Policy mentions in data literacy research: A bibliometric analysis of 127 research papers

Vol. 9 No. 2

October 2024

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Abstract

Rationale of Study – This study examines the policy landscape surrounding data literacy, focusing on the intersection between data literacy and policy.

Methodology – A bibliometric analysis was conducted on 127 documents related to data literacy out of the 997 indexed in Scopus. Keywords, titles, and abstracts were analysed to identify the presence and focus of policy-related discussions. Network visualisations of keyword clusters were employed to explore the interdisciplinary nature of data literacy.

Findings – The study reveals a relatively low engagement with policy in data literacy research, with policy frequently mentioned in abstracts (111 occurrences) but rarely in titles or keywords. Keyword clusters showed two primary areas where policy considerations are crucial: education and governance. The findings also identified the need for differentiated policy approaches tailored to specific sectors like education, governance, and scientific research. The isolation of terms like "scientific data" suggests niche areas requiring targeted policy interventions.

Implications – The findings suggest that data literacy initiatives need a more explicit focus on policy frameworks, particularly in education and governance, to ensure ethical and responsible data use. The study calls for policymakers to embed governance, privacy, and ethics discussions within data literacy education and decision-making processes.

Originality – This study contributes to the underexplored area of policy integration in data literacy research. By highlighting the gap in policy considerations, the research underscores the need for a more holistic approach to data literacy, combining technical skills with governance, privacy, and ethical dimensions.

Keywords

Data literacy, policy framework, policy implications, education policy, public policy

Citation: Nwagwu, W. E. (2024). Policy mentions in data literacy research: A bibliometric analysis of 127 research papers. *Regional Journal of Information and Knowledge Management*, 9(2),133-156. DOI: https://doi.org/10.70759/09stqm44

Published by the

Regional Institute of Information and Knowledge Management

P.O. Box 24358 – 00100 – Nairobi, Kenya

1 Introduction

Data literacy refers to the skill set and proficiency in comprehending, analysing, and assessing data and the capability to communicate findings and derive informed conclusions from data-driven evidence (Jefferson et al., 2019). It entails the mastery of technical competencies necessary for data manipulation and analysis and the aptitude to discern biases, uncertainties, and constraints inherent in data sources and methodologies. Data literacy empowers individuals to navigate intricate data ecosystems, pose pertinent inquiries, and distil actionable insights to tackle real-world complexities. This fosters a culture of evidence-based decision-making and perpetuates a cycle of continuous learning across personal and professional domains (Mendez-Carbajo et al., 2019; Ongena, 2023; Salman, 2024).

Perspectives on data literacy can also be influenced by cultural norms, organisational practices, and the broader societal context (Wolcott, 2024; Chu, 2024). For example, in some cultures, there may be greater emphasis on collective decision-making based on consensus, while in others, individual autonomy and data-driven decision-making may be valued more highly. Differences in technological proficiency can also shape perspectives on data literacy. Individuals more comfortable with technology may see data literacy as primarily technical skills. In contrast, those less familiar with technology may view it as a broader set of competencies, including critical thinking and ethical considerations (Park et al., 2021).

Cultures may differ in their attitudes toward data, information, and technology. This is the concern of Wolcott (2024), Chu (2024), and many others. In some cultures, there may be a strong emphasis on data-driven decision-making and evidence-based practices, while in others, traditional knowledge or intuition may be valued more highly. These cultural attitudes can shape how individuals perceive the importance of data literacy and its role in decision-making processes. Educational systems vary across countries, affecting the emphasis on data literacy in school curricula. Some countries may prioritise STEM education and include data literacy as a core curriculum component from an early age.

In contrast, others may emphasise quantitative skills and data analysis less. National regulations and policies related to data privacy, security, and ethics can influence how data is collected, managed, and used. Individuals in countries with strict data protection laws may have heightened awareness of data literacy's ethical and legal implications. In contrast,

those in countries with less regulation may have different perspectives on privacy and data sharing (Luz et al., 2024).

Disparities in access to technology and information resources can affect opportunities for developing data literacy skills. Countries with greater access to digital infrastructure and internet connectivity may have higher levels of digital literacy and data fluency among their population. In contrast, those with limited access may face difficulty acquiring data literacy skills (Nwagwu, 2024a). Cultural values and norms around collaboration, individualism, risk-taking, and decision-making can influence how data is used and interpreted in different contexts. For example, cultures valuing consensus-building and collective decision-making may approach data analysis and interpretation differently than those prioritising individual autonomy and innovation (Luz et al., 2024; Ghodoosi et al., 2023). Indeed, the rise of information technology has spurred the emergence and promotion of data literacy as a critical skill set in today's digital age. As information technology advances and permeates every aspect of society, the volume and complexity of data being generated, collected, and analysed have grown exponentially. In this context, data literacy has become a fundamental competency for navigating and making sense of the vast amounts of data available (Ghodoosi et al., 2023).

The proliferation of digital devices, sensors, and online platforms has resulted in an explosion of data creation. From social media interactions and e-commerce transactions to sensor data from IoT devices, vast amounts of data are generated every second. Data literacy equips individuals with the skills to access, analyse, and derive insights from this information. In both the public and private sectors, organisations increasingly rely on data-driven decision-making processes to gain competitive advantages, optimise operations, and improve outcomes. Data literacy enables individuals to understand and interpret data effectively, empowering them to contribute to informed decision-making processes (Ghodoosi et al., 2023; Koltay, 2016).

Data science has emerged as a multidisciplinary domain encompassing various techniques and methodologies for extracting knowledge and insights from data. Data literacy provides individuals with the foundational knowledge and skills to effectively engage with data science tools and methodologies. Technology advances have democratised data access, making it more accessible to a broader range of individuals and organisations. Data literacy enables people from diverse backgrounds and disciplines to leverage data in their respective domains, fostering innovation and creativity. Artificial intelligence, machine

learning, and big data analytics rely heavily on data inputs for training models, making predictions, and generating insights. Data literacy is essential for understanding these technologies' capabilities and limitations and critically evaluating their outputs (Nwagwu, 2024a; Nwagwu, 2024b).

As a new area of knowledge, data literacy requires strategic policies at various levels, including governmental, organisational, and educational, to ensure its effective integration into society. Policies help establish standardised frameworks and guidelines for defining and measuring data literacy. Policies ensure consistency in implementation across different contexts, organisations, and regions by providing a shared understanding of what constitutes data literacy. Policies allocate resources, such as funding, infrastructure, and personnel, to support developing and implementing data literacy programs and initiatives. Adequate resource allocation is essential for scaling data literacy efforts and reaching diverse populations (Goben & Griffin, 2019; Ongena, 2023).

Educational policies are vital in integrating data literacy into formal education systems, from primary schools to higher education institutions. By incorporating data literacy skills into curricula and educational standards, policies ensure that students receive the necessary training to thrive in a data-driven society. Policies can incentivise organisations to invest in workforce development programs to enhance employee data literacy (Atenas et al., 2023). By offering training programs, certifications, and career pathways in data literacy, policies contribute to building a skilled workforce capable of leveraging data effectively in various industries. Data governance and privacy policies are essential for responsible data use and protecting individuals' rights. Data literacy policies should address ethical considerations, data privacy regulations, and best practices for data handling to foster trust and accountability in data-driven initiatives.

Policies can support public awareness campaigns and community engagement initiatives aimed at promoting data literacy among citizens. By raising awareness of the importance of data literacy and providing opportunities for public participation, policies contribute to building a data-literate society (Stephenson & Caravello, 2007). Policies can encourage research and innovation in data literacy by funding research projects, supporting interdisciplinary collaborations, and fostering stakeholder knowledge exchange. Research-informed policies help advance the understanding of data literacy and drive continuous improvement in data literacy initiatives (Stobierski, 2021). Data literacy is still a relatively new concept, and policymakers may not fully understand its importance or how to

effectively promote it through policy measures. Data literacy encompasses a wide range of skills and competencies, making it challenging to develop comprehensive policies that effectively address all aspects of data literacy. Many policymakers may not be fully aware of the importance of data literacy or its implications for society, leading to a lack of prioritisation in policy agendas. Developing and implementing policies on data literacy requires significant resources, including funding, expertise, and infrastructure. Data literacy policies may not receive sufficient attention in contexts with limited resources or competing priorities (Ghodoosi et al., 2023).

Policymaking processes can be slow to adapt to new concepts and technologies. Resistance to change, bureaucratic inertia, and vested interests may hinder the development of innovative policies on data literacy. Data literacy spans multiple sectors, including education, technology, healthcare, and government. Fragmentation across different policy domains and lack of coordination among stakeholders can impede the development of coherent policies on data literacy. Data literacy needs and challenges vary across regions, countries, and communities. Developing one-size-fits-all policies may not be feasible, requiring tailored approaches that account for local contexts and priorities (Atenas et al., 2023).

Despite these challenges, there is growing recognition of the importance of data literacy in the digital age. Efforts to promote data literacy through policy measures, such as integrating data literacy into education curricula, supporting workforce training programs, and raising public awareness, are gradually gaining momentum. As awareness of the importance of data literacy continues to grow, policymakers may increasingly prioritise the development of policies aimed at enhancing data literacy skills and competencies across society. However, of the 997 documents produced on data literacy during the 18 years (2005 to 2022) (Nwagwu, 2024a), only 127 touched policy(ies) in their titles, abstracts and keywords, considered an indication of the extent of attention to the role of policy in promoting data literacy.

According to Chamorro-Padial and Rodríguez-Sánchez (2023), emphasising the title, abstract, and keywords is integral to a research paper's success in reaching and engaging its intended audience. These sections are crucial for the paper's initial impact and long-term academic influence. Ensuring that they are well-crafted not only aids in the paper's discoverability and readability but also enhances its overall contribution to the field. The emphasis on keywords, abstracts, and titles in research papers is critical due to their

significant roles in the paper's discoverability, comprehensibility, and impact within the academic community. The title of a research paper is the first element that potential readers and researchers encounter. It provides a snapshot of the research's content and focus (Bai et al., 2017; Bas et al., 2020; Callaham et al., 2002; Chamorro-Padial & Rodríguez-Sánchez, 2023).

Jiang et al. (2020) have shown that a well-crafted title can succinctly convey the core topic and main findings, attracting the appropriate audience and setting the context for the paper's relevance. Search engines and academic databases amplify the title's importance in the digital age. Researchers often use specific keywords to locate relevant literature. Sagi and Yechiam (2008) and Jamali and Nikzad (2011) show that a title that includes keywords significantly enhances the paper's visibility and searchability. Effective titles usually balance being descriptive enough to inform while being concise enough to remain readable. Finally, the title can influence the paper's impact by making it stand out in academic and research environments. A compelling title can increase the likelihood of the paper being read and cited by other researchers, thus enhancing its influence and reach within the academic community.

Alspach (2017) said the abstract serves as a concise summary of the entire paper, encapsulating the research problem, methodology, key results, and conclusions. It provides a quick overview for readers, helping them determine the paper's relevance to their interests and research needs. Since most readers decide whether to read the full paper based on the abstract, it is a gatekeeper to its content. A well-written abstract that presents the study's significance, primary findings, and implications can draw readers in and encourage them to explore the full document. Abstracts are crucial in indexing services provided by databases like PubMed, IEEE Xplore, and Google Scholar. These services often use abstracts to categorise and tag the paper, making it easier for researchers to find papers on specific topics.

Keywords are essential for indexing and retrieving search engines and databases (Yao et al., 2014; Bekhuis, 2015). They represent the core topics and themes of the paper, facilitating its discovery when researchers search for literature on specific subjects. Authors can ensure that their paper reaches a more targeted and appropriate audience by including relevant keywords. This increases the likelihood of the paper being read and cited by researchers interested in the same field of study. Keywords also help analyse research

trends and patterns within a specific domain. They contribute to bibliometric studies and highlight emerging areas of interest or gaps in the literature.

This study was designed to determine the prevailing trends, patterns, and characteristics of papers on data literacy with "policy" in their keywords, abstracts, or titles and to map and visualise the keywords of the 127 data literacy documents where the policy was mentioned.

The essence of the research lies in understanding how the term policy used in data literacy documents explains the attention of the documents to data literacy policing. By anal zing the 127 documents that have policy in their titles, abstracts and keywords, the research aims to uncover the ramifications and approaches being taken by researchers to develop data literacy through policy research. The research will advance data literacy initiatives globally by offering evidence-based best practices supporting informed decision-making and promoting data literacy policies across various sectors and contexts.

2 Literature review

To foreground this study, the literature review focused on items from the 127 documents that included 'policy' in their titles, abstracts, or keywords as of April 23, 2024. Focusing on these specific documents aims to establish a direct connection between data literacy and the discourses that address policy. Further linking the analysis and findings to these documents also provides some understanding of how data literacy is being integrated into policy discussions, reflecting the current trends and priorities in the field.

Laprise (2006) was the first paper to address the role of policy in data literacy. The study analyses how successful nations have leveraged data literacy from pre-modern times, when it was human-mediated and focused on espionage and social engineering, to the modern era, where technology plays a significant role. Laprise describes the modern landscape as involving the subdivision of data literacy into data acquisition, analysis, and application processes. According to Laprise, this subdivision has led to inefficiencies and inconsistencies, particularly in the US government, where varying levels of data literacy cause disjointed efforts and undermine overall competency. Laprise recommends a consultative model where data acquisition, analysis, and policymaking specialists collaborate closely to bridge gaps, reduce misunderstandings, and foster a more integrated approach to data literacy. This teamwork approach leverages each stakeholder's strengths, ensuring a more cohesive and effective application of data literacy in policymaking.

Gardiner et al. (2011) was the second paper that discussed the subject and presented a case study on developing a digital archive for social sciences data related to Australian

Indigenous communities. This project, led by the Australian Indigenous Data Archive (ATSIDA), exemplifies the application of data literacy in a culturally sensitive context. The project tackles several technical and ethical challenges, such as respectful engagement with Indigenous communities and developing pragmatic data management strategies. The ATS DA project demonstrates how data literacy extends beyond mere technical proficiency. It requires a deep understanding of the cultural and social contexts in which data is collected and used. The project team employed a dynamic approach, continuously adapting strategies to address emerging issues. This process involves close collaboration with Indigenous communities, ensuring that the data management practices are respectful and beneficial to these communities.

Fotopoulou (202o) developed a sociotechnical conceptualisation of data literacies about citizens' data practices, highlighting agency, contextual, critical, and social aspects of data skills and competencies. The article emphasises the importance of considering data literacies as plural and evolving within civic cultures' material and social contexts. Fotopou ou's work contributes to advancing the debate on conceptualising data literacy. It underscores the need for frameworks and training schemes to enable civil society actors to engage with data effectively. Gebre and Morales (2022) critically reviewed conceptualisations of data literacy in K-12 education, proposing a broader framework that integrates conceptions, competencies, and contexts. The study identified four orientations of data literacy: development of competence, inquiry with data, awareness of personal data, and civic engagement. Gebre's research provides valuable insights for researchers and educators seeking to enhance data literacy education by offering a holistic and context-oriented framing of data literacy.

It has been observed that transparency about decisions, accessibility to resources used to make decisions, and even participatory processes to engage in the meaning of available information in decision-making should be tethered to policy and regulatory actions. Umbach (2022) provided conceptual reflections on statistical and data literacy in policymaking, emphasising the relevance of statistics and data in shaping policy decisions. This introductory piece sets the stage for individual contributions from the ISI World Statistics Congress 2021, offering insights into statistical and data literacy initiatives and their implications for policymaking. Gal et al. (2023) presented a comprehensive conceptual framework of eleven facets and tools describing the knowledge, skills, and dispositions that adults need to engage with Civic Statistics effectively. The framework, organised around engagement and action, knowledge, and enabling processes, offers

insights into teaching and learning about Civic Statistics within mathematics education, statistics, and data science education. Their work highlights the importance of developing curricula, instruction, and assessments to promote citizen empowerment through data literacy.

Vilar and Zabukovec (2019) examined research data literacy and management in scientific disciplines in Slovenia. They identified perception-related and behaviour-related connections through bivariate and multivariate analyses, highlighting the need for tailored approaches to research data management and literacy across disciplinary domains. Their findings offer valuable insights into research data management and literacy among Slovenian scientists. Ducheva (2019) examined students' digital competence at the Faculty of Technics and Technology - Yambol, focusing on their attitudes and readiness to develop digital competencies. The study highlights the integrative nature of digital competencies and emphasises the importance of lifelong learning in developing digital skills for workforce readiness. Yang et al. (2020) presented a scientific data life cycle model and management system, offering a theoretical basis for scientific data management in China. Their study provides insights into scientific data management policies and practices, advocating for clear data literacy and responsibilities among stakeholders.

Popham et al. (2020) reported on community perspectives about regulating municipality-led Big Data initiatives through a deliberative democracy-informed approach. Thematic analysis identified recurrent concerns regarding publicly vetted data ethics, consultation and literacy practices, and regulatory frameworks. The study highlights the importance of public consultation in addressing challenges associated with Big Data initiatives and underscores the need for locally relevant regulatory frameworks. Costa et al. (2017) examined the DesignOBS project in Portugal, focusing on infusing data literacy into educational design contexts. Through a longitudinal case study approach, the authors followed fifteen students from a design master course over a semester. Their study created data-focused infographics about design companies, richer datasets, and a transformation in students' perceptions of their potential roles in data contexts. This research contributes to ongoing discussions at the intersection of data literacy and design, reflecting on the value of adopting design approaches to promote more participatory reflections about the discipline.

Espinosa and Rangel (2022) examined the roles of civil society organisations in monitoring and reviewing the implementation of Sustainable Development Goals (SDGs) in Ecuador,

Colombia, and Argentina. Through empirical analysis, they identified five key roles of civil society organisations (CSOs) in SDG monitoring and reviewing: participation promoter, information provider, data innovator, watchdog, and advocate. These roles include making SDG-relevant data available to citizens, enhancing data literacy, promoting open data for transparency, and producing counter-narratives. The study underscores the importance of CSOs in fostering governance for sustainable development. Rafiq and Ameen (2020) assessed academic researchers' research data management (RDM) awareness, attitudes, and practices in Pakistan. Through a comprehensive survey, they explored various aspects of RDM, including data file formats, acquisition sources, storage patterns, metadata practices, and data-sharing behaviours. The findings have theoretical implications for researchers and practical implications for policymakers, university administrators, and educational trainers in shaping effective research data management policies and practices.

Golub and Lund (2021) conducted an exploratory study to identify potential use cases for open data in modern local governments, focusing on the context of the Växjö municipality in southeastern Sweden. They employed a two-fold methodology of surveying potential end users and analysing survey results using a theoretical model of local strategies for implementing open government data. The study identified various datasets predicted to be useful, primarily related to sustainability, environment, preschool, school, municipality, and politics. The findings emphasise the importance of educating target user groups on data literacy and highlight a tentative pattern comprising both technical and social perspectives on open data. Roche et al. (2022) assessed 362 open datasets linked to papers published in ecology and evolution over seven years to identify data completeness and reusability predictors. They found that datasets scored low on these metrics, with only 56.4% complete and 45.9% reusable. While d ta reusability was slightly higher for more recently archived datasets and less senior principal investigators (PIs), PI identity explained a significant proportion of the variance in data sharing practices. The study underscores the importance of research data management training and culture within research groups for enhancing data-sharing practices.

Prabhu et al. (2022) examined the gender divide in digital competence among hospitality students in India using the DigiComp framework 2.1. Their study found no gender difference in most parameters except problem-solving competence, highlighting the importance of addressing gender disparities in digital competence for sustainable development. The findings suggest implications for designing effective policies and interventions to promote digital gender equality in education. Luo et al. (2022) investigated

the factors influencing teachers' instructional data use involving electronic data systems in twelve middle schools in northern China. Their findings suggest that to promote teachers' instructional data use with ICTs, schools need to focus on performance-based accountability policies, cultivate supportive relationships among teachers, improve the accessibility of data systems, and enhance teachers' data literacy and ICT literacy. This study contributes to understanding how ICTs influence teachers' instructional data use and provides insights for educational policymakers and practitioners.

Kim and Yu (2023) conducted a scoping review of teacher data literacies practice with pedagogical documentation to investigate its landscape and knowledge gaps. Their analysis identified 62 studies and discussed implications for educational researchers, policymakers, and teachers. The review calls for more classroom-based research on teacher data literacy practice and underscores the need to understand the relationship between teacher data literacies and pedagogical documentation.

Schüller (2022) proposed a taxonomy of data and AI literacy, delineating three key roles: the informed prosumer, the skilled user, and the expert creator. Their research, based on qualitative literature analysis and expert group discussions, emphasises the importance of data and AI readiness for informed decision-making in the data age. This taxonomy lays the foundation for defining the core knowledge, skills, and competencies needed for data and AI literacy, paving the way for informed educational programs and policies. Tran et al. (2023) investigated the relationship between digital skills, ICT specialists, and economic development in European Union countries. Through secondary data analysis, they found strong correlations between digital skills and economic development, highlighting the pivotal role of digital literacy in fostering economic growth and innovation. Their study underscores the importance of digital skills and ICT specialists in shaping policies for digital transformation in Europe.

The review reveals the critical role of data literacy in shaping effective policies across various domains. Conceptual studies by Fotopoulou (2020) and Gebre and Morales (2022) emphasise data literacy's evolving and holistic nature, which is essential for civic engagement and education. Umbach (2022) highlights its importance in policymaking, advocating for data-informed decisions. Empiric l research by Vilar and Zabukovec (2019) and Rafiq and Ameen (2020) underscores tailored research data management policies, while Popham et al. (2020) stress ethical considerations and stakeholder responsibilities in scientific and Big Data contexts. Educational studies by Costa et al. (2017) and Kim and

Yu (2023) highlight the integration of data literacy in curricula and teacher practices, reinforcing its importance in educational policy. Finally, Schüller (2022) and Tran et al. (2023) link digital and AI literacy to economic development, emphasising the need for policies that foster digital skills for economic growth and informed decision-making. These insights call for comprehensive data literacy policies to equip individuals and institutions to effectively navigate and leverage data in various sectors.

3 Methodology

A search was initiated in the Scopus database to establish the quantity of research on data literacy that touched on policy. In recent papers, Nwagwu (2024a, 2024b) explicates the benefits of using Scopus for bibliometrics analysis that involves global research in any area. It is more comprehensive in global research than Web of Science. The syntax used was ("POLIC*.*" AND "DATA LITERACY"). This search yielded 127 documents after one spurious result was deleted. The resulting database was exported as a CSV file. VOSview r ver 16.20 was used to visualise the network of the terms in the documents that included the term policy and also to develop the table of the keywords detailing their links, clusters, total link strength and occurrences, concepts that have been explained in Nwagwu (2024b). Python is used to develop a programme to count the occurrence of policy in the title, abstract and keywords of the documents downloaded from Scopus. In this regard, we counted (i) the number of times the policy occurred in title, abstract and keywords, (ii) the number of times the policy was followed by or (iii) preceded by a term.

4 Results

Scopus indexed a total of 997 documents on data literacy as of December 2023. Of this number, only 127 or 13% mentioned policy in their titles, abstracts or keywords. Of this 13%, policy is mentioned 153 times in the titles, abstracts and keywords of the 127 papers retrieved from Scopus. The figure shows further that "policy" is most frequently mentioned in the abstracts of papers on data literacy, with 111 mentions suggesting that discussions or considerations of policy are prevalent in the main content of these papers.

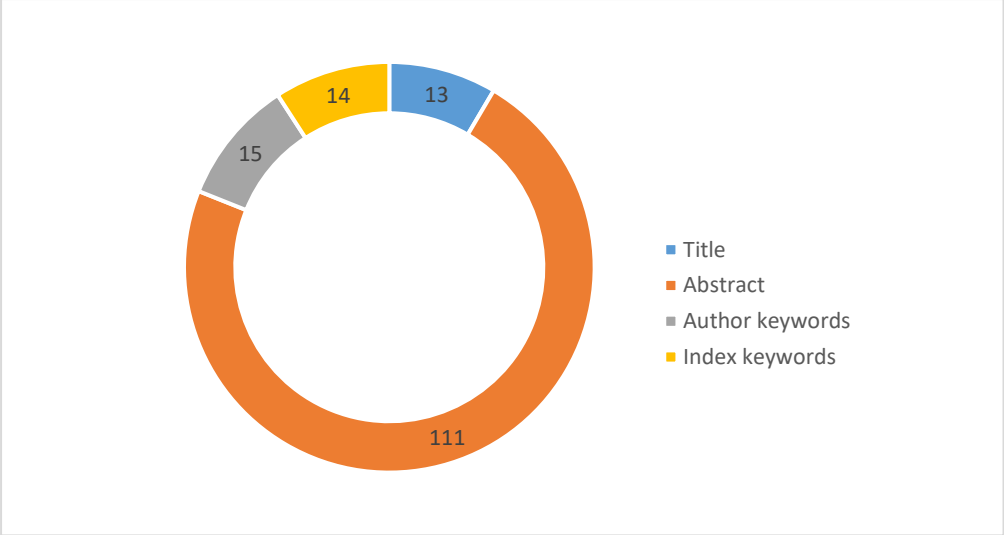

Figure 1: Number of times policy mentioned in titles, abstracts and keywords

Policy appears less frequently in the titles (13 mentions), showing that while policy is an important aspect of the studies, it might not be the central focus of many papers. The mentions in author and index keywords (15 and 14 times, respectively) indicate that policy is recognised as significant but is not always highlighted as a primary keyword by the authors and indexers. What follows is a visualisation of the keywords in the 127 documents that addressed policy in data literacy.

Figure 2 depicts a network visualisation of terms related to "data literacy" generated using VOSviewer. At the centre of the network, "data literacy" stands out as the most connected and prominent term, underscoring its broad relevance and critical importance across the documents. Surrounding this central node, distinct clusters of related terms emerge, each highlighting different aspects of data literacy. One prominent cluster focuses on the educational aspect, with terms like "students," "libraries," "secondary education," and "data science." This cluster emphasises the integration of data literacy into educational curricula and the role of libraries as critical resources for fostering these skills. It also highlights the importance of preparing students to navigate a data-driven world early on.

Another significant cluster revolves around governance and ethical data use, featuring terms such as "data privacy," "open government," "data use," and "data-driven decision making." This cluster reflects contemporary concerns about data privacy, the role of transparent governance, and the ethical implications of using data in decision-making processes. It highlights the necessity of establishing robust frameworks to ensure data is used responsibly and ethically. Educational strategies and civic engagement form another cluster, with terms like "learning design," "participatory approach," "civic engagement,"

and "learning analytics." This cluster focuses on how data literacy can enhance educational experiences and promote active participation in civic life, illustrating the transformative potential of data in both personal and societal contexts.

Yet, another cluster, emphasising the need for digital competence, features terms such as "digital competence," "statistics," "data practices," "ethics," and "misinformation." This cluster stresses the importance of equipping individuals with the skills to critically evaluate and ethically use data, particularly in an era of misinformation. It points to the crucial role of statistical literacy and ethical considerations in fostering a well-informed and responsible citizenry. Additionally, there is a cluster concentrating on statistical literacy and education, including terms like "statistical literacy," "statistics education," and "learning analytics." This highlights the foundational role of understanding statistics as a key component of broader data literacy.

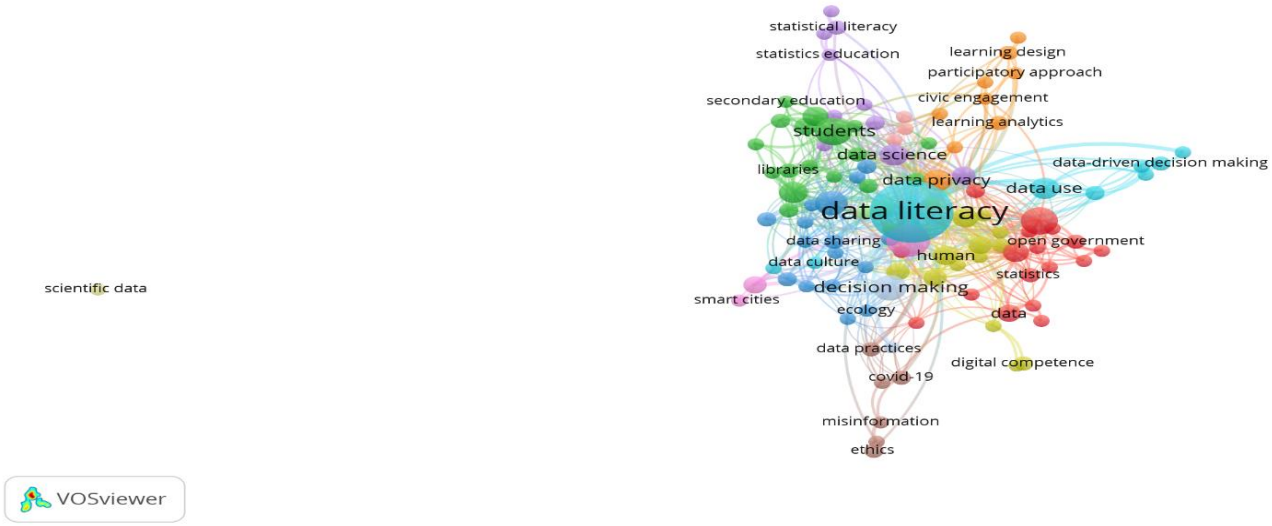

Figure 2: Visualisation of network visualisation of terms in documents that addressed policy in data literacy

Interestingly, the term "scientific data" appears isolated from the main network, suggesting that while it is related to data literacy, it may be considered a specialised or niche area within the broader context. The dense web of connections among terms like "data literacy," "decision making," "data privacy," and "learning design" illustrates the interdisciplinary nature of data literacy. It shows that advancing data literacy requires a multifaceted approach that includes education, ethical considerations, governance, and practical applications. This virtualisation vividly portrays the complexity and interconnectedness of

data literacy, indicating that efforts to improve it must be collaborative and holistic, spanning different sectors and disciplines.

Table 1 shows how the various keywords contribute uniquely to understanding the intersection between policy and data literacy. Sorting these keywords by different fields, such as clusters, links, total link strength, and occurrences, provides valuable insights into their thematic relationships and significance. Sorting the keywords by their cluster numbers reveals thematic groupings, indicating areas of focused research within the broader topic. Let us begin with clusters. Cluster 1 comprises keywords such as "Policy," "Open data," and "Public policy," reflecting a strong emphasis on governance and transparency in data use. This cluster includes seven keywords with 32 links, a total link strength of 14, and 14 occurrences, highlighting the importance of policy frameworks and government involvement in data literacy. In Cluster 2, the focus shifts to educational contexts, with keywords like "Students," "Curricula," and "Teachers." This cluster includes 6 keywords, amassing 82 links, a total link strength of 36, and 25 occurrences. The prominence of these terms underscores the critical role of education in fostering data literacy among students and educators.

Table 1: Top 30 Keywords of Research Connecting Policy with Data Literacy

S/N	Label	Cluster	Links	Total link strength	Occurrences
1	Data literacy	6	73	43	50
2	Big data	9	45	13	14
3	Students	2	28	10	10
4	Open data	1	32	9	10
5	Decision making	12	31	9	9
6	Information management	3	32	8	8
7	Data privacy	7	32	6	6
8	Data use	6	16	6	6
9	Data Science	5	25	6	6
10	Surveys	2	33	6	6
11	Human	4	30	5	5
12	Information literacy	4	27	5	5

13	Teachers	2	18	5	5
14	Public policy	1	24	5	5
15	Higher education	11	18	4	4
16	Data governance	9	9	4	4
17	Education	5	17	4	4
18	Article	4	25	4	4
19	Behavioural research	4	24	4	4
20	Data quality	4	24	4	4
21	Curricula	2	13	3	4
22	Data	1	9	4	4
23	Covid-19	8	10	3	3
24	Data practices	8	9	3	3
25	Ethics	8	2	1	3
26	Learning analytics	7	9	3	3
27	Learning design	7	7	3	3
28	Accountability	6	14	3	3
29	Data-driven decision making	6	6	3	3
30	Statistical literacy	5	5	3	3

Cluster 3 features keywords related to data accuracy and sharing, such as "Data accuracy," "Data sharing," and "Information use." This cluster contains 8 keywords with 97 links, a total link strength of 33, and 16 occurrences, highlighting the technical aspects of data management and the importance of reliable data handling practices. Cluster 4 includes terms related to data quality and ethical considerations, like "Data quality," "Behavioral research," and "Information literacy." With its 13 keywords, this cluster accumulates 219 links, a total link strength of 103, and 39 occurrences. The substantial figures here reflect the significant focus on ensuring high standards and ethical practices in data management. In Cluster 5, the keywords pertain to educational technology and its applications, including "Data science," "Education," and "Educational technology." This cluster comprises 11 keywords, contributing 125 links, a total link strength of 61, and 27 occurrences, indicating a robust interest in integrating data literacy within educational technologies.

Cluster 6 is characterised by terms associated with decision-making and data ethics, such as "Accountability," "Data ethics," and "Data utilisation." This extensive cluster includes

16 keywords, resulting in 134 links, a total link strength of 60, and 70 occurrences, emphasising the critical need for ethical data practices and informed decision-making in data-related policies. Cluster 7, meanwhile, focuses on privacy and civic engagement, with keywords like "AI in education," "Civic engagement," and "Data privacy." With 16 keywords, this cluster contributes 117 links, a total link strength of 46, and 32 occurrences, reflecting ongoing concerns about privacy and the role of artificial intelligence in education.

When sorted by Links, the keywords highlight the centrality of certain concepts within the research network. "Big data" has 45 links, indicating its central role in policy and data literacy discussions. The key word, "Data literacy", follows closely with 73 links; though its number of links is not the highest, its influence remains significant due to its widespread connectivity. "Decision making," with 31 links, also emerges as a crucial concept, reflecting its relevance across various research contexts. These highly linked keywords suggest focal points where multiple research themes converge, underscoring their importance in the broader discourse on data literacy and policy. Sorting by Total Link Strength provides insight into the intensity of the connections between keywords. "Data literacy" leads with a total link strength of 43, emphasising its pivotal role in the research papers network. This ke word's strong connections indicate its foundational position in the field. "Big data," with a total link strength of 13, shows that the individual link strengths may vary while it has numerous connections. This could suggest that "Big data" is widely discussed but with differing levels of impact across studies. "Information management," with a total link strength of 8, also stands out, highlighting its importance in managing and utilising data effectively within policy frameworks.

Finally, sorting by occurrences reveals the most frequently appearing keywords, indicating dominant themes in the research. "Data literacy" is the most frequently occurring keyword, with 50 occurrences confirming its prominence and critical importance in the field. This keyword's high occurrence reflects the central role of data literacy in connecting policy and research. "Big da a," with 14 occurrences, also features prominently, demonstrating the significant interest in understanding and leveraging large datasets within policy contexts. "Decision-making," appearing 9 times, focuses on the processes and implications of making informed decisions based on data.

5 Discussion

The results from the study on the policy mentions in data literacy research reveal several key insights about the relationship between data literacy and policy, alongside the broader context in which this relationship is situated. One of the most critical takeaways is the relatively low presence of policy discussions in data literacy research, with only 13% of the 997 documents on data literacy directly mentioning policy in their titles, abstracts, or keywords. This suggests that while policy is a significant aspect of data literacy, it is not consistently at the forefront of research in this domain. The implications of this are twofold: it indicates a need for greater integration of policy considerations into data literacy research and practice. It also highlights an underexplored area that could offer valuable insights for both academic and practical applications.

This finding aligns with recent studies that highlight similar gaps. For example, Kellner and Share (2019) identified a lack of focus on policy frameworks in data literacy education, emphasising that data literacy is often treated as a technical or skill-based area without adequately considering the policy dimensions that influence its broader societal impact. Similarly, a 2023 paper by Benton et al. explored the integration of data literacy into public policy, arguing that insufficient attention to policy undermines the effectiveness of data literacy initiatives, particularly in governance and decision-making contexts. Both studies support that policy considerations are vital but underdeveloped in the current discourse, reinforcing the need for more targeted research and policy integration to address this gap.

The most frequently mentioned policy in the abstracts (111 mentions) rather than titles or keywords suggests that policy is often discussed in the body of the papers, implying it is considered in a secondary capacity. This could reflect a broader tendency within the field to view policy as a supporting factor rather than a central focus of the research. However, the increasing importance of data governance, privacy, and ethical use may signal a gap in the literature where more explicit attention to policy frameworks is needed. The fact that policy is mentioned more frequently in abstracts rather than titles or keywords suggests that, in much of the research, it is treated as a secondary issue rather than a core focus. This reflects a broader trend of emphasising technical aspects over policy considerations in data literacy research. However, growing concerns around data governance, privacy, and ethical use reveal a gap in the literature where a more explicit focus on policy frameworks is needed. Addressing this could lead to a more comprehensive approach to data literacy that includes legal and ethical dimensions, as de Waal et al. (2018) highlighted.

The visualisation of keyword networks further emphasises the interdisciplinary nature of data literacy, with clusters highlighting different focal points such as education, governance, ethics, and digital competence. For instance, the prominent clusters around educational integration and governance suggest two primary areas where policy considerations are crucial. In education, data literacy is increasingly recognised as vital for equipping students with the skills to navigate a data-driven society. At the same time, governance-related clusters reflect the growing need for policies around data privacy, open data, and ethical data use. These clusters underscore the importance of creating comprehensive policy frameworks that support the educational infrastructure needed to foster data literacy and the governance structures necessary to ensure its ethical and responsible use.

The isolation of the term "scientific data" from the main network could indicate that scientific data literacy is considered a niche or specialised area within the broader field, possibly requiring more targeted policy interventions. This highlights the need for differentiated approaches to policymaking tailored to specific aspects of data literacy, whether for general education, governance, or specialised fields like scientific research. The clustering of terms such as "digital competence," "ethics," and "misinformation" draws attention to the urgent need for policies that address the challenges posed by misinformation and unethical data practices in today's digital environment. As the analysis reveals, there is an emerging focus on fostering critical evaluation skills and ethical data use, suggesting that policymakers must prioritise these areas to protect the integrity of data literacy efforts. This aligns with global concerns about misinformation and data manipulation, reinforcing that effective policies must safeguard data integrity and promote informed, ethical data practices. Similarly, de Waal et al. (2018) argue for stronger governance and ethical frameworks in data policy to handle data misuse and privacy issues, aligning with your findings' governance and ethics clusters. Both studies advocate for differentiated policy interventions in addressing data-related challenges.

The strong connection between keywords like "data literacy," "decision making," and "data privacy" reflects the increasing recognition of data literacy as a foundational skill for informed decision-making in both governance and everyday life. This has significant implications for policy development, particularly ensuring that individuals and organisations have the necessary literacy to make ethical, data-driven decisions. Policymakers, therefore, need to view data literacy not merely as a technical skill but as a crucial component of informed citizenship and governance. The analysis points to the need

for a more explicit focus on policy in data literacy research. The interconnectedness of terms in the network visualisation reflects the complex, multifaceted nature of data literacy, requiring policies that address educational, ethical, and governance dimensions in an integrated manner. Policymakers must consider this complexity when designing frameworks to support data literacy initiatives, ensuring that they address the diverse contexts in which data literacy is applied, from education to governance and civic engagement. By doing so, they can foster a more data-literate population capable of navigating the challenges and opportunities of the data-driven world.

The strong connection between keywords such as "data literacy," "decision making," and "data privacy" underscores the growing recognition of data literacy as a fundamental skill for navigating the complexities of today's data-driven world. Data literacy is no longer seen merely as a technical ability but as an essential component of informed citizenship and effective governance (Franks, 2022). This recognition highlights the importance of equipping individuals and organisations with the skills to make ethical and data-driven decisions. This is crucial for addressing the challenges and opportunities an increasingly data-centric environment poses.

Recent analyses reveal that the interconnectedness of these terms reflects the multifaceted nature of data literacy. Data literacy is not a standalone skill but a framework that encompasses understanding data's role in decision-making processes and managing data privacy effectively. The visualisation of this interconnectedness in recent studies illustrates that data literacy involves more than just interpreting numbers - it is about integrating data insights into decision-making processes while upholding privacy and ethical standards (Leon-Urrutia et al., 2022).

Policymakers must consider this complexity when designing frameworks to support data literacy initiatives. Effective policy development should address the educational dimensions of data literacy and its ethical and governance aspects. This involves creating policies that support data literacy from the ground up by embedding it into educational curricula, developing ethical guidelines for data use, and establishing governance frameworks that promote transparency and accountability (Kang & Kim, 2021). A holistic approach to data literacy policy will help foster a more data-literate population capable of making informed decisions and engaging meaningfully in the digital age. By incorporating data literacy into policy development, governments and organisations can better prepare

individuals to navigate the complexities of data privacy and make ethical decisions that impact both personal and societal levels (Ghodoosi et al., 2024).

6 Conclusion

The findings underscore the critical yet underexplored connection between data literacy and policy. Despite the increasing relevance of data governance, privacy, and ethical use, policy discussions are often secondary in data literacy research, signalling a gap that needs addressing. There is a clear need for a more robust integration of policy frameworks into data literacy discourse, particularly in education, governance, and ethical data practices. The visualisation of keyword networks further reveals the interdisciplinary nature of data literacy, highlighting clusters like education and governance, where policy considerations are crucial. To navigate the complexities of today's data-driven world, policymakers must adopt a comprehensive approach that integrates data literacy with governance and ethical frameworks, ensuring that individuals and organisations are well-equipped to make informed, ethical decisions. As research continues to emphasise these intersections, developing policy frameworks that reflect the multifaceted nature of data literacy will be vital in shaping a more data-literate society. This conclusion aligns with recent studies, such as Franks (2022), which emphasised the importance of data literacy as a crucial component of informed governance, and Kang and Kim (2021), which advocated for embedding data literacy into educational and governance frameworks. Additionally, Ghodoosi et al. (2024) and Leon-Urrutia et al. (2022) stress integrating data privacy and ethical decision-making into the policy landscape. Together, these studies reinforce the importance of a holistic, policy-oriented approach to fostering data literacy.

7 Recommendations for policy and practice

To enhance the integration of data literacy into broader societal frameworks, policymakers should prioritise embedding discussions on governance, privacy, and ethical considerations directly into educational curricula. This would ensure that individuals are equipped with the technical skills to manage data and a comprehensive understanding of the legal and ethical implications surrounding its use. Furthermore, data literacy policies should be tailored to specific sectors, such as scientific research, education, and governance, acknowledging that each has unique requirements. These targeted policies would address sector-specific challenges while promoting ethical data practices. Establishing strong governance frameworks is also crucial to safeguard against misinformation and unethical data use, ensuring accountability and transparency in the data-driven landscape. By

developing policies fostering ethical data practices, policymakers can better support informed decision-making, empowering individuals and organisations to navigate the complexities of responsibly using data.

8 Future studies

Future studies could address the question of exploring Policy Integration in Data Literacy and how policy frameworks can be more effectively integrated into data literacy initiatives across different sectors. This includes understanding the role of governance, privacy, and ethical issues in shaping data literacy practices. Also, to develop more tailored interventions, sector-specific data literacy needs could be examined to understand various industries' unique data literacy requirements, such as education, healthcare, and scientific research. Also, data literacy on decision-making could be assessed to assess the impact on decision-making processes at individual, organisational, and governmental levels, exploring how improved literacy influences ethical and informed decision-making.

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