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(Open) Data literacy: Which relationships with open data adoption? A systematic review of the literature

Alfabetizzazione ai dati (aperti): quali sono i legami con un uso efficace dei dati aperti? Una revisione sistematica della letteratura

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ABSTRACT Data literacy is considered a key dimension supporting citizens' enhancement of open data. Nevertheless, more precise definitions of its role and the consideration of nuances between the types of knowledge and abilities that influence a relevant use of open data are needed. Therefore, we carried out a systematic review of the literature, spotting: a) the role of data literacy among several barriers to use; and b) activities around open data that promote informal learning by supporting the development of critical data literacy as a proxy of the citizens' further engagement with open data. We screened and selected 66 articles, applying a keyword mapping technique, followed by coding and quantitative analysis of the articles. Our findings highlight that, on the one hand, limited data literacy interferes with the use of open data. On the other hand, open data activities appear to generate relevant opportunities for cultivating citizens' technical data literacy, allowing them to understand and interact with data-driven decision-making processes. Nevertheless, there is little attention on critical data literacy as a key driver for the strategic and transformative use of open government data. Finally, this study could set the basis to support lifelong learning interventions aimed at cultivating open data literacy.

KEYWORDS Open Government Data; Open Data Use; Informal Learning; Critical Data Literacy; Open Data Literacy.

SOMMARIO L'alfabetizzazione ai dati è stata evidenziata come una dimensione chiave a sostegno della valorizzazione dei dati aperti da parte dei cittadini. Tuttavia, si rende necessario approfondire la ricerca per fornire definizioni più precise sui i tipi di conoscenze e competenze che influenzano l'uso pertinente dei dati aperti. Abbiamo quindi condotto una revisione sistematica della letteratura, per mappare: a) il ruolo dell'alfabetizzazione ai dati tra le varie barriere all'uso dei dati aperti; e b) le attività intorno ai dati aperti che promuovono l'apprendimento informale sostenendo lo sviluppo dell'alfabetizzazione critica dei dati come indicatore del successivo impegno dei cittadini con i dati aperti. A tal fine, abbiamo esaminato e selezionato 66 articoli, applicando una tecnica di mappatura delle parole chiave, seguita dalla codifica e dall'analisi quantitativa degli articoli. I nostri risultati mostrano che, da un lato, una bassa alfabetizzazione dei dati interferisce con l'uso dei dati aperti. D'altra parte, osserviamo che le attività sui dati aperti sembrano generare opportunità rilevanti per coltivare l'alfabetizzazione tecnica dei cittadini

sui dati, per consentire loro di comprendere e interagire con i processi decisionali basati sui dati. Tuttavia, viene prestata poca attenzione all'alfabetizzazione critica dei dati come fattore chiave per un uso strategico e trasformativo dei dati pubblici aperti. Infine, questo studio potrebbe gettare le basi per sostenere interventi di apprendimento permanente volti a coltivare l'alfabetizzazione ai dati aperti.

PAROLE CHIAVE Dati Aperti di Governo; Uso dei Dati Aperti; Apprendimento Informale; Alfabetizzazione ai Dati Aperti.

1. Introduction

After the initial wave of enthusiasm about open data creation, the attention has gone over its use and reuse, to become relevant open knowledge (Open Data Foundation[1]). The literature is indeed concerned about the lack of open data use and reuse techniques (Matheus & Janssen, 2020) as this has major technological, empowering, and civic monitoring consequences for its social potential (Baack, 2015). While various open databases are available, independent of their size, software platform, administrative and territorial scope, most Open Government Data entries are underutilised (Quarati, 2021).

Among the various problems concerning the lack of use, data literacy appears to be relevant. It can be considered a recent, emergent part of information literacy, and it relates to the increasing attention to quantitative information and digital data representations generated within the digital environments adopted in professional and daily life. For instance, Usova and Laws (2021) point out that data literacy plays a relevant role within the overall context of new forms of information literacy. They basically conclude that what emerges from the body of literature is that data literacy becomes an essential competency to contribute to aggregated data, data visualisation, data storytelling, analytics, etc. as new forms of required information literacy. In line with this perspective, the European Digital Competence Framework for Citizens from the EU Commission, former DigComp 2.1 and recently upgraded to version 2.2. focus the relevance of data literacy. The framework distinguishes that at the most advanced and specialised level of this dimension, a citizen can create solutions to solve complex problems with many interacting factors that are related to browsing, searching and filtering data, information, and digital content (Carretero, Vuorikari, & Punie, 2017, version 2.1); and that the citizen must be aware of data collection and usage for algorithmic procedures in many areas of daily life, by both private and public providers (Vuorikari, Kluzer, & Punie, 2022). Moreover, Maybee and Zilinski (2015) consider it reasonable to assume that the development of data literacy may be informed by the scholarly discussion around information literacy. Hence, they refer to data literacy as a set of skills based on accessing, managing, communicating, preserving, and ethically using data to elaborate information within a context. In particular, they specify that data can be considered as a piece of information that needs to be analysed, elaborated, and that can be also integrated into information products, as well as informational outputs like written texts, articles, and social media communication. These authors even include in their model other informational forms such as videos.

The knowledge, attitudes, and skills of citizens to make targeted and effective use of open data for their own lives and socio-cultural contexts appear to be central (Boychuk, Lloyd, & Mackeigan, 2016). Thus, it could be hypothesised that the development of skills to deal with data infrastructures and domain knowledge for their application are elements that allow the citizen and the professional

[1] https://okfn.org/opendata/

to make more. specific and effective use of data (Gil-Garcia, Gasco-Hernandez, & Pardo, 2020). Nevertheless, technical data literacy would not be the only data required: open government data has been deemed a driver of transparency and transformation upon the basis of a holistic, situated, and critical view of data in their political contexts of production (Baack, 2015). There is a strand of literature covering the role of critical approaches to data advocating for the need of hacking" open data to promote citizens' empowerment and the visibility of hidden collectives (Milan & van der Velden, 2016; Pybus, Coté, & Blanke, 2015). However, the connection with the research on data usage appears to be less explored.

Therefore, we carried out a systematic review of the literature whose purpose is exploring the contexts in which the use and learning of open governmental data germinate, identifying the barriers that impede its use and that are deemed requirements for its optimal use, as well as considering the professional learning that emerges. Specifically, our work seeks to focus on the role of data literacy (particularly applied to open data and through a critical lens) in promoting open data usage; and the role of open data in promoting professional learning supporting data literacy.

In this context, we propose the following research questions:

- RQ1 What are the contexts of use and learning based on open data?
- RQ2 What are the barriers to using open data, and within those barriers, what role do technical and critical open data literacy play?
- RQ3 What types of learning are promoted by the use of open government data?

Answering the questions above through a systematic literature review aims to contribute to the scholarly debate generating a springboard for public and educational policy in the sector.

2. Background

The reuse of existing open data is tantamount to the lack of updated items (Degbelo, Wissing, & Kauppinen., 2018); the assumption that data are readily available or easily accessible when they are not (Jarke, 2019); and the low quality of open data (Ruijer, Grimmelikhuijsen, van den Berg, & Meijer, 2020), which means they cannot be reused due to missing features. For example, metadata deficiency has been highlighted (Quarati & Raffaghelli, 2020b). Attrition between disciplinary sectors employing incompatible nomenclatures and metadata tags has also been noticed (Edwards, Mayernik, Batcheller, Bowker, & Borgman, 2011). Data connectivity again limits data utilisation (Haklae, 2018). Moreover, technology and open data acceptability have also been linked to its utilisation (Zuiderwijk, Janssen, & Dwivedi, 2015). Also, several authors point to a mismatch between users' demands and expectations and the datasets' possibilities (Ruijer et al., 2020) and the fact that published data are not relevant to users' concerns (Bonina & Eaton, 2020).

A cross-cutting factor is represented by the skills and knowledge of citizens and professionals to adopt open data infrastructures. According to Van Veenstra, Grommé and Djafari (2020), for data analytics to be effective in the public sector, it is necessary to cultivate organisational, legal, and ethical competencies within a context of collaboration to guarantee their usage for improved efficiencies and/or operations. And while open data might provide some of the information citizens require, it is not always simple to comprehend, utilise, or collaborate with (Robinson & Johnson, 2016). Adults' lack of digital competency, as demonstrated by Jarke's (2019) study, leads to their exclusion from user groups during the creation of civic technology apps. Information technology, in this sense, is a transversal component that can either facilitate or obstruct the adoption of open government (Gil-Garcia, Gas-

co-Hernandez, & Pardo, 2020). The quality of data provision and the adoption and use of open data have been hampered over the past decade due, in large part, to a lack of investment in the development of data literacy, as stated by Davies and colleagues (2019).

However, a relevant problem is to re-centre the definition of data literacy, since the literature reports several perspectives and approaches to the skills, attitudes and knowledge to be considered as part of such a literacy.

Montes and Slater (2019) claim that the lack of a coherent and generally accepted definition of data literacy and requisite skillset leaves us without a real quantification of progress on open data literacy. Data literacy can be considered or should integrate technical and critical perspectives: one view of Data Literacy can be related to the skills required to work with math concepts and basic statistical elaborations. Along with its history connected with numeracy, the term acquired various meanings, including dimensions such as: critical reasoning; communicating, modelling, problem solving, represent numerical information; using the symbolic, technical, and formal language of the mathematical operations and the use of mathematical instruments. Recently, the use of open data can be defined as the competencies, knowledge and skills needed to download, clean, sort, analyse and interpret open data in a specific context (Zuiderwijk, Janssen, & Dwivedi, 2015). Given its relevance, data literacy has become an essential part of digital competence for all citizens as outlined in the DigComp Framework 2.1 (Carretero et al., 2017).

However, there is a clear need for competences development for the effective use of public sector data analytics in organisations (van Veenstra et al., 2020). Kassen (2020) states that the reuse or processing of open data to develop third-party applications and projects requires skilled enthusiasts and tech-savvy citizens who are willing to contribute with their time, knowledge and expertise to the creation or co-creation of products based on open data.

While the aforementioned definitions focus on technical proficiency, another perspective views data as a technological assemblage that is founded on and has an effect on preexisting sociocultural institutions (Sander, 2020). The ability to critically examine data, including its concepts, visualisations, and any operations performed on it that can expose some user groups to unfairness or ethical concerns, is what is meant by a "*critical approach to data*" (Knaus, 2020). Hence, the importance of data transparency, democratic design and control of data infrastructures, and the local ownership of data is emphasised as tools in the battle against inequality. As important is encouraging professionals who utilise data for services or projects to think critically about the inclusion gaps in data and the harm that can result from them (Montes & Slater, 2019, p. 283). This has implications for what is referred to as data justice where Taylor (2017) posits that "*fairness in the way people are made visible, represented and treated as a result of their production of digital data – is necessary to determine ethical paths through a datafying world*". Also, D'Ignazio and Bhargava (2015) worked on forms of popular education where data is assessed considering the needs of communities from participatory frameworks and socio-cultural reflection. More recently, D'Ignazio and Klein (2020) have developed the concept of "*Data Feminism*" in which they propose a critical instrumental conception, based on intersectional feminism, to review data structures and their consequences on the population.

Several authors contend, there is a need for the integration of both technical abilities with a critical perspective on the socio-political layers behind data infrastructures, labelling, algorithmic procedures etc., to promote people's empowerment, agency, and ultimately, social justice (Atenas, Havemann, & Timmermann, 2020; Raffaghelli, Manca, Stewart, Prinsloo, & Sangrà, 2020; Matheus & Janssen, 2020).

Reinforcing the crucial idea of assembling both technical and a critical perspective to embrace complexity in data literacy, a relevant strand of research analysing and evaluating interventions for

the development data literacy go in that direction. Some agencies like the Open Data Institute have encouraged the creation of data products, such as business and use cases, using real data, while developing their open data skills, as is the case of the public sector in Malaysia (Mustapa, Hamid, & Md Nasaruddin, 2019). Similarly, the study reported by Koltay (2017) considered the relevance and need to promote an open data literacy approach in researchers and librarians. The opportunity to engage with open data to reflect and to develop critical skills has been discussed in several empirical studies. Raffaghelli (2018) observed how the students performed a critical analysis by identifying limitation of open data portals coupled with the reflection on the importance of data literacy in society, especially in the most vulnerable groups. It was also observed how this debate was transferred by the students to their professional activity as social educators. Other authors have also emphasised the need of adopting open data for learning at all levels (Coughlan, 2019). After an initial survey, Boychuk, Lloyd and Mackeigan (2016) study on citizens' use open data for the full democratic use, posed data literacy skills solutions to higher education students and librarians, and encourage the development of applications or APIs. Finally, a study in Nigeria (Ifeanyi-obi & Ibiso, 2020) explains that the use of open data supports the development of an analytical methodology and a collaborative network in the agricultural sector key to innovation.

The activities aimed at developing the literacies to promote open data usage can take many different facets and forms. For instance, The Open Data Institute works on various data expeditions approaches to learn how to explore datasets, and download and reuse them. Another example is the School of Data[2], which promotes the philosophy of learning by doing with real data, with Data Expeditions and Data Pipeline being a series of methodological steps. Similarly, the European Open Data Portal[3] https://data.europa.eu/es/training/elearninghas an e-learning module that introduces open data, concepts, success stories, access, and exploitation. Moreover, annually there is the Open Data Day[4] where groups around the world create local events in which open data is used within their communities to show its benefits and encourage the adoption of OGD public policies, businesses, and civil society. However, according to Khayyat and Bannister (2017), field experiments, such as hackathons and competitions, continue to take place, but there has been no systematic research on the factors that contribute to a vibrant and sustainable co-creation ecosystem with civil communities. Still, there has been a focus on technical and managerial skills, with less emphasis on critical approaches (Raffaghelli et al., 2020).

Thus, our initial literature review supports the hypothesis that critical data literacy is needed to use data more diligently, but it also supports the idea that to critically engage with open data, one needs to be exposed to several digital infrastructures and types of data in situated civic participation spaces.

This literature review addressed our study of data literacy and other hurdles, particularly learning needs and techniques that could lead to lifelong learning policies to promote open data literacy as the integration of technical and critical perspectives in open data consumption.

3. Method

This publication reports transparently on systematic reviews and meta-analyses using the PRISMA methodological procedure (Moher, Liberati, & Tetzlaff, 2009). This strategy controls researcher bias

[2] https://schoolofdata.org/methodology/
[3] https://data.europa.eu/en
[4] https://opendataday.org/

in data gathering and analysis (Petticrew & Roberts, 2006). It involves analysing, summarising, and reporting a significant amount of unmanageable literature.

This selection was analysed to detect emerging concerns and problems related to the research questions. Papers were classified using thematic analysis (Braun & Clarke, 2006). The writers used the literature review and study objectives to construct a codebook with pertinent themes. Then, the selected articles' text was codified using ex-ante themes. As described below, interrater agreement measures confirmed the procedure.

Two phases elaborated extracted data. To answer RQ1, bibliometric maps based on article abstracts, titles, and keywords were employed to understand theme groupings and get first insight into the data.

Subsequently, a descriptive analysis of the articles classified according to the codebook completed the answer to RQ1, and by combining the variables' data in contingency tables, information was obtained to answer RQ2 and RQ3, as well as to clarify findings and conclusions about the problem and research questions.

3.1. Sampling and Data Analysis

For the sampling or selection of the articles under study, the PRISMA method was adopted as detailed below. The PRISMA protocol, (Moher et al. 2009) is widely accepted as a systematic method for prove review. It is applied in studies such as Patterson & Morshed (2021), Sangrà, Raffaghelli and Guitert-Catasús (2019), and as well as with a view of quantitative analysis such as Zawacki-Richter and Latchem (2018). The main PRISMA steps carried out are: 1. Selecting scientific databases, 2. Searching the databases with keywords of interest for several articles, 3. Analysing the selected articles by reading them in their entirety.

Selection of Databases. The literature review used SCOPUS, ISI Web of Science, and DOAJ (see Figure 1). The first two indexed high-quality, restricted-access journals. DOAJ, which promotes open access and connects to full-access materials, was deemed to balance this. These databases covered empirical and social research. Since EditLib and ERIC specialise in teaching and educational technology, their information was removed from the search.

Selection of several articles using keywords. The following keywords, according to the RQs formulated, were searched in the selected databases: Open Data AND Government AND Usage. From the word Usage, only us* is included to contain words related to usage. The following logical queries to the selected databases were used:

– SCOPUS and DOAJ: (open AND data) AND (government) AND (us*)
– WOS: (open AND data) AND (government) AND (usa*)

Then data was filtered by English language, articles, and reviews. A total of 383 articles was obtained from this query. Of these, 25 duplicates were identified. Once eliminated, 358 articles were available for the screening phase. Articles were screened through the process of reading abstracts and through the following exclusion criteria:

a) Date before 2016;
b) Absence of DOI;
c) Other open data topics apart from OGD;
d) Not an article or review;
e) Not in English;
f) Related to OGD but not its use;
g) Not available.

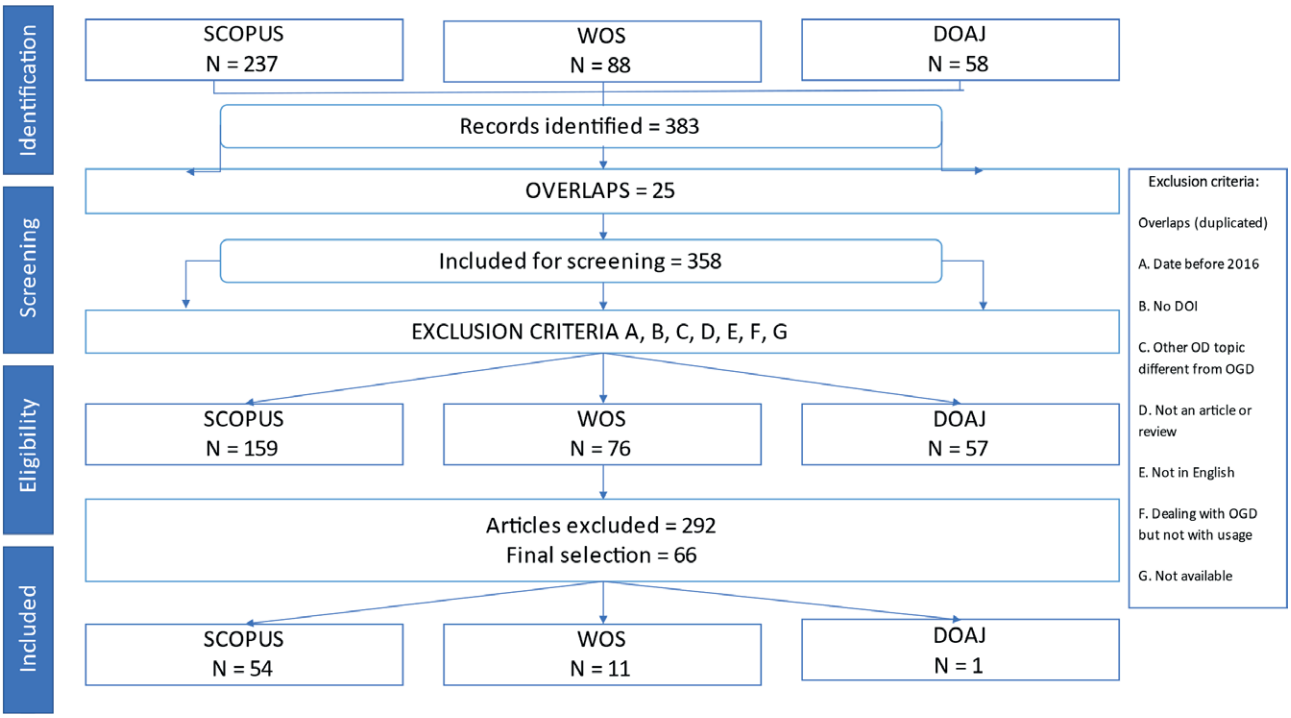

Figure 1. PRISMA diagram.

These exclusion criteria are defined based on the research objectives. After this process, 66 articles were obtained out of 358. Figure 1 illustrates the selection process.

The research of articles spanned the last five years, as general criteria applied to emergent phenomena. Indeed, from our general search only 20% of the papers fall below the 2016, and they focus on information literacy rather than data literacy. Moreover, the texts of the articles without DOI were requested to the authors and by interlibrary loan. A period of three months was considered before discarding the papers unavailable. Nonetheless, after a systematic review of abstracts, the mentioned papers were subsequently excluded because they did not include relevant information in terms of the research aim or because of some other exclusion criteria and numbered lists can be used as follows.

Analysis of the articles by reading them in their entirety. For this phase, a total of 66 articles were obtained: 82% from SCOPUS, 17% from WOS, and 1% from DOAJ.

For the quantitative analysis, the articles were coded and classified into different categories, according to the Codebook defined by the authors. As can be seen, the identified fields attempted to capture:

Identity of the research (Authors, Title, Year, Title of the source, No. of Citations, DOI, Type of Document, Abstract of the article, Keywords of the author).

Type of open data and applications on which the research is focused: Discipline, Type of Open Data, Open Data Applications.

Barriers to the use of open data.

Types of learning generated using open data.

Specifically, the CODEBOOK (Tab. 1) defines each of the fields or variables under study and presents the set of categories defined and then validated, their name, description, categories, type of variable (text, numeric, nominal). A full version of the codebook with text's extracts coded are provided in the open data record (Loría-Solano et al., 2021).

Table 1. CODEBOOK.

Fields	Description	Subfields: Codes assigned/Themes	Type of variable
Authors	Progressive number of Author: 1st, 2nd, ...n	Name and Surname of the Publication's author	Open Text
Title	Publication Title	Title assigned by the authors	Open Text
Year	Year of publication	Number	Numeric, discrete
Source title	Journal, Conference, or other information indicating the type and context of publication	Title/name of the source	Open Text
Cited by	Number of authors citing the publication under analysis	Number	Numeric, discrete
DOI	Digital Object Identifier	Specific DOI	Open Text
Document Type	Type of publication	Article	Text Labels, Nominal
		Review	
		Not categorised	
Abstract	Synthesis of the research as provided by the authors	Abstract found in the article or database	Open Text
Authors Keywords	Specific words describing the content/focus of the research	Keywords	Open Text
Discipline	Connected to the overarching disciplinary field where the research can be placed and based on the keywords given by the authors.	Health	Text Labels, Nominal
		Social Sciences	
		Natural and applied Sciences	
		Computer sciences	
		Other	
Type of Open Data	The conceptual definition and Characterisation of the types of Open Data	OGD	Text Labels, Nominal
		ORD	
		POD (Private Open Data)	
Applications of Open Data	The conceptual definition and Characterisation of Open Government Data, applications, and benefits	Governance	Text Labels, Nominal
		Open cities	
		Industrial Innovation	
		Education and training	
Types of Learning triggered	OGD usage and motivations. How OGD is used. Levels of OGD usage. Areas or topics where it is used.	Civic education	Text Labels, Nominal
		Political participation	
		Professional learning	
		Technical Data Literacy	
		Critical Data Literacy	
		not mentioned	
Issues preventing usage	Issues or characteristics that prevent the usage of Open Data	Technical Data Literacy	Text Labels, Nominal
		Critical Data Literacy	
		Quality of data	
		Technology	
		not mentioned	
		All others	

The definitions and extracts included are considered a sample to exemplify the concepts, due to the restriction of space to comment all the 66 papers selected.

To validate the classifications made in the database of articles generated, there was a double screening by the two authors of the publication. Firstly, one of the authors analysed the whole sample of 66

papers. In parallel, the other author reclassified a 10% of them. Finally, the first author also performed another analysis after six months of working with the database. To measure the consistency and agreement between them, a Cohen's Kappa was performed over the three codification outputs. The result obtained was k = 0.64, meaning that there is a substantial agreement between researchers as it is in the range between (0.6 and 0.8). An open data has been produced and published as supplementary material to this article (Loría-Solano et al., 2021).

As a critical appraisal of the research, a discussion of the paper was held in the context of a PhD school, where the selection of papers and initial classification were presented to students and instructors. In addition, the preliminary results were presented and improved through a conference (Loría-Solano & Raffaghelli, 2021).

Data Analysis. The extracted data were elaborated in two phases. As a first phase and to respond to RQ1, a keyword map was created following the bibliometric pattern (van Eck, Waltman, Dekker, & van den Berg, 2010). This type of visual representation is based on graphs consisting of nodes and edges: while the nodes may represent publications, journals, researchers or keywords, the edges represent forms of relationship between the nodes. In the keyword map, co-occurrent terms provide information about the distribution of topics in the abstracts of the articles under study. The visualisation shapes not only explore a current static relationship, but also highlight groups (clusters) that are "closer" within the relationship. VosViewer software was adopted to produce this type of visualisation. We adopted the clustering method to understand possible topics around data usage and the presence of data literacy, as emerging from the textual automated analysis. With respect to the second phase, a descriptive analysis of the data of the articles classified according to the codebook was carried out, which completed the answer to RQ1 and, by combining the data of the variables in contingency tables, information was obtained to answer RQ2 and RQ3 digging deeper on the types of data literacy and the learning opportunities generated from open data.

4. Findings

In the following, we introduce the findings organised as responses to the research questions.

4.1. RQ1 What are the contexts of use and learning based on open data?

The list of keywords from the abstracts of the articles under study is presented in Table 2, which specifies the term, the number of occurrences, as well as a term relevance according to the bibliometric keyword map's metrics (cfr. methodological section 3, above, as estimation made in VosViewer). Most relevant terms are presented at the top of the table.

In the top positions, keywords such as dataset, barrier, OGD, governance and public administration, among others, were identified, then the map was plotted. The map of keywords, which projected a first figure on the emerging themes, provided a first level of information about the contexts of research on the creation and use of Open Data.

Figure 2 presents the keyword map, and the clustering of most frequent terms shows their associations, represented in different colors and thickness of the lines; and the most frequent terms are represented by larger nodes.

Figure 2 shows that four groups or clusters are formed, each represented by a distinctive color. The clusters are composed by keywords that describe them and whose size depends on their relevance.

Table 2. Term, occurrences, and relevance of keyword map.

Term	Occurrences	Relevance	Term	Occurrences	Relevance
point	6	2.2	collaboration	6	0.82
world	9	1.91	society	7	0.8
dataset	11	1.87	need	12	0.77
issue	9	1.82	role	9	0.73
OGD	12	1.74	stakeholder	10	0.7
term	8	1.72	perspective	9	0.63
governance	10	1.62	city	10	0.61
public administration	7	1.54	challenge	10	0.57
open data policy	10	1.35	innovation	12	0.54
relationship	8	1.32	resource	14	0.48
open government data	15	1.3	factor	12	0.47
public sector	6	1.29	example	8	0.46
government data	6	1.25	country	16	0.45
opportunity	8	1.2	way	11	0.43
interest	7	1.17	model	14	0.4
data quality	7	1.16	set	14	0.38
order	8	1.14	area	9	0.37
benefit	9	1	access	14	0.35

Table 3 shows the words that constitute each of them and give us an idea of the areas or contexts in which the topics of the articles are developed.

The clusters were studied based on the relationship between the words in the summaries of the articles read. Thus, based on the frequencies and associations evidenced by the analysis, a series of themes per cluster emerged:

Red Cluster. Model and order of public administration with interest in the perspective and role of stakeholders and society for innovation in the public sector.

Green Cluster. Need for open data policy and quality for governance and its relation to the problem of obtaining the expected benefits.

Blue Cluster. Challenge in the way of accessing the type of data as a resource and opportunity for collaboration in the public sector and cities.

Yellow Cluster. Governmental open datasets of national value.

The clusters show contexts of use of the data that would help in the successive reading of the concepts coded and analysed quantitatively. Specifically, it is appreciated 1) the interest of the public sector in considering the perspective of stakeholders and society for social innovation and in public administration; 2) the need for public policy and data quality to obtain the expected benefits such as governance; 3) Access to open government data and how this can be an opportunity for collaboration in cities and with the public sector, for which the required capacities must be in place to be able to do so.

By observing the word map and its relationships, along with the reading of the articles, it can be concluded that government open data is a social resource that should be accessible to all stakeholders via public policy modelling quality data that enables collaboration of various sectors to achieve social innovation, public administration, and governance at both the city and country levels.

The information supplied by the keyword map and quantitative frequencies permits us to provide an initial response to RQ1. What are the uses and learning contexts for open data? Based on the sub-

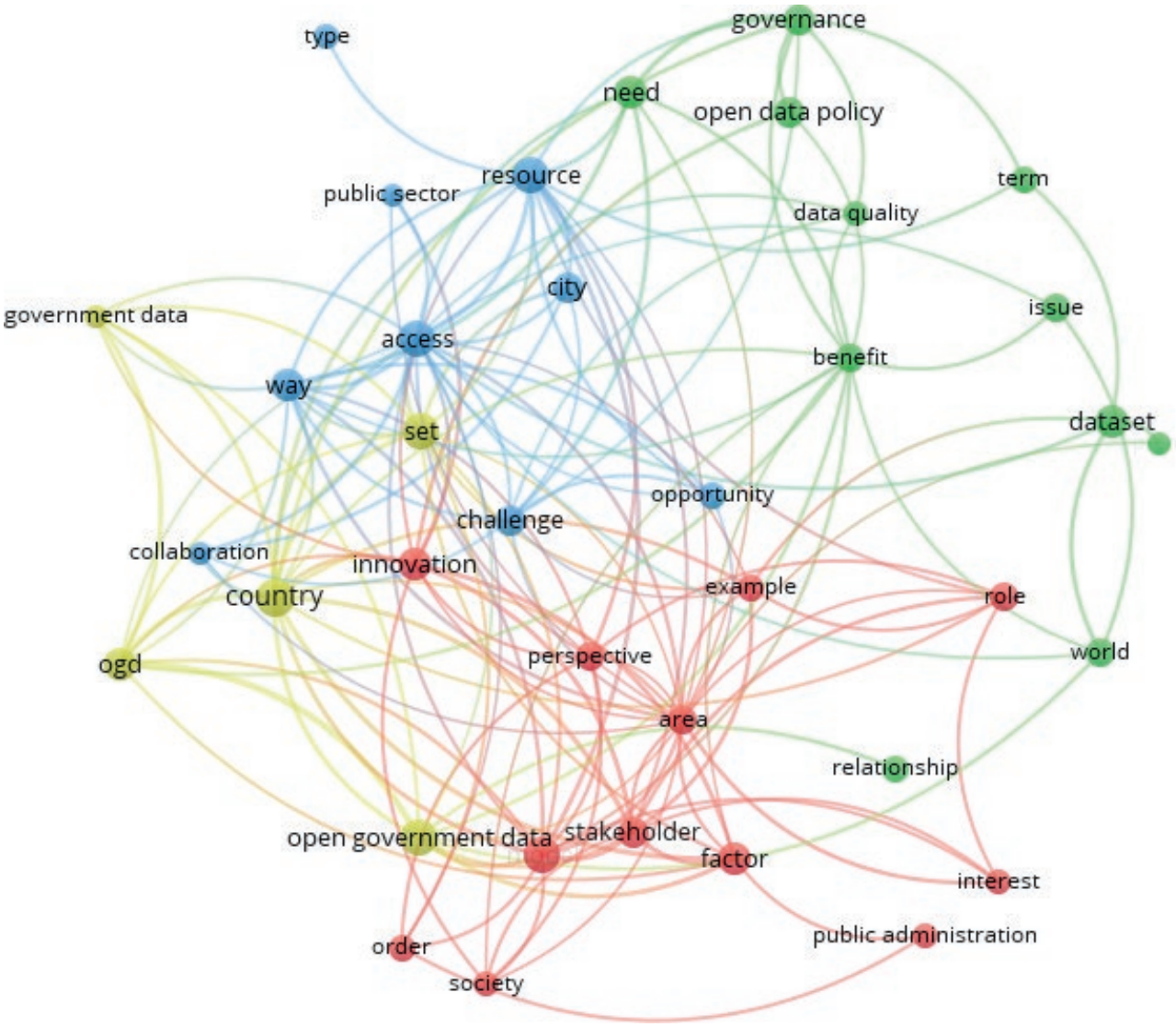

Figure 2. Keyword map (article abstracts).

jects found in the clusters, we hypothesised that the contexts of open data use are both at the city and national levels, where there is a policy of data availability for all stakeholders and where individual and collaborative data use is encouraged. Supporting usage in various circumstances could result in benefits such as innovation at the social level, in public administration, and in governance. The analysis suggests that collaborative access to and use of open data might facilitate innovation, a concept associated with learning processes that generate new knowledge, in this case about OGD. Further study can give information on the forms of learning that may potentially modify the use of open data, thereby characterising the contexts of use more precisely.

In accordance with the interpretation of the green cluster, the keyword map suggests that 41% of the articles under review discuss the use of open data for governance. Thirty percent of the data have innovation as a focus of application, where topics such as the generation of technological platforms and applications for increasing usage by stakeholders are mentioned, such as innovation in the red cluster

Table 3. Clusters identified in the key word map.

Red cluster	Green cluster	Blue cluster	Yellow cluster
area	benefit	access	country
example	data quality	challenge	government data
factor	dataset	city	OGD
innovation	governance	collaboration	open government data
interest	issue	opportunity	set
model	need	public sector	
order	open data literacy	resource	
perspective	point	type	
public administration	relationship	way	
role	term		
society	world		
stakeholder			

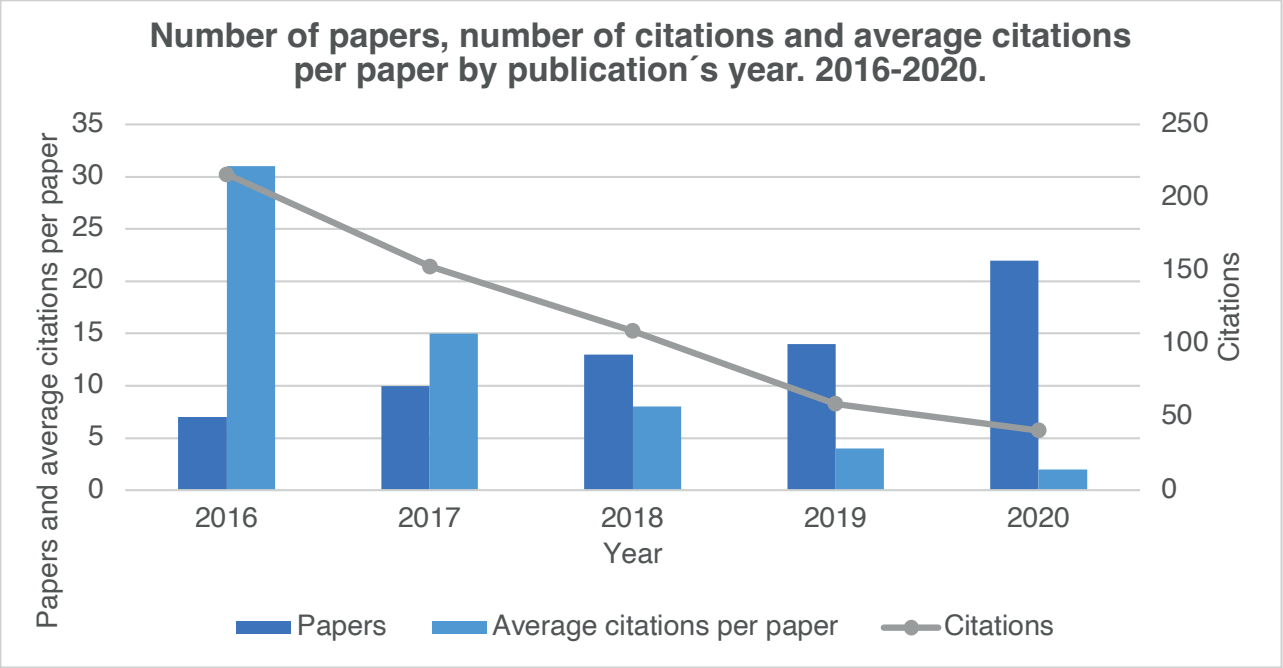

Figure 3. Trend of publications.

and, access in the blue cluster. Other applications are open cities present in 21% of the articles; in addition, 8% of the applications are in education and are related to knowledge for access and collaboration in cities and the public sector as identified in the blue cluster.

After keyword maps extracted topics, the analysis of the percentages with respect to the characterisation of the type of open data yielded further contextual information. In this regard, the 94% of the research articles deal with Government Open Data OGD, 5% with Research Open Data ORD and only 2% with private open data OPD. This scenario was to be expected since the literature search was conducted using OGD. Furthermore, regarding the Disciplines in which the use of OGD is applied, our

sample yielded the following: 85% of the articles focus on Social Sciences, 12% on Computer Sciences, 3% on Health Sciences. On the other hand, in a temporal analysis of how the subject of OGD use has evolved, with respect to the number of articles and citations, so the situation could change in the near future. The following graph visualises the frequency of articles by year and the average number of citations per article, and the line, whose axis is the right one, shows the total number of citations by year.

The number of scientific articles on this topic has increased yearly at an average annual growth rate of 34% and specifically in 2020 compared to 2019 with a growth of 57%. Which shows the increase of interest over the years in topics related to OGD usage. The number of citations decreases by an annual average of 34%, which is logical because, the newer the article, the fewer citations it may have at the beginning, and these increase as further research is conducted on the topic, and it is possible that they are cited over the years.

4.2. RQ2 What are the barriers to the use of open data, and, within those barriers, what role does technical and critical open data literacy assume?

To continue with the guided analysis considering the research questions, specifically RQ2 - What are the barriers that prevent the use of open government data? The analysis of relative frequencies of the barriers that prevent its use responds in first place to the lack of Open Data Literacy, which represents 65% of the cases. This classification includes technical literacy (with 62%) and critical literacy (3%), followed by 14% lack of data quality and 9% related to the lack of skills for access or basic use of the technology. To deepen the answer, it is necessary to perform a contingency table analysis to explore relationships between variables (i.e. the type of open data and the discipline) in which the identified barriers are present to a greater and lesser extent.

Therefore, to delve into the answers to the questions posed, RQ2 is represented by the barriers to use arranged in the columns, whereas in the rows the contexts, discipline, type of data, open data applications are showcased. Table 4 outlines the crossovers that exist between pairs of variables and at the same time it segments the responses to answer the questions posed.

The columns in Table 4 that show the barriers provide an answer to the question RQ2 and evidence that the most significant barrier that prevents people from using open data provided by the government is a lack of technical open data literacy skills. This is the case across all three context variables; more specifically, it is the barrier that is observed the most frequently in terms of discipline, type of data, and open data applications. The quality of the data is a persistent second obstacle that applies to all three factors. The third one is a limitation imposed by technology.

4.3. RQ3 What types of learning are promoted using open government data?

Similarly, to primarily answer the question RQ3 (what types of learning are promoted with the use of open government data?), when analysing the type of learning promoted, almost 38% of the articles show that technical open data literacy is generated, followed by civic education 26%, professional learning 23%, political participation 11% and only 3% of critical data literacy. It seems that the articles have paid attention to the technical aspects and data manipulation rather than to a critical and reflective analysis of the data. The answer to this question may be of great interest since it could lead to the applications that would arise from this learning, as well as the contexts in which they could be forged.

Table 4. Barriers that impede the use of OGD according to the context.

Open data		Issues preventing usage (absolute frequency)					Issues preventing usage (relative frequency)				
		Critical Data literacy	Technical Data literacy	Quality of data	Technology	Not mentioned	Critical Data literacy	Technical Data literacy	Quality of data	Technology	Not mentioned
Discipline	Computer sciences	0	2	4	2	0	0%	3%	6%	3%	0%
	Health	0	0	0	0	2	0%	0%	0%	0%	3%
	Social Sciences	2	39	5	4	6	3%	59%	8%	6%	9%
Type of Open Data	OGD	2	40	8	5	7	3%	61%	12%	8%	11%
	ORD	0	1	0	1	1	0%	2%	0%	2%	2%
	POD (Private Open Data)	0	0	1	0	0	0%	0%	2%	0%	0%
Applications of Open Data	Education and training	1	2	0	1	1	2%	3%	0%	2%	2%
	Governance	0	19	4	2	2	0%	29%	6%	3%	3%
	Industrial Innovation	0	11	3	2	4	0%	17%	5%	3%	6%
	Open cities	1	9	2	1	1	2%	14%	3%	2%	2%

Table 5. Type of learning OGD usage promote according to context.

Open data		Types of learning generated (absolute frequency)					Types of learning generated (relative frequency)				
		Civic education	Critical Data literacy	Technical Data literacy	Political participation	Professional learning	Civic education	Critical Data literacy	Technical Data literacy	Political participation	Professional learning
Discipline	Computer sciences	3	0	2	0	3	5%	0%	3%	0%	5%
	Health	2	0	0	0	0	3%	0%	0%	0%	0%
	Social Sciences	12	2	23	7	12	18%	3%	35%	11%	18%
Type of Open Data	OGD	16	2	24	7	13	24%	3%	36%	11%	20%
	ORD	1	0	1	0	1	2%	0%	2%	0%	2%
	POD (Private Open Data)	0	0	0	0	1	0%	0%	0%	0%	2%
Applications of Open Data	Education and training	0	1	1	0	3	0%	2%	2%	0%	5%
	Governance	8	0	12	3	4	12%	0%	18%	5%	6%
	Industrial Innovation	3	0	8	2	7	5%	0%	12%	3%	11%
	Open cities	6	1	4	2	1	9%	2%	6%	3%	2%

As shown for the RQ2, the Table 5 represents the crossovers between types of learning generated from OGD usage (columns), and the rows report the contexts, discipline, type of data, open data applications.

It has been discovered that technical literacy in open data is also the sort of learning that is promoted the most frequently in the same three variables that refer to the settings in which open data is used. In second place is the concept of civic education, which is defined as learning that is encouraged through the utilisation of open data. In third place is the concept of professional development.

5. Discussion

In order to address our research questions (RQ1, RQ2, and RQ3), we operationalized the embedded constructs into variables. They pertained to the classification of open data (types of open data, applications, and disciplines), the obstacles that inhibit the use of open data, and the forms of learning fostered by open data when utilised correctly. In two steps, we analysed the acquired data (articles referencing open government data).

As for a preliminary answer to question RQ1, we initially mapped and grouped the articles' keywords. This operation highlighted the settings of use in which OGD excelled at the national and smart city levels: as a social resource for civic participation and political transparency, and for collaborative usage relating innovation in public administration and society in general, consistently with the literature (Yin et al., 2015). Innovation is defined in terms of open data literacy as the process of developing new knowledge and learning based on OGD. This final piece also partially addresses RQ3, which is aligned with a new form of collaborative innovation, namely, civic society culture occurs when citizens reuse free data (Mergel, Kleibrink, & Sörvik, 2018).

In the second part of the investigation, 66 articles were classified into several fields and groups. Straightforward frequencies, contingency tables, and relative frequencies were estimated to answer RQ1 and RQ2 and RQ3 respectively.

The statistical study demonstrates that the highest proportion lies within the area of social science, with accessible government data serving as the foundation of governance. This prevalence is consistent with Altayar's (2018, p. 634) assertion that publishing OGD enables external parties to access, explore, manipulate, and discover government data, thereby facilitating the development and creation of beneficial services, products, and applications for the benefit of society and government institutions.

When coming to the barriers that limit the use of open data (RQ2), we observed that 62% of the articles referred to the lack of technical data literacy as a barrier to usage, followed by data quality 14% and in last place, critical data literacy with just 3%. The crosstabs show also that the lack of open data literacy stands out as the main barrier specifically in social sciences, government open data and governance. This is consistent with Matheus and Janssen (2020, p. 521) who indicate that the same data that creates a higher level of transparency for the expert, creates a lower one for someone with limited access and lack of knowledge on how to use it. While other studies discuss the absence of metadata (Raffaghelli & Stewart, 2020) or lack of linkage in the data (Haklae, 2018), our results confirm the importance of data literacy.

Our analysis of the literature indicates that, when there is appropriate engagement with open data, there is learning (RQ3). Although our analysis mainly yielded concern around technical learning on open data, it focused at the same time on how the lack of this capability is also connected with its low usage, so there is consistency in the emphasis given to this type of literacy. Civic education is also promoted, followed by professional learning, but the two categories are less mentioned. Moreover, the keyword map shows that collaboration in the use of open data for innovation is a crucial factor, and this does not only refer to technical skills, but also to critical appraisal and engagement with open data. Indeed, considering D'Ignazio and Klein's perspective on intersectional feminism and data justice (2020), the processes of co-creation and collaboration enable new social balances, which is the main goal of open knowledge.

On the other hand, the percentages reveal a pattern in the categories with the highest frequencies of the row variables: the main barrier impeding the use of open data is the lack of open data literacy,

while the type of learning promoted with the use of open data is precisely open data literacy. The three main categories showcase that the frequencies are higher in the technical literacy barrier than in the technical literacy learning promoted.

Furthermore, in the categories (Discipline Social Science, Data Type Government Open Data, and Open Data Applications), the barrier of open data literacy is greater than the open data literacy learning promoted through open data usage. Quantifying this difference, it is of the order of 24% in Social Sciences, 25% in Government open data and 11% in the Governance application. Learning around open data is probably hindered by several barriers beyond the same actors' basic knowledge and skills (Ruijer et al., 2020; Zuiderwijk et al., 2015).

Overall, our analysis suggests that illiteracy is a significant obstacle, that most literacy possibilities are technological, and that engagement with open data creates real learning when it occurs. However, our investigation was unable to determine the extent to which collaborative and co-creative components could develop synergies between the public sector, business sector, academics, and citizens in general, at the local and national level, in pursuit of innovation and governance. These are the remaining parts of a comprehensive and critical data literacy that require investigation.

6. Conclusions

Our findings have allowed us to identify the importance of data literacy in general, despite the paucity of reflection on the type of literacy, specifically holistic and critical, that enables individuals to view data as a complex socio-technical construction. The ultimate purpose of open data is strongly contingent on the levels of literacy and the possibilities to engage with open data in such a way that reflection, skills, and hence learning can be launched.

Our study is subject to a number of important constraints. The literature search in the databases was restricted to government information. The classification of the articles into the categories described in the Codebook was based on the objectives of the study. It should be highlighted that some articles included more than one category related the primary variables but were coded into a single category for data analysis reasons. In this study, the skills of downloading, managing, and interpreting open data, which are distinguished in some articles as digital, computational, or technological skills, are framed within the concept of technical open data literacy and are distinguished from a holistic, politically and socially contextualised understanding, or critical open data literacy.

Moreover, it should be noted that this study is exploratory regarding the settings of open data use and the function of open data literacy, therefore it sets the basis without delving into suggestions or consequences for the professional practise of open data literacy. Yes, this requires future research with a deeper depth and concentration.

Nonetheless, we supplement our empirical study with references to the literature. In this regard, we found that our findings are complementary to what has been described as a new sort of collaborative innovation culture, which happens when citizens manage open data in a meaningful way. In this approach, not only publication, but also this type of OGD usage might spur innovation. This type of participation enables external parties to access, explore, and manage OGD, hence facilitating the development and construction of contextually useful services, goods, and applications for the benefit of local communities and the larger society (Altayar, 2018). Our investigation revealed that there may be a discrepancy between these optimistic assumptions, which pertain to the required abilities and knowledge, and the conditions necessary to develop these skills and knowledge.

Echoing the literature, we argue that the enabling conditions for the development of capabilities in citizens and professional actors to make open data accessible, reusable, and situated (Mergel et al., 2018) are dependent on their basic skills and the educational resources and activities that generate formal, non-formal, and informal learning around open data. For instance, the construction of data usage laboratories with broad participation from individuals and interested organisations would enable the emancipation of society through playful and economical forms of peer-to-peer learning. Workshops, seminars, massive open online courses (MOOCs), and virtual classes with certification may also be significant (Matheus, Maia Ribeiro, & Vaz, 2018), but it must be determined to what extent these learning modalities help active professionals or global citizens in their engagement with OGD. Overall, research should focus on the production of educational resources for the development of key skills required to function in a data-driven society (Atenas et al., 2020). Indeed, only a handful of the models designed for capacity building have been evaluated at scale (Davies et al., 2019), and there is a lack of knowledge on data literacy baselines, a dearth of systemic interventions to improve data literacy, and scant research on what works (Montes & Slater, 2019). According to our research, data literacy remains a significant issue in an evolving context dominated by intelligent technologies based on data extraction and algorithmic manipulation. Therefore, fostering a lifelong learning dimension should be considered a top priority for both public and private entities in the near future.

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