Perspectives and approaches of articles on science communication published in Brazilian journals*[1]

Ana Regina de Oliveira Hungaro[2]
ORCID: 0000-0003-0665-3136
Adriana Pugliese[2]
ORCID: 0000-0002-4683-5834

Abstract

Science Communication (SC) plays a crucial role in the social, cultural, and economic development of a society. In Brazil, its history is long, but it has achieved continuous growth, which can be observed in the increasing number of articles published on the subject in recent years. Given this scenario, this paper intended to map how SC has been addressed in different publications, from 2014 to 2021, in six academic journals – *Anais da Academia Brasileira de Ciências* (Brazilian Academy of Sciences Records), *Revista Brasileira de Pesquisa em Educação em Ciências* (Brazilian Journal of Science Education Research), *Ciência & Educação* (Science & Education), *Educação e Pesquisa* (Education and Research), *Educação & Realidade* (Education & Reality), and *Revista de Ensino de Ciências e Matemática* (Mathematics and Sciences Teaching Journal) – categorized as "Class A" periodicals in CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Higher Education Staff Improvement Coordination) Qualis Program. Both the Knowledge State in the publications found and the material submitted to Content Analysis, as proposed by Bardin (2011), were reviewed. In all, 51 articles related to Science Communication were selected. In this corpus, the following was observed: 1) the distribution of articles over the years and how the topic has been treated; 2) the number of partnerships between Brazilian and foreign institutions; 3) the presence of major areas of knowledge (Physics, Chemistry, Biology, and Sciences); and 4) the journals conduct during the pandemic, between 2020 and 2021. Finally, in a qualitative analysis, eight categories were created, making it possible to identify the predominance of use of SC in the classroom as a teaching resource, while other areas showed gaps. Our intention was

***** English version by Otávio Albano. The authors take full responsibility for the translation of the text, including titles of books/articles and the quotations originally published in Portuguese.

1- Acknowledgements: This paper was supported by *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (National Council for Scientific and Technological Development – CNPq), Process Number 409899/2021-6, and by *Fundação de Amparo à Pesquisa do Estado de São Paulo* (Sao Paulo State Research Protection Foundation – FAPESP), Process Number 2020/05696-7.

2- Universidade Federal do ABC, Santo André, São Paulo, Brazil. Contacts: ana.regina@aluno.ufabc.edu.br: adriana.pugliese@gmail.com

https://doi.org/10.1590/S1678-4634202450275685en

not to exhaust what is known about the subject – after all, most publications on SC are fragmented – but to provide a general overview of the topic. In this sense, we believe in the role of area specific journals, as well as in the financing of projects that can contribute to SC's advancement.

Keywords

Science communication – Academic journals – Knowledge State.

Introduction

Science communication, popularization and publishing are some of the terms used around the world to define projects intending to spread science to the population. According to Bueno (2010), science communication and publishing differ mainly in terms of their target audience – while in the former the information conveyed is addressed to lay people, in the latter the main audience is made up of experts in certain areas of knowledge. In other words, science publishing is, at least, composed by both peer and nonpeer groups, while in Science Communication (SC) it is expected, in general, an audience that is not scientifically literate. The term "popularization of science" is of French origin and refers to the act of making science popular (Bueno, 2010). In this case, it is a broader effort than "just" communicating science – it also means being attentive to social (popular) movements, putting science amidst popular participation and in aid of all necessary cultural actions for oppressed and marginalized groups of the population (Germano; Kulesza, 2006).

Therefore, for methodological purposes, these are the three definitions we used to the development of the research. However, literature shows that there is still no consensus between those terms, and that scientific "communication", "dissemination", "popularization", "appropriation" and even "teaching" can be used to describe the domain which joins science and society (Rocha *et al.*, 2017).

SC's history in Brazil is intertwined with the political, economic and military interests of the time (Massarani; Moreira, 2016). Even if there was already a timid manifestation of scientific communication in the 19th century, due to the arrival of the Portuguese Court and the establishment of the metropolis in Brazilian territory, it was only in the first decades of the 20th century that science communication activities began to consolidate, especially in Rio de Janeiro (Massarani *et al.*, 2002).

Some of the main changes that happened during this period involve the scientist role and the way science began being represented. What was once an exhibition of techniques without the participation of academics became an assortment of activities to communicate knowledge on science, with the scientist in a prominent role. However, it was only in recent decades, from the 1980s onwards, that SC started to secure a continuous growth (Massarani *et al.*, 2002).

Science communication movements: the systematization of an area of knowledge

It seems that the scientific milieu has been trying to improve discussion on SC. According to Barata *et al.* (2018), this is an area that has recently emerged as a field of study, and its progress involves the creation of new jobs, research, conferences, etc. Furthermore, it can be seen an effort of creating laws and postgraduate courses, mainly in Latin America, that are boosting this domain and consolidating it as an academic field. Additionally, there has been an increase in articles related to SC in recent years, as shown in a survey made by Massarani (2018), who analyzed, among other aspects, publications in the area between 2014 and 2017.

This trend was followed by effective action in many countries, including Brazil. The first public research funding agency, *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (National Council for Scientific and Technological Development – CNPq), was created in the 1950s, a few years after the creation of *Sociedade Brasileira para o Progresso da Ciência* (Brazilian Society for the Advancement of Science – SBPC), the main institution promoting science communication events (Massarani; Moreira, 2016).

Since its creation, one of its main objectives has been to "divulge and communicate all generated knowledge, creating better conditions for the Brazilian population development and social inclusion" (CNPq, 2013, n.p.). Accordingly, CNPq has carried out several science communication actions, including: granting of the *José Reis* Prize for Science Communication; promoting Public Calls for Proposals in communicating and popularizing science (science fairs and scientific exhibitions at national, state and municipal levels; mobile science; science olympiads; financial support granted to Science and Technology centers, museums and related institutions); supporting the *Semana Nacional de Ciência, Tecnologia e Inovação* (Science, Technology and Innovation National Week); and also the creation of an Advisory Committee on Science Communication (CA-DC, acronym for its denomination in Portuguese) – catering to a demand from the academic community in the field, in order to systematize assessment and monitoring processes for this multidisciplinary area of knowledge) (CNPq, 2013, n.p.).

For CNPq, the SC area of knowledge "enables the production, communication and discussion of scientific themes, not only by and for peers, but for the entire society" (CNPq 2013, n.p.). Currently, *Lattes* Platform, which houses the productions of scientists, has also a specific communication subsection for researchers to enlist their work in the area, which allows the quantitative registration of these publications (Oliva, 2012).

In Rio de Janeiro, during the 1990s, the *Red de Popularización de la Ciencia y la Tecnología de América Latina y el Caribe* (Latin America and the Caribbean's Popularization of Science and Technology Network – RedPOP) was created to encourage, popularize and promote exchanges in the scientific area.

Following RedPOP's initiative, the *Journal of Science Communication*, a periodical focusing on communicating scientific communication, created its branch in Latin America, to stimulate SC in the region, considering there were already significant research efforts in here (Weitkamp; Massarani, 2018). This initiative was also adopted by Brazilian

universities, which founded journals focused entirely on science communication, namely *Revista de Divulgação Científica do Programa de Pós-Graduação em Ciências Biológicas* (Biology Postgraduate Program's Science Communication Magazine), from *Unirio*, and *Revista Arco* (*Arco* Magazine), created by *Universidade Federal de Santa Maria* (Santa Maria Federal University), specialized in scientific journalism.

Some periodicals also split off, creating sections specifically aimed at SC – such as the Science Communication and Science Teaching segment, linked to *Revista Educação Pública* (Public Education Journal), from *Fundação Centro de Ciências e Educação Superior à Distância do Estado do Rio de Janeiro* (Rio de Janeiro State Center for the Sciences and Distance Higher Learning Foundation – Cecierj).

In 2017, it was also launched *Instituto Serrapilheira* (*Serrapilheira* Institute), focusing on funding scientific communication projects. One of its domains, called Journalism & Media Program, aspires to combat scientific misinformation and has been fundamental, for instance, in funding projects focused on the Covid-19 pandemic (Instituto Serrapilheira, 2024).

Other actions in national instance have also begun to take place – one such example is *Semana Nacional de Ciência e Tecnologia* (National Science and Technology Week), a part of *Coordenação Geral de Popularização da Ciência* (General Coordination for the Popularization of Science), a section of the Brazilian Ministry of Science, Technology and Innovation; and the creation of *Canal Ciência* (Science Channel), a website maintained by *Instituto Brasileiro de Informação em Ciência e Tecnologia* (Brazilian Information in Science and Technology Institute) (Faria; Santos, 2023).

Digital platforms have proven to be a fertile ground for the development of SC actions. *Universidade Federal do ABC* (Federal University of ABC) developed *Divulga Ciência* (Publicize Science) blog, which maintains promotional texts written by the institution's internal and external audiences. In turn, *Blog de Ciência* (Science Blog), from *Universidade Estadual de Campinas* (State University of Campinas – Unicamp), created in 2006, has become the largest science blogs archive in the world and the first online science communication initiative in a Brazilian university (Agência Fapesp, 2020). This blog ended up being the promoter, since 2022, of *Encontro Brasileiro de Divulgadores de Ciência* (Brazilian Meeting of Promoters of Science), which takes place annually in Sao Paulo.

In addition to academic events and scientific journals, science communication and research promotion networks in the popularization domain, collections of studies publishing initiatives and actions have increased discussions in this area of knowledge. For example, Borges and Oliveira (2019) organized a book intending to create spaces where different voices and contexts, national and international, could discuss and question practices and studies on science communication, as well as the diversity of means to communicate Science. In this sense, the following actions stand out: scientific exhibitions experiences (Menezes; Reis, 2019), artistic practices (Silveira, 2019), use of digital platforms (Costa; Rocha, 2019), discussion on the relationship between teacher training and museum spaces (Marandino; Pugliese; Oliveira, 2019), different language systems and meanings intrinsic to these spaces (Afonso; Afonso, 2019; Ferreira; Reis, 2019), among others.

Another prominent collection deals with science communication and the challenge of systematizing writing, in which Arnt, França and Bessa (2015) discuss the theory and

practice of science communication and writing for teachers. The authors comment that, based on a course within CAPES' (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* – Higher Education Staff Improvement Coordination) *Programa Novos Talentos* (New Talents Program), they compiled significant questions based on their experiences as teachers, teachers trainers and promoters: they discuss and suggest how to communicate the texts produced and enumerate the work results of the teachers who attended the course, bringing to the table the "rich experiences they had in the classroom, putting into practice what they learned in the course and giving themselves permission to write" (Arnt; França; Bessa, 2015, p. 11).

It is worth noting that, within the scope of science communication and culture, the public is not the only one to benefit: those are the very methods which make it possible to achieve prestige and funding for their studies; after all, when research projects and scientific advances are communicated to a broader audience, such results can also reach research support institutions (Marandino *et al.,* 2004).

Within this context, in which science communication is increasingly important, we raise the following research questions: what is the current scenario of science communication in journals focused on Science Learning? Is there a standard topic or profile for this kind of work?

To answer these questions, this paper's intent was to map productions from 2014 to 2021 in six journals. The specific goals are: (1) to investigate the number of publications related to SC in prominent journals, mostly in the Teaching domain; (2) to assess whether there was an increase in the number of publications over the six years, especially in 2020 and 2021, in midst of the pandemic; (3) to know which are the most recurrent themes in the SC domain; (4) to understand how these themes have been addressed and whether there are differences in their approaches when comparing the evaluated journals, based on the creation of different categories; (5) to identify the existence of partnerships between Brazilian and foreign institutions; and (6) to detect the presence of major areas of knowledge in the selected articles.

Materials and methods

In this research, it was in effect an analysis of the diagnosis of the knowledge state in Science Communication in the main national scientific journals which publish research in the Science Teaching domain. According to Romanowski and Ens (2006), the term "knowledge state" refers to any research on a topic in a certain circle of publications. In this case, a specific analysis (Silva *et al.*, 2021) was carried out.

The choice of periodicals for the analysis was, at first, based on CAPES' *Qualis Periódicos* (*Qualis* Periodicals) system, equivalent to the "set of procedures used by CAPES to layer the quality of the intellectual production of postgraduate programs" (CAPES, 2019).

Levels A1 and A2 are the two highest levels in the grading, thus reflecting a status of excellence (Barata, 2016). Six well-ranked journals were chosen according to the *Qualis Periódicos* system, in the 2013-2015 quadrennium: *Educação e Pesquisa* (Education and Research), and *Educação & Realidade* (Education & Reality), both ranked at level A1;

Anais da Academia Brasileira de Ciências (Brazilian Academy of Sciences Records), *Revista Brasileira de Pesquisa em Educação em Ciências* (Brazilian Journal of Science Education Research), *Revista de Ensino de Ciências e Matemática* (Mathematics and Sciences Teaching Journal – RenCiMa), and *Ciência & Educação* (Science & Education), ranked at level A2.

It is worth noting that the new *Qualis Periódicos* scenario in the 2017-2020 quadrennium was established aiming to mitigate questions from the academic-scientific community, especially in what concerns the multiplicity of levels. When ranked in two or more distinct areas, the same journal could receive different evaluations, that is, "each evaluation area used a methodology with different ranking criteria, which made difficult any comparison and reproducibility" (CAPES, 2023). By following different principles from the 2013-2016 quadrennium evaluation, the new *Qualis* model (2017-2020 quadrennium), among other features, establishes a single ranking (only one quality level) and its leveling is assigned by a single evaluation area (parent area) (CAPES, 2023).

The period evaluated covers the years 2014 to 2021, and the search for topics related to science communication was carried out based on the articles' title and abstract, besides the following keywords: science communication/science publishing, popularization of science, scientific perception/communication, public perception, media, social networks, museums and science centers. Some of these terms are directly related to their subjects and some others, indirectly. Therefore, after this initial "screening" process, the texts were read in full.

Another source that guided the journals choice was Rocha and Massarani's (2017) paper, whose goal was to map the SC productions in Latin American journals between 1980 and September 2016, when the collection of articles came to an end. The authors analyzed journals ranked at different *Qualis* levels and, from those, selected the twenty-three (23) that published the most on communication in Latin America. In the present paper, some of these journals indicated as Level A1 were chosen to be analyzed along with others with the same A1 ranking, even if they were not part of the above-mentioned authors' work.

The selected texts were initially assorted according to Sá and Queiroz's (2011) study: at first, the total number of articles on the topic in each of the journals was verified; then, the number of publications per year was analyzed; finally, the most recurrent thematic focus was observed.

The second phase of data analysis was carried out through content analysis. According to Bardin's (2001) conceptualization, this method consists in a set of techniques that contribute to the interpretation of the collected data, and can be divided into three parts: pre-analysis, material investigation, and treatment and interpretation of the results. Pre-analysis is an arrangement phase, whose goal is to turn the analyzed material into functional data (Mozzato; Gryboyszki, 2011). In the second part, material investigation represents the coding, decomposition or enumeration of the material to produce an analytical description based on an in-depth study guided by the hypotheses (Bardin, 2011; Oliveira, 2015). In the final stage, results are treated to become meaningful, which is the moment assigned to any kind of criticism.

Results and discussion

During the research, we aspired to investigate how SC's topic appeared in some of the main journals in the Teaching domain. In total, 51 articles related to the topic were selected, eight ones from Educação e Pesquisa (Education and Research); fourteen from *Revista Brasileira de Pesquisa em Educação em Ciências* (Brazilian Journal of Science Education Research); six from *Anais da Academia Brasileira de Ciências* (Brazilian Academy of Sciences Records); thirteen from *Ciência & Educação* (Science & Education); ten from *Revista de Ensino de Ciências e Matemática* (Mathematics and Sciences Teaching Journal); and not a single article from *Educação & Realidade* (*Education & Reality*). Thus, it was difficult to observe trends of growth or decline in the number of articles published.

This fluctuation in the number of articles matches what the literature shows, which highlights that the SC domain in Brazil has been growing, even if research activity in the country is still small when compared to the international scenario, mainly in Europe and in the United States. An indication of this fact are the Brazilian journals referenced in international rankings, which are much less numerous than those in developed countries (Packer, 2011). Some factors that can explain this phenomenon are the language in which they are written and the habit of publishing only in national periodicals – which makes collaborations among Latin American countries one of the solutions to this problem (Barata *et al*., 2018). Even in this scenario, given the Latin American panorama, Brazil – besides showing an increase in production in the domain – remains hegemonic as one of the countries that publishes the largest number of articles in the main international periodicals in the field in the region (Orozco, 2018).

Trying to justify the difficulty in observing a growth trend, we again resorted to Rocha and Massarani (2017), who evaluated six hundred articles in journals from different areas with the topic "Science Communication in Latin American Countries". It was found that most of the selected articles appear in journals ranked as *Qualis B*, a level that includes journals with lower impact, which may be one of the reasons for the inconsistency in the number of publications over the years: all the journals discussed here rank as Level A1 or A2 and, therefore, show greater impact (Hungaro; Pugliese, 2021).

However, we reiterate that, as stated by certain authors, some of the journals analyzed stand out in specific aspects: the *Revista Brasileira de Pesquisa em Educação em Ciências* (Brazilian Journal of Science Education Research), for example, is one of the journals that produces the most articles on SC, besides standing out in topics such as arts and sciences (Rocha; Massarani, 2017; Aguirre; Nepote, 2017). The journal *Educação e Pesquisa* (Education and Research) is the result of the work carried out by *Universidade de São Paulo* (University of Sao Paulo – USP), coming therefore from a university whose researchers publish extensively in the SC area: USP is the second institution with the most authors with publications in the collection carried out by Rocha and Massarani (2017). The journal *Ciência & Educação* (Science & Education), on the other hand, is one of the journals that produces the most articles in the country related to science centers and museums (Cambre, 2017). In other words, although there is some fluctuation in the number of articles published, it's unthinkable to affirm that those journals have a "poor performance".

It was also verified the countries where the selected articles published researchers' institutions were located. Among the 51 articles, all came from at least one Brazilian institution. Besides that, there were also found partnerships between Brazilian and foreign institutions, from countries like Australia (1 article), France (1 article) and Mexico (1 article).

Guenther and Joubert (2017), in a study including three specialized journals in the area – *Science Communication*, *Public Understanding of Science* and *JCOM* – demonstrated that, although some countries, like the United States, dominate the production in the area, other affiliations between countries have emerged, indicating a trend towards internationalization and multiple collaboration between institutions. The study also reflected the need for greater contributions from countries in the southern hemisphere (Guenther; Joubert, 2017). In this perspective, there is also Massarani's (2015) speech, who encourages scientists to expand the frontiers of scientific public communication, especially beyond the Anglo-Saxon world, in search of an "international language of science".

However, in Rocha and Massarani (2017) analysis, which included many Brazilian journals, few collaborations between countries were identified – only eighteen articles, out of more than six hundred selected. On the other hand, among these collaborations, eight came from partnerships between Latin American countries.

Our results echo these two studies: few articles were established as partnerships between national and foreign institutions, as pointed out by Rocha and Massarani (2017). Meanwhile, we were able to detect a low presence of other Latin American countries in these partnerships (represented only by Mexico), as pointed out by Guenther and Joubert (2017), which reinforces the importance of actions that increase collaborations in the region.

Another brief analysis was performed to determine the presence of four major areas of knowledge in the selected articles. Biology was the focus in eight articles; Science in seven; Physics in five of them; and Chemistry in another five. To perform this division, it was taken into consideration the main area present in the articles, which could appear as a specific theme, as a methodological resource, among other arrangements. The articles that did not deal with any specific area were considered "generalist" and this group constituted most articles, with a total of twenty-six (26) of them.

In an attempt to explain the difference in the number of articles published in those areas – and even their absence in many of them – we can turn to Pinheiro and Oliveira (2020), who argue that choosing what will be published is connected to a political and epistemological dispute, which has as its backdrop the power relations that direct which themes should be privileged and which should remain neglected.

In this scenario, we grow close to Archer *et al.* (2015) discussion: the value attributed to the "scientific capital" lies in its potential to provide a way of understanding the reproduction of inequalities in science participation – and a potential vehicle for dismantling and restructuring current unequal power relations – that is, this scientific capital seems to offer a possibility to promoting social justice in science teaching.

Another goal of this study was to understand how the situation in Covid-19 pandemic early years has influenced this scientific production. Works such as Wirz *et al.*'s (2022) and Mora *et al.*'s (2021) highlight the important role of SC during the pandemic, by providing an effective communication, capable of opposing misinformation or incorrect facts – and, consequently, helping to change the behavior of the entire society.

Despite their importance, a lack of studies that quantitatively address SC production during this period was identified. Zamora (2021) presents one of the few surveys that show that SC actions increased during this period on television, in print newspapers, and in digital media – that is, mainly in communication means. The author, however, warns that: 1) this increase was still insignificant compared to its need; and 2) this increase does not necessarily guarantee access to a quality SC action. For example: the topic raise on social media does not imply a quality communication product, since content created without any educational and communicative elements remains only a new product. Furthermore, stating that the area is growing based on the number of hits is also hasty, since there must be considered significant visits by the public and not just "clicks" from the thousands of users who consume social media (Zamora, 2021).

Although this research did not map various SC actions, but rather only papers/articles on SC, it was not possible to observe an increase neither in the number of these papers in 2020 and 2021, nor the presence of this topic in the selected articles. This data reinforces the importance of "knowledge state" type research, so that the gap in production in the area can be filled.

Finally, the selected articles continued to be assorted according to their main themes, in categories established *a posteriori* by the authors.

Eight categories were listed[3], explained and described in Table 1, and the discussion about the articles that make up each category can be seen right after the table.

Table 1 - Description of categories set up for the selected articles

Categories	Number of articles
Science Communication and Teaching Resources: articles presenting the construction, application or evaluation of SC materials aimed at formal teaching contexts were considered, as an alternative and/or complementary resource to textbooks, text referencing, videos, plays, films, games, music, etc.	17
Science Communication and Bibliographic Production: articles presenting the essence of research in SC; state-of-the-art studies; current scientific productions in SC analysis and quantitative trends for future scenarios were considered.	9
Science Communication and Discourses: articles presenting SC discourse – or any other within the science theme – development were considered, as long as they were communicated or created having some kind of SC activity in its origin.	7
Science Communication and Public Perception: articles presenting research on science public perception were considered, as well as any SC activity originating from the results of this type of research.	5
Science Communication and Historical Contexts: articles presenting History, Philosophy and Sociology of Science and their relations with SC were considered, as well as any bibliographic review that retrieved events, facts and debates on scientific production and communication production.	4
Science Communication and Non-Formal Learning: articles presenting SC activities planned/carried out in museums, science centers and other non-formal learning spaces were considered, as well as those that highlighted these spaces communication potential.	4

3 - To make reading easier, the information about the 51 articles found will appear in the text using codes: *Educação e Pesquisa* shall be named Journal 1 (J1), *Revista Brasileira de Pesquisa em Educação em Ciências* shall be Journal 2 (J2), *Anais da Academia Brasileira de Ciências* shall be Journal 3 (J3), *Ciência & Educação* shall be Journal 4 (J4) and *Educação & Realidade* shall be Journal 5 (J5). The number of the article to which we refer shall appear next to the correspondent journal codes: J1A1 (Journal 1, Article 1).

Science Communication and Formal Learning: articles presenting SC activities planned/carried out either in partnership with or in formal learning spaces were considered.	3
Science Communication and Media: articles presenting the relationship between science and mass media were considered, as well as SC activities presented/planned for those media.	2

Source: Own authors based on Hungaro; Pugliese, 2021.

Science communication and teaching resources

Teaching resources can be diverse, including books, games, videos, presentations, and models (Nicola; Paniz, 2016). For this category, which had the largest number of selected articles, SC texts, scientific plays, movies, and TV shows were found to exemplify the role of such communication resources in science teaching.

An excerpt from one of the articles, investigating children's lines based in a SC teaching resource, justifies that "announcing popular science texts in the classroom [*sic*] was an important strategy for the children not only *to speak more clearly* about the article, but also *to speak in a different way* and understand the texts and the language system of science classes in a different way" (J1A1).

Similarly, another result indicates that SC texts as a teaching resource "have great value, because of all meanings created by the students, in their efforts to understand them in an everyday language" (J4A3). In this sense, in another article, this tool proved to be a possible way to establish relationships between scientific content and topics related to everyday life, as well as for the development of reading, writing and argumentation skills (J4A4). In fact, one of the articles goes further, showing that the use of SC in the classroom is a "strategy for reducing scientific illiteracy" (J5A1).

Another selected article, which also used the relationship between SC and written production, reports that texts can be useful as a didactic resource for science teaching, for they make it possible to discuss important aspects of the way science is currently constructed in the classroom, and also highlight facets of the researcher's work that are rarely present in the image of a scientist created by people in general (J2A6).

On the other hand, scientific plays represent a resource, when used, which provides students "a fertile moment of learning" (J2A2), in addition to functioning as a "teaching support for the transmission of scientific concepts" (J4A2), thus promoting "the communication of curricular content" (J2A13). Another article also highlights the playful side of this resource, arguing that "through theater, it's possible to approach complex scientific themes in a more engaging way" (J4A5), whilst representing a "possibility in the development of scientific literacy" (J5A2).

Finally, the results show that other teaching resources also contributed to the learning process. Another example is the movies, which – if directed to SC – can be an important instrument to establish a dialogue between science, culture and school, if the movies' analysis has the teacher's critical and pondering mediation. Thus, the presence of distorted views of science in the movies becomes, instead of a problem, a possibility

for classroom production activities, encouraging students to think critically on the role of science in their lives and in society (J2A3).

> As literature shows, the use of teaching resources related to SC in the classroom can have several purposes, addressing the students' "benefit": to assist the learning process, contributing mainly to the settling down of the content; to arouse curiosity and interest; to maintain motivation; to help in their cognitive development, etc. (Silva et al., 2017) SC as a teaching resource can also be seen as a way of updating – both the science curriculum and the teachers' methods – and even enabling teachers' continuous training, encouraging them to seek new methodological tools (Rocha, 2012).

Science communication and bibliographic production

As one of the results of this category points out quite emphatically, "communicating the results of scientific research, as well as discussing the problems and challenges it raises, is fundamental to Brazilian culture" (J3A1). Furthermore, according to another result, "it is not possible to treat scientific communication separately from the scientific production" (J1A4). Thus, knowing how the former is presented in studies, dissertations, theses, and papers helps taking a glance of the path taken by the latter. This is precisely why the results of this category have encompassed a broad spectrum, including the mapping of scientific communication itself, but also, for instance, the journals' production diagnosis and the research area.

As previously stated, it is widely known that the SC domain has grown, as has the public and governmental perception regarding scientific advances (Barata *et al.*, 2018). However, other studies, such as Caldas and Zanvettor's (2014), argue that there is still a disparity between what is produced and what is communicated. It is because of this that research encompassing the mapping of scientific production, such as those aimed at the state-of-the-art, contribute to the understanding of the reasons for this difference (Caldas; Zaventtor, 2014). In addition, this category is also validated for helping to recognize trends, tendencies, insights, recommendations, gaps to be worked on, etc. (Nascimento; Rezende-Júnior, 2010; Silva; Carvalho, 2014)

The overview presented by the articles that deal with bibliographic production is still necessary, given the expansion in the number of publications in any areas (Romanowski; Ens, 2006), but specifically in SC, which is constantly growing (Orozco, 2018). As two of the results of this analysis point out, there is a lack of diagnostic data in this area, which could help us to "guide and strengthen institutional efforts in scientific communication" (J3A2), besides allowing "the development of studies that are more pertinent and coherent with the gaps in literature" (J2A14).

Thus, it deems necessary to encompass all those studies to build a production systematization in the area (Romanowski; Ens, 2006). Because to this, there is a need – as one of the results of this research points out – for journals to undergo renewals in their management and operations, to "strengthen their condition as a research and learning infrastructure component, and to create conditions for the adoption of the state-of-the-art in scientific communication services" (J1A3).

A strategy that has proven efficient in this attempt to increase SC productions could be what Barbatho (2011, p. 131) indicates: collections – which are "on the rise" in History and Human Sciences domains in general. In fact,

> [...] publishing books continues to be a tradition, but other forms of production have also become intensely available, such as articles in periodicals and studies in collections, which are seen as an alternative to the pressure to publish, showing a steadfast growth [...] as book chapters or studies in collections are, today, CNPq's scholarship holders' output greatest productive strength.

Science communication and discourses

For Gonçalves (2013), SC is not a neutral activity. As an example, according to the author, we may consider the journalistic sources, which disclose topics related to science in different ways, besides treating their audience in the same way – each one with a different approach. It is because of this that it can be inferred that SC has multiple discourses, or at least, varied genres within the same media circle (Gonçalves, 2013).

According to Cunha and Giordan (2009), SC, in fact, has different discourses – and definitions: for some authors, this activity involves a "discursive rephrasing" to simplify scientific findings for the public. For others, it involves a completely new discourse, which is similar to the discourse of science, but aiming to transmit information. For the rest of them, SC discourse is a combination between the discourse of science and the journalistic discourse, not restricted to being just a mere translation. At this intersection, it would be worth mentioning a third one – the everyday life discourse – represented by common sense, and in which direction SC is also moving (Cunha; Giordan, 2009).

Some results found in articles in this category match the definition stating that "science communication presents its own discourse, intending to bring science closer to readers, whether they are adults or children" (J4A7), while others, supported by Cunha and Giordan's (2009) own reference, recognize that:

> SC's discursive formation originates from a scientific discourse, influenced and altered by non-scientific discourses, either by the journalistic discourse, characterized by the figure of the communicators themselves, or by everyday discourse, associated with the reader's persona. (J4A8).

Another result found in this analysis explains that this combination between discourses happens because "a process of scientific and journalistic discourses 'metaphorization' occurs in relation to everyday life" (J4A10).

Even though SC discourses are based on other discourses, it is worth remembering, as Cataldi (2007) points out, that it has a particular development, since it is under the guidance of those who conceive it and those who receive it, meaning that it depends on the conceptions and interests of these people, besides those pertaining to their own market. Due to this articulation between different discourses, including those of scientists and non-scientists, that Martins (2010) argues that SC presents a heterogeneous characteristic. Accordingly, as pointed out in one of the results presented here:

> Communication is thought of and produced by different social actors, in which these agents' ensemble, and their approach, may lead to actions able to enrich understandings about the relevance of science communication in the scientific domain and beyond (J4A9).

A clear example of the influence carried out by those who produce and those who receive SC discourse is the *Universidade das Crianças* (Children's University), an initiative born in Europe but also developed in Brazil in recent decades. It aims to bring students aged four to thirteen to university spaces and bring about actions to provide access to education and culture through SC. As Gontijo *et al.* (2019) show, during different outreach activities, children – unlike educators, for example – use a different discourse to communicate science, which often wouldn't include words, but gestures, and even silence – which could be challenging for the mediators who have their own discourse for the same activity.

Science communication and historical contexts

This category results showed that the scope of the selected articles varied: while one of them used SC materials to illustrate the history of science in Brazil, another one focused on reporting the proper history of SC in the country. A third one told the history of a Brazilian journal that was important for SC. This variety of data shows that this is a dynamic category. Even so, one similarity was clear: all sought to "examine the past considering the problems and questions posed by the present time" (J1A5). Furthermore, it became clear that "the history of science can foster a more contextualized and critical learning on scientific activities" (J1A6). Presenting science as a historical and social construct also helps to "improve science teaching, especially when training biology teachers" (J4A6).

Many authors see the history of science applied to learning as fundamental to improving the population's understanding of science (Brush, 1989; Ribeiro; Silva, 2017). Part of this because students gain a better understanding of the "scientific journey" from a cultural and more human perspective. In addition, it remains one of the factors responsible for helping to improve the learning of subjects related to Natural Sciences, enabling a better understanding of scientific concepts and methods (Ribeiro; Silva, 2017).

It is no different with SC, especially given the fact that it is a domain whose history is little known: understanding its history implies understanding how its practice varied according to interests (whether political, economic or military), the culture of the time, and the means and scientific knowledge available for communication (Moreira; Massarani, 2002).

Science communication and non-formal learning

The articles in this category that addressed museums and science centers reaffirmed the position of these spaces as science communicators. As the results indicate, "the activities of a science center are popularization initiatives, as they commit to the production and

democratization of science" (J2A10), and, like other science communication spaces, "contribute to the scientific knowledge enrichment in society" (J4A13). Similarly, another result conceives non-formal spaces in general as "potential places for learning and expanding their students' scientific culture, due to their interactive and playful nature and the diversified knowledge that is shared in these environments" (J1A2).

Museums and science centers stand out in the scientific knowledge circle and are distinguished by using their material with the public. For Jacobucci (2008), museums have collections that are part of a personal archive, and a technical team formed by scientists, which allows visitors to have access to the researchers' daily lives and observe how laboratories function in a daily basis. Science centers, on the other hand, use their collections for educational purposes and, therefore, are also known as "science communication centers", even though both spaces in Brazil are treated as synonyms (Jacobucci, 2008), which aligns the results presented previously.

Regardless of the semantics used, both museums and science centers are important, among other reasons, for discussions about non-formal learning, for expanding forms of learning and for creating new learning strategies, in addition to the communication strategies, as addressed by Pin *et al.* (2017). There is also a social and moral issue involved in non-formal spaces, as discussed by Vendrasco and Pugliese (2024, p. 335):

> Given the extent to which science-related issues affect our lives, accessible and equitable science teaching opportunities to think, learn, or question science are extremely relevant to citizen participation. Thus, non-formal science teaching environments not only contribute to science literacy, but also provide people with data and skills which enable them to take part in contemporary life.

Science communication and formal learning

When SC is applied in a formal educational space, results show that its use have specific purposes, such as explaining a concept, delimiting the history of science, promoting debate, etc. Thus, such use "requires a restructuring of educational activities associated with SC appropriation" (J2A8).

However, literature expands this use purpose, and lists a series of other ones, such as increasing students' curiosity; increasing their knowledge and understanding of their perception concerning scientific build up; encouraging students to actively participate in solving scientific problems, among others (Xavier; Gonçalves, 2014). In fact, as one of the articles shows, SC activities in the classroom "contributed to Science topics approaching and their correlations, in a way that arouses students' curiosity and questioning" (J5A4).

Beyond the classroom, but still within formal school environment contexts, some authors such as Gallon *et al.* (2019) highlight events present in the academic calendar that use science communication to bring students and the outer public closer to the scientific content. This is the case of science fairs – often combined with cultural exhibitions – that allow young people to carry out scientific investigations, bringing them closer to the work of scientists and helping them use the scientific knowledge.

Science communication and media

The results obtained in this category show that the media has been fundamental for the communication of science, also comprising a space that influences how the public perceive science. Accordingly, one of the selected articles states that media representations can "contribute on how the public sees, understands and trusts scientific knowledge" (J1A7). On the other hand, concerning SC, numerous media, like TV, newspapers, magazines and even, more recently, social networks, contribute in their own way to science reaching broad audiences. In our data compilation, however, internet in general stood out, since it

> [...] has enabled a wider range of scientific communication activities. As in many other countries in the world, internet use in Brazil for scientific communication appears to be an excellent means for its consolidation, as its access has been increasing to higher levels, where more than half of the Brazilian population has already access to a wide global network. (J3A5).

These results line up with literature, like Marandino *et al.*'s (2015) study, which states that since SC seeks, among other purposes, to render science more democratic, it becomes clear that this activity can be carried out by various circles, such as scientists, scientific and governmental institutions, formal and informal educational spaces, and the media. The authors also argue that all media outlets mentioned above are particularly important allies in sharing knowledge. This potential for communicating science also matches what is proposed by Righetti (2018), who argues that this is a part of scientific activity itself: through the official media, society has access to what is produced by science, and which was, eventually, built with taxpayers' money.

According to Moreira and Massarani (2002), throughout history, there has been hope of rendering the population's educational condition more democratic through new means of communication. The same happened more recently, when scientific shows began appearing on television and, later, were made available on the internet (Moreira; Massarani, 2002).

Massarani (2018) mentions that digital media have given space to SC, and technological resources have worked as allies to communicators. Rocha and Massarani (2017) corroborate this tendency by noting that "means of communication and science communication" is the most frequent topic in the main Brazilian journals. This raises the question: given that it is such a studied theme, why has the "Science Communication and Media" category the smallest number of articles – only two – among the six journals analyzed here?

Finally, besides SC, the internet, with all its websites, blogs, electronic magazines and many other facets, has also contributed to a faster and more far-reaching circulation of scientific knowledge, as mentioned above, in addition to bringing scientists closer together and contributing to the public perception of science (França, 2015).

Conclusions and implications

The results presented here provide a SC overview which refutes the domain's growth results presented in literature. Even so, our intention was to show that the journals analyzed stand out in the area – which justifies Brazil's hegemony in the context of communication – even if this happens only in specific topics. The creation of categories made it possible to visualize how and how frequently these topics have been addressed. The eight categories created also equaled our intention of mapping the communication's knowledge state, to obtain "clues" about possible gaps in the theme, which could become an important tool for future SC projects creation.

Another aspect worth highlighting is the difference in the number of articles related to SC published between the journals focused on Science Learning, which had the largest number of publications, and *Anais da Academia Brasileira de Ciências* (Brazilian Academy of Sciences Records), the scientific journal with the smallest number of SC articles, being specialized in publishing original research results in the scientific areas represented by the Brazilian Academy of Sciences. The disparity between these two types of journals matches what was discussed in the "Science Communication and Learning" and "Science Communication and Teaching Resources" categories, which shows how close to school spaces and teaching in general SC has become. On the other hand, *Educação & Realidade* (Education & Reality), specialized in Learning, did not present any SC articles over the eight years studied, which does not reiterate the previous hypothesis on the differences between these two types of journals. Therefore, it is necessary to analyze more journals outside the Learning domain.

Our goal, as Rocha and Massarani's (2017) own study recognizes, is not to exhaust what is known about the subject – after all, most publications on SC remain scattered – but to provide a general overview concerning it. The tendency of creating specific sections in academic journals seems to be quite effective in highlighting productions in the science communication area, besides enabling repositories that are easy to access and locate, for instance, in a bibliographic search. CNPq itself, as a funding agency for science communication actions, is also an important player in Brazil's scientific productions scenario, whether in the attribution of different types of research grants or through regular actions to promote science communication, directly influencing public policies for the popularization of science in the country.

We also understand that due to the new *Qualis* ranking methodological proposal – considering only one level and regardless of the research area – the SC publications outline may assume different panoramas, and, in a few years, new metrics may be perceived on the path taken by SC in academic journals in the areas of teaching and/or education.

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Received on: 06.17.2023
Reviewed on: 04.22.2024
Approved on: 11.06.2024

Editor: Prof. Agnaldo Arroio, PhD.

Ana Regina de Oliveira Hungaro is a Master's student in the Sciences and Mathematics History and Learning (PEHCM) Postgraduate Program at the Federal University of ABC, from where she holds a degree in Biology and another in Science and Technology.

Adriana Pugliese holds a PhD in Teaching from the University of São Paulo, specializing in Science and Mathematics Learning. She is a professor at the Federal University of ABC and supervises its Center for Studies and Research in Science Learning.