RETHINKING OPEN SCIENCE: THE ROLE OF COMMUNICATION

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Abstract: *The aim of this study is to present discourses on Open Science. My reconstruction emphasizes the role of communication in science. I use two models of communication for the analysis: the transmission model and the constitutive model. By reconstructing the main method of defining Open Science, I demonstrate that the role of communication in science has been reduced to the dissemination of the knowledge produced. Such theorizing is typical of the transmission model and ignores the stage of the social construction of knowledge. However, it is possible to consider this stage when the constitutive model of communication is used. My findings show that the constitutive understanding of communication is more useful in analyzing the Open Science phenomenon if we focus on the communicative dimension of scientific practices.*

Keywords: *Open Science; openness; models of communication; knowledge dissemination; metatheory*

1. Introduction

Open Science is enormously rich in terms of the range of scientific forms that fall within its nominal scope. "Open Science" is an umbrella term that is used to designate scientific and social practices that are based on principles of openness (e.g., open access, open source, open archiving, open data and citizen science). Moreover, this term is used in the literature to characterize a process of knowledge, creation and dissemination that focuses on "new technologies of communication." Therefore, the term "Open Science" is often identified with other buzzwords, such as "e-science" and "Science 2.0."

However, the term "Open Science" evokes quite different understandings of what science is or should be. Policymakers, publishers and researchers have their own interpretations of the meaning of Open

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Science. Nevertheless, the idea of openness in science and scholarly communication is promoted and described in various publications. This discursive ambiguity is caused by the various ontological and epistemological principles on which the contemporary understanding of the term "Open Science" is based. Although Open Science is not yet a theoretically elaborated concept, I believe it can and should become one. The opening of science is both a socially important goal and a question that cuts across various fields and disciplines.

In 2010, Peters analyzed the themes and metaphors that characterize the development and direction of open global science (Peters 2010). Fecher and Friesike (2014) identified the predominant thought patterns in the current Open Science discourse and described five distinct schools of thought. Both of these metatheoretical works show how we can provide an overview of the main discourses on Open Science and identify the major assumptions. However, these analyses focus on the concept of openness and the concept of technology. Thus, these studies have only examined the economic, technological, or bibliometric aspects of the process of opening science, whereas the present work focuses on the communicative dimension of the phenomenon. For this reason, we need a new metatheory because the existing theories are inadequate for the purposes of communication studies. The aforementioned purposes can be understood as constructing an interpretation of the socio-cultural reality through the category of communication. This approach derives from a cultural approach to communication (Carey 2009) and a cultural history that focuses on media (Eisenstein 1979/2005; Darnton 2008).

In this paper, I outline some assumptions for a new metatheoretical perspective of Open Science that fulfills the demand for a communicative approach. I argue that "Open Science" is based on communication practices that are the foundation of the openness of science and the new communication technologies in science. "Communication" is a conceptual construct that is more fruitful than the openness concept for describing the social reality of knowledge creation and dissemination. It should be noted that a new metatheory must connect with the "body of assertions" in the field of Open Science. Therefore, when referring to the diversity of discourses on Open Science, I argue that all discourses on Open Science can be reduced to one primary discourse, which I call *the openness and technology discourse*. This discourse contains some "communicative components." However, within this discourse, communication is understood as a process

of transferring knowledge. Consequently, "communication" is not the primary concept, which means that communication practices are not the foundation but the result of Open Science.

There are two basic claims in this paper. First, when we write and publish scientific publications (in other words, when we communicate science), we produce and organize our social reality (Tuominen and Savolainen 1996: 82). Second, the openness of science and new media use in science is possible thanks to communication. These claims – which originate from a cultural approach to communication – remain in opposition to the openness and technology discourse, which is based on different concepts of communication, even though it describes scientific practices in similar terms. I argue that the major discourse's metatheoretical assumptions are connected to views of communication theory (the so-called transmission model of communication, or the conduit metaphor) that define communication as an information or knowledge transfer (Reddy 1993; Short 2013; Wiseman 2007). Therefore, in this paper, the prerequisites of a new metatheory are presented. The results of this presentation demonstrate how we can rethink the concept of Open Science in terms of constructing scientific knowledge instead of using the transmission approach to communication practices. It is argued here that communication is not only a process of knowledge dissemination; it is also the *sine qua non* of knowledge production and may be seen as constitutive of scientific knowledge. In effect, communication can be understood as one of the foundations of Open Science. On this basis, the communication discourse is suggested.

The paper is structured as follows: In Section 2, the discourses on Open Science and their metatheoretical assumptions are presented. In Section 3, the role of communication in science is described through the openness and technology discourse. In Section 4, the new metatheoretical assumptions and the communication discourse are presented. Finally, in Section 5, conclusions are provided, and the communication discourse is discussed.

2. Open Science and Metatheory

The term "Open Science" has become an all-purpose word that is used to describe various phenomena in science. Indeed, discussions of "what Open Science really is" are rare. The Open Science concept is instead

treated as a justification for the revolution in scholarly communication, although the meaning that underlies the term is ambiguous. Nonetheless, Open Science is analyzed in various articles and books, especially in the context of open source tools and open access publishing (Grand et al. 2012; Cribb and Hartomo 2010; Caulfield, Harmon, and Joly 2012; Suber 2012; Laakso et al. 2011). This issue is widely discussed in information sciences (Hu 2012) and scientometrics (Eysenbach 2006; Kriegeskorte 2012). The authors primarily focus on the economic and technological aspects of the changes that have resulted due to the emergence of digital information. However, most of these publications focus only on the practical side of opening science: the best tools for open access, how to use social media in science, how to re-use and share open data, and how to evaluate research through post-publication peer review.

Open Science has thus become a cross-disciplinary topic, and scholars from various disciplines need a common denominator to ground the concept. Is this common denominator a set of rules for scientific practices, or is it perhaps just a description of science after the popularization of the Internet? It should be stressed that Open Science can be understood as a tool for describing contemporary science and as a normative concept that serves to regulate and evaluate scientific results. How exactly this concept is understood depends on the metatheoretical assumptions that are behind the theoretical and practical work in this field. The aforementioned publications investigate Open Science on a theoretical level, which means that they indicate which phenomena fall within its nominal scope and how to construct open solutions for science. A proper review of these publications and subsequent discussions would make adequately discussing the perspective proposed in this paper impossible. However, there is still a need to provide an overview of the major discourses and the main terms and approaches. A brief review of the common metatheoretical approaches is presented and discussed below.

According to Bates, metatheory can be understood as "the philosophy behind the theory, the fundamental set of ideas about how phenomena of interest in a particular field should be thought about and researched" (Bates 2005:). Implicit philosophical assumptions lie behind the work of Open Science theorists and open source producers and users. Therefore, bringing these assumptions into view is fruitful for describing the transformation of science and scholarly communication in the age of the Internet and social media.

The most interesting metatheoretical works on Open Science include various approaches to the openness of science. Three important topics pervade these papers. Typically, the Open Science concept is coupled with the concept of the *public character of knowledge*. In this first approach, the historical origins of Open Science have been investigated (Eamon 1985), and the economic dimension of this process has been highlighted (David 2008). In the second approach, Open Science has been examined through the concept of *openness* from various perspectives (Peters 2010). In the last approach, authors have structured the *overall discourses* on Open Science and highlighted preexisting problems in the theorization of this concept (Fecher and Friesike 2014).

The *public character of knowledge* is a crucial quality of science. As Merton (1973: 273) wrote, "substantive findings of a science are a product of social collaboration and are to be assigned to the community (…) [and] property rights in science are whittled down to a bare minimum by rationale of the scientific ethic." Ziman (2000: 33) added, "the fruits of academic science should be regarded as public knowledge." Moreover, Eamon noted that "one of the essential features of modern science is its public character, its commitment to co-operative research and to free sharing of information among specialists (...) 'scientific objectivity' is determined by consensus, arrived at through peer review, repetition of experimental findings, and criticism by competent and disinterested investigators. Such a consensus is possible only where there is free and open communication of the results of research" (Eamon 1985: 321). As Leydesdorff (2015) has argued, this understanding of science and its purpose appeared due to the recognition of the Book of Nature not as God's Revelation, but as an enterprise that is open to debate because, at its birth in modernity, science was based on discussions, sharing public (not forbidden) knowledge and communication. In this first metatheoretical approach, the public character of knowledge is the key concept. Knowledge, however, is founded on communication between thinkers and researchers.

Openness is a very broad idea that has been part of the understanding of Western culture. Peters analyzed the idea of openness as a philosophical, political, social and psychological metaphor. He argued that the concept of openness has its origins in Enlightenment thought, which "emphasizes freedom in its universal aspects" (Peters 2010, 108). Thus, openness in science can be identified as the freedom to read scientific

publications, the freedom to disseminate information, and the freedom to reuse scientific results. From this perspective, Open Science is based on the idea of equal rights and knowledge sharing. All Open Science tools should serve to implement these values. Peters' work is one of the few that examines contemporary science and scholarly communication through the philosophical idea of openness. In this way, he shows that this sort of reflection on social practices can be found in Karl Popper's *The Open Society and Its Enemies* or in Ludwig Wittgenstein's *Philosophical Investigations*.

The analysis of *overall discourses* on Open Science is a strictly metatheoretical enterprise. Fecher and Friesike (2014) reviewed the literature on Open Science and proposed five schools of thought: the infrastructure school ("efficient research depends on the available tools and applications"), the public school ("science needs to be made accessible to the public"), the measurement school ("scientific contributions today need alternative impact measurements"), the democratic school ("the access to knowledge is unequally distributed") and the pragmatic school ("knowledge creation could be more efficient if scientists worked together"). They concluded that the definition of Open Science varied so widely that it might be better theorized through the assumptions, goals, and keywords that are appropriate for a specific school of thought. Thus far, Fecher and Friesike's work is the only research that has investigated the concept of Open Science and presented an overview of the predominant thought patterns in the current Open Science discourse.

These metatheoretical studies suggest that Open Science can be understood in various ways. The studies can be distinguished analytically; however, it should be noted that these approaches are interrelated. When we reconstruct these considerations, however, we can reduce them to one main discourse, which I call *the openness and technology discourse*. Thus, it is a *prescriptive* sort of discourse.

This discourse focuses on the openness of science, which can be achieved through the use of new technologies. The spread of the Internet has provided an opportunity to return to the practice of free and open communication based on scientific publications. Theorists and practitioners who work with such an approach define Open Science as a set of specific instructions and rules. These rules are used to indicate what science should be, what scientists ought to do, and why public knowledge and open access to this knowledge are some of the most important values in contemporary science (e.g., "the access to scientific publications should be open", "the

results of taxpayer-funded research should be open", "openness is a prerequisite of science; therefore, scientists have to be open in the research process"). In the openness and technology discourse, Open Science is perceived as a goal that scientists should achieve (because it is good for science, the economy, and the public). Scientists fulfill this task by using new communication technologies. Therefore, Open Science is not so much a "new science"; it is instead a restoration of an inherent feature of openness in scholarly communication. This goal is presented in all of the aforementioned approaches, in which Open Science is perceived as a way to ensure the public character of knowledge in open societies. New media (new communication technologies) are identified as solutions for Open Science, especially in the infrastructure and measurement schools (Fecher and Friesike 2014). However, such media serve not only scholarly communication but also research evaluation.

Although the role of communication in science has been examined in the openness and technology discourse, it has rarely been mentioned explicitly, even though new communication technologies are treated as a crucial means of achieving the openness of science. In accordance with the purpose of this article, I argue that when we research, write and publish scientific texts, we produce and organize our social reality and science. Thus, I understand "the sciences as processes of communication" (Leydesdorff 2015: 3) and "configurations of modes of communication" (Nielsen 2012: 2068), and I assume that we can define "science as a form of communication" (Secord 2004: 654). For this reason, I believe that the role of communication in science should be emphasized to a greater degree. The constitutive role of communication in Open Science cannot be reduced to the transfer of knowledge because communication is not only a crucial part of this transfer but is also a crucial part of the knowledge-making process (Nielsen 2012; Secord 2004).

In the next section, I examine how the role of communication in Open Science is defined in the openness and technology discourse. Reconstructing the main perspectives, I use two classic models of communication as heuristic tools. I thereby suggest that the openness and technology discourse understands communication in terms of the transmission model of communication. I then move on to propose how we can use the constitutive model of communication to define the role of communication in Open Science. Thus, I attempt to show how we can

present the concept of communication in the ongoing metatheoretical debate on the communication perspective in science studies.

3. The Role of Communication in Science

The role of communication in science derives from, among other things, our understanding of what communication is. The scope of the communication concept is continually negotiated, which means that its understanding is determined by the socio-cultural context. Theorizing is a difficult task because "communication" is one of the most commonly used terms in the social sciences. Clevenger demonstrated that the creation of a universal definition of communication has failed. The task is not feasible because the term "communication" is used in so many different ways that it is impossible to satisfactorily identify what it relates to (Clevenger 1991: 351). Similarly, an attempt to identify a set of conceptual components on which the "concept" of communication is based has failed (Dance 1970). Therefore, it is worth noting that in characterizing the role of communication in science, we always have to accept some assumptions. Thus, we use metatheoretical examination to analyze how communication and its role in science are defined in the discourses of science.

Craig (1999) has demonstrated that all contemporary communication theories can be reduced to seven distinct traditions (in response to related critiques, he admitted that an eighth – the pragmatic tradition – can also be distinguished). However, this categorization can be even further simplified (Carey 2009; Kirtiklis 2011; Kulczycki 2014; Littlejohn and Foss 2011). Indeed, we can demonstrate that theorizing communication can be reduced to two fundamental models: (1) the transmission model of communication and (2) the constitutive model of communication. The transmission model of communication defines communication as a process of transferring information, knowledge, and ideas. Concepts such as Claude Shannon's mathematical information theory (1948) and Michael Reddy's conduit metaphor (1993) can be mentioned here. The constitutive model of communication defines communication as a social creation of meanings and a symbolic interaction between the participants in the process. In this model, the emphasis is placed not so much on the transmission of the message, but on its construction and the consequent co-creation of social relations. James Carey's cultural understanding of communication (Carey 2009) and Barnett

W. Pearce and Vernon E. Cronen's theory of coordinated management of meaning (Pearce and Cronen 1980) may be considered classic examples of the constitutive model. Based on the transmission metaphor, the first model focuses primarily on the dissemination and transfer of knowledge, the sharing of information, and the technological and media-related dimensions of the process (who sends a message, through what channels, what obstacles hinder communication, what the effect of communication is, to whom the message is directed, and who can receive the message). The second model emphasizes the fact that communication is a social activity that involves knowledge production and the co-creation of the symbolic dimension of our reality. Thus, the transmission model of communication can be reduced to the economic and technological dimensions of the analyses (for example, how much it costs to propagate knowledge and what media should be used to obtain the best efficiency). From this perspective, the communicative nature of the dissemination of knowledge is secondary to economic and technological factors. In contrast, the constitutive model demonstrates that communication is the foundation of every other dimension of social processes.

The transmission model of communication dominates the discourses on Open Science, which results from, among other things, its privileged position in information studies (Tuominen and Savolainen 1996: 83). Naturally, this model stems from a particular way of understanding the role of communication in science. Examining the reconstructed discourses in metatheoretical works (Fecher and Friesike 2014; David 2008) reveals the technological and disseminating nature of communication. Scholarly communication may be defined as a process of "knowledge transfer" or "knowledge dissemination." In this way, production processes are separated from the communication of scientific knowledge. According to the transmission approach, scientists produce knowledge in their laboratories and seminars and then send it to other scientists. Thus, we think about publications as "finished products" whose understanding does not depend on the socio-cultural context. Effective dissemination is of primary importance.

The role of communication in the discourses on Open Science is reduced to the "dissemination" of knowledge that has already been produced. In an analysis of the historical sources of openness in science, David wrote that because "open science (*qua* social organization) calls for liberal dissemination of new information, it is more conducive to both the

maximization of the rate of growth of society's stocks of reliable knowledge and to raising the marginal social rate of return from research expenditures" (David 2008: 22). Peters added, "Open source initiatives have facilitated the development of new models of production and mass innovation. The public and nonprofit sectors have called for alternative approaches dedicated to public knowledge redistribution and dissemination" (Peters 2010: 133). In contrast, in the introduction to a handbook published by the European Commission entitled *Open Access – Opportunities and Challenges – A Handbook*, Janez Potočnik noted, "We live in a digital age that has opened up unprecedented opportunities for the dissemination of scientific knowledge. Sharing this knowledge efficiently is crucial for the future of European research. One much debated way of sharing scientific information, and in particular peer-reviewed academic publications, is open access" (Potocnic 2008*:* 9). However, if we consider how communication is defined in the five main schools of thought presented by Fecher and Frisike, we see that the process of knowledge and information dissemination is the predominant way of understanding the role of communication in science. According to Fecher and Friesike, "[as] the scientific audience becomes broader and the topics more specific, the academic dissemination of knowledge needs to adapt" (Fecher and Friesike 2014: 24). In addition, because "the current journal system (...) works against the maximum dissemination of scientific data that underlies publications" (Fecher and Friesike 2014: 26), Open Science is a "method to make research and knowledge dissemination more efficient" (Fecher and Friesike 2014: 32). In reconstructing the discourses of the five schools of thought, Fecher and Frisike often used the phrase "knowledge creation and dissemination" to define the scope of Open Science. However, it appears that the production of knowledge is almost negligible. Only the pragmatic school mentions the use of Web 2.0, which "allows virtually anyone to participate in the process of knowledge creation" (Fecher and Friesike 2014: 35). Of course, one could say that the production of knowledge is implied in the process of its dissemination, which is an acceptable assumption if we adopt the transmission model of communication – we can focus on the dissemination of research results, not on their production. However, if we consider communication processes to be a production of knowledge and regard science itself as a type of communication, our definition of the role of Open Science should change. Secord (2004: 655) emphasized that we can only find an answer to the questions of why and how knowledge circulates

when the social nature of knowledge is recognized. I therefore agree with Kimmo Touminen and Reijo Savalainen, who wrote, "Although the transfer metaphor may be useful in the study of specific questions of information retrieval, the analysis of information use as constructive action requires alternative viewpoints" (Tuominen and Savolainen 1996: 83). Such an analysis is possible when we accept other assumptions about communication itself and its role in science.

4. The Assumptions of the Communication Discourse

As proposed in this paper, the communication discourse on Open Science is based on a fundamental assumption: communicative actions co-produce science. Naturally, one of the key functions of communication is the dissemination of research results. However, as correctly observed by Nielsen, "Communication is an important part of scientific practice and, arguably, may be seen as constitutive to scientific knowledge (...) knowledge transfer no doubt is part of what science communication is all about, but there is much more to it" (Nielsen 2012: 2067-2068). Therefore, the role of communication in Open Science should not be limited to the provision of open communication technologies and the possibility of accessing, modifying, and distributing publications. Such an approach reduces the basic concept of openness to the idea of (1) equal rights and (2) knowledge sharing (Peters 2010, 108). Communication instead becomes a mechanism for the implementation of these two conditions. In other words, communication enables the transfer and dissemination of scientific knowledge to allow everyone to access and share said knowledge. However, communication practices in science are much more complex and cannot merely be reduced to publishing and sharing magazines, books, and preprints. Peters (2010) argued that the category of Open Science can be addressed through various philosophies of openness that emphasize the communicative dimension of openness (e.g., Ludwig Wittgenstein's category of *family resemblances* or Umberto Eco's *open work*). Therefore, when theorizing about Open Science, it is worth moving beyond conclusions about how openness affects the transfer of knowledge. The matter should be examined from a broader perspective to also analyze how openness influences the very process of constructing scientific knowledge (i.e., the perspective offered by the constitutive model of communication).

The process of publishing research results includes multiple phases: (1) the generation (production) of knowledge, (2) the distribution (dissemination) of the published results, (3) the accumulation of knowledge, and (4) the reception and processing of knowledge. In the openness and technology discourse – i.e., within the dominant methods of theorizing about Open Science – only the last three stages are emphasized. In fact, the process of knowledge production is treated as something separate, which assumes the following approach: knowledge should be produced earlier to ensure that it can be transferred within Open Science. It is enough to examine the construction of knowledge within the so-called Citizen Science (Silvertown 2009). Citizen Science projects (e.g., *Galaxy Zoo*) involve nonprofessional scientists who cooperate at the stage of data collection and the production of scientific knowledge. Knowledge is therefore discursive and involves, among other things, negotiating meanings. Leydesdorff (2015) demonstrated that we can talk about the communication of meaning, the communication of information, and the communication of knowledge in the process of knowledge production.

According to Leydesdorff, the consequence of this perspective is the perception of a third context; in addition to the contexts of discovery and justification, he suggested a context of mediation that mediates between the first two contexts. In this way, "the communication turn in the philosophy of science adds to the linguistic turn (...) a sociological perspective" (Leydesdorff 2015, 8). Therefore, sciences are regarded as communication systems through which discursive knowledge is constructed. Only later is this knowledge transferred, e.g., through publications. However, this knowledge could not have been created without the communication process.

Communication is an action that reproduces the socio-cultural reality; therefore, communication in science is fundamental because it constructs meanings and enables an interpretation of scientists' work and of scientific results. Jacob emphasized that "to speak about the social construction of science should be just another way of saying that people make science" (Jacob 1999: 115). Therefore, the cultural approach to communication shares many assumptions with social constructionism: "When adopting the viewpoint of social constructionism to the analysis of information use, one is not studying internal and subjective but discursive constructions of information" (Tuominen and Savolainen 1996: 82). Thus, science is understood as "part of a distinct world of symbols, whose

meaning is determined by a network of relations with other symbols" (Secord 2004, 659). Of course, the analysis of science and Open Science will be subject to the same problems that researchers of cultural history and philosophy of culture face. However, thus far, the Open Science concept has been defined in a clearly one-sided way: from the perspective of the transfer and sharing of knowledge, not from the perspective of the rules that guide the production and validation of knowledge. According to Nielsen, "the meaning of scientific knowledge is not only established by its internal qualities or the method by which it has been produced, it also depends on what other scientists make of it, that is, how scientific knowledge is being communicated" (Nielsen 2012: 271).

The communication discourse changes the way that Open Science is defined. It shifts the emphasis from the transfer and dissemination of already produced knowledge to the process of scientists' co-production of knowledge. Therefore, openness cannot be understood as the mere absence of technological obstacles and the creation of tools for the effective dissemination of publications. The openness of science must also grapple with the fundamental phase of the *production of knowledge*. Therefore, I do not believe that Open Science is a "new science" or Science 2.0. Such conflations would mean that we are facing a paradigm shift or a re-evaluation of the context of discovery and validation. Open Science is instead a research perspective through which the inherent feature of openness in science is to be restored. Openness was born alongside modern science itself, and the rejection of scientific knowledge as a secret must be safeguarded. Eamon noted, "the rejection of secrecy in science in the seventeenth century was, in part, a reaction against what was perceived to be a closed, self-contained, and hierarchical system of knowledge, and against the official policies and institutions that maintained its exclusiveness (...) The debate over secrecy versus openness in science continues" (Eamon 1985: 346). Of course, scientific publications are the means through which such openness is implemented. However, communication is the prerequisite of such openness. Scientific knowledge is produced through communication: in the processes of determining meanings, negotiating perspectives, creating conceptual apparatuses, and discussing, commenting and reviewing. These activities are the actions and processes that "cannot be seen" in the final publications, although they are the foundation of this type of openness in science.

5. Conclusion

Communication plays a fundamental role in Open Science at every stage of the production and dissemination of scientific knowledge. Such a perception of the role of communication leads to science being understood as a process of negotiation and communication of information, meanings and socially constructed knowledge. In the introduction, I indicated that I would describe how we could rethink the concept of Open Science. To this end, I referred to the two major models of communication (the transmission and constitutive models). I used these findings to demonstrate that the main discourse on Open Science is based on the understanding that communication is the transmission of knowledge. I decided that such metatheoretical assumptions disregarded the role of communication in the process of constructing scientific knowledge. Therefore, I proposed the assumptions of a communication discourse in which communication plays a fundamental role in science and is not solely the result of scientists' work.

The metatheoretical dimension of this proposal is its limitation. The description and analysis of defining Open Science require metatheoretical tools. Therefore, if we want to describe how the role of communication in science is perceived in these discourses, we need to employ an appropriate solution. I have used two main models of communication and thus have recognized the dominant transmission approach within the openness and technology discourse. I have adopted a cultural approach to communication, and I have therefore indicated that the constitutive approach will be more useful for communication studies purposes. This approach will help describe the phenomenon of Open Science from the perspective of the construction of socio-cultural reality. Such metatheoretical assumptions lead to consequences in the form of a whole range of problems that plague almost all cultural perspectives: the imprecision of the concept of communication, discussions on the nature of the social construction of reality, the status of symbols and signs, and the social dimension of scientific knowledge. However, as I have tried to demonstrate, accepting such assumptions is a way of incorporating the issue of communicative knowledge production – as a fundamental stage for all scholarly communication – into reflections on Open Science.

My suggestion can be applied to analyze scientific practices that appear with the use of new communication technologies, such as *altmetrics*, in the evaluation of research and in *open notebook science*, such as an "online" research diary. However, the fundamental consequence of the

communicative approach to Open Science is the ability to consider a scientific work's intangible effects in the analyses. In other words, Open Science not only concerns the maximum dissemination of scientific publications but also the communicative activities that contribute to the development of scientific knowledge, even though their effects are not publishable (discussions of negative results, arguments and debates that are open to new interpretations, the method of selecting relevant research subjects, and the values shared by scientists).

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