RCA Revista de Ciências da Administração

v. 26, n. 66, p. 1-28, 2024

DOI: https://doi.org/10.5007/2175-8077.2024.e76382

How to Promote Collaboration in Open Data Platforms?

Como Promover a Colaboração em Plataformas de Dados Abertos?

Cómo Promover la Colaboración en Plataformas de Datos Abiertos?

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ABSTRACT

Goal: To identify and explore the collaborative elements in open government data, with a focus on open data platforms. **Methodology/approach:** An exploratory, qualitative and bibliographical research was conducted in the Scopus, ScienceDirect, Web of Science, Scielo, ACM, Proquest and IEEE databases with the aim of identifying studies that contemplate the development of open government data through collaboration. In addition, a benchmarking analysis was also performed on 32 interactive platforms to identify the best practices and functionalities in terms of collaboration. **Originality/relevance:** Open government data can be considered an important and influential innovation that has the potential to drive public value creation. Although many countries maintain open government data portals, the collaborative elements of the portals are limited. **Main findings:** The results revealed 25 collaborative elements that can expand the collaborative potential of the open government data environment. These elements have been shown to contribute substantially to a more collaborative and efficient approach, providing universal access and strengthening the use of open data for various purposes, in line with the promotion of transparency and accountability in multiple sectors. **Theoretical cntributions:** The research contributes by highlighting the need to deepen the study of collaboration in open data, proposing new approaches to develop more integrative and collaborative ecosystems. **Management contributions:** This work highlights the importance of seeking collaboration in government open data platforms, contributing to achieving greater transparency, effectiveness and innovation in the use of data.

Keywords: Open data; Collaboration; Open data platforms.

RESUMO

Objetivo: Identificar e explorar os elementos colaborativos em dados abertos governamentais, com foco nas plataformas de dados abertos. **Metodologia/abordagem:** Foi realizada uma pesquisa exploratória, qualitativa e bibliográfica nas bases de dados Scopus, SienceDirect, Web of Science, Scielo, ACM, Proquest e IEEE com o intuito de identificar estudos que contemplem o desenvolvimento dos dados abertos governamentais por meio da colaboração. Além disso, também foi executada uma análise de *benchmarking* em 32 plataformas interativas para identificar as melhores práticas e funcionalidades em termos de colaboração. **Originalidade/relevância:** Os dados abertos governamentais podem ser considerados uma inovação importante e influente que tem o potencial de impulsionar a criação de valor público. Embora muitos países mantenham portais abertos de dados governamentais, os elementos colaborativos dos portais são limitados. **Principais resultados**: Os resultados revelaram 25 elementos colaborativos que podem expandir o potencial colaborativo do ambiente dos dados abertos governamentais. Esses elementos demonstraram contribuir, de maneira substancial, para uma abordagem mais colaborativa e eficiente, proporcionando o acesso universal e fortalecendo a utilização de dados abertos para diversas finalidades, alinhado à promoção de transparência e responsabilidade em múltiplos setores. **Contribuições teóricas:** A pesquisa contribui ao destacar a necessidade de aprofundar o estudo sobre colaboração em dados abertos, propondo novas abordagens para desenvolver ecossistemas mais integrativos e colaborativos. **Contribuições para a gestão**: Esse trabalho destaca a importância de buscar a colaboração em plataformas de dados abertos governamentais, contribuindo para o alcance de uma maior transparência, eficácia e inovação no uso de dados.

Palavras-Chave: Dados abertos; Colaboração; Plataformas de dados abertos.

RESUMEN

Objetivo: Identificar y explorar elementos colaborativos en datos abiertos gubernamentales, con enfoque en plataformas de datos abiertos. **Metodología/enfoque:** Se realizó una investigación exploratoria, cualitativa y bibliográfica en las bases de datos Scopus, SienceDirect, Web of Science, Scielo, ACM, Proquest e IEEE con el objetivo de identificar estudios que contemplen el desarrollo de datos de gobierno abierto a través de la colaboración. Además, también se realizó un análisis de benchmarking en 32 plataformas interactivas para identificar mejores prácticas y funcionalidades en materia de colaboración. **Originalidad/relevancia:** Los datos gubernamentales abiertos pueden considerarse una innovación importante e influyente que tiene el potencial de impulsar la creación de valor público. Aunque muchos países mantienen portales de datos gubernamentales abiertos, los elementos colaborativos de los portales son limitados. **Principales resultados:** Los resultados revelaron 25 elementos colaborativos que pueden ampliar el potencial colaborativo del entorno de datos de gobierno abierto. Estos elementos han demostrado contribuir sustancialmente a un enfoque más colaborativo y eficiente, proporcionando acceso universal y fortaleciendo el uso de datos abiertos para diversos fines, alineados con la promoción de la transparencia y la rendición de cuentas en múltiples sectores. **Contribuciones teóricas:** La investigación contribuye resaltando la necesidad de profundizar el estudio de la colaboración en datos abiertos, proponiendo nuevos enfoques para desarrollar ecosistemas más integradores y colaborativos. **Contribución a la gestión:** Este trabajo resalta la importancia de buscar colaboración en plataformas de datos abiertos gubernamentales, contribuyendo a lograr mayor transparencia, efectividad e innovación en el uso de datos.

Palabras Clave: Datos abiertos; Colaboración; Plataformas de datos abiertos.

INTRODUCTION

Recently, a growing number of solutions for open data, both government and private, have been developed and implemented around the world, but the big challenge for all these solutions is the effective engagement of stakeholders (Albano, & Júnior, 2019). There is a widespread recognition that just making data accessible is insufficient to drive innovation and real benefits, and collaborative environments are needed (Roy 2014). Albano and Leaes Junior (2019) verified in their research that the existence of a collaborative environment involving open data is essential for co-productive processes of open innovation to happen.

The social or economic value of open data is given by their use, not just by their dissemination (Janssen et. al., 2012). Hence, open data are really open only if they can be easily found and used, and often this is not the case (Susha et al., 2015).

Open data research and solutions from the users' perspective are largely absent, which creates a gap between open data promises and their effective use; thus, they do not achieve the intended benefits, whether social, economic or related to innovation (Susha et al., 2015).

Regarding the government, the greatest value for citizens is the information that can be extracted from open data to meet specific needs (Camilo et al., 2018). However, the process of getting value from data is not simple, and requires minimal knowledge of the data for manipulating, understanding and interpreting them. In order to engage stakeholders, there must be an incentive for the collective generation of information and knowledge, by creating communities around topics of interest (Cordasco et al., 2018).

Within the government, data producers seem satisfied to provide data "as they are", without any guarantee on their quality or accuracy, either due to negligence or to avoid accountability for inaccurate data. Doing so on a large scale in open data portals is potentially dangerous, and can lead these portals to be considered unreliable by stakeholders and experts. In addition, it can put at risk the intended benefits from economic and civic engagement, which are or should be the goals of such portals (McArdle & Kitchin, 2016).

The Brazilian government makes available several databases and services in public transparency portals, in organizations' websites and in open data repositories. The main platform of the federal government is the Brazilian Open Data Portal (PBDA, http://dados.gov.br), which provides information and data on public spending, public servants, goods, programs, government actions, service providers, bids, etc.

PBDA was developed through the platform Comprehensive Knowledge Archive Network (CKAN®), which is an open source platform for developing open data portals, widely used to implement catalog systems of open data. In January 2020 there were 199 open data portals developed through CKAN®, such as those of the government in the United Kingdom (data.gov.

uk), USA (data.gov), European Union (publicdata.eu), and Canada (open.canada.ca/).

PBDA aims to stimulate interaction between social actors and the government, so that together they can determine the best use of data, achieving positive impacts both from the social and economic point of view. However, this goal has not been achieved, as PBDA and other government portals developed through CKAN® are static sources that only provide data, providing small interaction and collaboration within the portal between the stakeholders and the databases.

In short, there is a clear gap in empirical as well as in conceptual research, regarding the collaboration elements that have real and theoretical implications for the collaboration on open data. Therefore, this research sought to identify and analyze collaboration elements capable of expanding the collaborative potential for open data solutions. The term "collaboration elements" in this research should be understood as the processes, practices, techniques, arrangements, and relationships that provide greater interaction, integration and cooperation. The collaboration elements were categorized into collaboration mechanisms and primary resources for using the data.

To this end, we carried out a Systematic Literature Review (SLR) and an analysis of crowdsourcing platforms to identify and select elements capable of expanding the collaborative potential for open data solutions. The results will enable supporting and assisting the process of analysis of requirements and design of new solutions for government open data, such as new functionalities (extensions) or platforms that use CKAN® Application Programming Interfaces (APIs) to provide an open data environment. This environment will serve civil society and public administration in a modern and collaborative way, by co-producing and co-managing open databases, to achieve more public and scientific value collectively.

THEORETICAL FRAMEWORK

Open government data (OGD)

OGD are a subset of open data, which comprises the information listed, produced and stored by governments (Kučera et al., 2013). Government data may contain different sets of information, on budget, censuses, geography, legislative power documents, climate, pollution, public transportation, and education, among others. Numerous countries currently show interest in this policy and the commitment to open their data. An indication is that 79 countries, representing more than two billion people, have joined the Open Government Partnership (OGP, 2019).

The benefits of OGD are expected to reach several interested parts - citizens, government, research institutions and private organizations -, allowing individuals to make better decisions and increasing their participation in public affairs (Ubaldi, 2013). Thus, stakeholders become active collaborators and creators of content and services, taking part in a "more participatory and empowering relationship with the government".

Collaboration

Collaboration is the process by which individuals, groups, and/or organizations work together in a coordinated and cooperative manner to achieve a common goal or solve a problem. This concept involves the exchange of knowledge, skills, resources, and/or efforts among the participants involved, with the aim of achieving results that may be more effective or meaningful than those achieved through individual efforts (Zeng et al., 2022).

In practice, collaboration can take various forms, ranging from simple information exchanges to complex team projects. It can occur within a single group or between organizational or non-organizational groups, across different parts of the world, thanks to modern communication technologies (Jackson et al., 2022).

Effective collaboration generally requires clear communication, mutual trust, shared responsibilities, respect for others' ideas, and openness to feedback. Additionally, it may require clear definition of roles and objectives, proper allocation of resources, and the ability to resolve conflicts constructively (Zeng et al., 2022).

In the context of contemporary human interactions, collaboration is often valued as a means to promote innovation, increase efficiency, improve decision-making, and strengthen interpersonal relationships. Consequently, many organizations and projects actively encourage a culture of collaboration (Jackson et al., 2022).

Collaboration in government open data contexts

Collaboration in Government Open Data refers to the process of sharing, accessing, and collaboratively using datasets made available by the government in an open and accessible manner (Kitsios & Kamariotou, 2023). It is a concept that goes beyond simple publication and provision of data by the government, involving the creation of mechanisms and platforms that enable the participation and collaboration of various stakeholders, such as citizens, businesses, civil society organizations, and other government agencies (Daquino et al., 2023).

Yi (2019) highlights that the most common mistake governments make with open data is thinking that publication is the end of the activity, rather than the beginning. Collaboration among individuals from various sectors such as scientists, academics, the general population, and government representatives brings unique perspectives, knowledge, and skills that, when combined, can lead to more comprehensive and impactful results.

The literature presents benefits of collaboration in open data, including monitoring government activities, transparency, reduction of corruption, cost reduction, efficiency and improvement of services, multidisciplinary expertise, creative solutions, empowerment of the population, feedback, and continuous improvement (Kitsios & Kamariotou, 2023; Albano & Júnior, 2019).

There are real success stories of collaboration among scientists, academics, the population, and government in the use of government open data. For instance, in 2011, an earthquake killed 185 people in Christchurch (population 375,000), New Zealand, causing extensive damage to parts of the city. Shortly after the earthquake, a group of volunteers and government officials used open data and the Ushahidi platform (a disaster response plat-

form) to, with the help of the population, obtain information about damage, road closures, availability of products and services, and most importantly, offers and requests for help (Duc et al., 2014). Additionally, this project helped New Zealanders navigate the city safely after the earthquake.

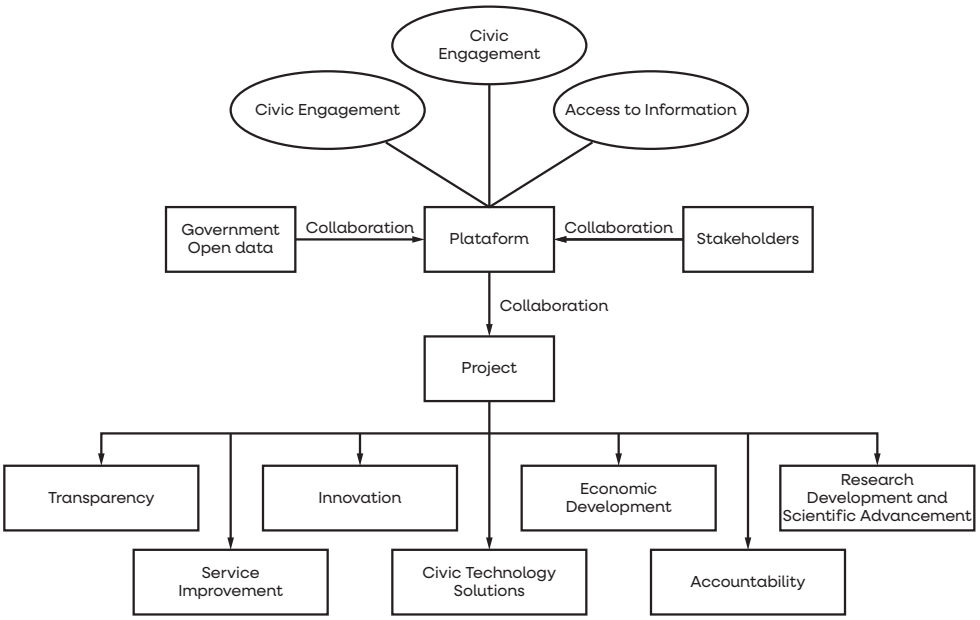
Another example is the LifeWatch platform, which is an initiative aimed at promoting ecological research and biodiversity conservation in Europe, facilitating collaboration and sharing of government and non-governmental data among the European Union member countries, currently with 22 countries participating in the project (Gougousis & Bailly, 2016). The project enables data integration, scientific collaboration, support for decision-making, contribution to understanding environmental changes, monitoring and conservation of biodiversity, public awareness, and capacity building and education.

Finally, during the pandemic, several collaborative open data projects played important roles, such as the COVID Tracking Platform, which was a collaboration between journalists, data scientists, and volunteers to track and report COVID-19-related testing, cases, and mortality data in the United States (Drew et al., 2020). They compiled data from state and local sources to create an open-access database, providing critical information about the pandemic. The platform provided a detailed view of the spread of COVID-19 in the US, helping guide public policies, inform the population, and provide insights for researchers and public health professionals.

Thus, it is observed that platforms play a fundamental role in facilitating collaboration in the contexts of government open data. By providing a centralized environment for data sharing, access, and collaboration, these platforms promote the participation of diverse stakeholders, such as citizens, businesses, civil society organizations, and other government bodies. Figure 1 illustrates this context.

Figure 1

Government Open Data Platform



The figure 1 depicts the structure and fundamental elements related to the government open data platform.

Collaborative elements

The concept of Collaborative Elements encompasses the different components, processes, tools, and strategies that contribute to promoting and facilitating collaboration among participants in a given context. These elements are essential for creating an environment conducive to cooperation, information exchange, resource sharing, and the achievement of common objectives (García et al., 2015).

Within Collaborative Elements, we can identify two main species: mechanisms and primary resources for data use (Randhawa et al., 2017; García et al., 2015). Mechanisms refer to processes, systems, organizational structures, policies, or tools designed to promote, facilitate, or coordinate collaboration among individuals or groups (Randhawa et al., 2017). On the other hand, resources are the essential elements of data or the environment that are fundamental for their effective use and contribute to their quality, accessibility, and usefulness (García et al., 2015).

Collaborative Elements can include a variety of aspects, such as technological platforms, communication systems, incentives, governance policies, training, and capacity-building, among others. They are designed to create an environment where participants can work together in a coordinated manner, exchange knowledge, solve problems collectively, and achieve results that are more effective or meaningful than those achieved through individual efforts (García et al., 2015).

Figure 2

The structure of Collaborative Elements

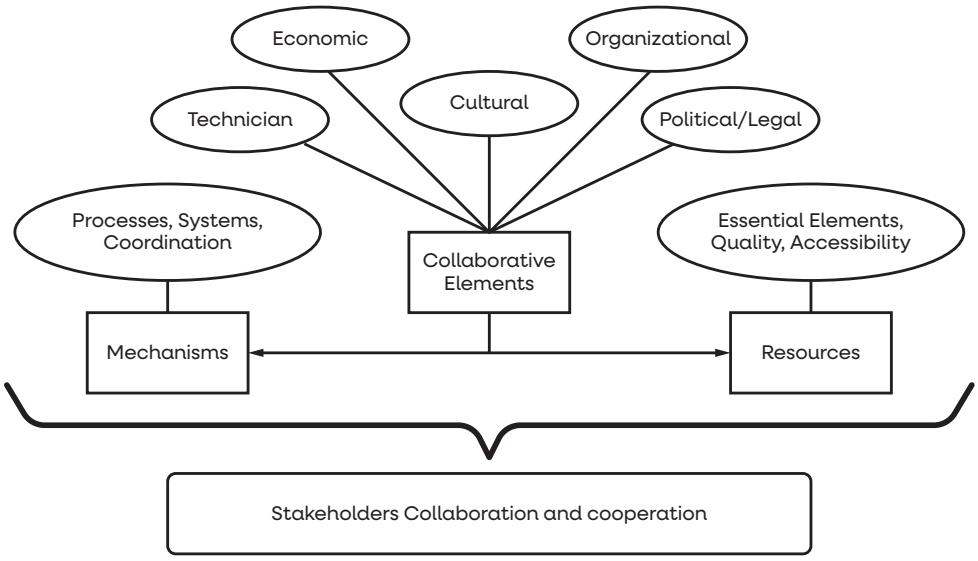


Figure 2 represents the structure of Collaborative Elements and their importance in promoting collaboration and cooperation among stakeholders.

Methodological Procedures

To achieve the objective of identifying and analyzing collaboration elements capable of expanding the collaborative potential for open data solutions, the Systematic Literature Review and benchmarking of crowdsourcing portals were used as a data collection technique, assisted by document analysis. SLR was used to identify collaboration elements that can support, foster and drive effective collaboration among open data initiatives, and to identify portals for benchmarking.

As Silva (2023) proposed, SLR followed the three-phase process proposed by Kitchenham (2004) and we used the software StArt (state-of-the-art) to support SLR (Lapes, 2014). As for benchmarking analysis, we performed the three initial steps proposed by Pagliuso (2005).

The process of identifying collaborative elements was conducted by two researchers, both of whom performed literature analysis and benchmarking analysis. The researchers identified mechanisms and resources, applying predefined criteria to assess their relevance, effectiveness, and suitability to the research context (Sigweni & Shepperd, 2015). This approach allowed for an impartial and rigorous analysis of collaborative elements, contributing to the identification of the most pertinent and effective ones for promoting collaboration on OGD platforms. The analysis followed the following steps (Kmet et al., 2004):

a) Definition of Selection Criteria: Before initiating the identification process, it was essential to establish clear and objective criteria for selecting primary mechanisms and resources. These criteria were based on the research objectives, relevant literature, and best practices in the field. Thus, the criteria are: relevance to promoting collaboration in OGD; evidence-based; capacity to enhance collaborative potential; adaptability and applicability; consistency with best practices; implementation feasibility; and, potential impact. These criteria helped ensure that the selected collaborative elements are relevant, evidence-based, applicable, effective, and aligned with the research objectives mentioned;

b) Task Assignment: Two researchers (first and second authors) were assigned to conduct literature review and benchmarking analysis. Each author worked independently to analyze and evaluate the elements based on the defined criteria;

c) Individual Survey: Each researcher compiled a list of mechanisms and resources, assessing their relevance, empirical evidence, suitability to the research context, and other established criteria. During this survey, the authors made notes and recorded their evaluations;

d) Comparison and Discussion: After completing the individual survey, the researchers met to compare their findings. During this phase, they discussed their discoveries, identifying which mechanisms and resources were considered more suitable and relevant based on the established criteria;

e) Discrepancy Resolution: Discrepancies between the selections made by the two authors were discussed and resolved collaboratively. This involved additional review of the elements in question, consultation with literature or other experts, or revision of selection criteria, if necessary;

f) Consensus and Final Selection: After discussion and resolution of discrepancies, the authors reached a consensus on the primary mechanisms and

resources to be included in the research. This final selection was documented and justified based on the established criteria;

g) Results Reporting: The results of the primary mechanisms and resources survey were reported transparently and in detail in the research manuscript.

By following these methodological steps, the authors rigorously and impartially identified primary mechanisms and resources for the research, ensuring the quality and reliability of the obtained results.

Systematic literature review (SLR)

In this section we present the results of the SLR; initially, we address general data from the selected papers, followed by the details of the collaboration elements; finally, we discuss and propose a research agenda. We searched the scientific bases in a single period, in April 2019.

We identified the need for this SLR, since there is a small number of software solutions and scientific research that effectively use OGD in Brazil. In addition, a preliminary search revealed researches related to our object of study, but we could not find any current research that systematizes information on open data and the attributes that can expand the potential for collaboration.

From this initial identification, we defined the goal of searching in the specific literature the collaboration elements that can expand the collaboration potential on Open Data. Thus, we examined the methods, processes, tools, good practices, and techniques used to enable the interaction and cooperation between stakeholders and databases, their versions with community characteristics, and projects.

Hence, after analyzing these elements we proposed the following research question: "What collaboration elements can support, promote and drive the effective collaboration on open data initiatives?"

Then we developed the SLR Protocol, and defined the criteria for studies' selection in order to identify which of them provided direct evidence on the research question (Kitchenham & Charters, 2007). To do that, we established the following inclusion criteria: English language; peer reviewed articles; and completed studies. As for the exclusion criteria, they were: publications that did not present in their abstracts or titles relationships with the search terms or were not related to the defined research question; duplicate publications; researches that mentioned just a few of the search terms, but did not focus on open data and collaboration; and short papers, theses, dissertations, and books.

We used the scientific databases Web of Science ACM, Science Direct, Scopus and IEEE Xplore (Chen et al., 2010). As for the Scielo base, we used it because it is considered a relevant base in Latin America (Collazo-Reyes et al., 2017), and the Proquest base, due to the results achieved by Barni (2017).

From preliminary research, we defined the following search terms: ("open data") AND (civi * participation OR "popular participation" OR citiz * participation OR crowdsourcing OR coproduction OR co-production OR Participative OR "public involvement" OR Collaboration Engag * OR stakeholder engag * OR "end-user engagement" OR stakeholder involvement OR end-user involvement).

Regarding search at the scientific databases, we defined the following fields: title, subject, abstract, and keywords. However, the use of these fields was limited to the specificities of each base, and we did not choose a time frame. Search results were downloaded automatically and organized with the assistance of software StArt. Table 1 shows the examined bases and the number of articles found.

Table 1
Number of articles identified in Databases

Base de dados	Número de artigos encontrados
Scopus	430
SienceDirect	99
Web of Science	156
Scielo	1
ACM	511
Proquest	65
IEEE	66
Total	**1.328**

We identified 1.328 articles, we searched for articles published until December 2023; first we removed 142 duplicates, and kept a set of 1.186. We reviewed the titles and abstracts of these articles, by applying the inclusion and exclusion criteria, and those that did not fit the research scope were excluded, remaining 137. These full-text papers were downloaded from the databases, and we read their introduction and conclusion, in order to make the final selection. In the end, 48 articles remained for data extraction. We describe the SLR Reporting phase in the following section.

ANALYSIS AND RESULTS

General summary of the review

This section is descriptive and summarizes the review. We observed few papers focused on the study of effective collaboration elements for the promotion of collaboration on open data solutions, with a strong trend of the topics 'transparency' and 'accountability'. Open data initiatives are less successful than expected, mainly due to the lack of engagement, since there is a growing demand for approaches that actively involve citizens in exploiting open data. Social collaboration is the key aspect for increasing the public value of data, by allowing individuals to participate in discussions and co-create knowledge and data (Cordasco et al., 2017).

The terms used in the search at the scientific bases were not restricted to the government context, since we did not include any limiting word. However, the sample of selected articles shows a strong representation of papers related to the government – 48 out of 40 regarded government solu-

tions, six addressed government and non-government issue, and two were not related to the government.

In addition, we observed a large number of papers with theoretical and generic research that needed more studies and better detailing to achieve practical applications. There were still few studies with validated results, which shows an initial stage of the research.

Collaboration elements capable of extending the potential for participation

For the identification of the information needed to answer the research question, we read the 48 articles. During this stage, we identified 25 collaboration elements that have the potential to encourage collaboration on open data. These collaboration elements are shown in Figure 3, ranked according to their frequency in the articles and classified into two classes, collaboration mechanisms and primary resources for using data.

Figura 3

Identified Collaboration Elements

Mechanisms

Collaboration Elements	Studies	%
Advertising (Dissemination)	Kassen, 2018; Aguilera et al., 2016; Hivon & Titah, 2017; Sayogo & Yuli, 2018; Ohemeng & Ofosu-Adarkwa, 2015; Nikiforov & Singireja, 2016; Roy, 2014; Ruijer & Meijer, 2019; Reggi & Dawes, 2016.	20
Hackathons/Competitions	Concilio et al., 2017; Chan, 2013; Ambrosino et. al., 2018; Kassen, 2018; Hivon & Titah, 2017; Sayogo & Yuli, 2018; Kitsios & Kamariotou, 2023; Temiz, 2021; Albano & Júnior, 2019.	18
Communities Formation	Cordasco et al., 2018; Sayogo & Yuli, 2018; McArdle & Kitchin, 2016; Handler & Conill, 2016; Ruijer & Meijer, 2019; Ambrosino et. al., 2018	14
Qualifying Stakeholders	Ohemeng & Ofosu-Adarkwa, 2015; Ruijer & Meijer 2019; Gascó-Hernández et al., 2018; Ambrosino et al., 2018; Sayogo and Yuli, 2018.	11
Gamification	Brovelli et al., 2018; Nikiforov & Singireja, 2016; Handler & Conill, 2016; Lungati, 2022.	9
Financial Incentives	Kassen, 2018; Ohemeng & Ofosu-Adarkwa, 2015; Perkmann & Schildt, 2015; Coladangelo et al., 2023.	9
Governance	Reis et al., 2018; Roy, 2014.	5
Agreement with Universities	Ambrosino et al., 2018; Perkmann & Schildt, 2015.	5
Semantic Web	Molli et al., 2016; Cáceres et al., 2020.	5
Stimulating scientific publication	Perkmann & Schildt, 2015.	2
Professional Recognition	Perkmann & Schildt, 2015.	2
Activities in Altruistic Contexts	Komninos, 2019.	2
Interactive and Shareable Charts	Cordasco et. al., 2017.	2
Integration with Social Media	Zuiderwijk & Janssen, 2015.	2
Blogs for Study Dissemination	Cordasco et al., 2017.	2

Primary Resources for Using Data

Collaboration Elements	Studies	%
Interactive Platforms	Kassen, 2018; McArdle & Kitchin, 2016; Johansson et. al., 2015; Ohemeng & Ofosu-Adarkwa, 2015; Reggi & Dawes, 2016; Ambrosino et al., 2018; Burégio et. al., 2015; Cordasco et. al., 2018; Aguilera et. al., 2016; Westerlaken et. al., 2022; Chua et. al., 2020; Chokki & Vanderose, 2023; Liu, Usta et. al., 2023; Barcellos et. al., 2022.	32
Data Quality	Cordasco et. al., 2017; McArdle & Kitchin, 2016; Ohemeng & Ofosu-Adarkwa, 2015; Nikiforov & Singireja, 2016; Vetrò et al., 2016; Zuiderwijk & Janssen, 2015; Kassen, 2018; Repasky et. al., 2020; Purwanto et. Al., 2020; Garcia, 2022.	23
Linked Data	Ohemeng & Ofosu-Adarkwa, 2015; Yagui & Vivacqua, 2019; Costa et al., 2019; Daquino et al., 2023; Adamou et. al., 2019; Biswas, 2020; Boytcheva et. al., 2019; Frey & Hellmann, 2021; Almendros-Jiménez et. al., 2019; Coladangelo et. al., 2023.	20
Appropriate Data	Cordasco et. al., 2017; Ohemeng & Ofosu-Adarkwa, 2015; Ruijer & Meijer, 2019; Reggi & Dawes, 2016; Zuiderwijk & Janssen, 2015; Ambrosino et. al., 2018.	14
Data Platforms with APIs	Chan, 2013; Burégio et. al., 2015; Cordasco et. al., 2018; Aguilera et. al., 2016; Hivon & Titah, 2017; Johansson et. al. 2015.	11
Versioning Control	Vetrò et. al. 2016; Zuiderwijk & Janssen, 2015; Cordasco et. al., 2017.	7
Metadata	Vetrò et. al., 2016; Ruijer & Meijer, 2019.	5
Open Source Platforms/ Softwares	Kassen, 2018; Scarano et. al., 2015.	5
Applications for Mobile Devices	Johansson et. al., 2015; Komninos, 2019.	5
Regulations	Sayogo & Yuli, 2018.	2

The Advertising (Dissemination), primary resource for using data, attained a 20% frequency; the way governments align and use traditional and new media is crucial for the engagement of open data ventures (Roy, 2014).

The resources Hackathons/Competitions show a 18% frequency. By creating a dynamic and collaborative environment, hackathons encourage participants to explore, analyze, and visualize data in novel ways, leading to the development of innovative solutions and applications that address pressing societal issues. Furthermore, hackathons serve as a platform for governments to engage directly with the community, soliciting feedback, and identifying areas for improvement in data accessibility, quality, and usability (Kitsios & Kamariotou, 2023). Through the collective efforts of participants, hackathons not only demonstrate the value of open data but also contribute to the democratization of information, empowering citizens to actively participate in decision-making processes and driving positive social change (Temiz, 2021). The resources Communities Formation, show a 14% frequency. Ruijer and Meijer (2019) observed the formation of a community of stakeholders, supported by a local government, as a first step; this group became a small stable community that provided mutual learning, with good results.

The resource 'Qualifying stakeholders' is present in 11% of the papers. The lack of synchronization regarding the planning of activities and the lack of preliminary training create difficulties for citizens to participate in the OGD environment. With an 9% frequency are Gamification and Financial Incentives. Gamification was applied by Handler and Conill (2016), who relied on the

basic resources of games to increase users' motivation and eventually trigger their participation. The high degree of participation was due to this resource.

Regarding Financial Incentives, Kassen (2018) proposes that financial compensation should be given to professionals for their work in open databases, and payment would be made through donations, similar to a successful practice currently used in scientific and academic communities, to foster innovations in the public sector and new knowledge.

In 5% of the articles, the resource Governance and Agreement with Universities. Regarding Governance, there should be a framework standard to provide governance capable of dealing with all important stages of open data management, from concept to delivery to stakeholders (Reis et al. 2018). Another resource identified was University Agreements; Ambrosino et al. (2018) and Perkmann and Schildt (2015) reported good results by including signed agreements into academic open data studies.

Finally, 2% of the papers present the resources Semantic Web Stimulating Scientific Publication, Professional Recognition, Activities in Altruistic Contexts, Interactive and Shareable Charts, Blogs for Study Dissemination, and Integration with Social Media. The Semantic Web allows greater integration of data and people, thus maximizing the modeling of collaborative spaces. Perkmann and Schildt (2015) applied the resources of Stimulating Scientific Publication and Professional Recognition. The first was designed to improve staff retention, by allowing researchers to publish high impact articles, thus improving their academic career prospects; and the second was granting honors.

Activities in Altruistic Contexts depend both on the context and the approach, and it is possible to motivate users to participate without any tangible benefit, based only on altruistic behavior (Komninos, 2019).

The Interactive and Shareable Charts resource stems from Cordasco et al. (2017) research, where the authors developed a shareable infographic functionality on their platform, which proved to engage users through data views, which they can use to support data-driven discussions. The resource Blogs for Study Dissemination also is an outcome from Cordasco et. al. (2017); the platform developed by the authors has a blog, a showcase where each artifact created on the platform can be publicly displayed off the platform.

The last resource is Integration with Social Media. Open data solutions should be integrated with existing social media such as Twitter, Facebook, and LinkedIn for greater collaboration (Zuiderwijk & Janssen 2015).

Regarding collaboration mechanisms, the mechanism with the greatest presence in the articles analyzed is the Interactive Platform, suggested in 32% of the studies. Current platforms, where open data projects prioritize data offering, should give way to Interactive Platforms; to that end, they should be uniform in order to improve interaction between government and citizens, to ensure balance in knowledge sharing among stakeholders (Ohemeng & Ofosu-Adarkwa, 2015). Burégio et al. (2015) propose a preliminary reference architecture for OGD platforms that combines open data and Social Machine paradigms, as a means of extending the power of open government initiatives.

Data quality mechanism achieved 23% frequency; it is a critical issue in the context of open data, since low quality data precludes their effective use. It is crucial to provide high quality data, so that open data applications

may achieve benefits such as innovation and participation (Zuiderwijk & Janssen 2015; Albano & Leaes Junior, 2019).

The next mechanism is Linked Data, 20%, plays a crucial role in the context of collaboration in government open data (Giagnolini & Tomasi, 2023). By enabling the connection and integration of dispersed datasets, Linked Data facilitates the discovery and access to relevant information, making it possible for a more holistic and comprehensive understanding of societal issues (Frey & Hellmann, 2021). Furthermore, the use of Linked Data promotes interoperability among different systems and data sources, which is essential for ensuring the effectiveness of government open data initiatives (Becerra-Terón & Torres, 2019). It is noteworthy that there are several recent research efforts focused on this primary resource, exploring its potential to enhance transparency, accountability, and civic engagement, as well as to drive innovation and the development of more advanced technological solutions (Frey & Hellmann, 2021).

The mechanisms Appropriate Data and Data Platforms with APIs show a 14% frequency. Appropriate data ensures that information is available when most needed, enabling citizens, researchers, and businesses to make informed decisions promptly (Ambrosino et al., 2018). Additionally, a Data Platforms with APIs facilitates access and integration of these data into various applications and systems, promoting interoperability and reuse of data. This not only enhances governmental transparency and accountability but also fosters innovation, technological solution development, and civic engagement, thereby strengthening democracy and promoting socio-economic progress (Cordasco et al., 2018).

Versioning control, show a 7% frequency, consists of applying control systems of data versioning to the platforms that provide them, making it possible to easily access and compare different versions of the same original database (Vetrò et al., 2016).

In 5% of the articles, the mechanisms Metadata, Open Source Platforms/Software and Applications for Mobile Devices were mentioned. Metadata are documents attached to the original data sets that describe them and help interpreting databases, thus affecting participation (Vetrò et al., 2016; Ruijer & Meijer, 2019). Kassen (2018) recommends that software and platforms that make available or manipulate open data should be developed under Free Licenses, especially if they are funded by public donations, thus adding a greater public contribution. Johansson et al. (2015) and Komninos (2019) proposed solutions for Mobile Platforms, and reported good results regarding collaboration, due to mobile devices.

Finally, 2% of the papers present mechanism Regulations, where strategies are important in open data collaboration environments, as they create awareness of rules and disseminate information (Sayogo & Yuli, 2018).

Figure 4 presents the collaboration elements grouped according to their most common features or nature. This classification seeks to better understand the general framework of the identified mechanisms.

Figure 4

Classification of Collaboration Elements

Categories	Collaboration Elements
Technical	Gamification, Interactive Platforms, Semantic Web/Ontology, Hackathons/Competitions, Data Quality, Platforms with APIs, Linked Data, Versioning Control, Metadata, Applications for Mobile Devices, Interactive and Shareable Charts, Blogs for Study Dissemination, and Integration with Social Media
Economic	Financial Incentives
Organizational	Governance, Advertising/Dissemination, Appropriate Data, Qualifying Stakeholders, and Agreements with Universities
Cultural	Communities Formation, Stimulating Scientific Publication, Professional Recognition, and Activities in Altruistic Contexts
Political/Legal	Open Source Platforms/Softwares and Regulations

The classification of collaboration elements shows research trends. The collaboration elements identified vary in complexity and in areas, thus they can lead to very different results, ranging from qualifying stakeholders to issues related to data quality.

Discussion: research agenda

Despite the recent speech and the development of open data policies, there is little theoretical and empirical support from the academia on the topic that focuses on the study of solutions to enable effective collaboration between stakeholders and databases. The sample of selected articles comprises only 48 studies whose content, for the most part, is still far from the challenges of implementing collaborative solutions on open data.

We aimed to identify a higher number of collaboration elements specifically targeted to technological solutions, as those found: Applications for Mobile Devices; Interactive and Shareable Charts; Blogs for Study Dissemination; Integration with Social Media; Data Platforms with APIs; and Versioning Control of databases. However, what we have observed, and was expected, were many collaboration elements oriented to the basic stages of the open data process, such as Meta Data, Data Quality, Linked Data and Semantic Web.

Interactive Platforms are the most popular collaboration element, and they are really critical, since they allow interested parts to effectively collaborate. However, in most of the studies analyzed there is only a general description of this collaboration element, without the appropriate level of detail. One exception is the research by Cordasco et al. (2017), which specifies several collaboration elements and functionalities oriented to this topic.

The analysis of the articles also identified research gaps or topics that need further study, in order to achieve a better understanding of the different aspects that make up a complex phenomenon such as open data. First, academia needs to investigate how to effectively engage external stakeholders in the organizations of the open data ecosystem, particularly for reviewing structures, processes, and roles.

We suggest qualitative studies using in-depth interviews, or a focus group with experts in the field, to identify further collaboration elements. It is important to further investigate and propose new collaboration elements and solutions.

Therefore, the big challenge for open data is to overcome the current early stage of data creation and publication towards a data ecosystem of effective collaboration, capable of adding value and innovation. Several international initiatives that rank the level of data openness simply encourage publication, because this is the most common evaluation criterion, used by Open Data Barometer when evaluating countries' governments.

A new approach to data publishing should be established, different from the current one, as this is mostly based on the simple availability of data in static repositories. There is a growing perception that the publishing process must be driven by demand, and especially problem-oriented, for solving real-life problems (Susha et al., 2015).

Starting from a new established approach and directed to the development of solutions that seek the creation of collaborative ecosystems, it is necessary to design software solutions that adds both characteristics, providing an integrative environment. Ohemeng and Ofosu-Adarkwa (2015) argue that open data projects are narrowly focused on data supply, so they propose the development of uniform platforms to improve interaction between government and citizens, in order to ensure a balance in knowledge sharing among all constituent groups. The benefits sought by OGD will only be achieved with the effective collaboration of stakeholders.

Hence, it is important to carry out benchmarking research on Interactive Platforms to identify those that have best practices and functionalities regarding collaboration and crowdsourcing, since this collaboration element attained the highest frequency in SLR. Next section presents the benchmarking analysis of Interactive Platforms.

Benchmarking of platforms with crowdsourcing characteristics

Benchmarking was done to identify the best platforms that have crowdsourcing and collaboration attributes, so that they can be studied and their functionalities and practices incorporated into future versions of OGD platforms. Hence, we analyzed 32 platforms, of which 19 are kept by public organizations and 13 by private ones.

The process for selecting platforms had three stages. The first comprised the analysis of the 26 articles, of the 48, from the Systematic Literature Review (SLR), described in section 4.2, to identify platforms that academia considers as collaborative. To complement the identification of platforms in the literature, in October 2019 we made searches on Google Scholar and CAPES Journals Portal, using the same search criteria as in SLR.

On Google Scholar we selected eight articles that indicated collaborative data platforms, while at CAPES Portal we chose just one. After reading the selected papers, we identified 15 platforms, which were analyzed to check the compatibility with our research scope, and finally six platforms remained. Figure 5 presents the selected platforms and the studies that suggested them.

Figure 5

Platforms Identified in the Literature

Plataforma	Estudos
SPOD (Social Platform for Open Data)	Ambrosino et al., 2018; Codarsco et al., 2017; Codarsco et al., 2018; Faria, 2014; Scarano et al., 2015
Open Street Map	Bravo & Sluter, 2018
Wikipedia	Neves, 2014
Waze	Faria, 2014
Data.world	Faria, 2014
DKAN	Faria, 2014

In the second stage, from the Open Data Barometer classification, we analyzed the portals of the national governments of the five best ranked countries: Canada, United Kingdom, Australia, France and South Korea. Finally, for the selection of the other platforms we looked into search sites, using the following criteria: a) platforms that stand out for collaboration; and, b) platforms recognized in their area of operation.

For each platform, we examined the following aspects: platform type; license; functionalities; stakeholders; how to contribute; validation; type of organization (public or private); permission to write or edit by third parties; and if the platform is free software, and the software license.

The platforms were ranked based on the features of the provided data; most of them had a scientific focus (15), followed by government (9), educational (5), article collaboration (1), source collaboration (1), and collaborative mapping (1).

Scientific platforms were GenBank, DNA Data Bank of Japan, European Bioinformatics Institute, iNaturalist, Catalogue of Life, Figshare, Dryad, Zenodo, Neuroscience Experiments System, CyVerse, DataHub, Social Platform for Open Data (SPOD), Mendeley Data, DKAN, and Data World. Government platforms were PBDA (Brazil), London Datastore (UK), Open Government (Canada), ParisData (France), USA Spending, Korean Government Portal, LINZ Data Service, Australian Government Catalogue, and Open Data Portal of the Federal University of Pernambuco (Brazil).

Educational platforms: Kaggle, Open University of the Health Unic System (Brazil), Oxford University Research Archive, Curriculum+ and Platform MEC of Digital Educational Resources (Brazil). Articles' Collaboration Platform was Wikipedia; Platform for Collaboration on Sources - GitHub; and Open Street Map as Platform for Collaborative Mapping.

Regarding platforms' functionalities, most of them have the role of scientific catalogue, as in Data Bank of Japan, European Bioinformatics Institute, GenBank, iNaturalist, and Catalogue of Life. In addition, there is a variety of types of data available and functionalities, such as open APIs and data views, to allow the user to employ open data easily. These cases were presented by governments more "faithful" to the policy of open data on their portals, as London Datastore (UK), ParisData (France), USA Spending (USA), Data.Go.KR (South Korea) and Australian Government Catalogue (Australia).

Among stakeholders, in addition to governments, there are six universities as platform keepers, such as University of Oxford, with platforms Dryad and Oxford University Research Archive; University of São Paulo, with the Neuroscience Experiments System platform; University of Arizona with the CyVerse platform; Federal University of Santa Catarina and Federal University of Paraná, with the MEC Digital Educational Resources platform; and Federal University of Pernambuco, with the Open Data Portal. The participation of Universities as stakeholders shows the importance of the data opening movement in academia, to enable data use for knowledge production, analyses, and innovation.

To receive contributions, almost all portals require a form of registration, except those of the government. For these, there is a model of collaboration and internal validation through entities of each government. In other portals validation is done by keepers, such as GenBank, DNA Data Bank of Japan, European Bioinformatics Institute, LINZ Data Service, Figshare and Curriculum+; in other cases, data providers are responsible for validation. In terms of co-production and co-management, the percentage is modest, and only in 15.6% of the 32 portals third parties can write or edit data, which shows little maturity for collaboration.

Best platforms

This section presents features and functionalities of the six platforms that have the best practices regarding collaboration and interaction. These are SPOD, Kaggle, Neuroscience Experiments System, Wikipedia, GitHub and Open Street Map.

SPOD allows social interactions between open data users and government data. There is a "public room" functionality for users to add different types of data. This platform improves comprehension and increases open data accessibility, thereby fostering social collaboration through a citizen-friendly environment.

Kaggle is an education and competition platform, with public and private data sets. There is a great deal of interaction among users, as it allows companies and institutions to publish data analysis challenges, where users from all over the world compete with each other to produce the best results. In addition, the user can create a data set, upload a file, and invite people to contribute.

The Neuroscience Experiments System is an open source scientific platform aimed at assisting neuroscience research laboratories in routine procedures for data collection. This platform focuses on the needs of the scientific society, by centralizing in a single repository the experimental data of an entire research laboratory, group or project; it also provides a modular structure and web interface that enable the intuitive use of its data management functionalities.

Wikipedia is a collaborative platform for articles, whose content is free and cooperatively built. Interaction is the highlight, since any user (registered or not) can create an article on this platform, by just following the creation guide and the indicated steps, provided that the topic to be created meets the platform requirements.

GitHub is a collaboration platform of source-codes repositories that has versioning control, forums, and many other features. By registering

on the platform, anyone can create a repository and send the source-code through the command line. Repositories can be public or private - the public are often used for sharing open source software.

Open Street Map is a collaborative mapping platform where a free and editable map is available. To contribute it is necessary to create an account and collect data by using GPS or other methods. There is a large integration through collaborative mapping for the creation of a free and editable world map.

Propositions for improving the technology of open data portals

With the social outcry for transparency, social participation, and monitoring by governments, intensive scientific research on open data becomes more important and challenging. Thus, based on our analyses, we propose functionalities and practices that can be implemented in OGD platforms to promote a collaborative ecosystem of "curatorship", co-production, sharing, origin tracking, and reproducibility.

For open data to stimulate more social and economic value over time, thus providing a better public service, we suggest the following collaboration mechanisms and primary resources for using data, based on our analyses and findings.

Primary resources for using data:

a) Open APIs;
b) A tool to assist data-based discussions, where users may create views directly from data sets stored in portals, by filtering and grouping their content and publishing the result into ongoing discussions to support the arguments;
c) Functions that allow filtering and gathering data and visualizations;
d) Rooms, virtual public places where stakeholders can meet and discuss a specific topic, form or join existing communities of interest, where discussions are supported by data and views, through creation and sharing;
e) Data co-creation, where stakeholders can learn and create new collaborative data sets, working in an interactive way, either starting from scratch or importing existing data;
f) Integration top-down between government spheres and their agencies, in order to overcome political partisanship and the fragmentation of organizations and their sectors.

Collaboration mechanisms:

a) Competitions on data analysis accessible to everyone;
b) Permission for different users to become co-keepers of a set of public data;
c) Dissemination environments, where all platform artifacts, documents, and findings can be publicly displayed off the platform, with open access to anyone;
d) A financing model through individual donations, similar to Wikipedia, together with government support;
e) A financing model that includes benefit packages granted to those willing to be regular monthly donors, by structuring a "sponsorship career";

f) Promotion of agreements between private companies and the platform, for the development of open data governance platforms that allow greater data transparency from both parties, thus including organizations with other characteristics, such as NGOs.
g) Promotion of schools' participation, so that, since early, students may learn basic programming languages and ways to make a learning environment more transparent, participatory, inviting and practical;
h) Direct engagement of universities, through project design for the participation of students and professors.
i) Development of a culture of constructive competition, involving civil society and academia.

FINAL REMARKS

Open data solutions are gaining space in private and public organizations, thus becoming a benchmark in good corporate governance. This research has proposed a number of essential questions and solutions to improve the open data context, regarding strategic actions and software solutions for public and private organizations, so that open data projects, processes, and decisions are more assertive and effective. This should improve the service and business management of institutions, so that they can fulfill their duties the best way possible and bring a positive return to society.

The need to encourage stakeholders to use open data is important, but providing the means for collaboration is essential, because only collaboration open data will achieve their true value. However, this is easy to say but very difficult to do, since several barriers hinder stakeholders from collaborating, including challenges that address cultural domain, technical and legal issues, governance, and publishing methodology.

The proposed improvements suggested in this research may contribute to the remodeling of open data solutions, as we understand that open data practices should be reviewed in order to provide ecosystems that promote not only transparency but collaboration. It is important to highlight that transparency is fundamental, but should not be the end itself, but rather a means to stimulate cooperation.

As future research, we suggest an in-depth study of the six best platforms identified, to detect best practices and implemented functionalities. The results of this analysis may support the design and analysis of the development requirements for CKAN® software extension or other Open Data sharing platforms.

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Publishers

- Rosalia Aldraci Barbosa Lavarda
- Leandro Dorneles dos Santos

History

Recieved:	14-08-2020
Approved:	16-04-2024
Published:	02-10-2024