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Article

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Importance of open science and science communication practices from the perspective of stakeholders

Nivaldo Calixto Ribeiro[1] Dalgiza Andrade Oliveira [2]
Célia da Consolação Dias[3] Angélica Conceição Dias Miranda[4]

ABSTRACT

Introduction: Composed by several movements, Open Science has been gaining considerable notoriety in the search for increasing confidence in the research results, seeking transparency in all the elements that make up a scientific investigation process. Objective: In this scenario, this article aims to analyze the importance attributed by actors involved with Open Science and its movements and initiatives. Method: A questionnaire was sent to personalities involved in the scientific process: two groups of messaging and communication applications in audio and video over the internet and a discussion list of actors interested in the topic, composed of librarians, researchers, professors and editors. Structured by 1 open question and 20 variables related to Open Science, the respondents were instructed to indicate on a 5-point Likert scale the importance of each one, observing the context of scientific communication developed at the public university. Results: With the assistance of SPSS, descriptive statistical analysis of frequency and mean were performed. In addition, a factor analysis was applied and the possibility of condensing the information into a total of four components was identified. Conclusion: Through this study, it was concluded that, in spite of alternating the frequency, the most important mode was registered for all variables, indicating that all the initiatives and movements listed in the study were considered important by the actors involved with Open Science.

KEYWORDS

Open Science. Scientific communication. Mathematical methods. Statistical methods. Factor analysis. Information Science

Author's correspondence

[1] Universidade Federal de Lavras, Lavras, MG – Brazil
e-mail: zoopas@gmail.com

[2] Universidade Federal de Minas Gerais, Belo Horizonte, MG – Brazil
e-mail: dalgizamg@gmail.com

[3] Universidade Federal de Minas Gerais, Belo Horizonte, MG – Brazil
e-mail: celiadias@gmail.com

[4] Universidade Federal do Rio Grande Rio Grande, RS – Brazil
e-mail: angelicacdm@gmail.com

Importância das práticas de Ciência Aberta e de comunicação científica na perspectiva de atores envolvidos

RESUMO

Introdução: Composta por vários movimentos, a Ciência Aberta vem ganhando expressividade considerável na busca pela ampliação da confiança nos resultados de pesquisa, buscando a transparência em todos os elementos que compõem um processo de investigação científica. Objetivo: Nesse cenário, objetivou-se com este artigo analisar a importância atribuída por atores envolvidos com a Ciência Aberta, seus movimentos e iniciativas. Metodologia: Um questionário foi enviado a personalidades envolvidas com o processo científico por meio de dois grupos de aplicativos de troca de mensagens e comunicação em áudio e vídeo pela internet e uma lista de discussão de atores interessados na temática, composta por bibliotecários, pesquisadores, professores e editores. Estruturado por uma questão aberta e 20 variáveis relacionadas à Ciência Aberta, os respondentes foram orientados a indicar, em uma escala Likert de cinco pontos, a importância de cada uma delas, observando o contexto da comunicação científica desenvolvido na universidade pública. Resultados: Com o auxílio do software SPSS, foram realizadas análises estatísticas descritivas de frequência e média. Ainda, aplicou-se a análise fatorial e identificou-se a possibilidade de condensar as informações em um total de quatro componentes ou agrupamentos. Conclusão: Por meio deste estudo, concluiu-se que, apesar de alternar a frequência, todas as variáveis apresentaram como moda o fator cinco, indicando que todas as iniciativas e movimentos elencados no estudo foram considerados muito importantes pelos atores envolvidos com a Ciência Aberta.

PALAVRAS-CHAVE
Ciência Aberta. Comunicação científica. Métodos matemáticos e estatísticos. Análise fatorial. Ciência da Informação.

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1 INTRODUCTION

Actions that advocate for open science, both inside and outside of academia, have expanded. These actions include government initiatives, open access to research results, open data, open science policies, accountable metrics, among many others. Many are the proponents of Open Science, and due to the global health emergency caused by the new coronavirus, we have never seen so much debate in the popular media, on the web, and on broadcast television about research and analysis methods, making for an important era that may have impacted, significantly, the scientific modus operandi.

Over 60 years ago, Decker (1957) announced the need for society to be brought closer to scientific products and that science communication should be improved, a statement that reverberates to this day. On another occasion, McNutt (2013) exposed that even the most brilliant discovery, if there is no wide dissemination, has little value. And with the expansion of science, information dissemination, once the domain of scientific societies and publishers, has become a promising niche market. Along this path, standards for science communication have demanded restructuring. For Oliynyk (2020), scientists are so used to the conveniences of the information age that it is hard to imagine the difficulties that researchers faced in previous centuries.

In the science communication cycle, journals carry the status of being considered the main publication channel adopted by researchers. However, around the 1990s, the beginning of the so-called "journal crisis" was perceived, caused by several issues, among them the high cost of subscriptions and the loss of the capacity of American libraries to maintain and access their contents. Thus, by means of technologies, other forms of access were demanded, appearing resources that allowed free and free access to scientific publications, enhancing the open access movement, one of the pillars of Open Science (AUTRAN; BORGES, 2014).

"Open Science is a collaborative and open movement with a focus on the use of technology for sharing and access to research" (NASCIMENTO; ALBAGLI, 2019, p. 7). With the massive use of technologies, the format of doing science has been reformulated, impacting, significantly, the traditional models used in scientific communication. Countless data are generated as a result of the use of technological apparatuses. The forms and tools of analysis have also evolved, which, hypothetically, can make science more effective, transparent, integral, and collaborative.

This is where the practices foreseen by Open Science fit in, encompassing multiple facets for scientific development. When it comes to the openness of science, one can understand that it involves present postures and guidelines in all stages of research, including interoperable resources, infrastructures, methodologies, and tools. Thus, aligned to this approach, one can understand that different actors have different and important roles that converge towards an open scientific communication. This new format of doing science has brought impacts to the activities of researchers, editors, librarians, teachers, educators, programmers, and several other professionals who work with scientific information in public universities.

Many of the movements have arisen mainly due to the advent of new technologies and have manifested themselves in various regions, research institutions, such as public universities, in different ways, involving various entities and organizations sensitive to movements that move towards the total and/or partial opening of science, observing the legal limits of each location. It is important to emphasize that "[...] Open Science is not a dogma; it is a matter of more efficiency, productivity, transparency, and a better response to the needs of interdisciplinary investigations" (AYRIS et al., 2018).

Given the approach presented, this study asks: how do actors involved with Open Science actions or initiatives perceive the importance of their movements? It is assumed that most of the attention of these actors focuses differently on different movements, especially those that arouse commercial and economic interest, as is the case of open access and open data.

By observing the transformations that have occurred in the last decades, other facets or pillars of Open Science have gained strength, emerging relevant movements, such as Open Educational Resources, Alternative Metrics, Open Peer Review, Citizen Science, which glimpse an approximation with society in the way science is done, among others.

The current scenario allows us to consider that "we experience a new paradigm for scientific communication, access and circulation of information, with impact on both the quality and quantity of scientific production" (MIRANDA; DAMÁSIO; FIRME, 2020, p. 11). Thus, this article aims to analyze the importance attributed to several factors related to science communication by actors involved with Open Science and its movements and initiatives.

Understanding how actors involved with Open Science perceive the importance of each movement justifies this study, because, in this way, it is possible to develop assertive strategies for open scientific research practices, establishing tactics that strengthen less noticed movements or actions.

2 SCIENCE COMMUNICATION IN THE CONTEXT OF OPEN SCIENCE

The popularization of Open Science changed the way scientific information was treated (PINHEIRO, 2014). Until the middle of the first decade of this century it was addressed in a dispersed way, few were the databases with this type of content. According to the author, studying the concepts related to free access to information and Open Science, within the scope of scientific communication, in the scope of Information Science, addressing, above all, the imposition and pressure of governmental political circumstances, presents itself as an irreversible path.

2.1 Open Scientific Communication

Humanity is experiencing a moment in which all information seems to be as accessible as possible, at our fingertips, by means of smartphones, laptops, or other mobile technological resources, on various platforms, including digital social media. Such situation also occurs when we observe scientific communication. For Alves (2011, p. 2), "scientific production and communication are linked to the dissemination of research results and the exchange of information among peers in a community. In order to contribute to the development and progress of knowledge, scientific communication seeks resources to make research procedures and results known to the public and especially to their peers in science (RENTIER, 2016). Peer review is a crucial process for the credibility of research and scientific publication.

The peer review system is overwhelmed by the increasing number of journal articles compared to the small group of reviewers, distinct from a few decades when the number of journals was smaller (BARROGA, 2020). Due to the lack of incentives and shortage of reviewers, peer review can be a thankless task and be close to a collapse, compromising the entire scientific communication system.

According to Rentier's (2016) study, for centuries, research was disseminated in print form, occasionally with illustrations, figures, tables, drawings, and photos. Until recently, including films, videos, 3D images in a publication were complex, due to the limitations of printing. For the author, science events are another interactive way of making science public. Principles such as open critique and questioning can be adopted in these cases, as well as more versatile presentation tools, using color, video, and a wide range of more dynamic strategies. As Vieira (2010) emphasizes, science communication and its communication systems are an important constituent element of science, resulting in a relevant role for scientific journals, acting as a showcase for the knowledge of recent research results.

The modern scientific world is based on a devastating network of journals (OLIINYK, 2020). For the author, every renowned journal also has an online version, which makes the communication of scientific information almost instantaneous. He reinforces that scientific journals have become a priority means of disseminating information, and a scientific article has gone from an ordinary letter to a more structured document and has taken on a more appropriate format.

It is undeniable that the Internet has changed the way scientific research results are communicated. However, in the mid-1980s, the high cost of maintaining subscriptions to journal titles and their consequent unavailability or limited access triggered the so-called "journal crisis" (AUTRAN; BORGES, 2014). According to the authors, these obstacles resulted in the application of the open access strategy and the pioneering initiatives, known as Budapest Open Access Initiative, Bethesda Statement on Open Access Publishing and Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities, which established the philosophy of open access, laying the foundations of a new paradigm, commonly associated with the Open Science movements. Despite these advances, there is still no definitive or satisfactory solution.

Recently, in their study, Heise and Pearce (2020) questioned how open and transparent a scientific paper can be. The paper investigated the potential way to make all information and research processes, such as a doctoral thesis, comprehensively and freely accessible on the internet. Although the study shows that it is possible to publish everything related to research processes as quickly and as comprehensively as possible under an open license, a certain lack of understanding by scientists about open access, support for Open Science and their actual practice of open communication was also revealed. What is observed is that Open Science practices can significantly change the production and dissemination of scientific knowledge.

2.2 Open Science and its facets

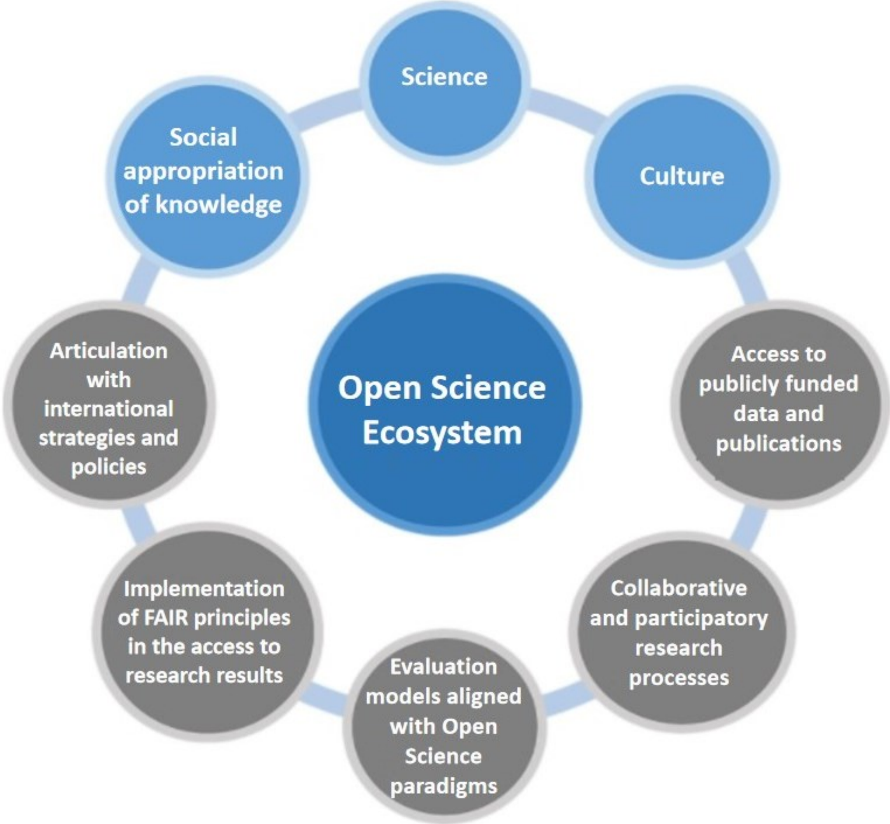
Open Science is not a new concept in itself, although the agreement on this expression and its widespread use are relatively recent. The expression was selected by stakeholders during the public consultation organized by the European Commission to represent the constant changes occurring during the research process, the collaboration of researchers, the sharing of knowledge and the organization of science (LOPES; ANTUNES; SANCHES, 2018).

With an approach that seeks to minimize the barriers associated with traditional ways of sharing research results, Open Science has emerged (HOWE et al., 2017). Often highlighting conflicting situations among stakeholders in the products of science, it involves various movements, actions, policies, as well as institutional and government initiatives. For Howe and Grechkin (2017) and Katz et al. (2018), this movement is moving forward, but they suggest considering a more transformative vision for Open Science. For Revez (2019), this is a movement of tension and disruption.

In the words of Albagli (2014), Bueno de la Fuente (2016), Silva (2017) and Ribeiro and Oliveira (2019), when adopted as a new philosophy of doing science, it can be considered as a term that houses several pillars aimed at reducing barriers to sharing any result, method at any stage of the research process, encompassing different types of practices and approaches, it also allows multiple interpretations in its realization and in its practices.

For Sayão and Sales (2019), science presents itself in a collaborative way, traveling in a dialectical trajectory of errors and successes, whose processes, and interlocutions, grounded in the scientific method, are gradually converging towards new knowledge and discoveries. According to the authors, this dialogue is most evident in the continuous cycle of confrontations that is historically broken between the prevailing paradigms and the inevitability of new ideas. According to Rollo (2016), Figure 1, expresses the strands that fit into the proposed eight pillars of the Open Science ecosystem.

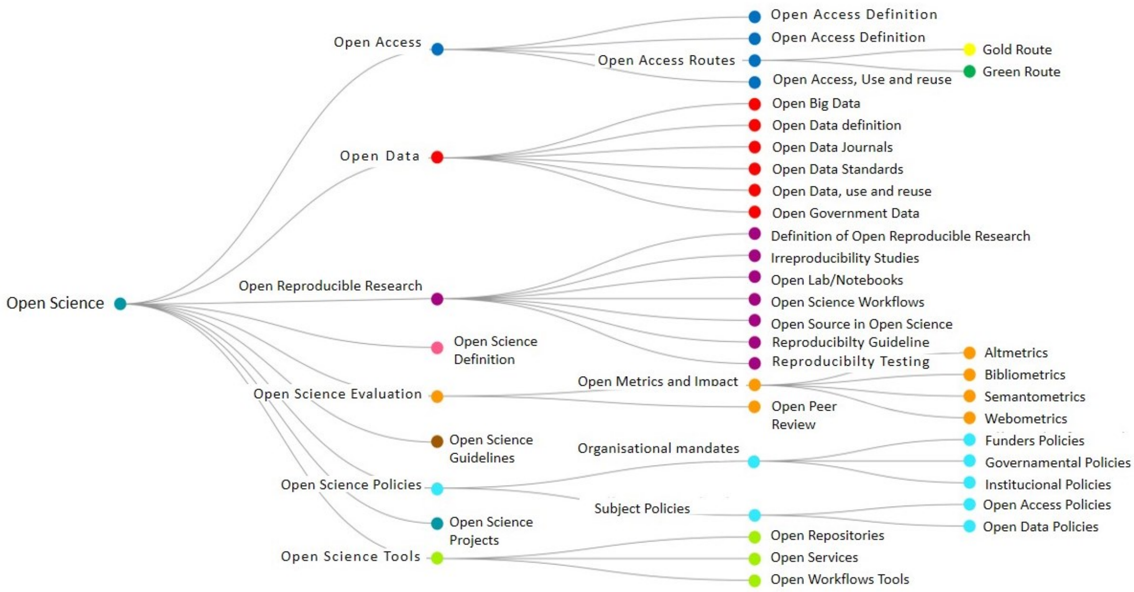
Figure 1. Pillars of Open Science



Source: Rollo (2016).

Open Science practices can also be seen in its taxonomy, developed by the Facilitate Open Science Training for European Research (FOSTER) initiative team. The FOSTER project initially aimed to support various stakeholders in the adoption of open access at the European level and in complying with the policies and rules of engagement defined for Horizon 2020 (H2020). Currently, it brings together training resources focused on Open Science. A free translation of the Open Science Taxonomy of Pontika et al. (2015), prepared by Ribeiro, Silveira and Santos (2020) and later validated and expanded by Brazilian researchers, in the study by Silveira et al. (2021), is presented in Figure 2. In this version, the facets were distinguished from each other using colors, facilitating reading fluidity and the identification of their taxonomic ramifications.

Figure 2. Open Science Taxonomy



Source: translated from Pontika et al. (2015) by Ribeiro, Silveira, and Santos (2020).

It is understood that a taxonomy aims to present a domain in a simple and hierarchical way (MACULAN; LIMA, 2011). According to the authors, it can be faceted, presenting a domain in facets and, in each facet, there may be a hierarchy, allowing the establishment of relations, indicating the multidimensionality of a term in the same domain. According to Medeiros (2013, p. 48), "it refers to systematic ordering and nomenclature." For Aganette, Alvarenga and Souza (2010), it is considered an important tool for understanding how an area of knowledge is organized, how this area relates and how it interacts with others.

In a way, the taxonomy of Open Science of Pontika et al. (2015), presents a desirable cycle of scientific communication, addressing from the conception of a research, in a transparent way, through dissemination tools in scientific journals, the reproducibility of a research, the evaluation through alternative metrics, the preservation of raw data and the availability of the final product, in open access journals, digital or institutional repositories. The understanding is that when talking about Open Science, implicitly, we are talking about open science communication.

3 METHODOLOGICAL OPTIONS

From the point of view of the approach of the question presented for this study, according to the conception of Prodanov and Freitas (2013) and Creswel (2014), this research can be considered mixed, with predominance of the quantitative method, because it sought to translate into numbers of opinions of actors involved with Open Science and science communication.

To achieve the objectives, a web questionnaire was used, structured by one open and 20 closed questions, composed of Open Science actions or movements, used as variables of the study, defined from its taxonomy: Open Access; Open Access Policy; Institutional Repositories; Open Science Policies and Guidelines; Open Science Projects; Open Data Policy; Open Government Data; Open Educational Resources; Open Codes; Open Research Data Repository; Open Data; Open Data Journal; Scientific Dissemination; Open Licensing; Open

Science Evaluation; Open Lab Notebooks; Specialized Policies; Citizen Science; Alternative Metrics and Open Peer Review.

Prepared and managed through the Google Forms platform, in August 2020, the questionnaire was sent, initially as a test, to actors involved in some of the stages of the scientific process, registered as members of the Open Science stakeholder mailing list (cienciaaberta@listas.ufmg.br). In parallel, it was forwarded to two WhatsApp groups, an application to exchange messages and instantaneous audio and video communication over the Internet (#Repositórios do Brasil e #Drs. em Ciência Aberta). These groups and the discussion list were selected for having at least one of the authors of this research registered as a participating member, thus, it was possible to clarify doubts, as well as capture manifestations of participants about the questionnaire, about the option used for application and management of data collection and other relevant information for the study. The questionnaire was answered by 11 librarians, 9 professors, of these 2 also work as journal editors, 4 researchers, and 6 did not identify their functions.

It is important to note that in a universe of 250 possible actors to be reached with the sum of the two groups (38 registered) and the discussion list (212 registered) at the time, 30 answers to the questionnaire were identified, characterized as the sample of the study, which represents 12% of the potential population investigated.

As specified in the questionnaire, the respondents were instructed to indicate, on a five-point Likert scale, the importance of each of the variables, actions, or movements of Open Science, ranking them from one to five, where closer to one, the less important the variable was, and closer to five, the more important it was considered. The information gathered was classified and analyzed with the support of descriptive statistics methods and techniques. Arithmetic averages, factor analysis, and frequency analysis were applied.

Descriptive measures are numerical methods that integrate the branch of descriptive statistics, used to describe, and analyze collective phenomena (MARTINS; DOMINGUES, 2017). According to the authors, descriptive statistics of arithmetic mean is the most common, most intuitive of position measures, of generalized use, that is, it applies to a large number of practical situations. It must be used with care, because it is influenced by all the values present in the series. It is represented by a sample and for a population. In this study, it was used to rank the study variables, listing which were considered most and least important for the group studied.

Factor analysis is a multivariate analysis technique for identifying groups or clusters of variables. This technique has three main uses: (1) to understand the structure of a set of variables; (2) to construct a questionnaire to measure an underlying variable; and (3) to reduce a data set to a more manageable size while retaining as much of the original information as possible (FIELD, 2009). According to the author, by reducing a data set from a group of interrelated variables into a smaller set, factor analysis achieves parsimony by explaining the maximum amount of the common variance in a correlation matrix and using a smaller number of explanatory concepts. In this study, this technique was used to group the 20 Open Science actions or movements proposed in the questionnaire with the intention of facilitating the understanding about the importance attributed by the actors involved.

Descriptive frequency statistics refers to the number of times the event occurred in an experiment or study. In the words of Mann (2015), the value (or values) that occurs most frequently in a data set can be described as the mode.

The Statistical Package for the Social Sciences (SPSS) was used as a support tool for this research, a set of statistical resources with different modules for the use of professionals in humanities and exact sciences, which enables statistical and graphical analysis with a range of data (FIELD, 2009). Originally created by SPSS Inc., known for the proprietary software of the same name, in 2009, the International Business Machines Corporation (IBM) bought the company that developed it and renamed it to Statistical Product and Service Solution or IBM SPSS Statistics.

4 DATA ANALYSIS AND DISCUSSION

As in the arts, this analysis was structured in acts. According to Ferreira (1986), in the scenic context, these are the divisions or units that make up a play or an opera. In the author's words, the number of acts can vary, depending on the structure of the production. In the case at hand, this refers to three acts: the descriptive statistical analysis of mean, factor, and frequency analysis, orchestrated with the help of SPSS.

In the first act, through the mean analysis, it was possible to establish the ranking of the actions and movements of Open Science, which can be seen in Table 1. Note that the first three top ranked variables refer to issues involving open access. It is important to consider in this result that this movement has as a landmark the year 2002, with the beginning of a sequence of worldwide public declarations of principles related to open access to scientific literature. Brazil is the most active country in the region in open access implementations (GUIMARÃES, 2018). It was the first country to submit a bill in 2007 to Parliament proposing a mandatory national open access policy, although so far it has not been passed and is shelved. Open access journals have been well accepted in the country and are available through various initiatives. In addition, in 2009, the Brazilian Institute for Information in Science and Technology (Ibict) started a national action to support the development of institutional repositories in universities and research institutions (LA REFERENCE, 2019; GLOBAL OPEN ACCESS PORTAL, 2017), which has certainly contributed to the consolidation of this movement in the country, given its due importance.

Following the ranking, it is found among the main notes of importance attributed variables related to Open Science policies and guidelines, revealing a demand for guidance, institutionalization and referrals aimed at this way of doing science, potentially more efficient, transparent and integrity, brought by the movements of open science.

The central part of the ranking is composed of movements that have been gaining notoriety, with the popularization of Open Science and its facets: Open Government Data, Open Educational Resources, Open Data, Open Codes, Scientific Dissemination, Open Licensing. Possibly, the recognition of these movements has been growing due to the permissibility of access, transparency, integrity in all stages of a scientific process, marked by the facilities provided by technological innovations.

Chart 1. Descriptive statistics of mean

	N	Reach	Minimum	Maximum	Average		Deviation	Variance
	Stat.*	Stat.	Stat.	Stat.	Stat.	Error	Stat.	Stat.
Open Access	30	3	2	5	4,90	,100	,548	,300
Open Science Policy and Guidelines	30	4	1	5	4,77	,141	,774	,599
Open Access Policy	30	3	2	5	4,73	,126	,691	,478
Scientific Dissemination	30	4	1	5	4,73	,166	,907	,823
Institutional Repositories	30	3	2	5	4,70	,128	,702	,493
Open Science Projects	30	4	1	5	4,67	,146	,802	,644
Open Data Policy	30	4	1	5	4,67	,154	,844	,713
Open Government Data	30	4	1	5	4,67	,154	,844	,713
Open Data	30	4	1	5	4,67	,161	,884	,782
Open Educational Resources	30	4	1	5	4,60	,156	,855	,731

Open Licensing	30	4	1	5	4,60	,170	,932	,869
Open Research Data Repository	30	4	1	5	4,57	,157	,858	,737
Open Data Journal	30	4	1	5	4,50	,164	,900	,810
Open Science Assessment	30	4	1	5	4,50	,178	,974	,948
Citizen Science	30	4	1	5	4,43	,184	1,006	1,013
Open Codes	30	4	1	5	4,40	,156	,855	,731
Open Labs Journal	30	4	1	5	4,27	,179	,980	,961
Specialized Policies	30	4	1	5	4,23	,184	1,006	1,013
Alternative Metrics	30	4	1	5	4,20	,194	1,064	1,131
Open Peer Review	30	4	1	5	4,00	0,249	1,365	1,862

*Est.=Estatística

Fonte: Dados da pesquisa (2020).

Still, regarding the ranking, the position assigned to the Open Peer Review variable calls attention. In this research, it was pointed out as the least important movement. For Abadal and Silveira (2020) and Shintaku et al. (2020), considered one of the fronts of Open Science, Open Peer Review represents the process of openness and transparency of review by experts of scientific articles, and can be applied to scientific journals, one of the protagonists in the area of scientific communication. According to the authors, this format of scientific review can be conducted at several levels. Synthetically, it consists of:

(a) Open identities: refers to the evaluation process in which the author and the referee are aware of their identifications.

b) Open opinions: refers to the possibility of publishing, along with the article, the document with the annotations of the evaluator.

c) Open participation: refers to the possibility of interaction of the evaluator and authors to discuss the article. Another possibility is the interaction with the community, in the format of public consultation, in the same way that occurs with the updating of standards, with the use of preprint (ABADAL; SILVEIRA, 2020; SHINTAKU et al., 2020).

In Brazil, the idea of opening the reviewers' comments, in an Open Peer Review, still does not arouse interest in the scientific community, prevailing the blind peer review system in journal articles (NASSI-CALÒ, 2015). The research conducted by Ross-Hellaeur, Deppe, and Schmidt (2017) showed that among the developments of Open Science, Open Peer Review has the lowest acceptance rate. Thus, convergence with these studies can be seen through the research under analysis.

In the second act of the analysis, a variable grouping strategy was used, by means of descriptive factor statistics. With the help of SPSS, a rotated component matrix was generated, using the extraction method of principal component analysis, by means of the Varimax rotation method, with Kaiser (1958) normalization and rotation converged in eight interactions. The Varimax rotation is a method that seeks to minimize the number of variables that present high loadings in each factor. As shown in Chart 2, the data from the factor analysis with four factors are presented, and the components with predominance values higher than 580 were highlighted.

Chart 2. Descriptive Factor Analysis

Component matrix	
	Component

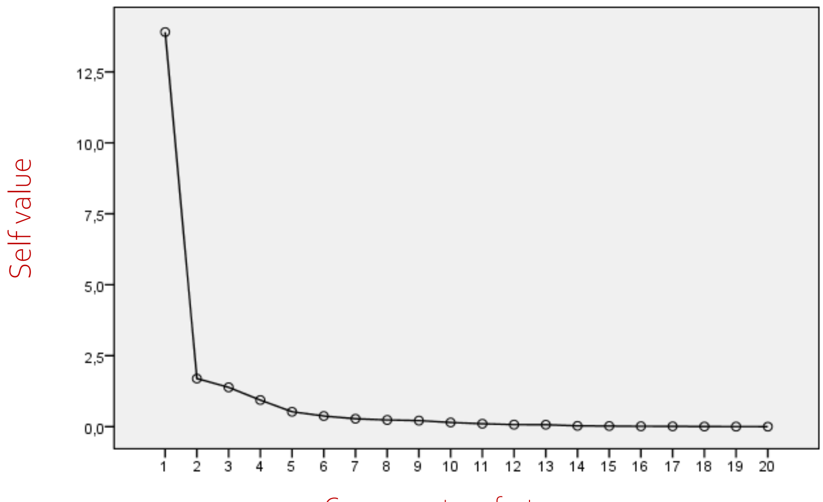
	1	2	3	4
Open Access	,584	,584	,325	,234
Open Science Assessment	,451	,232	,290	,759
Open Data	,783	,550	,069	,090
Alternative Metrics	,511	,072	,361	,706
Open Peer Review	-,049	,231	,148	,934
Open Science Policies and Guidelines	,718	,382	,392	,269
Open Science Projects	,683	,577	,352	,118
Open Access Policy	,845	,165	,418	,195
Open Data Policy	,801	,470	,265	,133
Institutional Repositories	,787	,195	,436	,142
Open Educational Resources	,394	,338	,663	,195
Citizen Science	,397	,225	,822	,085
Scientific Dissemination	,628	,156	,613	,276
Open Labs Notebooks	,220	,353	,777	,368
Specialized Policies	,279	,316	,752	,406
Open Data Journal	,302	,611	,431	,432
Open Codes	,615	,455	,290	,418
Open Government Data	,255	,789	,264	,417
Open Research Data Repository	,286	,823	,217	,344
Open Licensing	,305	,864	,289	-,026

Source: Research data (2020).

The value of the Kaiser-Meyer-Olkin (KMO) index, which indicates whether the factor analysis is appropriate, was 0.475, close to the acceptable level indicated by Hair, Anderson, and Tatham (2005). In function of the total variance of the data[1], according to Graph 1 - Data Variance Scree Plot, it is shown that the data can be explained by 89.599% when using four components or factors to group the variables. Also, the initial eigenvalue of 0.936 contributed to the use of four factors. Kaiser (1960) recommends that one should use principal components with eigenvalues up to close to 1, that is, close to the 0.936 used. Aligned to the previous premise, Chart 1 demonstrates that there is no relevant variance in the data from the 4th component on, pointing to a more linear variance, which possibly has little impact on data analysis.

[1] Scree Plot is a graph of eigenvalues in function of the order of principal components, graphically representing the percentage of variance explained by component (MARTINS, 2011).

Graph 3. Scree Plot of data variance



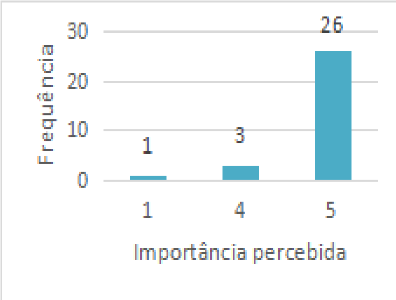
Source: Research data (2022).

When observing the descriptive factorial, it was decided to arrange the variables into four groups: 1**. Open Access:** 1. Open Science Policies and Guidelines, 2. Open Science Projects, 3. Open Data Policy, 4. Open Access Policies, 5. Open Access, 6. Institutional Repositories, 7. Scientific Dissemination, 8. Open Codes; 2. **Open Data:** 9. Open Data, 10. Open Data Journal, 11. Open Government Data, 12. Open Research Data Repositories, 13. Open Licensing; 3. **Emerging Open Science Movements**:14. Open Educational Resources, 15. Citizen Science, 16. Open Labs Notebooks, 17. Specialized Policies; 4**. Evaluation of Open Science:** 18. Evaluation of Open Science, 19. Alternative Metrics, and 20. Open Peer Review, with the data arranged in 20 graphs which presented the analyses in the next act, by means of the descriptive frequency statistics technique. Although the results indicate the association of the variable Open Licensing with Group 2. Open Data, conceptually, it can be considered more appropriate if classified in Group 1. Open Access, where the more general and Open Science oriented variables are found.

In the first grouping, composed of 8 variables, it is observed that, besides the items Open Access, Open Codes and Scientific Dissemination, there is an emphasis on policies, projects, and guidelines of Open Science, which may indicate the scarcity of guidelines for the openness of science in the context of public universities. Regarding this issue, when observed from a broader angle, one notices that there is no single institutional planning, but rather, sectored actions. It is notorious the efforts of the defenders of each movement struggling to emerge or to sustain the ideals proposed in each one of them.

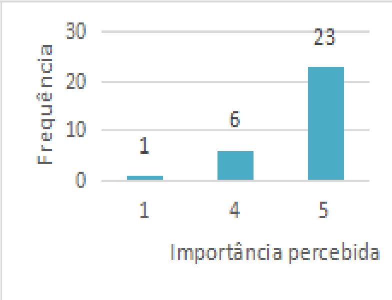
Group 1. Open Access

Graph 1 - Policies and Guidelines of Open Science



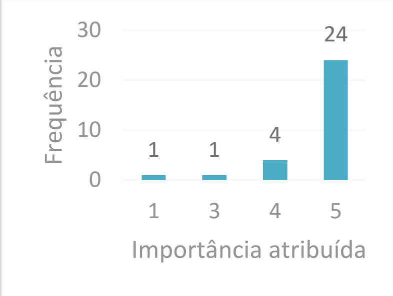
Source: Research data.

Graph 2 - Open Science Projects



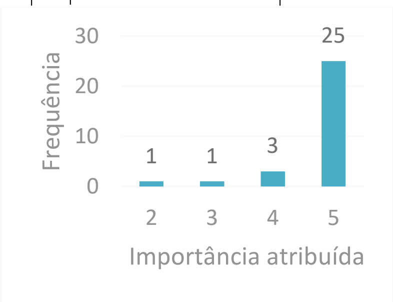
Source: Research data.

Graph 3 - Open Data Policies



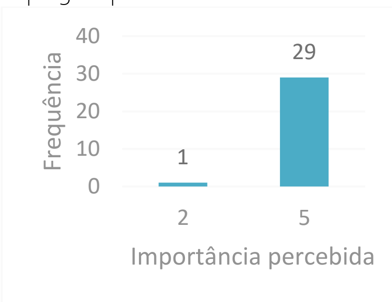
Source: Research data.

Graph 4 - Access Policies Open



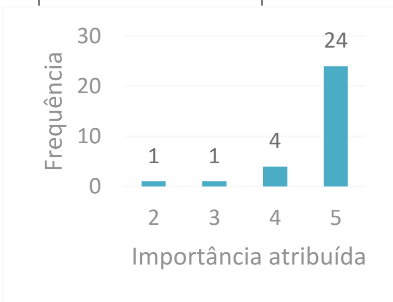
Source: Research data.

Graph 5 - Open Access



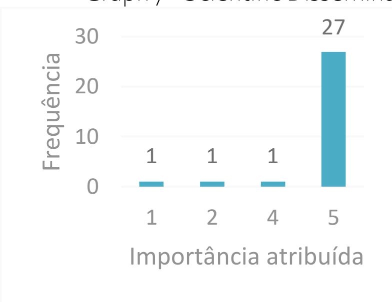
Source: Research data.

Graph 6 - Institutional Repositories



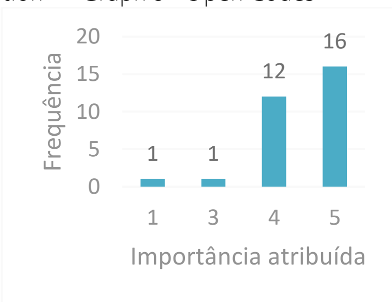
Source: Research data

Graph 7 - Scientific Dissemination



Source: Research data.

Graph 8 - Open Codes



Source: Research data.

Considering that public universities are responsible for the largest amount of research in the country, one of the solutions to amplify Open Science practices is the development of policies with this approach at the governmental level, of course, observing university autonomy. Graphs 1-4, from the first group, show that policies are considered extremely important for Open Science actors. With the exception of the variable related to Open Source, the mode in the others of the first group, in general, was especially important for at least 23 of the respondents in each variable.

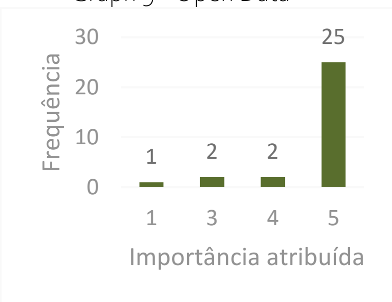
About Open Codes, they can be considered as a social movement, initiated by computer programmers who reject secrecy and centralized control of creative work in favor of decentralization, transparency, and unrestricted sharing of information (RAYMOND, 2019). Possibly, by having a smaller number of programmers in the survey population, this movement has a little more variation in responses, from four to five.

When the goals of the Open Access movement of fostering the reading and obtaining of knowledge, as well as promoting the exchange of information between scientists more quickly and effectively, are noted, it is safe to say that they may have more access to research results through open publishing. In this survey, the mode for Open Access was five, with 29 responses, the highest of the variables. It can be noted that, although Open Access is about dialogue among experts, the importance of Scientific Dissemination for Open Science is inexorable. In Bueno's (2010) studies, this facet is strongly associated with the concept of science journalism. For Albagli (1996), Scientific Dissemination supposes the translation of a specialized language to a lay one, aiming to reach a wider audience. For Bueno (1984, p. 75), it is the "[...] use of technical processes and resources for the communication of scientific and technological information to the general public". The mode for this variable was especially important, corresponding to 27 of the 30 answers obtained in the survey. In the same line of Science Dissemination, the Open Science Public School, proposed by Fecher and Frieseke (2013, 2014), values scientific research that encompasses and dialogues with the general public and not only with experts.

By analyzing the second cluster of variables, it can be seen that it reflects the Open Data facet of the Open Science Taxonomy. In the context of Open Data, one can assume here the metaphor that "data is the new oil." According to Arthur (2013), this idea was originally created by London mathematician specializing in Data Science Clive Humby in 2006 echoing ever since, resonating across a variety of business-oriented communication channels. In the context of Open Science, it is understood to reinforce the premise by making the association that both data and oil only have value when they are extracted and treated (JULIO, 2019).

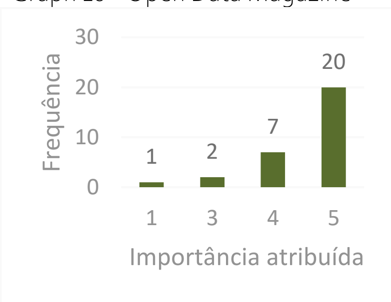
Group 2. Open Data

Graph 9 - Open Data



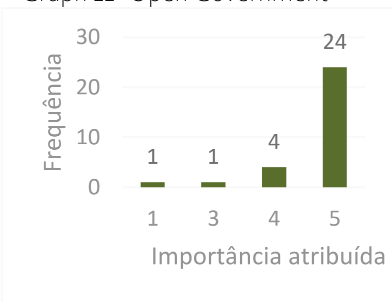
Source: Research data.

Graph 10 - Open Data Magazine



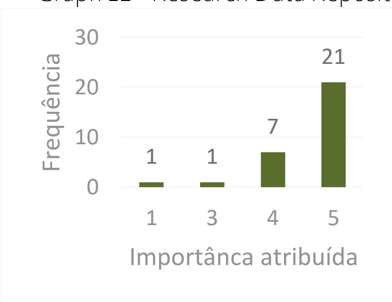
Source: Research data.

Graph 11- Open Government



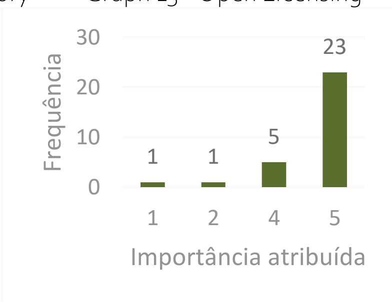
Source: Research data.

Graph 12 - Research Data Repository



Source: Research data.

Graph 13 - Open Licensing



Source: Research data.

In general, the variables in this group reflect the need to create standards for research data that allow them to be findable, accessible, interoperable, and reusable, as provided for in the FAIR Principles[2]. With regard to the mode for this group, all of them strongly indicate indicator 5, especially important. Regarding the variable that deals with Open Data Journal, "journals that publish peer-reviewed articles and the set of data produced, openly accessible for reuse" (CARVALHO, 2018, p. 75), it can be considered that it is a recent publication format and presented the lowest mode of this component.

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[2] FAIR Principles. Available at: https://www.go-fair.org/fair-principles/. Accessed on: 28 feb. 2022.

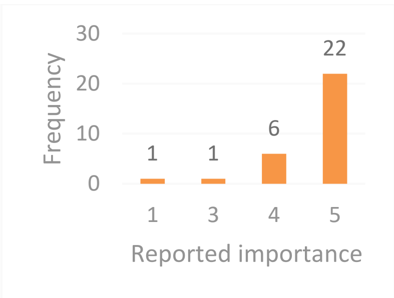
With regard to Open Government Data, the Open Data Policy of the Federal Executive Branch, established by Decree No. 8,777, of May 11, 2016, defines rules for the availability of open government data within the Federal Executive Branch. This instrument consists of several normative, planning, guidelines, and guidance documents. It can be cited as the main objectives: to promote the publication of data contained in databases of organs and entities of the federal public autarchic and foundational administration in the form of open data; enhance the culture of public transparency and provide citizens with access, in an open way, to data produced or accumulated by the Federal Executive Branch (BRASIL, 2020). Still, regarding this variable, Law No. 12,527, of November 18, 2011, known as the Access to Information Law (LAI), can be cited, which regulates the transparent management of information, allowing broad access and disclosure of public data and ensuring its permanent availability and integrity in organs and entities linked to public power. For Guanaes (2018), both the Access to Information Law and the National Open Data Policy can be considered as legal frameworks that guarantee access to open data and government information, including those produced within public universities.

When it comes to Open Licensing, for Reis (2020), there is a dichotomic situation between the scientific and the commercial as to research results. On the one hand, especially when financed with public resources, Open Science aims to expand collaboration and provide free access in a transparent way. On the other hand, Industrial Property is based on monopoly, competition, and profit. In order to narrow this polarity, licenses were created, a legal document that grants specific rights to the user to reuse and redistribute a licensed material under certain conditions (BEZJAK et al., 2018). For this author, applying an open license to a scientific work enables the copyright holder to determine how their creation may be used or modified, consistent with regulated copyright and related rights. For this variable, the mode was concentrated on option 5, important.

The third grouping involves Open Science movements that have been gaining visibility with the opening of science and the popularization of technological resources.

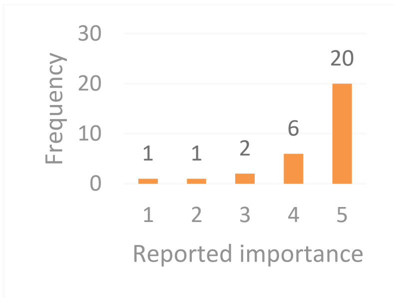
Group 3. Emerging Open Science Movements

Graph 14 - Educational Resources Open



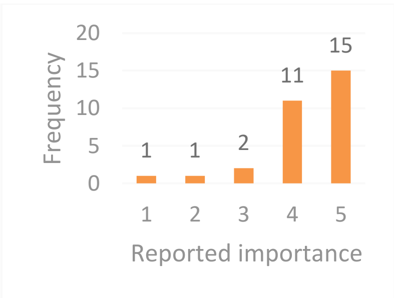
Source: Research data.

Graph 15 - Citizen Science



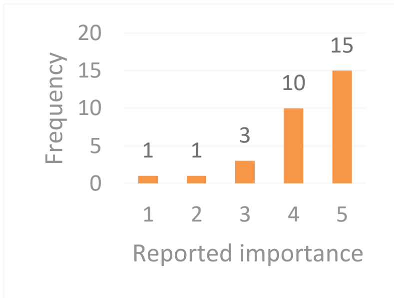
Source: Research data.

Graph 16 - Open Policy Notebooks Lab



Source: Research data.

Graph 17 - Specialized Policies



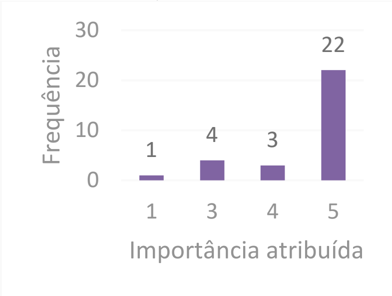
Source: Research data.

Open Educational Resources can be understood as any educational resource openly available for use by educators and students, without the need to pay copyright or license fees (FUNIEL; MENDONÇA; SILVA, 2012). They are related to an open pedagogical form that provides for the use and creation of intellectual production by students and teachers that allows free access. Another movement, Citizen Science, focuses on increasing citizen participation in the directions of science and the social appropriation of its results, involving various aspects, including digital (BRAZIL; ALBAGLI, 2020). As for the Open Lab Notebooks, Rocha, Sales and Sayão (2017) present them "[...] as an alternative that facilitates the obtaining and interconnection of research data by researchers," they have a similar function to a printed notebook, but the procedures and findings of the research are recorded in an open tool, available online. The mode for the group remained at item 5, particularly important, varying the frequency, Educational Resources with 22, Citizen Science with 20 and the Open Lab Notebooks with 15. About the Specialized Policies, it is understood as a flaw in the construction of the questionnaire, because this variable refers to the Open Data Policy and Open Access Policies, contemplated in more specific variables.

The variables of the last grouping, referring to the Evaluation of Open Science, Alternative Metrics and Open Peer Review involves the recommendation of the use of metrics and indicators responsibly, observing beyond the formal use of citation, the analysis of altimetric indicators and others that have emerged with the technologies and web resources.

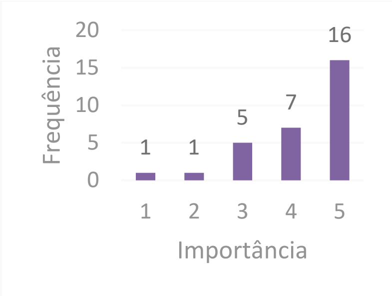
Group 4. Evaluation of Open Science

Chart 18 - Open Science Assessment



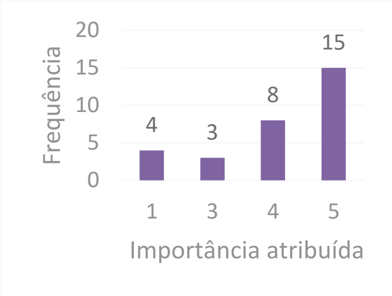
Source: Research data.

Chart 19 - Alternative Metrics



Source: Research data.

Chart 20 - Open Peer Review



Source: Research data.

It is noteworthy that these variables obtained a very dispersed frequency and that it was recorded the indication of the respondents in all points of the Likert scale, resulting in a mean lower than the other variables of the questionnaire. It is important to mention that, despite the dispersion, there was more concentration on item 5, especially important.

5 FINAL CONSIDERATIONS

This study sought to identify the importance attributed by actors involved with Open Science and its scientific communication movements and initiatives in public universities. Therefore, it was possible to identify that all the variables listed in the data collection instrument of the research obtained a high degree of importance, with a common frequency above 20, mode 5, very important.

With the research, it was found that the Open Science policies, as well as those specialized ones that govern actions in other movements, arouse the interest of the actors. Open Data and Open Access policies stand out. As in this study, in the research of Rodrigues et al. (2019), more popularity was found for Open Access. The position of the variable related to Open Peer Review in the ranking of the most important initiatives drew attention, as evidenced by descriptive statistics.

The use of descriptive statistics tools and techniques of mean, factorial and frequency for data analysis is noteworthy, as they proved to be relevant for study in Applied Social Sciences and Information Science.

As the questionnaire was made available in two application groups and a discussion list, there was room for reflections on the option used for application and management of the data collection. One recommendation raised was the suggestion of using free and decentralized alternatives for the management and construction of the questionnaire or using resources from institutions that do not rely on data extraction as a business model. LimeSurvey was recommended as it allows free use on the organization's server, with some restrictions. It is also possible to install it on one's own server, which is in line with the Open Science ethic of transparency. It was mentioned that surveys that announce the anonymity of those who answer the questionnaire are common, but due to the privacy policies of private companies this is not always possible to guarantee.

As limitations of the research and difficulties encountered, we can mention the low sample of participants in the research, only 30 questionnaires were answered out of a total of 250 possible. It is understood that, in other similar studies, the results may vary. Another point that must be considered refers to the descriptive analysis of the mean, because, normally, the data obtained with Likert is treated as interval and not as ordinal, making sense when dealing with the mean. In other words, usually to use the average with more property it is necessary to have a large number of respondents, which is not the case in this research. However, there is a great methodological debate about this approach in the scientific literature, whether interval or ordinal. For example, the study by Carifio and Perla (2008), who present this dichotomy surrounding the application of the Likert Scale and verify the possibility of using it in both formats.

As a complement to this study, in future work, it is intended to use the results of the questionnaire to develop mechanisms to create a digital object that allows managers of research institutions to analyze how much the institution under their responsibility is engaged with the proposals of Open Science. To this end, metrics will be created related to the importance of each movement or action directed towards the practice of open science based on this study.

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