Open Science: Overview, Issues, and Postprint Solutions

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Date: 2023-10-08T00:00:00+00:00

Abstract

Although open science has gained recognition across various sectors since its emergence in the 1990s, its development has been relatively slow, and it has not yet become mainstream within the scientific community. To address this issue, this study systematically reviews the current state of open science development both domestically and internationally, summarizes and analyzes the primary factors influencing its advancement, and proposes three implementation pathways for fostering open science in China: formulating national open science policies, enhancing financial support, and establishing systematic and in-depth open mechanisms. Finally, the paper examines open science practices in China, highlighting that the OSID model offers a highly valuable exploration for open science implementation.

Full Text

Open Science: Overview, Problems, and Solutions

Abstract: Although open science has been recognized by various sectors since its development in the 1990s, its progress has been relatively slow, and it has not yet become mainstream in the scientific community. To address this issue, this paper systematically reviews the current state of open science development both domestically and internationally, summarizes and analyzes the main factors influencing its development, and proposes three implementation pathways for the development of open science in China: designing national open science policies, increasing financial support, and building systematic and in-depth open mechanisms. Finally, the paper introduces and analyzes open science practices in China, noting that the OSID model represents a highly beneficial exploration for open science implementation.

Keywords: open science; open data; scientific research; publishing integration; OSID

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Since the late 20th century, technological transformations have facilitated increasingly frequent scientific collaboration and communication. However, access to research resources has been monopolized by several major international scientific publishing giants such as Elsevier and Springer, who have reaped substantial profits by controlling these channels. In particular, for research projects funded by government resources, researchers have had to pay high fees to publish and access academic results, causing considerable dissatisfaction within the research community. This has triggered open access and open data initiatives, which have evolved into the open science movement [1]. The open science movement has flourished, garnering enthusiastic attention from research institutions, publishers, and researchers alike [2].

At present, scholars both domestically and internationally have elaborated on the concept of open science from various perspectives. The European Commission (EU) defines open science as the dissemination of research and transformation of scientific research methods through digital tools, networks, and media, making scientific knowledge more accessible and promoting more efficient, transparent, and effective scientific research processes by providing new tools for scientific collaboration, experimentation, and analysis. It relies on the combined influence of technological development and cultural change on research cooperation and openness [3]. The Organisation for Economic Co-operation and Development (OECD) defines open science as efforts by researchers, governments, funding agencies, or the scientific community to make publicly funded research results (publications and research data) publicly accessible in digital form with no or minimal restrictions, thereby enhancing research transparency and promoting collaboration and innovation [4]. Chinese scholars Chen Xiujuan and Zhang Zhiqiang summarize that open science in the modern sense combines concepts, tools, platforms, and media to promote knowledge creation and dissemination in a free, open, and more inclusive manner, thereby deriving greater benefits from research [5]. Although no clear and precise definition has yet been established, scholars generally focus on building an open, free, collaborative, and shared academic exchange platform that ensures publicly funded projects are accessible to all, and improves the reproducibility and authenticity of research results.

Unlike early open access and open data initiatives, open science is no longer simply limited to the free access to literature and data, but rather focuses on knowledge dissemination and application, strengthening scientific communication among researchers and even between researchers and citizens, and promoting the depth and breadth of exchange and collaboration among various stakeholders, thereby greatly advancing scientific development and elevating it to the level of national strategy. Developed countries in Europe and America, building upon open access and open data, emphasize the deployment of macro-level policies and strategies to enhance national innovation capacity and promote socio-economic development. In February 2018, the European Open

Science Cloud Initiative (EOSCI) proposed a framework for open science; on July 4, 2018, the French National Academy of Sciences released its national open science plan; on July 17, 2018, the U.S. National Academy of Sciences published *Open Science by Design*. These national strategies and policies share the following common and similar characteristics across three dimensions.

(1) Strengthening exchange and collaboration among research stakeholders. Research stakeholders include research institutions, universities, libraries, governments, enterprises, and even citizens. Due to industry and interest barriers, these stakeholders have historically operated independently in scientific research. Open science aims to enhance cooperation in human resources, funding, technology, and ideas among all stakeholders.

(2) Emphasizing the construction of resource open platforms. Resource open platforms are built upon the foundation of free access to literature and data. Previously, due to technological, policy, and interest barriers, platform construction has lagged behind. Open science policies promote platform development based on communication networks, fair data principles, and mandatory dissemination norms.

(3) Basing on national innovation strategic deployment. For the first time, open science development is being holistically planned and deployed at the national level, with specific macro-level and guiding norms established for comprehensive resource openness, construction of research database platforms, international exchange and cooperation mechanisms, and intellectual property protection.

In May 2014, the National Natural Science Foundation of China and the Chinese Academy of Sciences issued an open access policy, explicitly stating that funded projects must be opened to the public. In September of the same year, the Ministry of Science and Technology promulgated the *Guiding Opinions on Accelerating the Establishment of a National Science and Technology Reporting System*. In December 2018, at the 14th Berlin Open Access Conference, the National Natural Science Foundation of China, the National Science and Technology Library, and the Documentation and Information Center of the Chinese Academy of Sciences issued a position statement, clearly expressing China' s support for the OA2020 initiative and Plan S, demonstrating the country' s supportive attitude toward open science and indicating that open science construction has gained national-level attention. However, open science in China remains in its foundational and initial stages, limited to the digital open access of print journal resources, without deep utilization or management of knowledge or opening of various educational resources. Precisely because many challenges persist in areas such as macro-level policy guidance at the national level, the attitudes and management capabilities of research stakeholders, comprehensive coordination of interests among parties, and copyright protection, the development of open science in China is severely constrained, which is detrimental to long-term economic development and the construction of the national innovation system. These challenges can be summarized into three main points:

(1) Insufficient attention from research stakeholders. China' s academic evaluation system remains oriented toward final research outcomes, without incorporating the principles of open science, and there are also considerations of interests and competition. Consequently, research stakeholders (as previously described) lack strong ideological motivation to prioritize open science.

(2) Low construction standards for open platforms. Although China currently has platforms such as the National Social Science Database, National Natural Science Database, and OA journals of the Chinese Academy of Sciences, these platforms only serve the function of storing journal article data. They lack the capacity to serve the entire research process, and their knowledge service capabilities and standards lag behind.

(3) Deficient macro-level layout of national policies. Although China has expressed support for open science at the national level, there is a lack of top-level design for specific national strategies and policies, resulting in open science development lacking programmatic guidance and appearing disorganized.

2. Factors Influencing Open Science

Although multiple countries have issued open science strategies for planning and deployment at the national level, as mentioned earlier, these remain at the macro-construction level rather than being mandatory national policies, with many implementation details yet to be perfected. Due to unresolved issues such as economic and competitive pressures among stakeholders and compensation incentive mechanisms, deep exchange and collaboration remain difficult to achieve. Simultaneously, regarding data sharing, concerns persist about malicious use, tampering, and intellectual property issues [6]. China has not yet promulgated dedicated open science policies or strategies, with open science policies scattered across various government agencies and university documents [7]. Moreover, the participation rate of stakeholders in open access remains relatively low [8]. Furthermore, the main driving factors influencing scientific data sharing in China include individual drivers (economic compensation, data accumulation awareness, cost savings, moral incentives), research drivers (data returns, academic exchange, academic recognition), and social drivers (policy drivers, social evaluation) [9]. Overall, factors currently hindering open science development can be categorized into three aspects.

2.1 Lack of Incentive and Return Mechanisms for Open Science

Academic incentive and return mechanisms are guided by academic evaluation systems, which are primarily based on peer review and bibliometric indicators, focusing on research publication as the endpoint. These systems emphasize the journal hierarchy of published papers rather than the quality and contribution of the research itself [10]. This leaves researchers lacking motivation to partici-

pate in open science, as they remain oriented toward traditional journal impact factors. Since participating in open science requires additional effort, the inability to obtain incentive returns (such as financial support, project applications, industry recognition, career development, etc.) significantly constrains the promotion of open science.

2.2 Low Enthusiasm for Exchange and Collaboration Among Research Stakeholders

Due to differing cultures across disciplines and the distinct nature of each field, interdisciplinary collaboration faces difficulties. Meanwhile, scholars in the same field compete in publishing articles, conference papers, and monographs, creating relationships that are simultaneously collaborative and competitive. The current research culture hinders the enthusiasm for exchange and collaboration among research stakeholders. Under the influence of cultural and economic barriers, researchers continue to conduct scientific research in traditional compartmentalized states, making truly deep and meaningful open scientific collaboration difficult to achieve.

2.3 Severe Lag in Open Data Platform Construction

Open data is a crucial prerequisite for open science, and data platform construction involves the contribution of data from various research stakeholders. First, at the technical level, establishing an information infrastructure that ensures the free and smooth flow of scientific data requires extremely high technical capabilities. Second, at the property rights level, relevant and detailed laws for open intellectual property protection are inadequate. Third, at the mechanism level, although platform construction cannot proceed without national support, platforms generally lack their own "blood-making" functions and have weak market capabilities to serve research, making it impossible to provide better services through "blood transfusions" alone. These factors collectively result in open data platform construction failing to keep pace with the development needs of open science.

3. Implementation Paths for China' s Open Science Development

3.1 Designing National Open Science Policies

China should prioritize top-level design of national-level policies, focusing on guiding open science implementation from a macro perspective to change the current situation of development without clear policy guidance. Recommendations should proceed from three aspects: (1) Continuity: Policies should be consistent throughout, with five-year or longer-term planning; (2) Integration: Policies should mutually support other relevant data openness and free access policies without conflict; (3) Implementability: Policies need to be grounded in

the practical problems faced by open science stakeholders, providing targeted guidance.

3.2 Increasing National Financial Support

Traditional academic evaluation is impact factor-oriented, leaving researchers lacking motivation for openness. Systematic and diversified incentive and return mechanisms encompass financial support, project applications, industry recognition, career development, and other aspects, among which financial support is the key link to activate the entire mechanism. Only by unblocking funding channels and increasing financial investment in open science—by supporting journal operations through covering article processing charges and encouraging authors to submit to open access journals—can China truly address the concerns of researchers and open access journals, and establish a systematic and diverse academic incentive and return mechanism.

3.3 Building Systematic and In-Depth Open Mechanisms

A nation' s innovation capacity depends on its society' s ability to access and utilize knowledge. Research resources created with public funds should be shared by society. To build systematic and in-depth open mechanisms, industry regulatory departments need to break through compartmentalized interest barriers with greater determination and perseverance, overcome the "small, scattered, and weak" predicament of journals, and systematically promote comprehensive openness of journal platforms and databases. The industry needs to explore new business models for academic journals under the new normal of openness. Research stakeholders need to integrate open thinking throughout every aspect of research activities, fully leveraging the advantages of networked-era knowledge creation through collective intelligence, co-creation, and collaboration to liberate research productivity. In summary, systematic and in-depth open mechanisms will create a free and open academic environment, promote knowledge innovation, dissemination, and application, fully stimulate and enhance the innovation awareness and capabilities of all stakeholders—particularly the enthusiasm and vitality of small and micro entities—and comprehensively elevate national knowledge innovation capacity, providing strong support for the construction of the national scientific and technological innovation system and the innovation-driven development strategy.

4. Practical Exploration of Open Science in China

The development of information technology is driving human society from interpersonal connectivity toward intelligent connectivity of all things. The form of knowledge is evolving from being constrained by physical containers to a networked and open form. Open science is becoming an unstoppable historical trend. Therefore, this paper proposes that China should improve its open science level through three aspects: policy design, financial support, and open

mechanisms. From the perspective of entry points, China has primarily attempted two directions: integrating and opening OA databases and constructing public open platforms. However, neither has fundamentally resolved the problems of one-way, non-dialogic, and centralized knowledge flow from production to dissemination. In 2015, media convergence and publishing integration were elevated to national strategies. Based on the "convergence" mindset, emphasizing connection, communication, scenarios, and services has become a new direction and focal point for promoting open science development. In early 2018, the "OSID Open Science Initiative," launched by the Publishing Convergence Development (Wuhan) Key Laboratory of the National Press and Publication Administration, enables journals to achieve lightweight digital transformation by adding QR codes to papers. Through online Q&A, academic circles, and deep openness of paper-related data, it facilitates open exchange and collaboration [11-12]. From micro and meso perspectives, the OSID model represents a highly beneficial exploration for open science practice. However, from a macro perspective, the advancement of open science is holistic and systematic, and the industry' s active exploration urgently requires resonance with top-level layout, necessitating national-level guidance from macro strategic planning to lead its high-quality development.

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Note: Figure translations are in progress. See original paper for figures.