

Landscape of Open Science

Open Science and Research Initiative

Contact: The Ministry of Education and Culture



Licensed under Creative Commons Finland 4.0



Table of Contents

1. History of Open Science	3
2. Open Science Bibliography	4
<i>2.1 Infrastructures</i>	<i>4</i>
<i>2.2 Public Accessibility.....</i>	<i>6</i>
<i>2.3 Collaborative Research.....</i>	<i>8</i>
3. Typology of Open Science	11
References.....	13

1. History of Open Science

Before the introduction of academic journals in the late 16th century, scientists had little to gain from the publications of their scientific discoveries. Regulations – both social and economic – and relatively basic as well as costly technologies available for the scientific community reinforced the resistance of openness in regards to the disclosure of scientific discoveries (David, 2007: 8). Thus, scientists employed symbols, paradoxes, allegories, and anagrams to disclose “Secrets of Nature”. As William Eamon (1985: 325) has expressed it, the obligation to conceal scientific discoveries was “a conviction woven into the very fabric of medieval thought”.

William Eamon (1985, 1994) has documented and proposed an explanation regarding the change in science during the 16th century from the previously prevailed secrecy among scientists to public disclosure of new knowledge. A new set of norms, incentives, and organizational structures reinforcing scientists to commit to the disclosure of new knowledge, were brought about by the Scientific Revolution. During this time, there was a growing societal demand for scientific knowledge requiring researchers to begin to share their work with each other. The practice and idea of open science, therefore, emerged during the late 16th and early 17th centuries (Eamon, 1994). This marked a break from the previously dominant ethos of secrecy and gave way to new norms supporting the practice of open science. However, not all forms of science witnessed the emergence of open science. Particularly, throughout the 17th and 18th centuries, the medieval and Renaissance traditions of alchemy involved a persisting imperative of secrecy since the discipline was regarded as a form of personal knowledge – rather than a science of nature – or a “divine science” (David, 2007: 9).

There are, however, opposing views and discussion concerning the history of open science specifically in relation to the Scientific Revolution. It should be noted here that historical developments, and especially significant new institutional formations, are likely to have a multitude of factors as well as conditions in their formation rather than a single cause. In sociological terms, the actions of individual actors and groups, alterations in the social system, and political as well as economic arrangements interplay to cause wider societal developments (David, 2007: 22).

David (2007), for example, argues that rise of new knowledge and the break away from the ethos of secrecy, which the Scientific Revolution introduced, should be considered as having independent and antecedent roots rather than viewing the changes automatically deriving from the intellectual changes. David (2007: 21-22) goes on to argue that these were specifically “functional changes to heightened asymmetric information problems that had been posed for the Renaissance system of court-patronage of the arts and sciences”. Here, scientists were able to gain reputational renown and mutually validate claims by disclosing new knowledge along with reliable techniques for solving practical problems.

2. Open Science Bibliography

Open science is a relatively young discourse, which has emerged as one of the catchphrases used within today's scientific community (Fecher and Friesike, 2013: 1). The term itself encompasses a variety of assumptions concerning knowledge creation, its future, results, and dissemination as well as assumptions concerning the researcher or the relationship between research and the society. In simplicity, the need for academic research to open up more could be regarded as the discourse of open science (*ibid.*). The term, however, has different understandings regarding the manner in which science could open up, for example, access to knowledge, public engagement in research, and the tools used for collaboration as well as for sharing research outputs (*ibid.*). Additionally, today's technological innovations bring about new opportunities to share knowledge and the use of the internet enables tools to be built through which our collective knowledge can be amplified.

In sociological terms, open science and its essence of communism, or in other terms the ownership of goods, can be summarized by Merton's (1968: 610-11) statement: "The substantive findings of science are...assigned to the community...The scientist's claims to 'his' intellectual 'property' is limited to that of recognition and esteem...Secrecy is the antithesis of this norm; full and open communication its enactment". Other sociologists have also argued that an essential institutional characteristic of scholarly communication is openness and, therefore, openness is compulsory for the advancement of scientific knowledge (Schroeder, 2007).

A review of the relevant literature on open science highlights the differences in the way open science is understood and defined. Below is a compilation of three predominant categories that could be found from the literature in which the authors defined open science. These are infrastructures, public accessibility, and collaborative research. The ideas presented by Fecher and Friesike (2013) in their article on the five schools of thought regarding open science serve as the basis for the categories. It should be noted that there are also other categories that can be considered as relevant in relation to open science, however, as this report focuses specifically on how open science is defined by authors, these have been left out. Such categories are for example measurement as well as open data and open access.

2.1 Infrastructures

De Roure, D., Goble, C., Aleksejevs, S., Bechhofer, S., Bhagat, J., Cruickshank, D., Fisher, P., Hull, D., Michaelides, D., Newman, D., Procter, R., Lin, Y., and Poschen, M. (2010) 'Towards Open Science: the myExperience Approach', *Currency and Computation: Practice and Experience*, Vol. 00, pp. 1-6.

- *The Open Science movement, though currently niche, vocally advocates the large scale, open distributed collaboration that is enabled by making data, methods and results freely available on the Web.*

Schroeder, R. (2007) 'e-Research Infrastructures and Open Science: Towards a New System of Knowledge Production?', *Prometheus*, Vol. 25, No. 1, pp.1-17.

- *'Open science' is used here to designate research efforts that aim to contribute to a resource that is shared among scientists or researchers. 'Open' will be used specifically to designate unrestricted access and use, being free of charge to users, and using non-exclusionary (open) standards.*
- *In fact, a key feature of open science is that it consists of disparate initiatives, mainly by researchers and academic institutions and NGOs.*

Guadamuz, A. (2006) 'Open Science: Open Source Licenses in Scientific Research', *North Carolina Journal of Law and Technology*, Vol. 7, No. 2, pp. 321-366. Available at <http://ssrn.com/abstract=886906> [Accessed 11.08.2015].

- *Despite these misgivings, there would appear to be almost universal agreement about using the word "open" to describe a philosophical the movement that shares the principles and objectives of the two main non-proprietary software camps. The use of these ideals in the area of scientific research presents the birth of a new movement that could be called "open science".*
- *The suggested definition of open science can be used to cover the many different types of scientific outputs.*

Perkmann, M. and West, J. (2014) 'Open Science and Open Innovation: Sourcing Knowledge from Universities', in Link, A.N., Siegel, D.S., and Wright, M. (eds.) *The Chicago Handbook of University Technology Transfer and Academic Entrepreneurship*, Chicago: University of Chicago Press, pp. 44-74. Available at <http://ssrn.com/abstract=2133397> [Accessed 11.08.2015].

- *Open science means that research is conducted with the objective of publishing results openly.*

Maurer S.M. (2003) *New institutions for doing science: from databases to open source biology* [Online], available at http://www.epip.eu/papers/20031124/200411_conference/papers/maurer_paper.pdf [Accessed 12.8.2015].

- *Open science is variously defined, but tends to connote (a) full, frank, and timely publication of results, (b) absence of intellectual property restrictions, and (c) radically increased pre- and post-publication transparency of data, activities, and deliberations within research groups (p. 4).*
- *Open Science: Commercial scientific databases are often expensive and restrict users' ability to copy, redistribute, extract, or modify data. These factors limit the number of users and applications, making commercial products less valuable to society (p. 6).*
- *Social scientists – and eventually government funding bodies – can make a major contribution by refining the open science concept so that it provides clear guidance about which transactions are and are not acceptable (p. 11).*

2.2 Public accessibility

Cribb, J. and Sari, T. (2010) *Open Science – Sharing Knowledge in the Digital Age*, Collingwood, Australia: CSIRO Publishing.

- *Open science demands early and constant feedback between science and society, with knowledge travelling in both directions (p. 100)*
- *In open science, new and better knowledge flows most swiftly (p. 165)*
- *The 21st century is the century of open science (p. 130)*
- *Open science encompasses the principles of full and open access to information (p. 208)*

Grand, A., Wilkinson, C., Bultitude, K. and Winfield, A. F. (2012) 'Open Science: A new 'trust technology'?', *Science Communication*, Vol. 34, No. 5, pp. 679-689.

- *Open science expands the concept of virtual witnessing to cover the entire scientific process (p. 2).*
- *Open science could offer a novel method to represent themselves directly and communicate personally with a variety of audiences. For members of the public, it could offer a route for direct access to original work (p.3).*
- *Openness can encompass a spectrum of activities, and many scientists already incorporate some aspects within their existing practice. For example, they may deposit papers in publicly-accessible repositories; publish in open access journals; include datasets with publications; write and collaborate through blogs; or maintain project websites (p. 3)*
- *Open science thus has the potential to contribute to the substantiation of the relationships which are central both to people's trust in science and to science's trust in people (p. 3).*
- *Open science has the potential to enable citizen scientists' participation to go beyond counting, checking and organizing data, to involvement in the full complexities of the research process and in dialogue with researchers (p. 7).*
- *Open science has the potential to create fluid spaces within which distributed, differently-peopled and differently-acting communities can work together and develop mutual trust (p. 10).*
- *Not only could the practice of open science allow producers of information to map out their processes and contextualize their data, it could also support consumers in developing the critical awareness and judgment that enables us to separate pseudo-science from real (p. 10).*
- *Open science has the potential to become a new trust technology, of benefit to both the scientific community and public groups (p. 10).*

Irwin, A. (2008), 'Risk, science and public communication: third-order thinking about scientific culture', In M. B. (Eds.), *Handbook of public communication of science and technology*, London: Routledge.

- *Open science creates opportunities to open up fresh interconnections between public, scientific, institutional, political and ethical visions of change in all their heterogeneity, conditionality and disagreement (p. 210).*

Morris, T. and Mietchen, D. (2010), *Collaborative Structuring of Knowledge by Experts and the Public* [Online], Cornwall University Library: Digital Libraries available at <http://ceur-ws.org/Vol-575/paper5.pdf> [Accessed 10.08.2015].

- *The open science movement - which has formed around the combination of providing open access to journal articles, making scientific data more openly available in raw forms, using and sharing open source software and experimenting with some of the new techniques appearing from the community that is formed under the 'Web 2.0' banner - is exploring the edge of what is now possible for scientists to do to create new knowledge (p. 8).*

Neilsen, M. (2009), 'Doing science in the open', *Physics World*, Vol. 22, No. 5, pp. 30.

- *Open science, which at its fullest extent makes everything—data, scientific opinions, questions, ideas, folk knowledge, workflows and everything else available as it happens.*

David, P.A. (2007) 'The Historical Origins of 'Open Science': An Essay on Patronage, Reputation and Common Agency Contracting in the Scientific Revolution', *Capitalism and Society*, Vol. 3, Issue 2, Article 5.

- *The specific functionality of the information-disclosure norms and social organization of open science rests upon the greater efficacy of data- and information-sharing as a basis for the cooperative, cumulative generation of eventually reliable additions to the stock of knowledge (p. 21).*
- *Open science (qua social organization) calls for liberal dissemination of new information, it is more conducive to both the maximization of the rate of growth of society's stocks of reliable knowledge and to raising the marginal social rate of return from research expenditures (p. 22).*
- *Open science norms and institutions are a social innovation whose workings must be continually re-created as "social facts" (p. 88).*

Fecher, B. and Friesike, S. (2013) 'Open Science: One Term, Five Schools of Thought', *RatSWD*, Vol. 218, pp. 1-11.

- *Open Science is an umbrella term that encompasses a multitude of assumptions about the future of knowledge creation and dissemination (Abstract).*
- *'Open Science' is one of the buzzwords in the scientific community. It is accompanied by a vivid discourse that apparently just grasps any kind of change in relation to the future of knowledge creation and dissemination; a discourse whose lowest common denominator is perhaps that academic research somehow needs to open up more. The very same term however*

evokes quite different understandings about how science could open up, ranging from the democratic right to access knowledge (e.g. open access to publications), the demand for including the public in the research (e.g. citizen science) to the use of tools for collaboration and sharing (p. 1).

- *It appears that the ‘open’ in Open Science can refer to pretty much anything: The process of knowledge creation, its result, the researching individual, or the relationship between research and the rest of society (p. 1).*
- *It is therefore hardly surprising that a discourse about Open Science is accompanied by the crucial question of how scientific impact can be measured in the digital age (p. 6).*
- *Open Science covers in the broadest sense anything about the opening of knowledge creation and dissemination (p. 6).*
- *In many instances Open Science appears to be somewhat like the proverbial electric car—an indeed sensible but expensive thing that better parks in the neighbor’s garage; a great idea that everybody agrees upon but urges the others to take the first step (p. 6).*

2.3 Collaborative research

David, P.A. (2008) ‘Will e-Science be Open Science?’ [Online], A contribution to *WORLD WIDE RESEARCH: Reshaping the Sciences and the Humanities in the Century of Information*, William H. Dutton and Paul Jeffrey (Eds.), Forthcoming from MIT Press, available at <http://www-siepr.stanford.edu/repec/sip/08-010.pdf> [Accessed 17.06.2015].

- *The availability of access to those resources on “share-and-share alike” terms can induce researchers’ participation in passive as well as active collaboration arrangements, acquainting them with benefits of cooperation and thereby reinforcing the ethos of open science (p. 2).*
- *The specific functionality of the information-disclosure norms and social organization of open science rests upon the greater efficacy of data and information-sharing as a basis for the cooperative, cumulative generation of eventually reliable additions to the stock of knowledge (p. 3).*
- *Interrelated e-science activities thus illustrate four facets of open science practice: (a) using the Globus and web services open source grid software, (b) providing web access to shared resources for a diverse research community, (c) open access archiving and dissemination of results through an open repository, and (d) formatting of information using open standards (p. 7).*

David, P.A. (2003), ‘The economic logic of ‘open science’ and the balance between private property rights and the public domain in scientific data and information’, in *The Role of the Public Domain in Scientific and Technical Data and Information: An NRC Symposium*, J. Esanu and P. F. Uhler (eds.), Washington, D. C.: Academy Press.

- *As a mode of generating reliable knowledge, open science depends upon a specific non-market reward system to solve a number of resource allocation problems that have their origins in the particular characteristics of information as an economic good.*
- *Open science is properly regarded as uniquely well suited to the goal of maximizing the rate of growth of the stock of reliable knowledge.*

Mukherjee, A. and Stern, S. (2007) *Disclosure or Secrecy? The Economics of Open Science* [Online], Social Science Research Network, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=998548 [Accessed 10.08.2015].

- *Open Science is a dynamic system of knowledge production that depends on the disclosure of knowledge by researchers as an input into knowledge production by future researchers (p. 1).*
- *Open Science is characterized by a distinctive set of economic incentives for cumulative knowledge production, including the adoption of norms that facilitate full disclosure and diffusion of knowledge. This system includes the recognition of scientific priority by future scientific generations, the importance of demonstrating experimental replicability, and a system of public (or coordinated) expenditures to reward those who contribute to cumulative knowledge production over the long term (p. 2).*
- *In our analysis, Open Science is an endogenous economic outcome of the microeconomic environment, and the potential for Open Science depends on strategic interaction among researchers in their access, investment, and disclosure decisions (p. 3).*
- *Our model highlights two features of Open Science: the ability to draw upon prior (disclosed) research and the fact that the incentives to produce and disclose abstract knowledge depends on receiving credit from follow-on researchers (p. 3).*
- *“Open Science” in which each generation invests in access to prior knowledge, chooses a constant level of investment, and discloses knowledge to the next generation (p. 3).*

Caso, R. and Ducato, R. (2014) *Intellectual Property, Open Science and Research Biobanks* [Online], University of Toronto, The Trento Law and Technology Research Paper Series available at <http://ssrn.com/abstract=2511602> [Accessed 10.08.2015].

- *In fact, both data sharing and collaborative research have become an imperative in contemporary open science, whose development depends inextricably on: the opportunities to access and use data, the possibility of sharing practices between communities, the cross-checking of information and results and, chiefly, interactions with experts in different fields of knowledge (Abstract)*

Destro Bisol, G., Anagnostou, P., Capocasa, M., Bencivelli, S., Cerroni, A., Contreras, J., Enke, N., Fantini, B., Greco, P., Heeney, C., Luzi, D., Manghi, P., Mascalzoni, D., Molloy, J.C., Parenti, F., Wicherts, J.M., Boulton, G. (2014) 'Perspectives on Open Science and Scientific Data Sharing: An Interdisciplinary Workshop', *Journal of Anthropological Sciences*, Vol. 92, pp. 179-200.

- *There is now a growing international movement for “open science”, by which is meant making publication of scientific concepts and the data on which they are based readily accessible to all, together with procedures for sharing important data sets. This trend is not only limited to technical and IT aspects, but extends to epistemological, sociological and political issues and to governmental initiatives to open official data both to citizens and to entrepreneurs able to offer new data-based services (p. 180).*
- *Such cooperative efforts are essential if open science principles are to be adapted effectively to the needs of different knowledge domains, and if they are to be successful in achieving deeper involvement of the public in science (p. 180).*
- *Open science, in other words, influences the quality of both scientific knowledge and democracy within the knowledge-society (p. 182).*
- *Effective open science requires “intelligent openness”, which means that data and metadata must be: a) Discoverable - how can you find out that they exist? b) Accessible - can you obtain them? c) Intelligible - can they be understood? d) Assessable - e.g. are the originators trustworthy? e) Re-usable - can the data be used for replication or re-purposing? These are the fundamental criteria for truly open data (p. 183)*
- *The impact of open science is greatest when it operates as a collaborative process (p. 185).*
- *One of the most difficult ethical challenges for open science relates to the privacy of human subjects and the confidentiality of data about them (p. 193).*
- *Open science involves processes of sharing that cross traditional boundaries of use to allow faster, better analysis of larger datasets and may conflict with or be incompatible with traditional processes that protect privacy (p. 193)*
- *Although there are strong arguments for open science, a question hangs over those areas where personal data is an important part of the research process, and whether and under what circumstances, public benefit from new knowledge generated by scientific research outweighs consequent threats to personal privacy (p. 193).*
- *Moving on to the societal implications of Open Science, an important message is that we need to devise strategies which may more effectively involve the public in the discourse about open data (p. 196).*

3. Typology of Open Science

There seems to exist a lack of conceptual clarity regarding the definition of Open Science. In its entirety, the concept of open science can be seen to broadly include “anything about knowledge creation and dissemination”, as Fecher and Friesike (2013: 6) argue. Based on the bibliography of open science presented in this report, the definition of open science seems to differ in regards to the categorical specificities – the central assumption, the aim, and the actors involved. In this sense, the three categories identified in this report – infrastructures, public accessibility, and collaborative research – present similarities as well as differences when it comes to creating a typology of open science.

Essentially, the infrastructures category has the assumption that efficient research depends on the available tools and applications. The category includes scientists and platform providers. The central aim is to create openly available platforms, tools, and services for scientists. Overall, the category defines open science as being large scale and involving openly distributed collaboration. Open science, in terms of infrastructures, involves the free availability of data, methods and results of research on the Web with unrestricted access and use along with being free of charge to users. Through open platforms it is possible to copy, redistribute, extract, and modify data.

Contrary to the previous category, the public accessibility category involves both scientists and citizens. The central assumption and aim are, therefore, that science should be made accessible to the public. Open science, as defined by the public accessibility category, is knowledge travelling between science and society meaning that both scientists and researchers are able to deposit their papers in publicly-accessible repositories, in open access journals, include datasets with publications, collaborate through the Web, and generally make their data more openly available in raw forms. Open science is stressed as full and open access to information covering the entire scientific process. Here, the members of the public have direct access to original work. Furthermore, the category described open science having the potential to contribute in creating spaces where communities can work together and develop mutual trust – referring to people’s trust in science and science’s trust in people. In this sense, open science can open up interconnections between the public, scientific, institutional, political, and ethical visions of change.

The collaborative research category generally involves only scientists and assumes that collaboration among scientists would make knowledge-creation more efficient. Opening up the process of knowledge creation can be considered as the central aim of this category stressing the interaction among researchers regarding open science. Importance is placed upon disclosing knowledge to the next generation of scientists and future researchers. Thus, open science is defined as operating as a collaborative process where open access to shared resources through an open repository, the ability to draw upon prior research, gaining credit from follow-on researchers, and cross-checking of information and results are viewed as highly important. Overall, open science is seen to involve data and metadata being discoverable, accessible to all, assessable, and re-usable. These would enable the analysis of larger datasets to be carried out faster and better.

In a broad sense, open science implies the open availability of resources through an open repository that is publicly-accessible, collaboration where knowledge can travel openly, and the availability of tools that will enable the previously mentioned. This, of course, is not a precise typology of open science, but one that is generated based on the similarities of the three categories presented in this report.

References

David, P.A. (2007) 'The Historical Origins of 'Open Science': An Essay on Patronage, Reputation and Common Agency Contracting in the Scientific Revolution', *Capitalism and Society*, Vol. 3, Iss. 2, Article 5.

Eamon, W. (1985) "From the Secrets of Nature to Public Knowledge: The Origins of the Concept of Openness in Science." *Minerva*, Vol. 23, No. 3, pp. 321-347.

Eamon, W. (1994) *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Science*, Princeton: Princeton University Press.

Fecher, B. and Friesike, S. (2013) *Open Science: One Term, Five Schools of Thought*, *RatSWD*, Vol. 218, pp. 1-11.

Merton, R.K. (1968) *Social Theory and Social Structure*, New York: Free Press.

Schroeder, R. (2007) 'e-Research Infrastructures and Open Science: Towards a New System of Knowledge Production?', *Prometheus*, Vol. 25, No. 1, pp. 1-17.