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ARTICLES

Brazilian science communication research: national and international contributions

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ABSTRACT

Science communication has emerged as a new field over the last 50 years, and its progress has been marked by a rise in jobs, training courses, research, associations, conferences and publications. This paper describes science communication internationally and the trends and challenges it faces, before looking at the national level. We have documented science communication activities in Brazil, the training courses, research, financial support and associations/societies. By analyzing the publication of papers, dissertations and theses we have tracked the growth of this field, and compared the level of activity in Brazil with other countries. Brazil has boosted its national research publications since 2002, with a bigger contribution from postgraduate programs in education and communication, but compared to its national research activity Brazil has only a small international presence in science communication. The language barrier, the tradition of publishing in national journals and the solid roots in education are some of the reasons for that. Brazil could improve its international participation, first by considering collaborations within Latin America. International publication is dominated by the USA and the UK. There is a need to take science communication to the next level by developing more sophisticated tools for conceptualizing and analyzing science communication, and Brazil can be part of that.

Key words: academic training; Brazilian science research; science communication; scientific culture

INTRODUCTION

Modern science communication emerged at the end of World War 2. As science moved from traditional concerns such as agriculture into the new frontiers of biochemistry, nuclear physics and genetic engineering, it shifted from dealing with issues familiar to ordinary citizens into areas quite remote from their everyday lives. And as it became less familiar, science dealt with concepts and ideas far beyond normal human experience.

All over the world, the scientific community realized it needed a public face, in order to make the case for increased government funding and public support. It needed to alert the public to new ideas and better ways of doing things. It recognized an obligation to satisfy public curiosity, and for its own survival, to persuade people of the value of

the public investment in science. It also needed to counter opposition to some of its products: vaccination, genetic modification, nuclear experimentation and agricultural practices.

Gradually, governments began to move, at different speeds, to encourage and support science communication activities. They realized that if society is to take full advantage of the discoveries of scientists, then the public must have a basic appreciation of science and its significance. People need to comprehend the issues involved and the risks and benefits of scientific research because ultimately, citizens make decisions about how their governments operate. This led to the funding of national programs aiming to increase public awareness of science and technology.

Growing awareness of science and the communication challenge was spurred by government reports: the 1985 Bodmer Report in the UK (Royal Society 1985) urged scientists to make stronger efforts to communicate with the public, and resulted in the formation of the Committee for the Public Understanding of Science (COPUS). In the USA, science communication activities were less centralized. They were carried out by federal government departments and agencies, along with the American Association for the Advancement of Science (AAAS) and individual professional or learned societies.

By the 1990's, science communication was advancing on three fronts. First, there were new jobs, typically connected to a research institute or museum, and responsible for explaining the work of the institute. Second, staff for these new positions could be formally trained. Previously communication staff had been recruited from areas such as journalism, public relations, teaching and the sciences; and learned on the job through trial and error. Now there was a greater demand and new training courses were established to meet their needs. The third advance was in research related to communication methods, to measure the effects of various activities, analyze media coverage and track public opinion, for example. The pattern of development on these three fronts - jobs, training and research - varied from country to country, depending on their history, culture and current demands.

A recent comparison¹ of the development of science communication in 17 different countries collected information on the dates they reached various milestones (1). The surveyed countries included Australia, Brazil, Canada, Denmark, Estonia, France, Germany, India, Ireland, Mexico, the Philippines, the USA, the UK, Spain, New Zealand and China. Each study nominated a date when the following initiatives took place: first interactive science center; first science festival; first courses to train science communicators; first postgraduate research degrees in science communication; and formation of national associations for science communicators. The pathways and dates varied, but the surveyed countries shared a common objective: strengthening science communication. A sample of data for five countries illustrates the similarities and variations ([Table I](#)):

TABLE I A sample of pioneer contributions in science communication in 5 countries. Source: [Gascoigne \(2014\)](#), based on data collected on panel discussions at PCST 2014.

	First course to train science communicators	First Master degree course	Year National Science Week was established
Brazil	1972	2008	2004
Germany	1979	2011	-
Australia	1988	1992	1997
China	1989	1989	2001
UK	1990	1990	1993

The results for Brazil were typical, leading in some areas and trailing in others: a world leader in establishing training course for science communicators (1972), but lagging other countries when it came to establishing master's courses (2008).

PROGRESS, TRENDS AND ISSUES IN SCIENCE COMMUNICATION

The progress science communication has made since it emerged after World War 2 is significant. At both national and international levels, there are associations, conferences, active programs in training and research, and a growing literature devoted to the subject. The term "science communicator" is increasingly recognized as an occupation and job title. Journals devoted to science communication have improved their visibility and are attracting more papers.

Both the theory and practice of science communication has shifted in the last 30 years, with a reconsideration of how best to engage people in science. Prior to 1990 it was assumed the role of science communicators was to provide enough facts to allow people to make up their mind on an issue, by filling a "deficit" in their knowledge. But the validity of this "deficit model" was questioned, with recognition that people make decisions on more grounds than scientific facts, including economic, ethical, religious and political considerations. Now "engagement" and "dialogue" are part of the discourse of science communicators, along with the simple provision of providing facts and information.

The position of international science communication activity was documented at the third PCST (Public Communication of Science and Technology) conference in Montreal in 1994. Conference Chair Bernard Schiele commissioned 39 authors from 21 countries to report on the status of the scientific and technological culture in their countries, and the consequent proceedings are a benchmark in science communication (Schiele 1994).

Both the practice of and research into science communication have changed since the Montreal conference, typically from counting and measuring media coverage of science to a more sophisticated approach of analyzing publics and other players, and their motivations and attitudes. Evaluation is an increasingly important consideration: how do science communicators know the activities they promote are having the desired effect, whether it is to garner support for investment in science, or stimulate students to study science at higher levels, or enable more sophisticated consideration of issues like vaccination and climate change?

International discussions on science communication have widened, and the PCST network took full advantage of the emerging internet to become a global force. The Network spread from its European foundations to become an international body, with members in 60 countries and conferences held on each of the six inhabited continents, including South America: Brazil in 2014. These conferences are the most important international gatherings for science communicators, providing a biennial opportunity for practitioners and theoreticians to debate new approaches and regularly attracting 500 registrants. Recently the PCST website published papers and presentations made at these conferences, thus allowing researchers to track the shifting focus of science communicators over the last 30 years².

Complementing the PCST archives are publications such as the anthology edited by [Trench and Bucchi \(2015\)](#). More far-reaching than PCST archives, it lists 79 major papers published over 50 years, chosen according to nine criteria (broadly: highly cited, enduring texts which have explicitly addressed processes of communicating science). The authors went on to identify patterns and trends: authors are getting younger, the dominance of the US and the UK is fading, joint authorship is increasing, and the discipline base of authors is shifting from the natural and social sciences to communication scholars.

As the authors say, it is a mark of how science communication studies have “come of age” when a major publisher commissions such an anthology.

It is not, though, a time for science communicators to become complacent. In a recent editorial, [Bucchi \(2016\)](#) as the new editor of the journal *Public Understanding of Science*, urged researchers to move beyond concepts that have been discredited (like the deficit model) to tackle new research challenges. He said a remarkable body of research and discussion has been produced over the past few decades, but there are still pressing issues to address. One is diversity in “audiences” of science communication and a recognition that they vary widely in their interests, attitudes and needs. Both practical and theoretical work needs to take this into account.

[Nisbet and Scheufele \(2009\)](#), p. 1767) had earlier made a similar point:

Any science communication efforts need to be based on a systematic empirical understanding of an intended audience’s existing values, knowledge, and attitudes, their interpersonal and social contexts, and their preferred media sources and communication channels.

Paralleling this diversity of audiences is an explosion in the methods of communication. The last 20 years has seen a relatively small number of trusted sources of information like the *New York Times* and the BBC being swamped by websites, blogs and new media information. The internet has opened debates of science to a thousand new voices, including citizen science, traditional knowledge and concerned citizens, and this fits modern recognition of the importance of dialogue. It also presents challenges: anyone can post a blog or host a website, the material is largely unmoderated, and the emergence of “alternative facts” challenges a scientific approach carefully built up over the last 100 years. Science is still working out how to maintain its authority as the source of the best currently-available knowledge, and science communicators have a key role.

Recently the status of science communication came under the microscope: has it developed to such a stage where it could be considered a discipline? Five papers were commissioned by *Journal of Science Communication*, and broadly concluded that science communication was both interdisciplinary and multi-disciplinary, that it fell short of meeting the requirements for being a discipline, and is more properly regarded as a “field of study” ([Gascoigne et al. 2010](#), [Trench and Bucchi 2010](#), [Bell 2010](#), [Priest 2010](#)).

Gascoigne tested science communication against four classic elements of a discipline: the presence of a community; a history of inquiry; a mode of inquiry that defines how data are collected; and the existence of a communications network. While all these elements are contained within science communication, its cross-disciplinary nature and some ambiguity in the definition of a “discipline” led the authors to their conclusion.

[Trench and Bucchi \(2010\)](#) see the potential for science communication to become a discipline, and nominated two ways to advance this: first, by articulating theories that address key issues in the field (they nominated 5 issues); and secondly by resolving boundary issues with neighboring areas of study such as science and technology studies, and science education.

In concluding this brief survey of science communication, it is appropriate to say Brazil has been part of all these international trends, leading in some cases, following in others. Detail of research and training in Brazil is discussed below, and these activities were given a significant boost in 2014 when Brazil hosted the biennial PCST Conference. It attracted 530 registrants from around the world with major contingents from Latin America. The conference theme was “science communication for social inclusion and political engagement”. The first plenary (on the conference theme) featured speakers from Nigeria, Brazil and Colombia; in the second plenary speakers from the US and Egypt addressed the theme “science communication and social media”; the third on “science communication and audiences” had speakers from Denmark, the US and Brazil; and in the final plenary on “science

in culture” speakers came from Thailand, Ireland and Brazil. Hosting the conference was a significant incentive to Brazilian science communicators to work more closely with their international colleagues.

SCIENCE COMMUNICATION IN BRAZIL

Disseminating the results of scientific research, as well as the discussion of the problems and challenges it raises, is essential to Brazilian culture. The current debate about the advances, promises and limitations of science, technology and innovation (ST&I) enables the active participation of society in decisions regarding the country’s direction and public policy.

The last few decades have brought together scientists, journalists, publishers and government representatives to invest and legitimize science communication in Brazil. Since the 1980s, when science communication was systematized in the country, a long path has been travelled in order for journalists, science communicators and scientists to establish a dialogue and a respectful relationship. Scientists often blamed self-taught or inexperienced journalists for inaccurate articles about their work, including distortions, inaccuracies, hype, or not considering scientific risks and benefits ([Caldas et al. 2005](#)).

Dialogue between scientists and journalists does not happen by chance, and there is recognition of the relevance of science communication in the training of science journalists. Training is also needed for scientists to help them understand the media’s modus operandi and timing, and to allow a more effective relationship.

Since 1947, when the physician and science communicator José Reis began his science column in the newspaper Folha de S. Paulo, the Brazilian media have devoted more space to science. To reflect on the dissemination of science in Brazil and the professional training improvements that followed, we can look at initiatives beginning in the 1970’s that brought together science communicators and researchers.

These include:

- the creation of the University News Agency (AUN) in 1971 at the School of Communications and Arts at São Paulo University (ECA/USP), under the leadership of José Marques de Mello.
- The promotion of the first extension course on science journalism, at USP in 1972. This was offered by the Spaniard Manuel Calvo Hernando, and led to the publication of the book *Teoria e Prática em Jornalismo Científico* (Theory and Practice of Science Journalism), translated by Marciel Prieto Gonzales and Lícia Matheus Mercês (58 pages).
- The launch of a pioneering line of research in the country: “Science and technology communication” in 1978, at the Methodist University of São Paulo (UMESP) lasted until 2012 ([Bueno 1988](#), 2002, [Caldas et al. 2005](#), Caldas 2011, Caldas and Zanvettor 2014, [ABJC et al. 2011](#)).

UMESP also created the project “Comsalud” in 1996, sponsored by the World Health Organization (WHO) and the Pan American Health Organization (OPAS) to study health communication in the media in Latin American countries. Other courses have followed.

The first online specialized course (Latu Sensu) was organized by the Coordination for the Improvement of Higher Education (CAPES) of the Ministry of Education in 1982. Thirty Brazilian journalists were selected to learn science, supervised by scientists from different fields. A seminar financed by the Fulbright Foundation took place in Brasília (DF) with members of the National Association of Science Writers (NASW) ([Caldas and Macedo 1999](#)).

The first specialized course on science communication was offered by the José Reis Nucleus of Science Communication in 1992 by the School of Communications and Arts at the University of Sao Paulo (ECA-USP). The course was upgraded and a new version ran from 2000 to 2012. USP is currently planning a new science communication course. A long-lasting specialized course (360h) in science journalism was created in 1999 by the State University of Campinas (UNICAMP), and 314 science journalists have graduated. Students are journalists and scientists working in partnership ([Vogt et al. 2009](#)).

The increasing interest in science communication contributed to the inclusion of some science communication topics in undergraduate journalism courses in Brazilian private and public institutions ([Caldas et al. 2005](#)). Some institutions offer outreach and specialized courses in science communication, including the first online specialized course at Vale do Paraíba University (UNIVAP) in 2007, and a great number of specialized courses created by different institutions: the Oswaldo Cruz Foundation (FIOCRUZ) in 2009; the Federal University of Bahia (UFBA) in 2010; the Federal University of Rio Grande do Sul (UFRGS) in 2012.

The first Master’s degree course in science communication was offered in 2008 by UNICAMP; and later FIOCRUZ began its Master’s degree in Science, Technology and Health Communication (2016). Almost a decade later, and with 100 dissertations completed in March 2017, UNICAMP is planning a new PhD program in Science and Culture Communication.

Brazilian universities and research institutions have expanded their science communication interest in recent years, either in communication or other faculties such as linguistics, education and health. The Brazilian School of Science Journalism (EBJC) was created in 2011 for undergraduate students of journalism, and offered a free workshop during the Annual Meeting of the Brazilian Society for the Advancement of Science (SBPC). In 2014, UNICAMP

began the first undergraduate course of science communication open to students from different fields, and in 2016 the Federal University of Minas Gerais (UFMG) started a multidisciplinary training program similarly open to students from all backgrounds.

ASSOCIATIONS, AWARDS, ACTIVITIES AND JOBS

Organizations like the Brazilian Association of Science Journalism (ABJC) have led to more frequent discussions about science communication and training in Brazil. The ABJC was founded in 1977, and its first president, José Reis, is considered our “father” of science journalism. Three hundred people attended the first Brazilian Congress on Science Journalism, organized by ABJC in 1982 in São Paulo during the Ibero-American Congress.

The ABJC is older than the international World Federation of Science Journalists (WFSJ) which was established in 2002. It is a matter of interest that the WFSJ was founded in Brazil during the 3rd World Science Journalism Conference and the 7th Brazilian Congress of Science Journalism, in the UNIVAP, São José dos Campos (SP), Brazil.

The Brazilian Association of Science Communication (ABRADIC) was created in 1980 by scientists and science communicators ([Oliveira 2002](#)). The José Reis Science Journalism Award was established in 1978 by the National Council of Scientific and Technological Development (CNPq), and offers an annual prize to journalists, science communicators and institutions. It is currently in its 37th edition.

In 1999, two decades after the first training course, the São Paulo Research Foundation (FAPESP) started the “Media-Science” scholarship³, the first public funding specifically dedicated to science communication. Other states (such as Minas Gerais, Amazonas and Bahia) and federal research foundations now also offer funding for science communication, a recognition of the importance of the field.

Reflections on the theory and practice of science communication are part of the role of science journalists and communicators, as well as experts from other fields. Unsurprisingly, the dissemination of ST&I knowledge no longer has an exclusively positivistic and reductionist view. The importance of ST&I’s role for the country’s development has shaped a more critical role for science communication, where problems and risks are pointed out as well as the benefits of science. Brazilian science communication has reached a new level of maturity.

The job market for science communicators has changed. Traditional jobs in media newsrooms have shrunk, following worldwide trends, but there has been an increase in niche positions in virtual news networks: science blogs, social media and vlogs (blogs in video format). New positions have been created for science communication in universities, research institutions, enterprises and government agencies. Large research projects may also include science communication professionals and they are increasingly requested by government funding agencies to develop activities for knowledge diffusion, including for example, two of the highest budget research project types, the National Institutes of Science and technology (INCT) from CNPq, and the Thematic Projects from FAPESP include science communication activities. More recently the scientific electronic library online (SciELO), the main open-access journal database in the country, has ruled - among different criteria - that journals planning to index in the database must communicate their papers and issues in the social media or blogs.

PUBLIC PERCEPTIONS OF SCIENCE

Like other countries, Brazil has conducted surveys on the public perceptions of science. The first was carried out in 1987 (CNPq/GALLUP), but it was only in 2006 that the Ministry of Science, Technology and Innovation (MCT 2007, 2010, CGEE/MCTI 2015) undertook surveys on a regular basis.

The results reveal strong interest in science, technology and innovation (ST&I) in Brazil. When 1,962 people were asked what media stories interested them in the most recent survey on Public Perception of S&T (CGEE/MCTI 2015), science and technology came ahead of politics, fashion, sports, arts & culture. Respondents chose medicine and health (78%) and environment (78%), ahead of religion (75%), the economy (68%), art and culture (57%), sports (56%), fashion (34%) and politics (27%). But while respondents said they were interested in science, the survey also revealed a fundamental lack of understanding of the field, due to poor scientific culture or limited access to ST&I information.

Among the different media, television was the main source of information for 21% of respondents, closely followed by the internet (18%). Despite some major changes observed in the time series, the number of visits to science museums and science centers is still rather small, although it has grown from 4% in 2006 to 12% in 2015. When visits to zoos, parks or botanical gardens are added to those visiting science museums, the number of visits grows to 41% of respondents. But the same survey showed 87% of Brazilians could not name a research institution and 94% could not name one Brazilian scientist (CGEE/MCTI 2015), which indicates a need to intensify efforts on communicating science to the public.

Despite the increased interest in science and technology, research on media coverage of science presents discouraging results. The study “Science, Technology and Innovation in Brazilian Media” analyzed 2,599 news items from 62 Brazilian newspapers in 2007 and 2008 (FUNDEP 2009); and concluded that most news (86.4%) is decontextualized. Fifty five percent of the news has only one information source, with the majority (51.2%) coming from universities and research institutes. A further 8.8% came from the business sector, 3.5% from civil society organizations, and 1.5% from international organizations. Only 12.3% of articles mentioned ethical issues; and 3.8% correlated the role of ST&I with the eradication of poverty. There is little room for science controversy in the

media: only 10.6% of the articles presented opposing points of view (FUNDEP 2009). Although public interest has increased and many journalists have been trained, there is still room for improvement of science coverage by the media. This is the only recent large-scale research of content analysis across major newspapers, and surveys like this should be repeated to monitor changes in media coverage.

GOVERNMENT ACTION TO STIMULATE SCIENCE COMMUNICATION

Science communication entered the official government agenda during the National Conferences of Science and Technology (in 2001, 2006 and 2010). The new programs of science popularization include financial support for schools, science museums and media. The creation of the Department of Science and Technology Popularization and Diffusion (DEPDI), at the Ministry of Science and Technology, was an important step to boost science communication at the national level. It was responsible for the creation of the National Week of Science and Technology (SNCT) in 2004, as well as guaranteeing investments to research and activities as the Science Olympiads and science fairs ([Massarani and Moreira 2016](#)). Although the SNCT is probably one of the biggest science weeks in the world, it still faces challenges related to the improvement of activities and increasing public and science institutions' participation (Idem).

Another important program is the National Program for Popularization and Social Appropriation of ST&I (POP Ciência 2022), whose general objectives are:

“to strengthen the Science Communication Advisory Committee of CNPq; enhance the activities of popularization of S&T and promote qualified training for journalists, scientists, science communicators and media relations, as well as train scientists, teachers and students for the public communication of science; create programs that attract young people from all social layers into S&T careers, and strengthen, enhance and extend progressively the National Week of S&T for all Brazilian municipalities”. (MCT 2010, p. 92).

As part of this process, CNPq created in 2012 a tab of “Education and Popularization of S&T” in the Lattes Curriculum Platform⁴. This national online database encourages researchers to record their activities and research related to science communication. The Science Communication Advisory Committee was formed, and a productivity fellowship for science communication researchers established, further emphasizing the importance of science communication. Additionally, new funding from state research foundations contributed to an increase in research initiatives in science communication in several Brazilian states.

Thus, the debate on science communication that had been restricted to national or international conferences of science communicators (ABJC, ABRADIC, ABCMC, Red POP, PCST)⁵ became part of the broader agenda of national and international meetings of science, such as Brazilian Society for the Advancement in Science (SBPC), the Brazilian Academy of Sciences (ABC)⁶ and the World Science Forum held in Brazil in 2013.

There have been many public statements in favor of science popularization in Brazil, including the official communique of the 6th World Science Forum in Rio de Janeiro⁷ in 2015. This emphasized the educational role of science communication in forming a critical spirit that would contribute to advances in science. Media involvement was considered “fundamental to the dissemination of scientific knowledge and to political decisions in the field” (WSF 2013).

At the end of 2016, the Department of Science and Technology Popularization and Diffusion was discontinued following a deep economic crisis and a restructuring process of Ministries. This has alarmed the science communication community in terms of the future level of investment, as well as maintaining what has already been accomplished.

BRAZILIAN SCIENCE COMMUNICATION RESEARCH

Brazil has grown its scientific research production globally from 0.8% in the mid 1990's to 2% in 2015, and figures as the 13th nation in rank, according to the SCImago Journal & Country Rank database (SCIMAGO 2015). Thomson Reuters shows a higher figure of 2.44% in 2015, and claims that Brazil has increased the publication of scientific research papers faster than the world at large (145% versus 50%) (Thomson Reuters 2014). Brazil's scientific development has been matched by a rise in the number of papers on science communication.

[Mugnaini et al. \(2014\)](#) observed that there are two reasons for this increase:

- 1) an improvement in the quality of Brazilian journals indexed in international databases; and
- 2) investment in research and education.

The social sciences, where the areas of communication and science communication belong, remain strongly represented in national journals ([Mugnaini et al. 2014](#)). An analysis of national communication research over a decade (2000-2009) concluded that researchers involved in 37 graduate programs publish equally in books and journals, and are mainly located in the Southeast region (56.8%), especially in Sao Paulo State (37.8%) ([Toffoli and Ferreira 2011](#)).

Toffoli and Ferreira analyzed the curriculum vitae of professors of communication at the Brazilian Lattes Platform⁸. Among 503 CVs, they found only 12% of the listed papers were published in international journals, and this increase took place mainly in 2002. We would expect similar results related to the publication of international science communication papers.

There has not been any similar detailed investigation concerning national and international research in science communication. We investigated the publication of dissertations and theses in Brazil; the publication of papers in the field, nationally and internationally; and examined important databases, specifically three relevant international journals about science communication:

- The Brazilian Digital Library of Theses and Dissertations from the Brazilian Institute of Science and Technology Information (IBICT), which includes 358,482 documents from 122 institutions⁹;
- The Scientific Electronic Library Online (SciELO)¹⁰, the main database of open-access science journals in Brazil, which includes 895 journals from 11 countries in Latin America, Portugal, Spain and South Africa, as well as 354 Brazilian journals;
- The Web of Science (WoS), one of the most prestigious international databases, which has included since 2014 the SciELO Citation Index and therefore the national journals indexed in SciELO.
- Three science communication journals: Public Understanding of Science (PUS), Science Communication and Journal of Science Communication (JCOM).

By analyzing Brazilian publication on science communication, we aim to evaluate how training in postgraduate programs has contributed to national and international levels of research. We also wanted to discover which keywords are most often used to define "science communication"; the main fields leading the research through the postgraduate programs and journals; and the capacity to establish international collaborations. This analysis should lead to an appreciation of the Brazilian potential to contribute to science communication research, and indicate future challenges.

DISSERTATIONS AND THESES

[Caldas and Zanvettor \(2014\)](#) investigated the theses and dissertations on science communication in Brazil using the archive of the Brazilian Federal Agency for the Improvement of Higher Education (CAPES). They discovered 45 postgraduate programs in communication in Brazil, by using 6 keywords related to science communication (science communication; education and science; public communication of science; communication, technology, science and society; popularization of science; and science journalism); and 761 publications. Most programs were in São Paulo State. The analysis showed "science communication" was the most frequently-used keyword, and the publications involved research from different fields of knowledge, not only communication but also science and society.

Several institutions in the Southeast region¹¹ of Brazil offer extension and specialized courses on science communication, either online or face-to-face. Contrary to what one might assume, those courses are more often offered in programs managed by different subjects - education and language rather than communication ([Caldas and Zaventtor 2014](#)). This emphasizes the multidisciplinary character of science communication, and its ability to bring together various fields of knowledge.

We made a similar analysis of the Digital Library of Theses and Dissertations (BDTD)¹² of the Brazilian Institute of Information in Science and Technology (IBICT). The search was up to 2015 and used different keywords in Portuguese to describe the field: "science communication" ("divulgação científica"); "science journalism" ("jornalismo científico"); "science literacy" ("alfabetização científica"); "science museum" ("museu de ciência"); "scientific culture" ("cultura científica") and "science popularization" ("popularização da ciência"). The search resulted in 559 on-line documents that contain at least one of the 6 keywords ([Figure 1](#)). There has been a huge increase in research about science communication since 2002, with the most frequently-used keywords "science communication" followed by "science literacy": a similar result to [Caldas and Zanvettor \(2014\)](#). The huge drops registered in 2015 should not be considered as the final picture, since there is a delay on new publications entering the database.

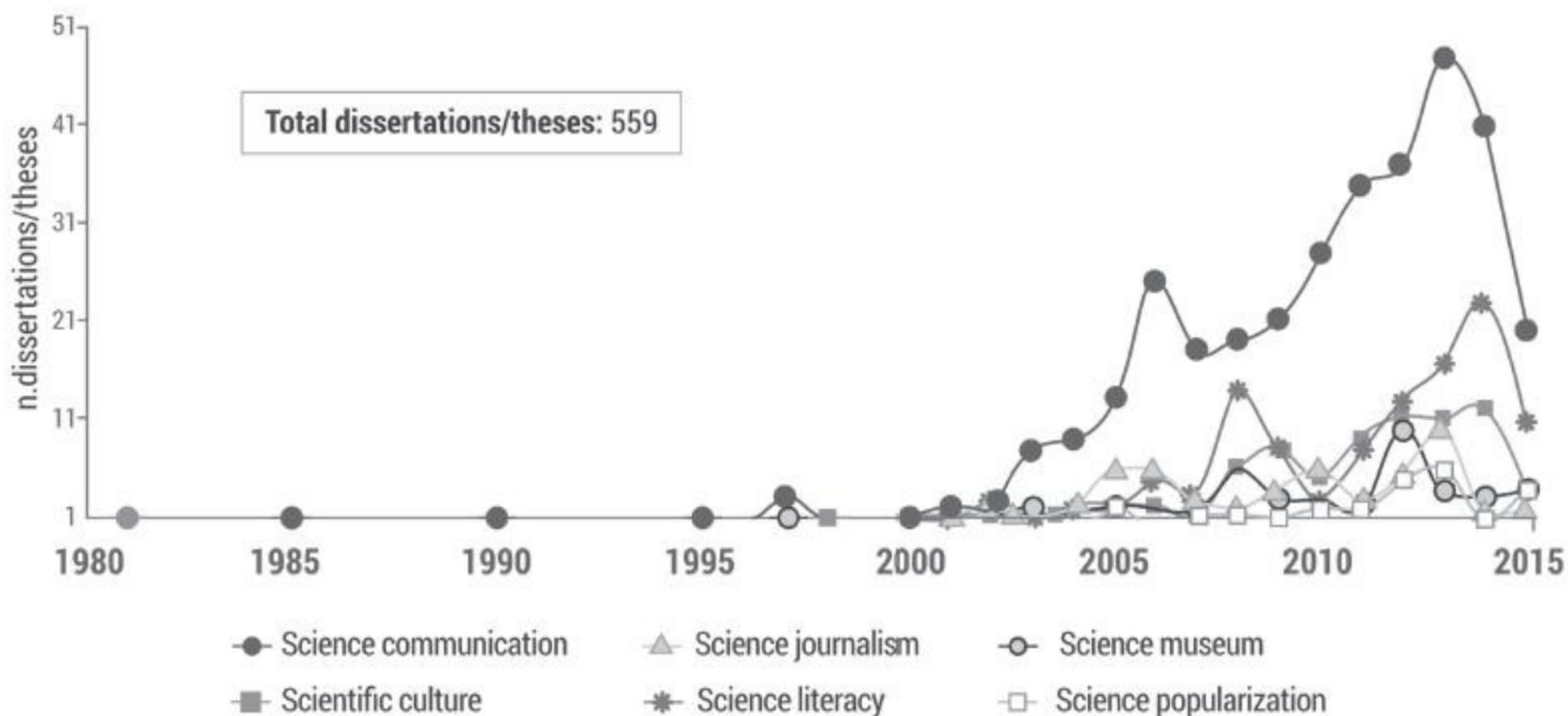


Figure 1 Distribution of dissertations and theses published in Brazil (1980-2015). Based on data collected from IBICT database.

The majority of dissertations and theses on science communication from 1981 to 2015 were produced in institutions based in the Southeast (60.9%) and the South (22.9%), followed by the Northeast (11.3%), Central-West (4.5%) and the North (0.3%). São Paulo State is responsible for 48.6% of all research, reflecting the fact that it has the greatest amount of investment, research institutions and science research in the country. In a total of 46 institutions, there were 114 postgraduate programs with the majority concentrated in education, communications, and literature and languages. The greatest number of contributions came from the following postgraduate programs: education and education in sciences at University of São Paulo (USP); science and culture communication at State University of Campinas (UNICAMP) and communication at Methodist University of Sao Paulo (UNIMEP); language at Federal University of Santa Maria (UFSM) and philology and Portuguese language at USP. And there were important contributions from information science at the Brazilian Institute for Information in Science and Technology (IBICT) in partnership with Federal University of Rio de Janeiro (UFRJ); education at Federal University of Minas Gerais (UFMG); psychology at Federal University of Santa Catarina (UFSC); production engineering at UFSC (although earlier than 2005) and applied linguistics at UNISINOS University.

The high number of postgraduate programs shows that science communication in Brazil is multidisciplinary, although it has strong connections with education and communication. The first two decades up to 2001 were much more multidisciplinary¹³. There have been increasing contributions from postgraduate programs specializing in the topic or with a line of research dedicated to science communication (such as education in sciences; science and culture communication; and science, technology and society). We expect to see stronger contributions from those programs as new masters and PhD programs dedicated to science communication are created.

Our data collection from IBICT database has some limitations, since technical instabilities may lead to gaps or overlap of information. Additionally, some institutions with publications on science communication may not have digitalized them or entered them in the database¹⁴; and some theses and dissertations on science communication might use different keywords. Despite these limitations, our analyses provide a useful and fruitful view of research of science communication.

PAPERS ABOUT SCIENCE COMMUNICATION RESEARCH IN BRAZIL

A search conducted in the Scientific Electronic Library Online (SciELO)¹⁵, using the same 6 keywords as above and covering the period from 1997 to 2015 has identified 402¹⁶ papers. There was huge rise in the number of papers using "science communication" (in Portuguese, Spanish or English)¹⁷ as the keyword (Figure 2), with a total of 195 papers (48.5%). The keywords "scientific culture" (19.1%) and "science literacy" (12.7%) are the next highest, while "science journalism" (7.7%), "science popularization" (6.5%) and "science museum" (5.5%) are less often used.

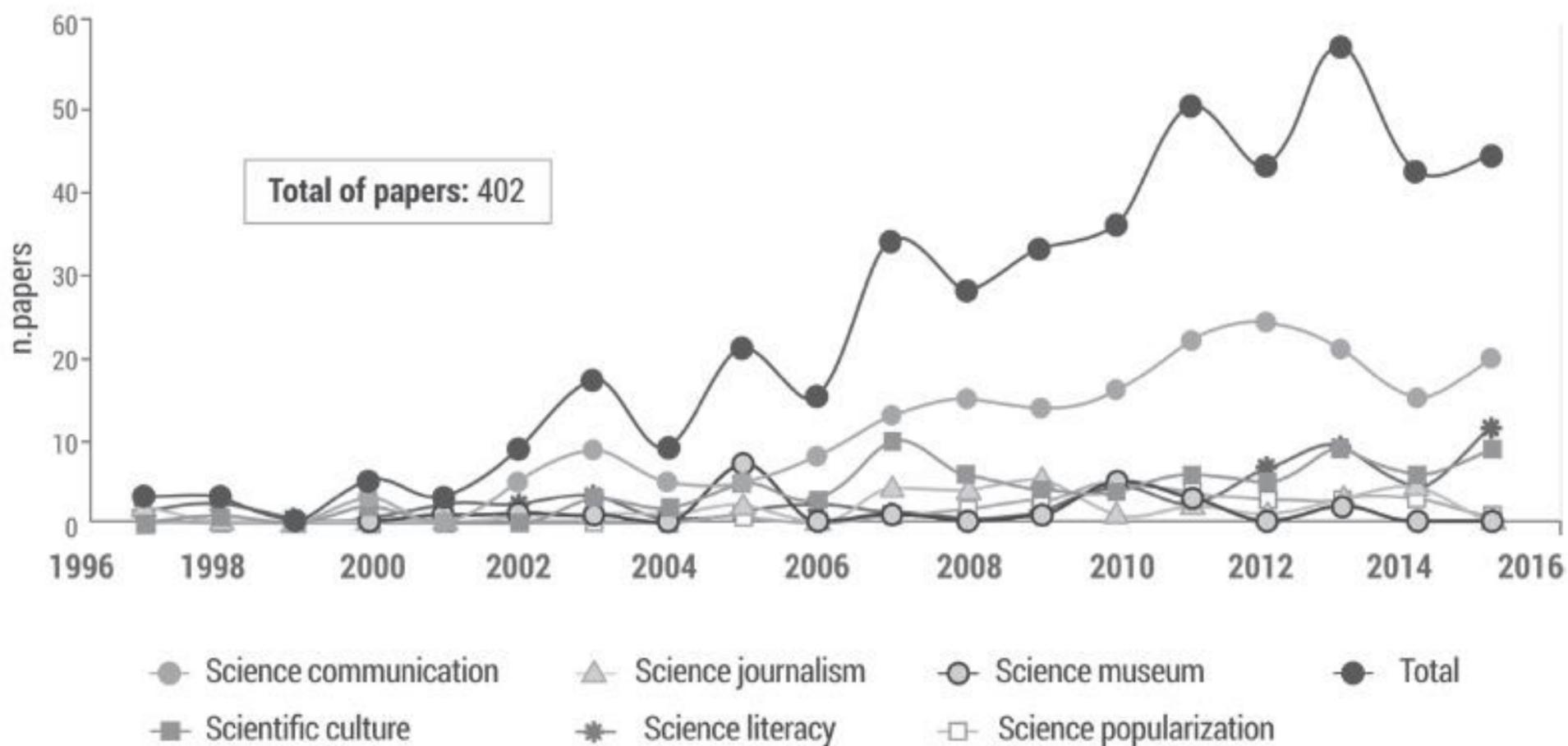


Figure 2 Distribution of papers published in the SciELO database using 6 keywords related to science communication (1997-2015). Based on data collected from SciELO in February 2016.

Brazil published 62.7% of all papers, followed by Colombia (7.5%); Argentina (4%); Spain (3.5%); Portugal (3.5%); Cuba (2.5%); Venezuela (2.5%); Chile (2%); Mexico (1%) and Peru (0.5%).

SciELO's homepage generally does not provide information about the author's institution, so we used the SciELO Citation Index to discover this information. Even though 19 States¹⁸ have published papers, we identified a concentration in Brazil in the southeast (66%), followed by the south (17%), northeast (11%), central-West (5%) and north (1%). The institutions with the highest publication of papers are: São Paulo University (USP); Federal University of Rio de Janeiro (UFRJ); Oswaldo Cruz Foundation (FIOCRUZ); State University of Campinas (UNICAMP); Federal University of Santa Catarina (UFSC); Federal University of Minas Gerais (UFMG); State University of Rio de Janeiro (UERJ); State University of São Paulo (UNESP); Federal University of Bahia (UFBA); Federal University of Santa Maria (UFSM); University of Brasília (UnB); and the Federal University of ABC (UFABC). All are public institutions with postgraduate programs either to train researchers or practitioners; and this emphasizes their important role in research.

Not many papers are co-published with authors from other Latin American countries, a pattern found in other fields ([Meneghini and Packer 2008](#)). Only 4.5% of the papers with authors from Brazil have co-authorship with other countries: Spain, Portugal, the Netherlands, Colombia. This result shows an urgent need for international collaborations, mainly within Latin America because these countries share common social and economic realities. SciELO is an important open access database in Latin America so the results are quite indicative.

Most papers with authors from Brazil are in education (40%) or history (14.2%), with a focus on education of science and history of science. Communication was responsible only for a tiny portion of papers (1.3%). Among the 76 journals listed, half the papers about science communication were published at: *Ciência & Educação* (from UNESP) 15.6%; *História, Ciências e Saúde - Manguinhos* (from FIOCRUZ) 12%; *Ensaio Pesquisa em Educação em Ciências* (UFMG) 9.3%; *Revista Brasileira de Ensino de Física* (Brazilian Society of Physics) 5.8%; *Linguagem em (Dis)curso* (University of the South of Santa Catarina State, UNISUL) 4%; *Interface Comunicação Saúde Educação* (UNESP) 2.7%; and *Ciência & Saúde Coletiva* (Brazilian Association of Collective Medicine) 2.2%. These results are consistent with those above on the publication of dissertations and theses, and not surprisingly, come from institutions in which education is robust.

BRAZIL IN THE WORLD OF SCIENCE COMMUNICATION RESEARCH

Although Brazil has increased its production of papers in both science and science communication research and practice, the country is barely represented in international attempts to map science communication ([Schiele 1994](#), 2006, 2012, [Bauer et al. 2007](#), [Bucchi and Trench 2008](#), [Polino and Castelfranchi 2012](#)). Developed European nations and the US are the main contributors.

We have examined research papers on science communication in the Web of Science (WoS) (1976-2015), one of the most prestigious international databases of journals. It includes two international journals in the field: the

British Public Understanding of Science (PUS) and the American Science Communication. Although it has been concluded that the Scopus database by Elsevier Group is superior in terms of communication papers and publications ([CODINA et al. 2014](#)), we have chosen WoS since it includes specific journals of science communication as well as journals indexed in the Brazilian SciELO database and other national databases, such as the Chinese Science Citation Database and the Korean Journal Database.

We searched for publications using the same six keywords as above, including only articles, reviews, editorials or letters ([Figure 3](#)). The keywords "science communication", and "science literacy" are most frequently used for Brazilian papers in the SciELO database, as already noted. The growth in these keywords begins in 2001, while the use of "science journalism" and "science popularization" has decreased.

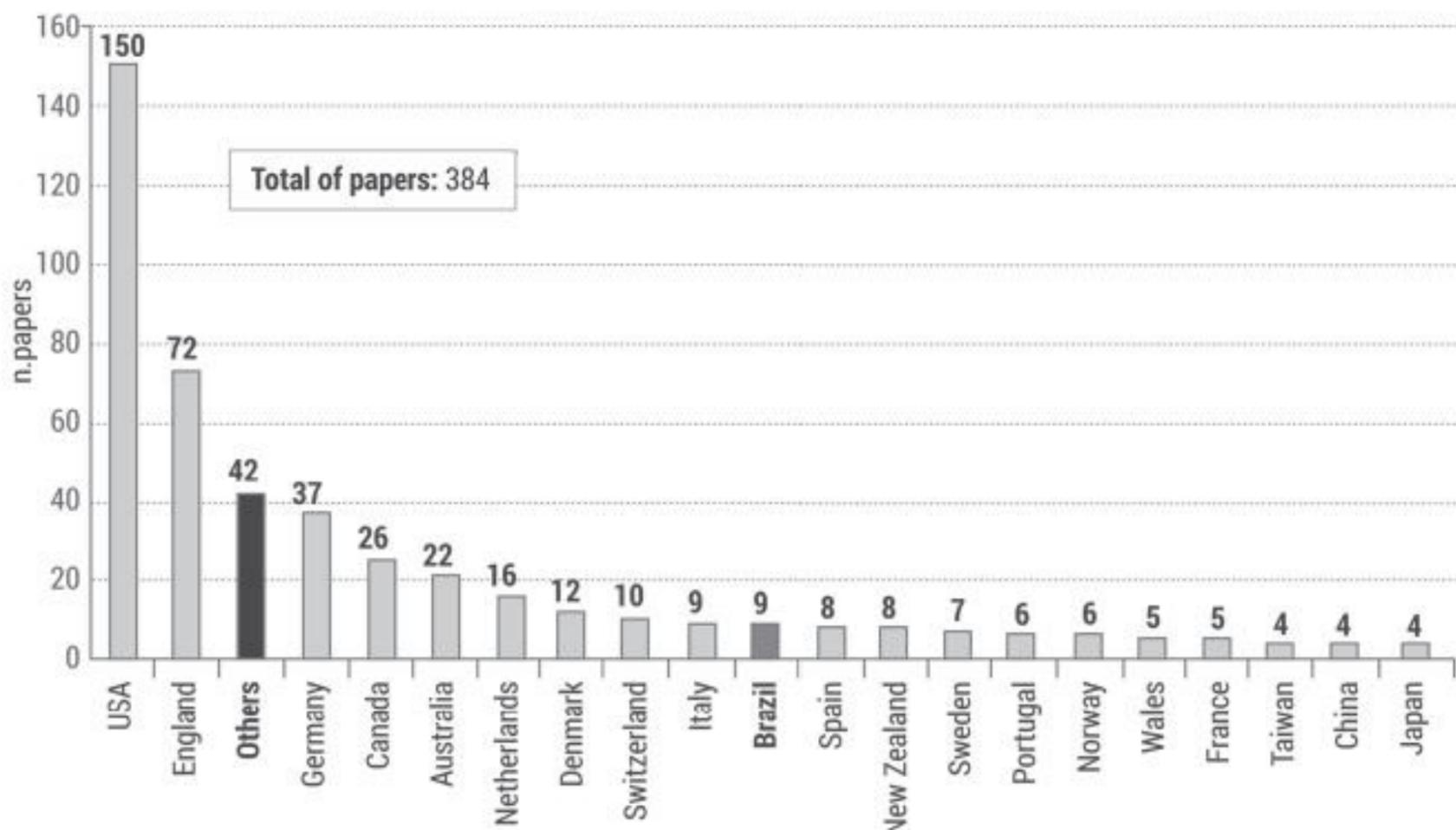


Figure 3 Papers with keywords [science communication and public] indexed in the Web of Science database (1976-2015).

A closer examination revealed that searching with the keyword "science communication" located papers about formal science communication (peer to peer) as well as popular science communication. When we added the keyword "public" a total of 444 papers were identified. We filtered the results to exclude proceedings papers, book reviews and news; and this reduced the total to 384¹⁹ papers, mostly articles (89.3%), but also editorials (6.2%), reviews (4.2%) and letters (0.3%).

Over the last 40 years, the United States (39%) has been the main producer of science communication papers indexed in the WoS database, followed by the UK (18.7%). Together this adds up to 57.7% of all papers. Brazil ranks 9-10th, together with Italy, each with 2.3% of papers; and altogether a total of 41 countries were represented. Although other countries such as China, India, Japan and Russia are significant producers of research in science, they have a low rate of papers in searches with the keywords [science communication + public] in the WoS. There are a number of possible explanations for this: that these countries mainly publish in national journals, as commonly occurs in the humanities and social sciences; that (perhaps because of language issues) they prefer to publish in international journals not indexed in WoS; or possibly they use different keywords for "science communication".

The papers identified in the search were published by 131 journals, with one third (33.3%) appearing in the three specific journals of science communication described below. Other journals with interest in the topic [science communication + public] were: Proceedings of the National Academy of Science (4.7%), Plos One (2.3%) and Science and Public Policy (2.1%). The papers we looked at focused mainly on communication (39.6%) and the history and philosophy of science (24.2%); but also on multidisciplinary sciences (8.8%), educational research (6.8%), environmental sciences (4.7%); social science interdisciplinary research (4.2%); information and library science (3.6%), and other topics (8.1%). Since Brazil has had solid contributions from postgraduate programs as well as papers both from education and communication, and education has little presence internationally, this might have affected Brazilian submissions to international journals.

Among the 9 papers with authors from Brazil, four were published in the Brazilian journal *História, Ciências, Saúde - Manguinhos*, dedicated to the history of science (yet with a line of research of science communication). This

journal is also published in English and Spanish and it has been included in the Web of Science database with all SciELO collections²⁰. Most of the 9 papers were by authors from institutions with a postgraduate line of research on science communication and science communication practitioners (such as FIOCRUZ, UFRJ and UFMG). If we consider non-Brazilian journals, the presence of Brazil in international journals is minimal and generally includes only co-authors from Brazil.

BRAZIL IN THREE SCIENCE COMMUNICATION JOURNALS

We analyzed the contributions of different countries to the three most prominent journals dedicated to science communication: Public Understanding of Science (PUS), Science Communication - mentioned above, indexed in WoS (1994-2015) - and the Italian Journal of Science Communication (JCOM), which is open access and indexed in Scopus database. Recently new publications have emerged in the area: the International Journal of Science Education, Part B Communication and Public Engagement (2011); Science Communication and Informal Education; China Study on Science Popularization and Public Communication of Science and Technology ([Gascoigne et al. 2010](#)). These were not included in our analysis.

A total of 1,809 papers²¹ were published in the three journals ([Figure 4](#)) in the period we analyzed. Most appeared in Public Understanding of Science (created in 1992): 908 papers with authors from 47 countries. This was followed by Science Communication (1979) with 653 papers from 41 countries; and the Journal of Science Communication (2002) with 248 articles from 38 nations. Brazil's contribution was relatively small, with 34 papers (1.9%) in the three journals, 27 with solely Brazilian authors and 7 as collaborations with authors from 9 different countries (England, the USA, France, Italy, Canada, Mexico, Argentina, Colombia and Chile). Only one paper had co-authors from Latin America.

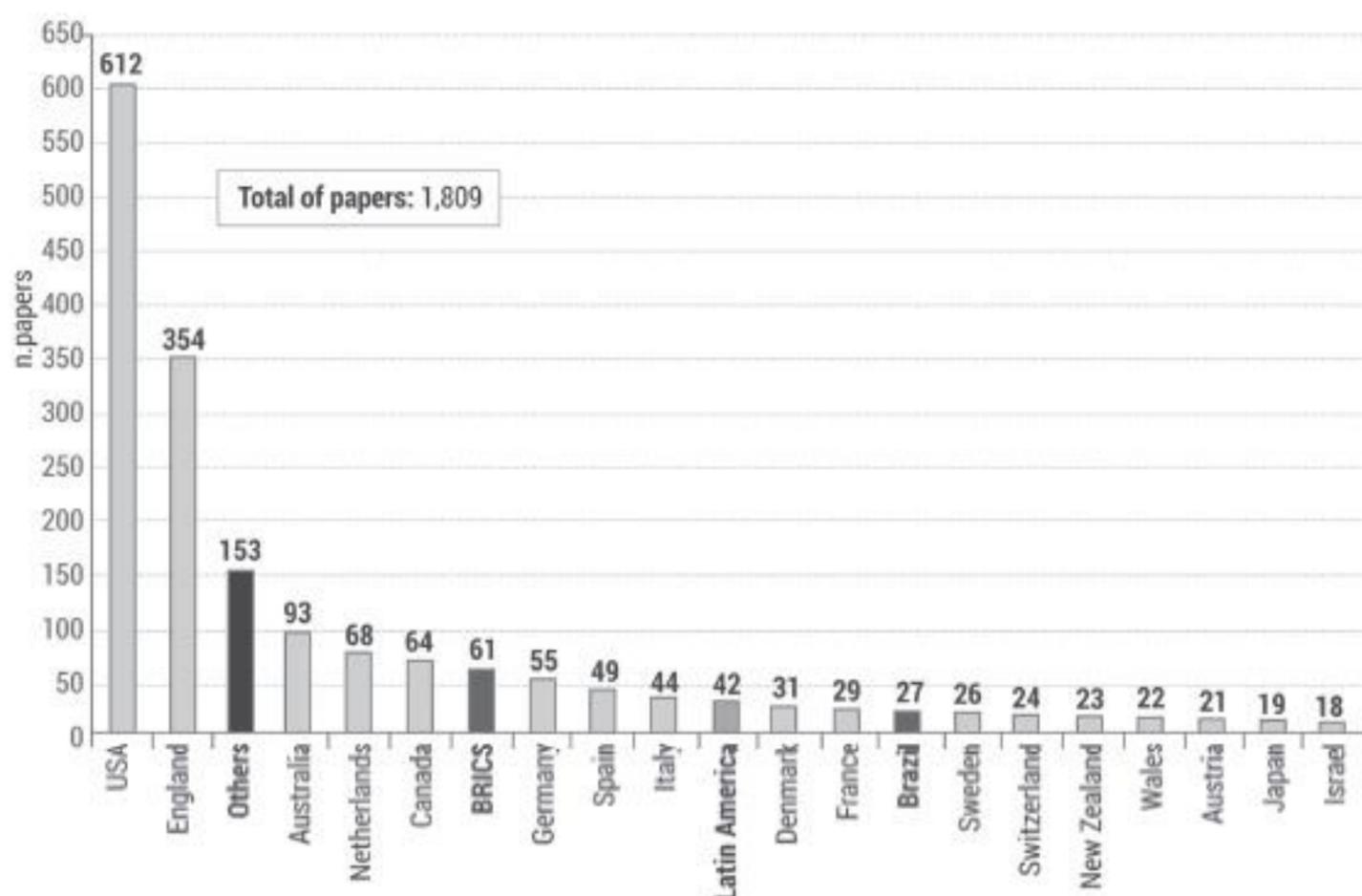


Figure 4 Paper contributions by country in 3 journals of science communication: Public Understanding of Science; Science Communication and Journal of Science Communication. Based in data collected in Web of Science and Scopus (1994-2015).

There is a clear difference between world science and the international science communication research productivity in our sample. While China (2nd), Japan (5th), India (9th), Korea (12th) and Russia (13th) are among the 15 top countries in world science research, they have a modest or insignificant presence in the science communication journals we analyzed. This contrasts with the strong presence of the USA and England, responsible for 53.4% of all papers.

It is clear that the national origin of each journal encourages the participation of authors from the host country or familiar with research in the host country. In the Public Understanding of Science, England and the USA are responsible for 54.6% of the papers; in Science Communication, the USA is responsible for 54.1%; while the Journal of Science Communication has a more balanced international participation with England, Italy, the USA, the Netherlands, Brazil and Spain responsible for 52%. One reason may be related to JCOM's open access that allows a wider readership, as well as its policy to publish both in English and the original author's language.

China, South Korea, Japan and India are not strongly represented in these results although they are all active in

science communication, with institutions, national journals and national events. The most likely explanation is a failure of the international databases to include information published outside European languages, compounded by a difficulty in science communication journals to promote multinational debate.

CONCLUSIONS

As we have shown above, there has been an increase in public and governmental awareness of scientific and technological advances, as well as a growth in science communication. The quality, accuracy and enhanced dialogue between journalists and scientists have all contributed to increased activity in Brazil, as well as the increase in training and research in science communication at Brazilian universities.

To develop a better public understanding of scientific information and practices, we should consider science communication as an integral part of the general political and historical process, including its cultural, ethical and social dimensions. In doing this we need to recognize science itself as the product of fallible human beings.

It should be recognized that science communication is still a relatively new field of study, taking a multidisciplinary approach, and drawing its tools and concepts from sociology, psychology, media studies, and other areas. This cross-disciplinary approach ([Gascoigne et al. 2010](#)) will help resolve challenging issues concerning the most effective ways of enabling science to be harnessed by society in a manner which society understands, discusses and appreciates.

To make a useful contribution to the challenges facing Brazil, science communication must maintain its critical spirit in relation to science, and be willing to discuss both the good side and the potential bad side of any research results. It is not a cheerleader for science, but a mediator and critical interpreter between research and the community.

Far beyond merely registering science communication research results, it is critical to understand and grasp its processes, funding methods, and historical and political context. Only then can we understand the mechanisms of ST&I to ensure their full social use.

Modern science communication has emerged and grown rapidly in the world in recent decades. Brazil has invested in training programs, research and media coverage in science communication, with important initiatives as some of the first training programs in the world.

The first training course in science journalism took place in Brazil in 1974, and since then undergraduate, extension and postgraduate courses (*Lato* and *Stricto sensu*) of science communication have been created in different regions of the country. The increase in training courses and in interest toward science communication is demonstrated through documenting the rise in the number of dissertations, theses and papers (particularly since 2002).

Our examination of the theses, dissertations and papers on science communication in Brazil shows authors publish mainly at a national level and in education and communication fields. They favour "science communication" (a broader term) and "science literacy" (with educational approach) as keywords appropriate to their work, with fewer references to keywords from other fields. Contributions from researchers nominating themselves as "science communicators" are increasing, as postgraduate programs develop and the subject matures. We pointed out that science communication is a field in development that needs to develop stronger theoretical contributions as well as solving boundary issues with other fields of knowledge, as [Trench and Bucchi \(2015\)](#) have pointed out.

The rising number of dissertations and theses on science communication from 2002 has strengthened the practice, values, and presence of research in science communication. Science communicators, both practitioners and researchers with postgraduate training have contributed to incorporate science communication more consistently in the academic, media and social agenda, leading to better science coverage and public access to scientific knowledge, and stimulating interest and engagement towards science.

The next step will be to increase the number of international collaborations by Brazilian authors, by developing more sophisticated tools for conceptualizing and analyzing science communication from a global perspective and developing further links with researchers from other countries. Science communication is developing and changing, and Brazil needs to be part of the international community if it is to benefit from work done in other countries. Brazil has hosted the three main conferences of international science communication and we need to capitalize on these contacts to increase our international profile, as it has happened in all fields of knowledge in the country in the last couple of years.

Our analysis of papers indexed in the Web of Science show most are published (33%) in the journals *Journal of Science Communication*, *Science Communication* and *Public Understanding of Science*. Most are written by authors from the US and UK, with little evidence of participation from regions such as China, Japan, South Korea, Russia and India, and Latin America. These countries do have relevant initiatives in science communication research and practice, and our recommendation is that editors of these three leading journals should intensify efforts to seek contributions from a wider variety of countries. Offering more options and less expensive fees for open access papers, and publishing bilingual papers - as JCOM has done - can also help motivating other nations' submission.

There may also be local incentives to encourage science communication researchers and practitioners to publish papers in international journals.

Brazil, as the leading country in science communication in Latin America and as part of BRICS, should join efforts to cooperate further with countries with similar social challenges, promoting more research cooperation, boosting financial support, and sharing policy ideas. The focus should be multiplying and fortifying research and practice groups in a more equitable way in the country, in Latin America and worldwide.

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¹Panel presented at the 13th Public Communication of Science and Technology Conference (PCST), in May 2014, in Salvador, Brazil. "How did modern Science Communication emerge in different countries around the world?", organized by Gascoigne (2014).

²PCST presentations are now available on-line at: <http://www.pcst.co/archive/>

³José Reis Scholarship Program of Science Journalism (Media Science), launched in October 1999, offers professional training to improve coverage of science and technology issues in the media and research institutions. It has offered 155 scholarships in São Paulo State (July 2016).

⁴Lattes Curriculum Platform, in the CNPq site, is the national curriculum database where researchers and research groups register their science production. Currently there are more than 4.5 million curriculums registered.

⁵ABJC (Brazilian Association of Science Journalism); ABRADIC (Brazilian Association of Science Communicators), ABCMC (Brazilian Association of Science Museums and Centers); Red POP (Science Popularization Network); PCST (Public Communication of Science and Technology).

⁶SBPC (Brazilian Society for the advancement of Science); ABC (Brazilian Academy of Sciences).

⁷The 6th World Forum of Science included 700 participants from 120 countries,

⁸Lattes Platform was developed in the 1990's and launched in 1999 by the Ministry of Science and Technology. Today it has more than 4 million curriculums, in which more than 130,000 of PhDs. See <http://lattes.cnpq.br>

⁹Data collected on March 1, 2016 at: <http://bdtd.ibict.br/vufind/>

¹⁰Data collected on March 3, 2016 at: <http://www.scielo.org/php/index.php>

¹¹Mainly in São Paulo, Rio de Janeiro and Minas Gerais States.

¹²<http://bdt.d.ibict.br/vufind/>

¹³A look at the first dissertations/theses using the six keywords selected exemplifies the multidisciplinary programs and fields that have contributed to science communication research. The main focus is on education. The first dissertation about "science museums" in Brazil is from the Math, Statistics and Scientific Computing Institute at UNICAMP, by Franklin (1981). The first one using the keyword "scientific culture" is from Getúlio Vargas Foundation (FGV), by Saad, (also 1981). As for the keyword "science communication", the first was from the psychology Institute at USP, by Granja (1985). The first dissertation using "science journalism" was from the production engineer postgraduate program at the Federal University of Santa Catarina (UFSC), by Lara (2000). The same university Lorenzetti (2000) published the first dissertation on "science literacy", from the education postgraduate program. More recently, the keyword "popularization of science" first appeared in a PhD thesis by Vergara (2003), at PUC-RJ, focusing on history.

¹⁴A well-known example is what has been considered the first these about science journalism in Brazil, by Wilson da Costa Bueno entitled "Jornalismo científico no Brasil: os compromissos de uma prática dependente". PhD Thesis. São Paulo, ECA/USP, 1985.

¹⁵SciELO is considered an important database of open access journals in Brazil, Latin America and other Portuguese and Spanish speaking countries <http://www.scielo.org>

¹⁶The data was collected on February 22, 2016.

¹⁷The search was made using the keywords "divulgação científica" or "divulgación científica" or "science communication", among other five keywords presented in Figure 2.

¹⁸From a total of 26 and the District Capital.

¹⁹The total of 384 includes valid papers among articles, editorials, reviews and letters.

²⁰SciELO is the Scientific Electronic Library Online, a database that includes open access journals of Brazil and other 13 countries.

²¹We have considered all types of papers. The average citation per article in each journal was: 10.78 at Public Understanding of Science; 8.32 at Science Communication; and 1.11 Journal of Science Communication.

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Contribution to the centenary of the Brazilian Academy of Sciences.



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