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RESEARCH ARTICLE

Open Science Movement and Researchers' Perspectives in Higher Learning Institutions: A Conceptual Framework

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ABSTRACT

This study investigates the role of researchers in the open science movement and its impact on conducting research activities. The open science movement advocates for the broader sharing of research outputs by emphasizing transparency, productivity, and reproducibility. The current study presents a conceptual framework grounded in open science, one term, five schools of thought, and practical guidelines from both print and online sources. The framework developed five key concepts: Research Data Management (RDM), storage and publishing, Responsible Conduct of Research (RCR), ethical considerations, and infrastructure and measurements. These components reflect researchers' perspectives on their involvement in the open science movement. The findings underscore the significance of the open science movement throughout the research lifecycle, highlighting benefits such as increased collaboration, publishing, easier sharing of research data, and greater visibility of published works. This framework serves as a practical guide for researchers in higher education, aiming to enhance the accessibility and openness of their work. Additionally, it provides institutions with a clear strategy to advance the open science movement more efficiently and effectively. The framework emphasizes the growing importance of open science in improving research quality and transparency. It will also assist policymakers in guiding Higher Learning Institutions (HLIs) in developing policies for implementing the open science movement within HLIs and other research organizations.

INTRODUCTION

The Open Science (OS) movement represents a significant shift in how scientific research is conducted and shared. This movement advocates unrestricted access to scientific knowledge, enabling researchers and society to engage with, utilize, and publish scientific findings without constraints such as copyright, patents, or other control mechanisms (Medeiros, 2021; Schmidt, Orth, and Franck, 2016). The Organisation for Economic Co-operation and Development (OECD, 2015, p. 1) defines OS as the process of "making the primary output of publicly funded research, namely, scientific publications and research data, openly accessible to researchers and innovators alike." This concept is further supported by the European Commission (2016, p. 6), which describes OS as "a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge through digital technologies and collaborative tools". OS movement involves conducting scientific research to promote collaboration and contributions from others, ensuring that research data, lab notes, and other processes are freely accessible under terms that facilitate reuse, redistribution, and reproduction, along with the underlying data and methods (FOSTER, 2020).

Historically, the term OS emerged in the late 16th and 17th centuries, signifying a shift towards openness in scientific practices (David, 2008). Adopting the OS movement over the past decade has significantly enhanced scientific results' rigor, reliability, and reproducibility across various research

fields (Allen and Mehler, 2019; Munafò et al., 2017). This transformation coincided with epistemological changes stemming from integrating experimentalism and renaissance mathematics, which altered the cultural ethos and social organization of scientific activities in Western Europe (David, 1998; 2008; Medeiros, 2021; Schmidt, Orth, and Franck, 2016). However, scientific inquiry often operated in secrecy, with knowledge being closely guarded and exclusive. The advent of OS can be used to enhance collaboration and knowledge-sharing, largely driven by exchanging letters and establishing scientific journals (Medeiros, 2021).

The OS movement gained further traction in the late 20th century when CERN (the European Organization for Nuclear Research) placed World Wide Web (WWW) software in the public domain (European Commission, 2016). CERN has developed several technologies designed with open access (OA|) in mind, including Invenio, an open-source library management system; Indico, an open-source platform for conference and event management; and INSPIRE, the High Energy Physics information system, created in collaboration with DESY, Fermilab, and SLAC (European Commission, 2016). Today, the OS movement continues to evolve, offering new opportunities for researchers to share their work openly, enhance collaboration, and improve the transparency and reproducibility of their research (OECD, 2015). As a developing research paradigm, OS has become one of the most prominent topics within the scientific community (Friesike et al., 2015; Fecher and Friesike, 2014). The core idea behind the OS movement is to ensure that scientific research products, including information, data, and research outputs, are freely available, transparent, and openly accessible (Zarghani et al., 2023). The OS movement is not limited to publications alone; it also encompasses various initiatives such as OA, open research data, open data sharing, open-source software, open collaboration, peer review, educational resources, and citizen science (OECD, 2015; Schmidt, Orth and Franck, 2016; Medeiros, 2021). For instance, OA aims to make all scholarly communications freely available with full reuse rights, while open-source and open-data initiatives focus on sharing materials like questionnaires, forms, procedures, collected data, metadata, and source code. These efforts promote replication studies, increase data reuse, and facilitate peer review (Goecks et al., 2010). The COVID-19 pandemic has powerfully illustrated the global significance of the OS movement (Mitchell, 2022). According to Mitchell (2022), the pandemic underscored the necessity and benefits of making knowledge accessible and openly sharing research data, results, and the entire research process. The swift dissemination of COVID-19 data and research findings enabled scientists worldwide to collaborate effectively, accelerating the development of treatments and vaccines and showcasing the critical role of OS movements in addressing global challenges (Besançon et al., 2021).

OS movement in higher learning institutions

In higher learning institutions (HLIs), the OS movement has become crucial for scholarly communication, enabling researchers to share their data and findings more openly (Mullen, 2024). While OS is often seen as an extension of the OA movement primarily focused on making published knowledge freely available, it promotes access to the entire research process. This includes open data, methodologies, Free and Open-Source Software (FOSS), and libre hardware (Heise and Pearce, 2020). By adopting OS principles, researchers in HLIs can enhance their societal impact, facilitate the reproducibility of their findings, and reduce the costs and time involved in research activities (Grahe et al., 2020; Heck et al., 2020; Older, 2021). Paic (2021). identifies several benefits of the OS movement for researchers, including opportunities for new scientific discoveries, improved reproducibility of results, enhanced cross-disciplinary collaboration, economic growth through innovation, greater resource efficiency, and increased transparency and accountability in the use of public funds. However, increased access also brings risks related to privacy, intellectual property, national security, and public interest concerns, such as the protection of rare and endangered species (OECD, 2015). Despite its numerous advantages, OS movement remains a complex and evolving concept. Many researchers and institutions still struggle to implement OS practices effectively (OECD, 2020; Pontika et al., 2015; Heise and Pearce, 2020; OECD, 2020). Van de Stadt (2017) emphasized that researchers operate in a demanding and competitive environment that requires new tools and resources to enhance their research efficiency and productivity. Also noted is the significance of adopting the OS movement, which can substantially improve researchers' visibility and impact.

METHODOLOGY

To address the gap for researchers in HLIs who do not comply with the OS movement to address their research activities, the present study has developed a conceptual framework to guide researchers in engaging with the OS movement. This framework builds on the work of Fecher and Friesike (2014), who identified five key schools of thought within the OS movement, each providing a comprehensive understanding of its various dimensions as follows:

i. Infrastructure school focuses on the technological architecture necessary to support OS, including digital repositories and OA platforms.
ii. A public school emphasizes the accessibility of knowledge creation and the democratization of science.
iii. Measurement school that addresses alternative impact metrics, moving beyond traditional citation metrics to incorporate social and collaborative measures.
iv. The democratic school advocates for open access to knowledge and ensures that scientific research is freely available to everyone.
v. A pragmatic school that highlights the importance of collaborative research and using open-source tools and platforms to foster scientific cooperation (Fecher and Fireside, 2014; Van de Stadt, 2017).

Figure 1 presents the five identified OS, one term, five schools of thought schools, their central assumptions, and the goals and keywords employed to achieve and promote these aims.

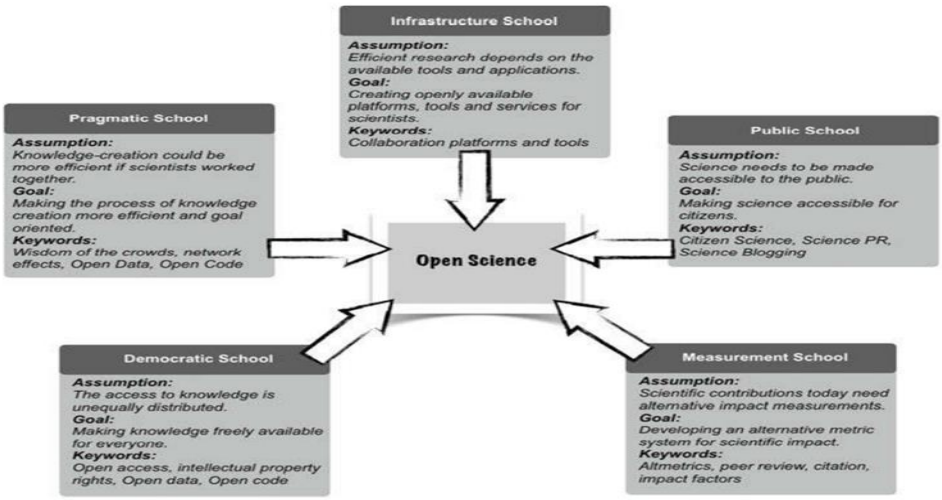

Figure 1: Open science, one term, five schools of thought (Fecher and Friesike, 2014)

Van de Stadt (2017) has further refined Fecher and Fireside (2014) framework to emphasize research productivity, providing practical strategies for integrating OS movement into researchers' workflows as follows:

i. Infrastructure school as research data.
ii. A public school as science for society.
iii. Measurement school as alternative metrics.
iv. The democratic school as an open access.
v. A pragmatic school as scholarly collaboration and networks.

By embracing the principles of these five schools of thought (original and modified), researchers can enhance their productivity, increase the visibility of their work, and contribute to the broader OS movement. Figure 2 illustrates the open science, one term, five schools of thought after being modified by (van de Stadt, 2017)

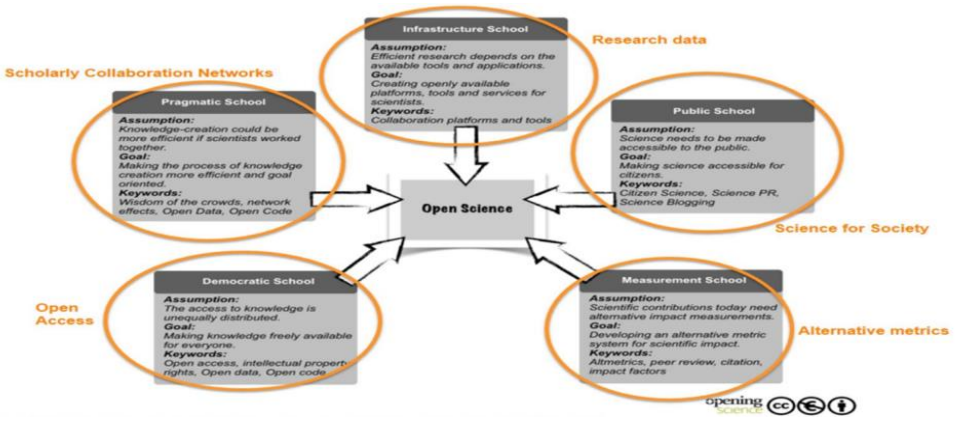

Figure 2: Modified open science, one term, five schools of thought (Van de Stadt, 2017).

Description of the open science, one term, five schools of thought

Public school (science accessible to the public)

The central idea of the public school of thought in the OS movement is to make science more accessible to a broader audience (Fecher and Friesike, 2014). This school raises a key question: "Can anyone be a scientist?" (Fecher and Friesike, 2014). The basic assumption herein is that scientists in the social web and Web 2.0 technologies participate in the OS movement by sharing research hands to process and prepare the research product for interested non-experts (Fecher and Fireside, 2014). Fecher and Fireside (2014) recognized two sub-streams: the accessibility of the research process (the production) and the comprehensibility of the research result (the product). Both streams involve the relationship between scientists and the public and define openness as a form of devotion to a wider audience (Fecher and Fireside, 2014). Fecher and Friesike (2014) distinguished between two streams of this school: one focuses on the accessibility of the research process, while the other emphasizes the comprehensibility of research results. Both streams underscore the relationship between scientists and the public, framing openness as a commitment to a broader audience.

Van de Stadt (2017) referred to this school as "Science and Society," recognizing the impact of scientific, technical, and medical research on people's lives worldwide. Within the OS movement, public schools seek not only to make science accessible to communities but also to involve citizens directly in the research process.

The democratic school (access to knowledge)

The democratic school of thought focuses on the concept of equal access to knowledge, arguing that knowledge should be distributed equitably (Fecher and Friesike, 2014). This school emphasizes the importance of ensuring that research outputs are accessible to all. Fecher and Friesike (2014) highlight the principal goal of providing access to research products. Cribb and Sari (2010) provide a compelling example, arguing that open access to scientific knowledge is a fundamental human right. Van de Stadt (2017) similarly views the democratic school as advocating for open access to research.

Pragmatic school (collaborative research)

The pragmatic school, also known as the scholarly sharing and collaboration school, aims to make research more accessible, participatory, and inclusive (Bartling and Friesike, 2014; Fecher and Friesike, 2014; Van de Stadt, 2017). The key principle here is fostering research collaboration. Bartling and Friesike (2014) argue that pragmatic OS promotes knowledge creation through interactions between scientists and various stakeholders. This approach supports the concept of networked science, where open collaboration is seen as a transformative way to understand the world and the role of science within it (Nielsen, 2020). Nielsen (2020) further explained that the goal is to create common scientific information in a world where all scientific knowledge is available online, promoting unprecedented openness and collaboration in science. Van de Stadt (2017) highlighted that a pragmatic school entails sharing and collaborating on research activities and renamed this school a scholarly collaborative network. Van de Stadt (2017) highlighted that scholars have shared various versions of their scholarly articles with their colleagues in specific journals, and

sometimes online versions and online distribution make it much easier to share scholarly articles and research data (Van de Stadt, 2017).

Infrastructure school (technological architecture)

The infrastructure school is concerned with the technical infrastructure that enables emerging research practices on the Internet (Fecher and Friesike, 2014). That concerns mainly software tools and applications and computing network requirements for projects, e.g., OS Grid (Fecher and Fireside, 2014). In a nutshell, the infrastructure school regards OS as a technological challenge. Van de Stadt (2017) renamed these schools as data. According to Van de Stadt (2017), various innovations throughout the data cycle, including lab data tools and data repositories, data micro-articles (Data in Brief), data availability, in-article data visualization, data linking programs and standards bodies, and working groups. Various missions and policies were also established including Elsevier Research Data Policy, "Raw research data should be made freely available to all researchers wherever possible" STM Brussels Declaration 2007, as well as we help researchers store, share, discover, and use data (Van de Stadt, 2017).

Measurement school (with alternative impact measurement)

The measurement school is concerned with alternative standards to ascertain scientific impact (Fecher and Friesike, 2014). Accordingly, this school argues the case for an alternative and faster impact measurement that includes other forms of publication and the social web coverage of a scientific contribution (Fecher and Friesike, 2014). The general credo is: As the scholarly workflow is increasingly migrating to the web, formerly hidden uses like reading, bookmarking, sharing, discussing, and rating are leaving traces online and offer a new ground to measure scientific impact (Fecher and Fireside, 2014). The umbrella term for these new impact measurements is altmetrics (Fecher and Friesike, 2014). However, Van de Stadt (2017) renamed these schools as Metrics. Van de Stadt (2017) highlighted some of Elsevier's views on research metrics concerning metrics:

- A diversity of metrics is essential
- The methodology should be open and data-agnostic
- Metrics should be transparent, valid, and replicable
- The community should own definitions
- Metrics should be used appropriately
- No proprietary/black-box metrics.

FINDINGS

The current study has developed a conceptual framework encompassing OS, defined through one term and five schools of thought (Fecher and Friesike, 2014; Van de Stadt, 2017). Figure 3 illustrates this framework, titled "Open Science Movement Conceptual Model: A Researchers' Perspective". The study also drew on published literature to explain how the OS movement can support researchers in conducting their research more effectively.

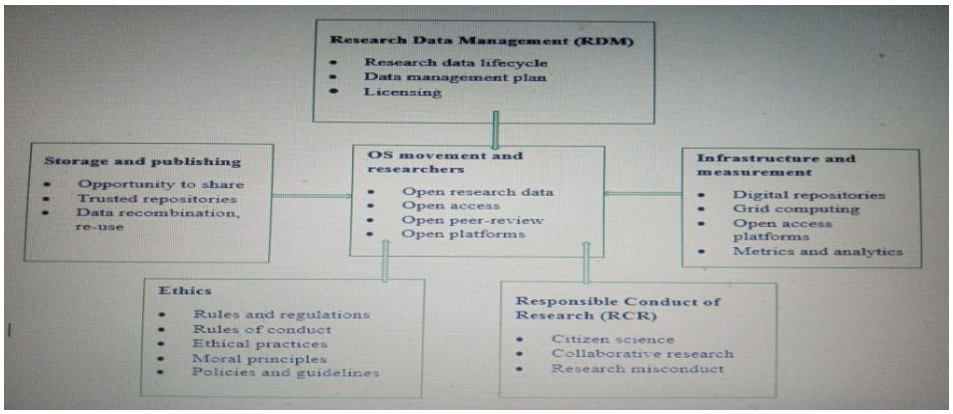

Figure 3: OS Movement conceptual model: A researchers' perspective

OS movement conceptual model: a researchers' perspective

The developed OS movement conceptual model: A Researchers' Perspective. This framework incorporates concepts from OS, defined through one term and five schools of thought (Fecher and Friesike, 2014; Van de Stadt, 2017), while specifically focusing on the researchers' perspective. It introduces new components and modifies existing ones under the umbrella of the OS movement, including RDM, ethics in research, RCR, storage and publishing, infrastructure, and maintenance. These components enhance the "openness" of research data, published articles, and related materials. For instance, RDM practices provide a valuable entry point for promoting OS practices for researchers, librarians, and other data stakeholders through RDM components like Data Management Plans (DMP) and research data sharing (Borghi and Van Gulick, 2022).

Borghi and Van Gulic (2022) emphasized that the term RDM encompasses a variety of activities related to how researchers save, organize, and describe the materials they work with throughout a research project. This highlights the necessity of connecting RDM, reproducibility in scientific outputs, and the OS movement, along with guiding realizing the value of data management from a laboratory perspective (Borghi and Van Gulick, 2022). This connection can also relate to RCR, where collaborative research, engagement of citizens, and opportunities for sharing and publishing intersect. The FAIR principles of findability, accessibility, interoperability, and reusability (Mons et al., 2017; Wilkinson et al., 2016) offer a foundational framework for addressing RDM and sharing considerations. These principles were established to define the characteristics that data-related infrastructures should adopt to facilitate data reuse. Opportunities for sharing can also be enhanced by implementing effective data storage mechanisms, which allow researchers to choose trusted repositories for storing research data through research data repositories (RDR) and other documents like research articles, conference proceedings, books, and book chapters using institutional repositories (Markiewicz et al., 2021).

These repositories play a crucial role in maintaining and promoting standards. For instance, the Brain Imaging Data Structure (BIDS) is integral to the Open Neuro Repository, enabling effective curation, sharing, and reuse of data (Markiewicz et al., 2021) while adhering to the FAIR principles for data sharing (Markiewicz et al., 2021). The concept of openness in scientific data is deeply intertwined with the FAIR principles (Khalil, Shinwari, and Islam, 2022). Similarly, the Inter-university Consortium for Political and Social Research (ICPSR) promotes the Data Documentation Initiative (DDI) (Vardigan et al., 2008) as a standard for survey data. The OS movement comprises a variety of practices aimed at enhancing research reliability, including sharing data and research materials (Allen and Mehler, 2019; Harremoes, 2019). Resources such as FAIRsharing.org and the Registry of RDRs offer valuable information on standards and repositories tailored for specific data types and disciplinary communities (Allen and Mehler, 2019; Harremoes, 2019). Similarly, the upcoming NIH data policy (National Institutes of Health, 2020) outlines a set of "desirable characteristics for all research repositories," which include assigning persistent identifiers and establishing a plan for long-term sustainability. This guidance is intended to inform decisions regarding platforms for managing and sharing data generated from federally funded research (Harremoes, 2019).

Depending on the nature of the data, deidentification or anonymization may not always be feasible (Rocher et al., 2019). This means that while granting access to the data to specific individuals under certain conditions might be possible, public sharing may not be an option. Like RDM, open data sharing must address issues that extend beyond the research team's expertise (Borghi and Van Gulick, 2022). Standards regarding what data should be openly shared, such as raw versus processed data, may vary by discipline or data type, including specifications for data formats and licensing. Moreover, there is a distinction between openly available data and shared in a truly usable format (Borghi and Van Gulick, 2022). Without ethical considerations and guidance from RDM experts, efforts to make data and materials accessible may not lead to sharing them in a reusable form. Datasets should ideally be made accessible through trusted repositories, accompanied by code, explanations, and other elements of the research process to ensure reproducibility (Chen et al., 2019). Ethical considerations, including policies and guidelines related to RDM, storage, and publishing, have successfully ensured that data is made available in a usable format (Couture et al., 2018; Federer et al., 2018). Even when data and materials are claimed to be available, they may not truly be "available upon request" when sought (Stodden et al., 2018; Vines et al., 2014), may not actually be deposited in a repository (Danchev et al., 2021), or may not be shared in a usable or

reproducible manner (Hardwicke et al., 2021). Additionally, when presented in isolation, RDM, reproducibility, and OS activities may not resonate with researchers with different motivations and incentives (Borghi and Van Gulick, 2022). Researchers' perception of ethics in the context of OS encompasses policies that reflect open data and OA principles, promoting the sharing of resources, dissemination of ideas, and the creation of collaborative research forums (Khalil, Shinwari, and Islam, 2022). Despite the potential benefits of openness, significant ethical concerns arise, presenting a dual-use dilemma (Khalil, Shinwari, and Islam, 2022). Access to sensitive information can pose security risks and raise confidentiality, privacy, and affordability issues (Borghi and Van Gulick, 2022). Hartter et al. (2013) highlighted that a major concern regarding OS models entails the potential violation of the fundamental ethical principle of protecting the privacy of uninformed and/or nonconsenting individuals and communities. This is why ethical considerations are regarded as a key component that researchers must adhere to when engaging with the OS movement and ensuring research integrity. As one of the framework components, E-infrastructure presented the need for engaging researchers to consider the resources required for the OS movement. Drach et al. (2023) emphasized the necessity for specialized tools, resources, and services designed to support research activities in HLIs. These tailored initiatives aim to improve mechanisms for ensuring open access to publications and storing and managing open data. Additionally, they highlight the importance of professional development initiatives and similar efforts (Drach et al., 2023). The proposed framework also comprised the need for research metrics and analytics. Pourret et al. (2022) emphasized the need for researchers to ensure the research metrics and analytics to the OS movement to measure the assessment of publications and their impact on societies. For instance, one article might be cited for the robustness of its findings, while another could be referenced for its main limitation (Aksnes et al., 2019). Consequently, two articles may receive the same number of citations for entirely different reasons, highlighting the limitations of using citations to measure scientific quality (Tahamtan, Safipour Afshar and Ahamdzadeh, 2016). Moreover, traditional methods of assessing scientists tend to favor certain individuals over others and do not adequately reflect or promote the dissemination of knowledge back to the public, which ultimately supports scientific research.

Another key component is RCR, encompassing citizen science and collaborative research elements. Researchers must take ownership of their work and view the OS movement as a new framework for accountability, effectively for becoming "OS citizens" (Burgess et al., 2017; Serbe-Kamp et al., 2023). Citizen science involves community members working alongside researchers to benefit their local communities (Hecker et al., 2018). Cohn (2008) referred to citizen science as "Science 2.0," emphasizing that individuals do not need advanced degrees to contribute to scientific research; they can participate as volunteers or research partners. Citizen science, or community science, has a long-standing tradition and encompasses various levels of community engagement, from short-term data collection to more extensive collaboration with scientists and volunteers on research topics (Serbe-Kamp et al., 2023). Participatory Action Research (PAR) is a process wherein community members and professional scientists work together to address local, place-based issues (Caraballo et al., 2017). Collaborative research is also a crucial aspect of RCR, and researchers must consider how to foster global collaboration. Publishers are increasingly committed to facilitating responsible sharing and collaboration among researchers. As academic research diversifies into specialized fields, institutional and paradigmatic barriers often arise between research teams, highlighting the necessity for enhanced collaboration and sharing (Gilmour, 2023).

HLIs have frequently promoted innovative strategies for academic staff and students to collaborate on research, broadening knowledge horizons beyond their specific disciplines (Ansell and Marshall, 2016; Woolhouse et al., 2000). Studies by Morris and Mietchen (2010) underscored the advantages of utilizing Web 2.0 tools for research and knowledge sharing, which foster public participation, collaboration, and communication. Collaborative research enhances the student experience, improves employability, enriches the research culture, and enables universities to address skills and knowledge gaps in the local and national economy (Ansell and Marshall, 2016, p. 2). Furthermore, strengthening research collaboration is essential for maintaining a research-informed curriculum and ensuring that HLIs remain relevant to civil society (Coonan and Pratt-Adams, 2018). Thus, these five components collectively define the OS movement and the researchers' perspective, fostering greater openness. This concept is consistent with related terms such as open scholarship and open-

access scholarly publications, all of which emphasize the free and unrestricted availability of academic work online (Bailey, 2006; Getz, 2005). However, successfully implementing these practices requires careful planning and consideration.

DISCUSSION

The OS movement has gained significant momentum in recent years, evolving from a niche concept into a major force in contemporary research practices. Recent studies indicate that OS is transforming the ways in which research data are produced, shared, and accessed (European Commission, 2016). The conceptual framework developed in this study offers practical guidance for both researchers and institutions, highlighting the importance of openness throughout the entire research lifecycle, from data collection to publication and beyond. The framework emphasizes connecting all identified components from the researchers' perspective by focusing on five key areas. Ensuring that RDM practices are in place is critical, as they provide essential details that enable researchers to manage their activities from data collection to storage efficiently, ultimately facilitating the sharing and reuse of research data in trusted repositories. Storage and publishing are vital for encouraging researchers to deposit their data into reliable repositories, ensuring access and reuse by other researchers. Ethical considerations are also crucial for researchers when developing their research activities, particularly regarding data sharing and privacy, especially with sensitive information in the context of OS. Infrastructure is important, encompassing the necessary software and hardware that support research activities. The framework also addresses RCR, focusing on citizen science and collaborative research.

However, while the framework addresses researchers, including the broader research community and society is essential. By promoting greater access to knowledge, OS dismantles barriers that have historically excluded certain groups from participating in scientific discourse (Fecher and Friesike, 2014). Additionally, OS enhances research reproducibility, fostering trust in scientific findings and improving the overall quality of research outputs (Tennant et al., 2020). There is also a need to address the identified barriers, such as the lack of understanding and guidance on effectively implementing OS (European Commission, 2016). This issue is particularly pronounced in HLIs, where traditional publishing models and metrics continue to prevail. The conceptual framework developed in this study seeks to bridge this gap by providing a clear roadmap for researchers, outlining practical steps to align their work with OS principles (Fecher andFriesike, 2014). This study emphasizes that collaboration among researchers, institutions, and the public is crucial for the OS movement to flourish, reinforcing the notion that science should be inclusive and accessible. Looking ahead, the OS movement will continue to influence the future of scientific research. As more HLIs adopt relevant policies and practices, researchers will increasingly benefit from the visibility, impact, and collaborative potential of openly sharing their work. The conceptual framework presented in this study serves as a timely and practical tool to guide researchers in this transition, ensuring that the the OS movement becomes integral to the research culture (Fecher and Fireside, 2014; Tennant et al., 2020).

CONCLUSION

The OS movement represents a transformative research approach emphasizing transparency, collaboration, and accessibility. This study has developed a conceptual framework that addresses the needs of researchers and highlights the importance of involving the broader research community and society. By breaking down barriers to knowledge, OS enhances participation in scientific discourse and fosters greater trust in research findings. The framework provides practical guidance for implementing OS principles, addressing key components such as RDM, ethical considerations, RCR, infrastructure, and sharing and publishing. It recognizes HLIs' challenges, where traditional publishing models and metrics still dominate. It offers a roadmap for transitioning toward a more open and inclusive research culture. As the OS movement continues to evolve, it will play a pivotal role in shaping the future of scientific research. By promoting collaboration among researchers, institutions, and the public, the OS movement can ensure that science remains accessible and beneficial to all. This framework equips researchers with the necessary tools to embrace Open

Science, ultimately enhancing their work's visibility, impact, and quality while contributing to a more informed and engaged society.

LIMITATIONS

While this study provides a comprehensive conceptual framework for the OS movement, several limitations should be acknowledged:

- **Scope of research:** The framework primarily focuses on the perspectives of researchers and may not fully capture the diverse needs and experiences of other stakeholders in the research ecosystem, such as librarians, policymakers, and the public.
- **Dynamic nature of OS:** The OS movement continuously evolves, and the framework may not encompass all emerging trends, technologies, and practices. Future developments in OS could necessitate updates to the framework to remain relevant.
- **Institutional variability:** Implementing OS movement can vary significantly across different HLIs due to differences in resources, culture, and existing policies. This variability may affect the applicability of the framework in specific contexts.
- **Ethical considerations:** While the framework emphasizes ethical considerations, it may not address all ethical dilemmas associated with data sharing, particularly in sensitive research areas. More nuanced guidance may be required to navigate these complexities.
- **Cultural resistance:** There may be resistance to adopting OS practices within certain research communities that are accustomed to traditional models. The framework does not fully explore strategies to address this cultural resistance.

Acknowledging these limitations can help inform future research and adaptations of the framework, ensuring it remains a relevant and useful tool for promoting and adopting the OS movement.

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