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## Co-creation and open innovation: Systematic literature review

### Co-creación e innovación abierta: Revisión sistemática de literatura

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#### Abstract

Open science, as a common good, opens possibilities for the development of nations, through innovations and collaborative constructions, which help to democratize knowledge. Advances in this area are still emerging, and the open science, co-creation of knowledge and open innovation triangle, is presented as an opportunity to generate an original contribution from research to open educational theory and practices. The study analyzed the articles that addressed this triangle, in order to identify the contexts and challenges that arise in open innovation and the co-creation of knowledge to promote open science. The method was a systematic literature review (SLR) of 168 articles published in open access format, from January 2014 to May 2017 in the Web of Science and Scopus databases. In the validation process, the York University criteria were used: inclusion and exclusion, relevance of the pertinent studies, evaluation of the quality / validity of included studies and description of data / basic studies. The findings showed that the most-widely publicized contexts were in the United States and Brazil, in the business and academic sectors (closely followed by the social sector), and the challenges were open to innovation, opening and research. The research concludes that the context and practices of collaboration are substantial elements for innovation and open science.

#### Resumen

La ciencia abierta, como bien común, abre posibilidades para el desarrollo de las naciones a través de innovaciones y construcciones colaborativas que ayudan a democratizar el conocimiento. Los avances en la materia aún son incipientes y el triángulo ciencia abierta, co-creación del conocimiento e innovación abierta se presenta como una oportunidad de generar un aporte original, desde la investigación, para la teoría y las prácticas educativas abiertas. En el estudio se analizaron los artículos que abordan este triángulo, con el fin de identificar los contextos y retos que se presentan en la innovación y en la co-creación de conocimiento para impulsar la ciencia abierta. El método fue una revisión sistemática de literatura (SLR) de 168 artículos publicados en acceso abierto, de enero 2014 a mayo 2017, en las bases de datos Web of Science y Scopus. La validación se dio con los criterios de la Universidad de York: inclusión y exclusión, pertinencia, evaluación de calidad / validez de los estudios y descripción de datos. Los hallazgos reflejan que los contextos de mayor publicación sobre el tema son los de Estados Unidos y Brasil, en los sectores empresariales y académicos (seguido de cerca por el sector social) y los retos se abren en las posibilidades de innovación, apertura e investigación. Se concluye que el contexto y las prácticas de colaboración son elementos sustanciales para la innovación y la ciencia abierta.



## Keywords / Palabras clave

Open science, citizen science, knowledge, collaboration, openness, innovation, knowledge co-creation, validation.

Ciencia abierta, ciencia ciudadana, conocimiento, colaboración, apertura, innovación, co-creación de conocimiento, validación.

## 1. Introduction and state of the art

The democratization of knowledge, as a common good, has been driven by open science. Álvarez and Sintas (2012) have posited that the paradigm of open science is re-enforced with the commitment for e-Science that implies the collaborative use of resources that are geographically distributed but interconnected through the Internet. Other areas of open and collaborative science are found in what is named “crowd science,” “citizen science,” or “network-connected science”. Franzoni and Sauermann (2014) have mentioned two important characteristics: participation in a project is open to a wide base of potential contributors, and the intermediate consumables, such as data or problem-solution algorithms, are openly available. An important part of open science is comprised, without a doubt, by ethical processes to maintain high standards of integrity and consciousness, where the sharing and communication of knowledge requires that it be worked upon starting with a training course for scientists that integrates ethics in the sciences, training in history and the philosophy of science and their cultural impact (UNESCO, 2004). In these ethical guidelines, the participation, the collaboration and the public policy are of great help for endorsing this training and the practices needed to make knowledge accessible to everyone.

The support for open science is differentiated according to the contexts and the policies of the research and development councils. García Aristegui and Rendueles (2014) have mentioned that the criticism of the monopolist power can be explained from at least two very different political perspectives (liberal or institutionalist), with divergent consequences in the conception of the organization, financing and the scientific research programs. Lasthiotakis, Kretz, and Sá (2015) have identified approaches utilized by Canada, the U.S. and the United Kingdom to push forward open science, as a step towards the understanding of how politics and policy in this sphere are evolving. Along the same lines, the drive towards open access has been gradual in India, although it still lacks the support of national bodies that could provide a greater push and sustainability (National Knowledge Commission, 2007). Likewise, Mulder (2013) makes allusions that many other countries (for example, Brazil, China, Indonesia, Japan, Korea, Poland, South Africa, Turkey, United Kingdom, Vietnam) have introduced specific measures or subsidies. This is in contrast with the Latin American sphere, where the policies of support for open science are very recent in some countries (Argentina, Peru, Mexico) and there is still a lack of extension in the countries in the region (Betancourt, Celaya, & Ramírez-Montoya, 2014; Ramírez-Montoya, 2015). The drive for open science brings with it practices of innovation that can greatly affect the development of many countries, especially if the myths that for diverse motives have been associated with the movement of open knowledge are eradicated.

Speaking about open science implies relating it to the capacities of openness and linkage. Dahlander and Gann (2010) systemically worked on the term “open innovation” with the aim of clarifying the definition of “openness”, such as used in “open innovation”, and the research indicated that open innovation in the educational process would imply the visualization of internal factors or openness (institutional processes and strategies) and internal ones as well (link to the exterior). Other authors (García-Peñalvo, García-de-Figuerola, & Merlo-Vega, 2010; Lichtenthaler, 2011; Olalla, Sandulli, Menéndez, & Duarte, 2014; Rodríguez-Ferradas & Alfaro-Tanco, 2016) are in agreement, through their studies, in that the models of open innovation do not only depend on internal factors of the enterprises such as their R&D capacity or their technological stock available, but intrinsic factors of the industry in which the enterprise operates also intervene. From this perspective, once again, the



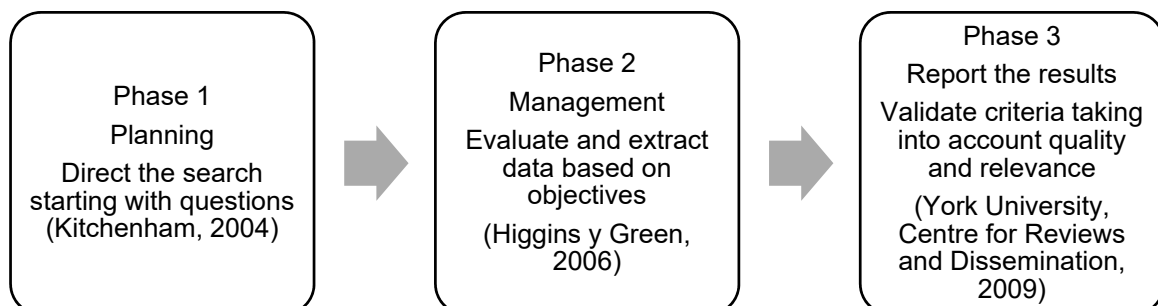
elements of the context (internal or external) are related to the type of knowledge for administering the processes of open construction and innovation in the organizations and in science itself.

The interrelation between open science, innovation and co-creation has important vacuums in research. Randhawa, Wilden, and Hohberger (2016) conducted a systematic revision, and they found absences in knowledge in existing research, among which we find that the researchers do not sufficiently base their work on theoretical perspectives that are external to the field to examine multiple facets of open innovation. Likewise, the studies that are centred in open innovation businesses are focused on role of knowledge, without delving into technology and R&D from the perspective of the innovative company. Another challenge is presented by Huizingh (2011) when the author concludes that the dependence of the context of open innovation is one of the less-understood subjects; more research on the characteristics of the external and internal environments that affect their performance is required. Accordingly, Wallin and Von Krogh (2010) have said that the challenge is to find the place of knowledge, and later try to integrate diverse domains of knowledge in open innovation. Užienė (2015) alerts that the limits become blurred in the co-creation of something new, and in this sense, the intangible resources, such as intellectual capital, become a factor of influence for open innovation. Sloep and Berlanga (2011) state, through a study of formal and informal networks, that co-construction requires bonds of trust, the creation of profiles in the learning networks, and the creation of instances of support among the participants. Along the same lines, and related to informal learning, García-Peñalvo and others (2013) define a methodology for the co-creation of an e-portfolio of informal learning activities that could act as the focal point for decision-making for a person and the company he or she works for.

It is from these absences that this article is presented, which has as the main objective the analysis of recent studies (2014-17) that have been conducted on the structuring of open science, co-creation of knowledge and open innovation, in order to understand what research has been conducted on this triangle, the contexts within which these practices have been developed, and which challenges have been detected to subscribe to open science. The results of this study will contribute knowledge that allows for the construction of theoretical frameworks and the contribution of directions for the practice of open access to knowledge.

## 2. Materials and methods

To conduct the study, a systematic review of the literature (SRL) was utilized as the strategy for identifying the most relevant studies on the challenges that open innovation and the open co-creation of knowledge have, within the field of open science. The SRL is used to identify, evaluate and interpret the available data within a period from a specific field of research. The process of this revision is based, in general terms, on the guidelines established by Brereton, Kitchenham, Budgen, Turner, and Khali (2007), focused on the conducting of SRL in software engineering, and in specific terms, on the contributions by Higgins and Green (2006), Kitchenham (2004), Centre for Reviews and Dissemination de York University (2009). The three phases of the review are shown in Figure 1.



**Figure 1. Process of systematic review of literature (author created, based on Higgins & Green, 2006; Kitchenham, 2004; Brereton & al., 2007; York University, Centre for Reviews and Dissemination, 2009).**



### 3. Results

The steps taken in each phase and the results that emerged are described below.

a) Phase 1: Planning the review. The planning stage consisted in carrying out a strategy to direct the dataset search, which implied starting with questions that emerged due to the lack of knowledge detected, keywords, the choosing of specialized databases and defined search criteria. In the initial exploration, systematic searches and formal summaries of the literature were conducted to identify and classify the results of the studies on a subject in particular (Kitchenham, 2004). The objective of this study was focused on answering the following Research Questions:

- RQ1 How many studies are there in the SCOPUS and Web of Science (WoS) databases on open innovation, co-creation of open knowledge and open science, from January 2014 to May 2017, in open access journals?
- RQ2 What contexts (academic, business, social, cultural) have been the object of study in open science?
- RQ3 What are the challenges for open innovation and the co-creation of knowledge to drive open science?

The protocol for the review and the guidelines on how to select and evaluate the relevant studies was developed in the following manner:

i) Search resources: SCOPUS (DB-S) and WoS (DB-W) databases.

ii) Categories and keywords: Open innovation, co-creation of knowledge and open science.

iii) Inclusion and exclusion criteria: Period of time: from January 2014 to May 2017; Type of document: articles; Type of Journal: open access; Defined field of study: open science; Language: English.

b) Phase 2: Management. The management phase was conducted to provide answers to RQ1: How many studies are there in the SCOPUS and Web of Science (WoS) databases on open innovation, co-creation of open knowledge and open science, from January 2014 to May 2017, in open access journals? The process, following the recommendations by Higgings and Green (2006) was comprised of the evaluation and extraction of the article's data by two people, independently and following a protocol of objectives of the review and steered for each new review. The first search included the keywords in both databases (DB-S and DB-W); in the second search, only the articles that were found in open access journals, as related to the inclusion and exclusion criteria, were selected, and the duplicates were eliminated. In a third round, health and medicine subjects were eliminated, as they did not have any relation to open science (Table 1).

**Table 1. Results from three delimited searches**

Keywords	First search				Second search			Third search	
	Articles with "open science" OR "open innovation" OR «co-creation of knowledge»		Articles delimited to open-access journals		Sub-total of the two open access databases	Duplicates	Open access in BD-S y BD-W	Eliminated for not being related to the field of open science	Selected for belonging to the field of open science
	BD-S	BD-W	BD-S	BD-W					
# open innovation	730	648	73	68	141	28	113	9	103
# open science	235	200	116	89	205	69	136	75	62
# co-creation of knowledge	15	12	2	2	4	1	3		3
<b>Totals</b>							<b>252</b>		<b>168</b>

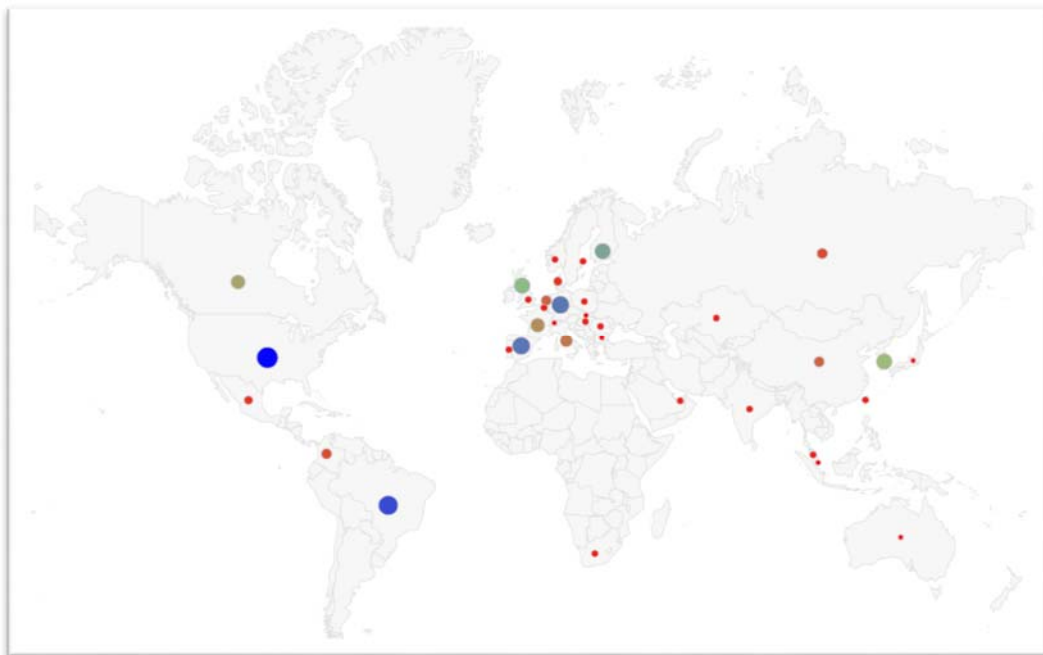
The 168 delimited articles are accessible in the database (<https://goo.gl/eS7tH6>).



The extraction of data was conducted on the 168 articles selected that included all the criteria defined. They were classified to answer the research questions and are presented in Tables 2 and 3.

Range	Open innovation	Open science	Co-creation of knowledge	Total
2014	18	9		
2015	31	20	1	
2016	46	23	1	
May 2017	8	10	1	
<b>Total</b>	103	62	3	168

From the 168 articles, the countries that had the greatest number of publications were: United States (18), Brazil (15), Germany (13), Spain (13), Finland (11) and the United Kingdom (10). Figure 2 shows the geographical distribution, where the size of the circles graphically indicates the number of publications that each country has generated.



**Figure 2. Publications according to the country.**

c) Phase 3: Report of the results. Lastly, to create the report for RQ2: Which contexts (academic, business, social, cultural) have been chosen as the object of study in open science? And RQ3: What are the challenges (difficulties, problems, areas of opportunity) for open innovation and the co-creation of knowledge to drive open science? A validation process was conducted where the criteria by the University of York, Centre for Reviews and Dissemination (2009) were used: Criteria of inclusion and exclusion of the review, coverage of the relevant studies, evaluation of quality/validity of the studies included and description of data / basic studies.

In RQ2: What contexts (academic, business, social, cultural) have been chosen as the object of study in open science? Content analysis was conducted to identify the publication's sector. The results were drawn in Tableau, by number of articles, which at the same time, were organized



according to the year. Figure 3 uses colour to identify the occurrence of the publications to outline data on the sectors addressed in the articles: academic, business, social and cultural.

The studies analyzed show that the open science experiments have been most commonly conducted in the business sector (Bauer, Berleant, Cornell, & Belford, 2015; Hackseq Organizing Committee, 2017; Katsikis, Lang, & Debreczeny, 2016; Krause & Schutte, 2016; Oumlil & Juiz, 2016; Arabito & Pitrelli, 2015; Poehlman, Rynge, Branton, Balamurugan, & Feltus, 2016; Pernet & Poline, 2015; Rodríguez-Ferradas & Alfaro-Tanco, 2016; Sarrión-Viñes & Vidal, 2016; Seguí-Mas, Signes-Pérez, Shim, & Park, 2016; Yang & Wang, 2016; Yoon, Shin, & Lee, 2016; Zander & Kralisch, 2016).

This was followed by articles related to the academic sector (Bond-Lamberty, Smith & Bailey, 2016; Bubela, Guebert, & Mishra, 2015; Carey, Davis, Ferreras, & Porter, 2015; Lahti, Ilomäki & Tolonen, 2015; Lee, Workman, & Jung, 2016; Lenart-Gansiniec, 2016; Schmidt, Orth, Franck, Kuchma, Knoth, & Carvalho, 2016; Labastida i Juan, 2015; Tandon, Singh, Clover, & Hall, 2017; Yun, Ahn, Park, & Yigitcanlar, 2016).

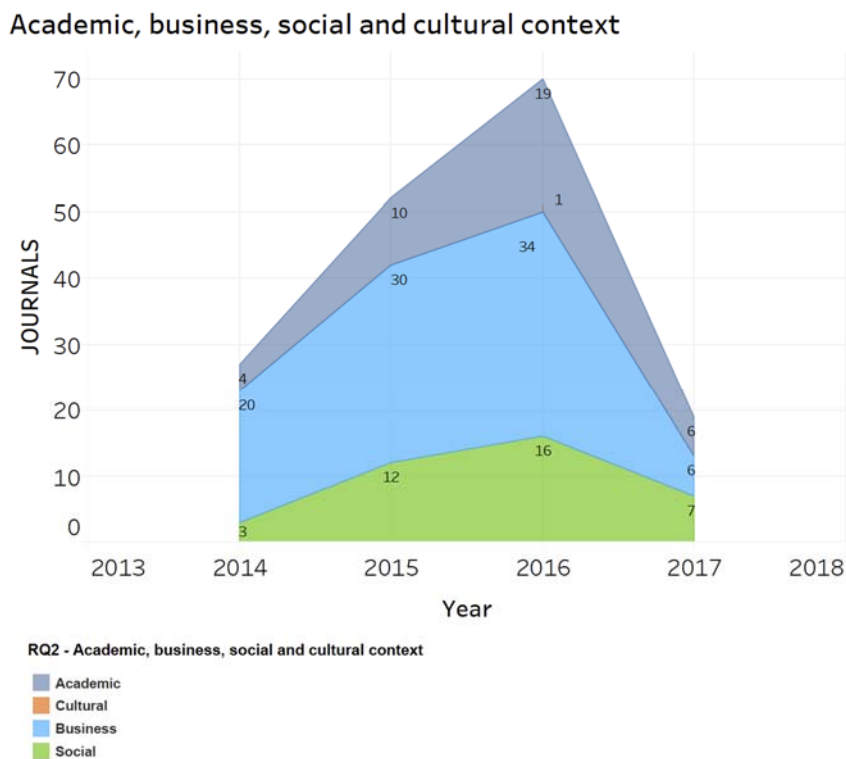


Figure 3. Publication according to the contexts.

In third place we find the articles from the social sector (Ayrís, 2017; Bernhard, Bittel, Bettoni, & Mirata, 2015; Castillo-Molina, 2016; Chalk, 2016; Das & al., 2016; Schuurman, De-Marez, & Ballon, 2016; Joly, Dalpé, So, & Birko, 2015; Higham, Batty, Bettencourt, Greetham, & Grindrod, 2017; Hormia-Poutanen & Forsström, 2016; Jørgensen & al., 2015; McCormick, Liu, Ibanez, & Jomier, 2014; Ojasalo & Tähtinen, 2016; Okret-Manville, 2016; Kudryavtseva, Shinkevich, & al., 2016; Lhoste & Barbier, 2016; Tukiainen, Leminen, & Westerlund, 2015; Naqshbandi, Singh & Ma, 2016). In RQ3: What are the challenges (difficulties, problems, areas of opportunity) for open innovation and the co-creation of knowledge to drive open science? A content analysis was conducted, keywords from the challenges described by the authors in their text descriptions were defined, and these data were cross-referenced with the contexts identified, with the results used to create a diagram in Tableau (Figure 4). The findings show that there was a greater incidence in three great areas: innovation, openness and research, in the more-common contexts (business, academic and cultural).



Challenges are identified in open science studies for the co-creation of knowledge and innovation in open

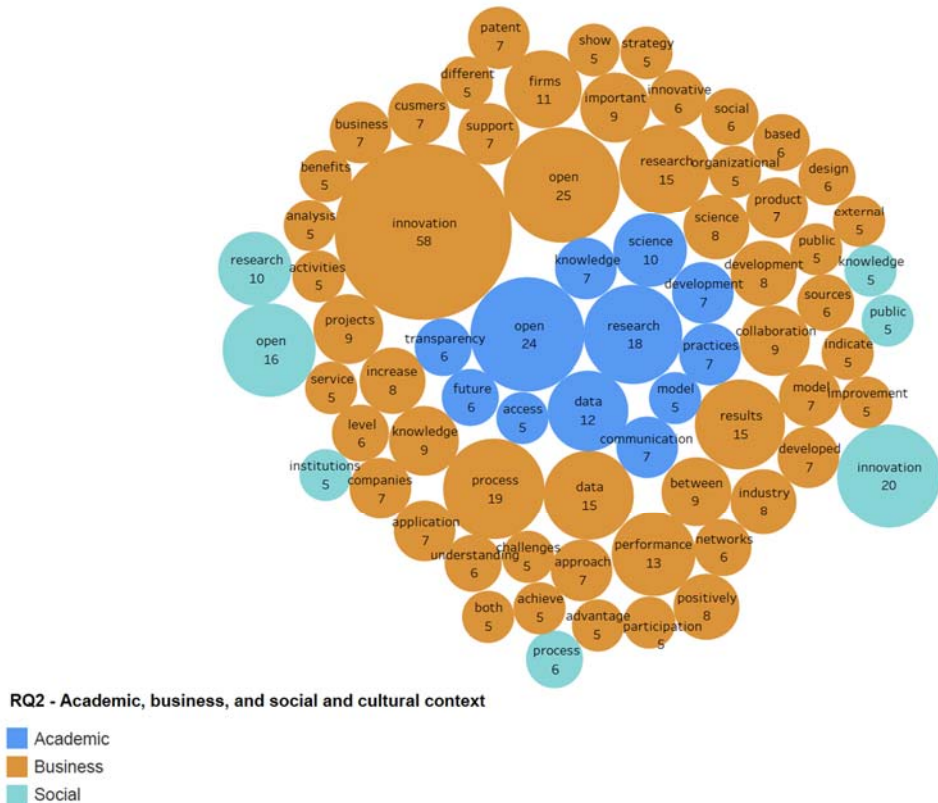


Figure 4. Challenges of open innovation and co-creation for driving open science.

On the challenge of open innovation, for example in the social sector, Hughes (2017) states the need to create new forecasting models that include a combination of analysis of technological sequencing and great data tools within the organizations, the government and industry, at the same time that experts from the entire spectrum of open innovation are profited from. In the business sector, Tripathi (2016) postulates fomenting collaboration to work in open innovation in businesses and to promote the intensity of R&D, the ability and the capacity to take on risks, as well as the nature of the business and industry.

Another major challenge was the “openness,” such as the capacity of the converging of instances of openness that allows for the dissemination into diverse sectors, for example, in the business sector. Buttliere (2014) states that the best way to realign the individual and group motives would probably be the creation of a centralized platform that is easy to use, with a profile, a review of specific scientific stories, based on the previous interaction of the system, a sophisticated section (public) of discussion and the impact of metrics that use the associated data. Also in the academic sector, Carey, Davis, Ferreras, and Porter (2015) bet for pedagogy with support from open education resources, to create a greater teacher commitment in the integration and mobilization of diverse sources of knowledge in teaching.

On the area of research, for example, in the social sector, Aleksic and others (2015) mention that it should be fomented in the community that is constantly (and consciously) up to date on the principles of open science, so that the published documents are improved, to increase the confidence in the reproducibility of the work, and in the last case, to provide strategic benefits to the authors and their



institutions. Likewise, in the business sector, McCormick, Liu, Jomier, Marion, and Ibanez (2014) mention the supporting of research communities with the most modern infrastructure of verification of reproducibility, as the challenge.

## 4. Discussion and conclusions

Open science opens a wide spectrum of possibilities for production of resources and use in social and cultural areas for collective creation, and with this, to propound shared knowledge. In recent years, technologies and the internet have made open practices possible, and at the same time, the academic community has been contributing evidence on the findings that have emerged. However, the empirical contributions still have areas of opportunities to explore (mainly within social and cultural contexts); from this perspective, this article focused on the treatment, through a review of recent literature (2014-17), of the triangle between shared science, co-construction, and open innovation, as the new meeting point for opportunities to support theoretical frameworks and open practices.

The context (defined as the space where it is constructed) can mark a substantial difference in the possibilities of innovation and open science. The data analyzed allowed for the finding, in the length of time explored in both databases (SCOPUS and WoS), of 168 open access articles. The context data placed most of the publications in the United States, Brazil and Germany (Figure 2). Likewise, the publication contexts (Figure 3) mainly pointed to the business and academic contexts (followed very closely by the social sector). Huizingh (2011), and Wallin and Von-Krogh (2010) are in agreement when pointing to the importance of finding the context to try to integrate the knowledge of how open science and innovation are being shaped. Beginning with these data, different issues for theoretical frameworks can be found that contextualize the open scientific knowledge, from the contextual and disciplinary views where these open practices are being developed, up to the possibilities of joint construction. Aspects such as the objectives, the reasoning and the contributions are comprehensible when they are analyzed in light of the publications that are being contributed. More interestingly, was detecting that the cultural sector represents an area of opportunity for the subject of open science.

Open science brings with it the possibility of shared co-construction and the generation of open innovation, to contribute to the public sphere as well as private contexts. Although the contributions have been provided in the last decades, there is still much to be done in the practices of open access. The authors of the articles analyzed demonstrate the challenges they found in order to keep on expanding the subject of open science. In Figure 4, the areas of opportunity that are still in need of work are highlighted: innovation, openness and research. Sloep and Berlanga (2011), and Užienė (2015) warn on the difficulties of delimiting the co-creation of something new and the collaboration that they contribute to open science. Collaborative construction becomes, in this sense, substantial for the continued contribution in the area of open science.

The intersection of the triangle between shared science, co-construction, and open innovation gives rise to an interesting opportunity of analysis for linking it to ethical considerations. Most notably, the implications to science, more specifically within the contexts of education, humanities, communication, media literacy studies, qualitative data, citizen science, among other subjects that were addressed in this article, requires a special view to nurture scientific research, contribute possibilities for development, and the use of technologies with open access. The UNESCO (2004) subscribes to paying attention to training processes on ethics competencies to work on standards of integrity, agreement and collaboration. Although reality makes us see that the advances in science could play a destructive role, they can also play another role in the assertiveness of tending to needs and problems that could create better conditions of life in a world that requires positive energy from all. In addition to the ethical implications, the data found in this study link other consequences for science, in the sense that new forms of construction of knowledge, new participating actors, new interrelations of disciplines, new possibilities for opening the knowledge created, and new tools for the transferring of this knowledge became evident. These implications can become engines for





innovation, the resolution of problems and the creative planning of possibilities for civil society. However, there is still a long road ahead, from the public policies, the systems of funding, the closed systems linked to business models that are unrelated to the common good, to the promotion of changes that push for a culture of collaboration that promotes open knowledge for society. Open science therefore represents an interesting issue for the learning processes in any area and context. This article presents original data that can support future studies on open science, co-construction, and educational innovation. The database of the articles can be used as a foundation for studies that analyze other theoretical/practical elements (types of practices, methodologies, tools, among other aspects). The study of the literature review was delimited to open-access articles, intending to be consistent with the possibilities of openness to knowledge. However, due to this delimitation, a great number of articles were not analyzed (Table 1), and this could be a limiting factor in the generalizing of the data that emerged, and at the same time, it could also be a new possibility for the continuous contribution to the subject of science and shared knowledge. Thereby, the present document is an invitation for the continuous search for shared construction alternatives that support the democratization of knowledge through open practices.

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