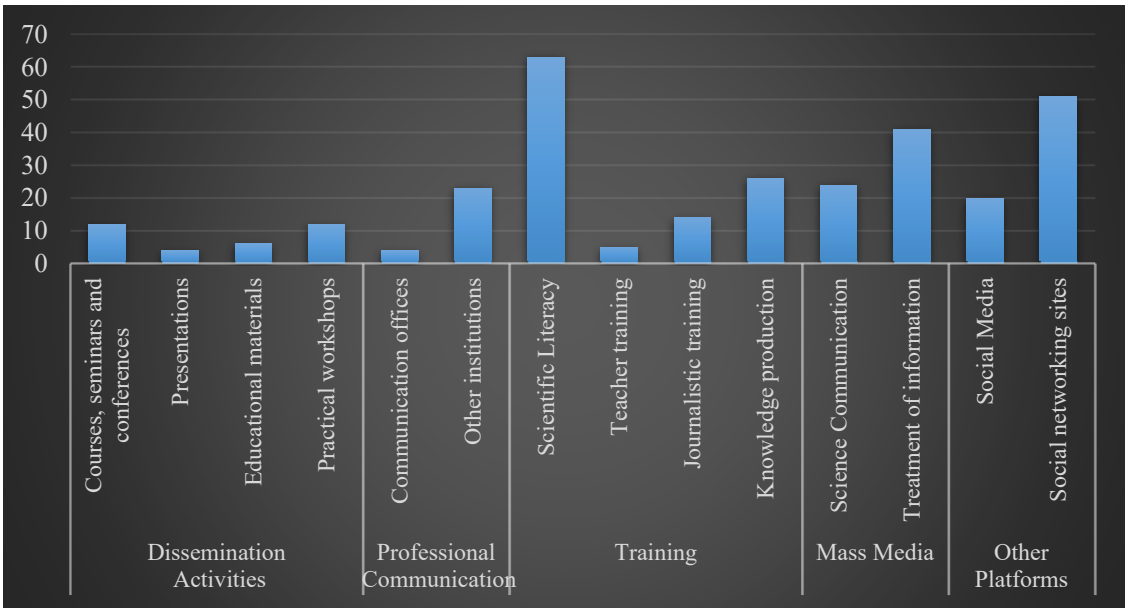
Graph 3. Output by category.



Source: own elaboration.

The next graph (4) shows scientific output by journal categories containing two or more articles published on the subject. It shows that the journal that has published the most articles related to the concept of "science communication" during the years indicated is *El profesional de la información* with 11 articles, this journal is categorized in social sciences in the areas of audiovisual communication, cultural studies, library and information sciences, and in computer sciences in the area of information systems. Secondly, the journal *Revista Mediterránea de Comunicación* with 8 papers, this publication is categorized within the social sciences in the areas of business communication, journalism, and communication. In third and fourth place are the publications *Prisma Social: revista de investigación social* y *JCOM-Journal of Science Communication*, both with 7 published articles, these journals fall into the category of social sciences in the areas of sociological studies and communication, respectively.

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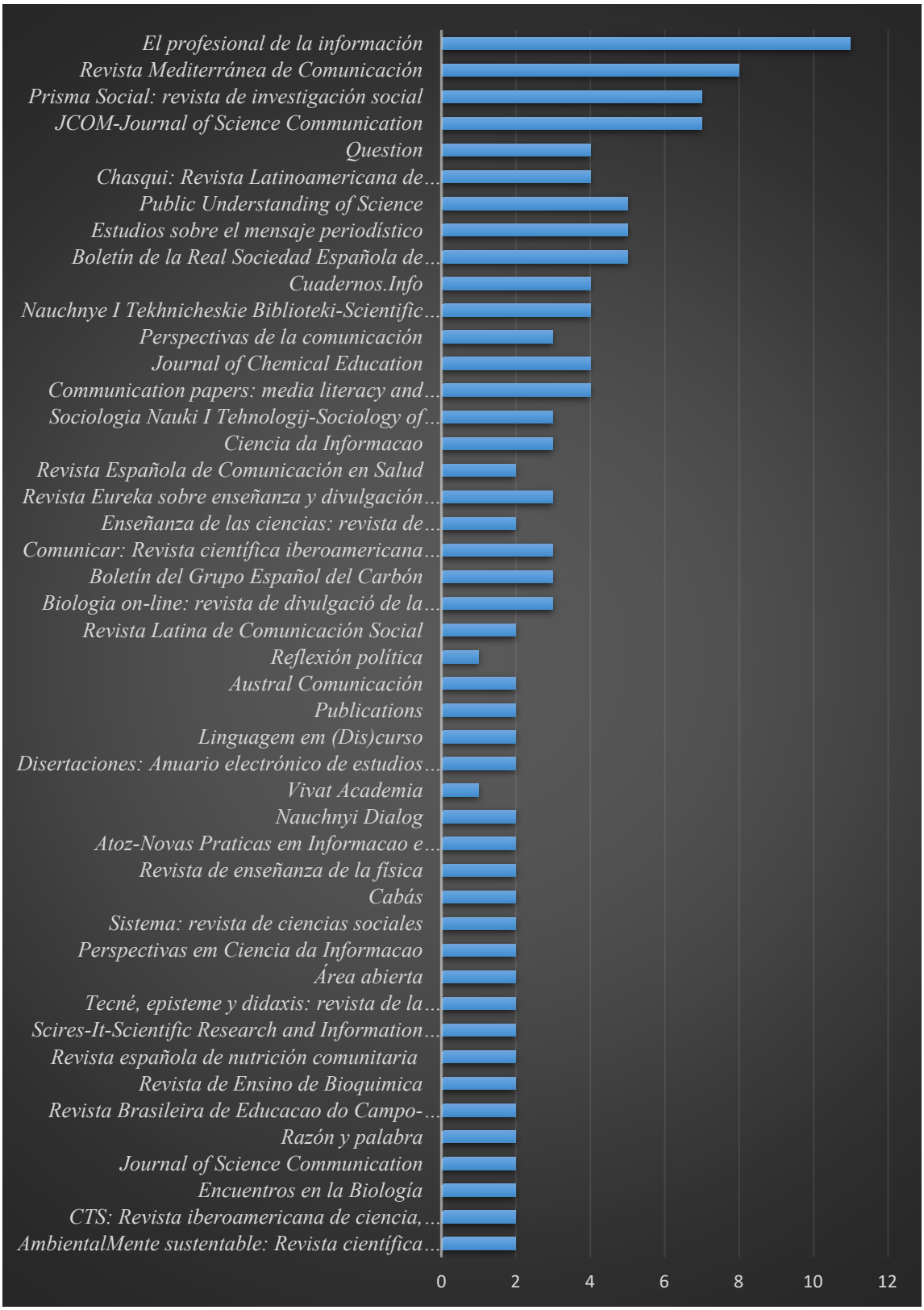
Graph 3. Output by Journal category.



Source: own elaboration.

These data highlight the interest in science communication, which is present to a greater extent in Social Science journals.

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5. Discussion and conclusions

As has been shown, the interest in studies related to science communication has not gained great importance in recent years, which translates into a small percentage (approximately 2%) of the entire scientific output generated in the years studied. However, it is true that the output of science communication articles has increased during the epidemic years (2019-2020) and in 2021.

5.1. *Articles on dissemination science outreach activities*

In the articles focused on dissemination activities, which corresponds to one of the lowest results in the production, they focus on showing the results, planning and dynamics of training courses, conferences, congresses and seminars. Interest in the organisation of scientific dissemination workshops also stands out (Rodrigo Sanz, 2017; Ormaetxea Arenaza *et al.*, 2019).

5.2. *Articles focusing on professional science communication*

Research directed at studies related to professional science communication is scarce, perhaps this is where it would be interesting to show more attention. There is little scientific production that shows the communication strategies of the communication offices of different companies concerning scientific dissemination. This research focuses to a greater extent on the communication departments of universities (Ojeda-Romano & Fernández-Marcial, 2017; Alonso-Flores *et al.*, 2020; Sanz-Hernando & Parejo-Cuéllar, 2021). It would be interesting to know how different companies use these cabinets for the dissemination of scientific information, in order to learn about their communication strategies.

5.3. *Articles focusing on the field of training*

The focus of these studies has been on science dissemination with a literacy approach. Thus, we find studies related to citizen science and science education to the general public and children (Martí Feixas & Amat Vinyoles, 2017), in outreach activities such as conferences and talks (Ayala & Hidrobo, 2021; López-Cantos, 2021) and collaborative projects (Cheng *et al.*, 2018; Verbena Córdula & Giraldez Alvarez, 2019; Viguera *et al.*, 2018).

In this area, the studies focused on scientific literacy in the field of formal and non-formal education stand out. However, more emphasis is placed on formal education, where practical studies on science didactics in the classroom are shown. Despite this, there is some interest in citizen science.

5.4. *Articles focusing on science communication in the media*

At this point, the research focuses on the treatment of science information in the media (Cisneros Estupiñan & Muñoz Dagua, 2021; Lugo-Ocando & Glück, 2018; Urrego Zuluaga, 2019).

The most abundant research deals with the way in which these media, especially the written press, treat and disseminate scientific information.

5.5. *Articles focusing on science communication on other platforms*

Other articles focus on the study of social networks as tools for the dissemination of scientific knowledge (Andreeva & Kopchuk, 2020; Restrepo Betancur *et al.*, 2020; Sidorenko-Bautista *et al.*, 2021; Zaragoza & Roca Marín, 2020b). It is on this topic that a greater number of publications have focused on studies related to scientific literacy.

With the rise of social networks and their versatility, it is not surprising that they are becoming ideal tools for the dissemination of scientific knowledge. While it is true that these studies show the suitability of these media for the dissemination of knowledge, there has been a lack of teaching researchers how to use these tools in an appropriate way.

In general, if we analyse these results, the studies have focused on the more traditional concepts linked to science communication, especially in the field of education. However, it should be noted that new communication channels for the dissemination of science, such as

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social networks and the need for proper communication of science through more traditional media, have gained importance.

If we look at the temporality, a slight increase in science communication interest can be seen since 2019, a moment that coincides with the Covid-19 pandemic. This period fostered a need to publish research related to the disease (Estrada-Lorenzo *et al.*, 2021), which also derived from the need to study the different methods and channels of communication, although this increase has not been considerable compared to 2018 and 2019.

Although it is true that due to the requirements of communication projects and the dissemination of scientific results, the need to disseminate this type of information has increased. Interest is limited to the social sciences in areas such as communication, journalism and information and documentation sciences, with little interest for other disciplines. As we have seen, although the largest volume of articles published on the object of study falls into the category of social sciences, we can highlight journals such as *Boletín de la Real Sociedad Española de Historia Natural*, *Revista Española de Comunicación en Salud*, *Biologia on-line: revista de divulgació de la Facultat de Biologia*, which to a lesser extent have published on the subject.

The concept of "science communication" covers different fields of study. Perhaps this transversality may be the reason why scientific journals, in general, do not arouse special interest in works that deal with this subject due to their direct link with the area of communication (Parejo-Cuellar, Flores-Jaramillo & Carcaboso-García, 2023).

While it is true that science communication has become important in some research projects, there is still a long way to go before all sciences share an interest in disseminating knowledge outside academic channels.

In conclusion, this study aims to show, by way of a literature review, from what point of view science communication is being approached and the interest that journals have in this type of work.

6. Limitations

In addition to the limitations that can be subtracted from the methodology used for this study, the temporality of the material analysed (2017-2022) can be considered a limitation of the analysis. However, the authors consider that this does not detract from the validity of the results.

Likewise, as a future line of research, it would be interesting to repeat the study with a longer analysis over time in order to gain a broad understanding of the evolution of scientific production in science communication.

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Annex

Table 2, Table 3, Table 4 and Graph 1 are available in the Figshare data repository with the following doi: https://www.doi.org/10.6084/m9.figshare.25813993

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