

Defining Open Science

Author's note: Much of the words, diagrams, and ideas in this chapter make generous use of Creative Commons licensed materials. The basic framing and many words and sentences are borrowed directly from Kramer and Bosman's [Defining Open Science Definitions](#). The chapter was then developed by Micah Vandegrift, with some rewrites, edits, updates, and contextualization.

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Overview

This chapter lays out some definitional landscape for “open science.” It offers a brief overview of key points, core topics, and common discussions in this area.

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I. Introduction

Open Science encompasses a multitude of assumptions about the future of knowledge creation and dissemination. Defining this term is important because it is picking up momentum in practical use as a shorthand umbrella term for a variety of activities that stem from a variety of principles on university campuses, across higher education and in affiliated industries. As global scholarship continues to be more deeply intertwined, concerns about the unequal availability of participation in human knowledge are being unearthed. Open science is one of a few movements that are responding to the injustice of information access that tends to privilege the Anglo-Euro western culture and northern hemisphere.

Because openness in higher education and research has been a public policy topic in Europe for years, many of the core definitions, ideas, and concepts of open science come from the European Union, member states, and organizations in Europe. Only recently has the United States begun to utilize the language of open science, due in part to the distributed nature of our higher education/research industry (we don't have a Department of Higher Education, Science, and Technology, for example), and also based on deeply entrenched ideals about American

individualism and bostrampism which can often be resistant a communal, share alike orientation, which open science represents.

Open Science is “ongoing transitions in the way research is performed, researchers collaborate, knowledge is shared, and science is organised.”¹

In the broadest spectrum, open science is related to open access (how academic publications are shared), open data (sharing raw materials of research), open source software (reuse and adaptation encouraged), open educational resources (barrier free teaching and learning), and many subcategories of each of these. Additionally, open science bumps up against science and technology policy and the challenges and opportunities in the public policy sphere. To state it bluntly, a broad literacy in open science means to dabble a bit in each of these areas, and to pull good ideas and aspects from all of them into a way of doing or supporting research.

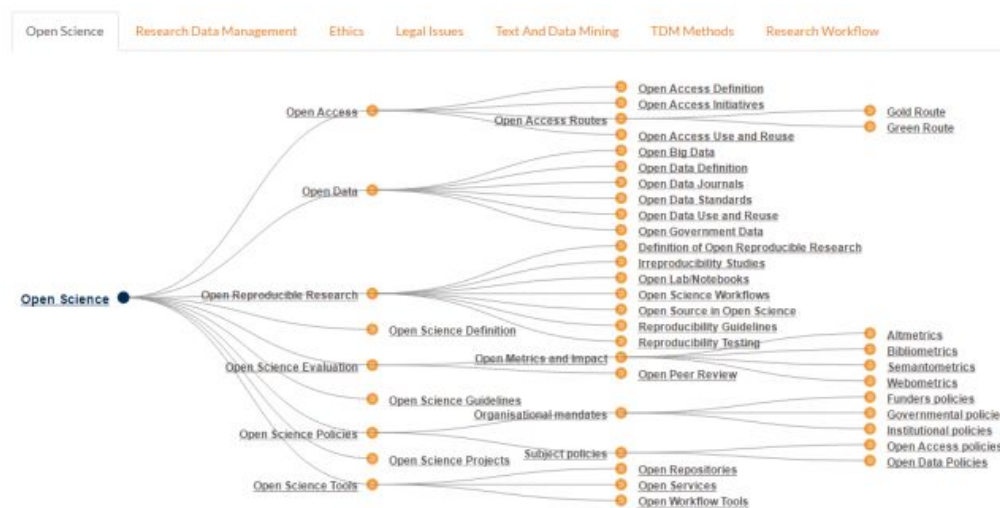


Fig. 1 - The EU’s FOSTER taxonomy² is an essential tool for visualizing the connections between these areas, and also referencing basic definitions for the related terms.

Danille Robinson and the Open Source Alliance helpfully define open as “Transparent and freely available for use, reuse, remixing, and sharing... modify[ing] another term such as open source or open access, implying a difference from a conventional, closed or non-transparent approach.”³ Open science in their estimation is a new way of doing research and scholarship, where the goal is the advancement of knowledge through gracious giving to the common pool of

¹ From the European Commission report “Open innovation, open science, open to the world: a vision for Europe.” Accessible at <https://op.europa.eu/s/oHun>

² <https://www.fosteropenscience.eu/taxonomy/term/7>

³ <https://osaos.codeforscience.org/what-is-open/>

resource⁴ from which anyone with an internet connection can pull. As outlined in their umbrella diagram (Fig. 2), all the opens participate in creating a more just, equitable, diverse and welcoming system of knowledge.



Adapted from: <https://www.meetup.com/Berlin-Open-Science-Meetup/>

Robin Champieux and Danielle Robinson

The broad scope of open science makes it unrealistic and counterproductive to expect there to be one unifying definition of open science that fits all. While there are common descriptors, the concept is evolving, so a helpful way to approach defining open science is to talk about what it does and to what it applies, rather than what it IS.



So, what does open science do? Open Science, according to the National Academies report *Open Science by Design*, aspires to “increase transparency and reliability, facilitates more effective collaboration, accelerates the pace of discovery, and fosters broader and more equitable access to scientific knowledge and to the research process itself.”

Mirrored in the National Academies report and in the European Union’s FOSTER Open Science Training Handbook⁵, the phrase “open science” applies to principles as well as practices (Fig. 3⁶). For example, a researcher might believe in open access in principle, and make

judicious decisions about how to make their own work open. Open science is a spectrum rather than an on/off switch. Another helpful phrase from European open advocates is that research should be “as open as possible, as closed as necessary.”⁷

⁴ Cribbing Elinor Ostrom via [Open Knowledge Institutions: Reinventing Universities](#)

⁵ <https://book.fosteropenscience.eu/en/01Introduction/>

⁶ <https://github.com/open-science-promoters/opensciencelogo>

⁷ This phrase first began to appear in relation to privacy and data use as the EU adopted open research data policies, and has been adopted more widely in and across open science language. It is especially

We also need to be aware that some challenges of defining this area come from an English language-focus and Euro-centric perspective. The German word *wissenschaft*, “incorporates scientific and non-scientific inquiry, learning, knowledge, scholarship and implies that knowledge is a dynamic process discoverable for oneself, rather than something that is handed down”⁸ and is helpful for broadening open beyond just STEM (Science, Technology, Engineering, and Math). More recently, phrases like “open scholarship” and “open knowledge” are being employed for wider utility.

This chapter will default to the term “open science” in an effort to align with global efforts and established literature in this area. Practically in the United States, a phrase like “**open research and scholarship**” would probably best represent the fullest variety of activities, methods, and principles, and also explicitly include, welcome, and make space for the social sciences and humanities in the conversation.

II. Frameworks

Much like digital scholarship and/or digital humanities, open science resists a monolithic definition. Even so, it is a helpful umbrella for situating lots of related concepts, ideas, services, technologies, and projects. We tend to talk about these umbrellas as “frameworks”, which can encompass workflows (processes/procedures which are not always explicit), best practices, and/or just theoretical models. The idea of frameworks is helpful in shaping the concept of open science that is explored here.

Fecher & Friesike compiled a five “schools of thought” framework (Fig. 4) through which open science is approached:

- the infrastructure school - concerned with technological architecture
- the public school - concerned with accessibility or invitational qualities of knowledge
- the measurement school - concerned with evolving impact measurement
- the democratic school - concerned with free access to knowledge
- the pragmatic school - concerned with efficiency of collaborative research

helpful when discussing sensitive research data about human subjects and/or endangered or marginalized populations. Referenced in EU policy at <https://op.europa.eu/s/oHuo>.

⁸ <https://en.wikipedia.org/wiki/Wissenschaft>

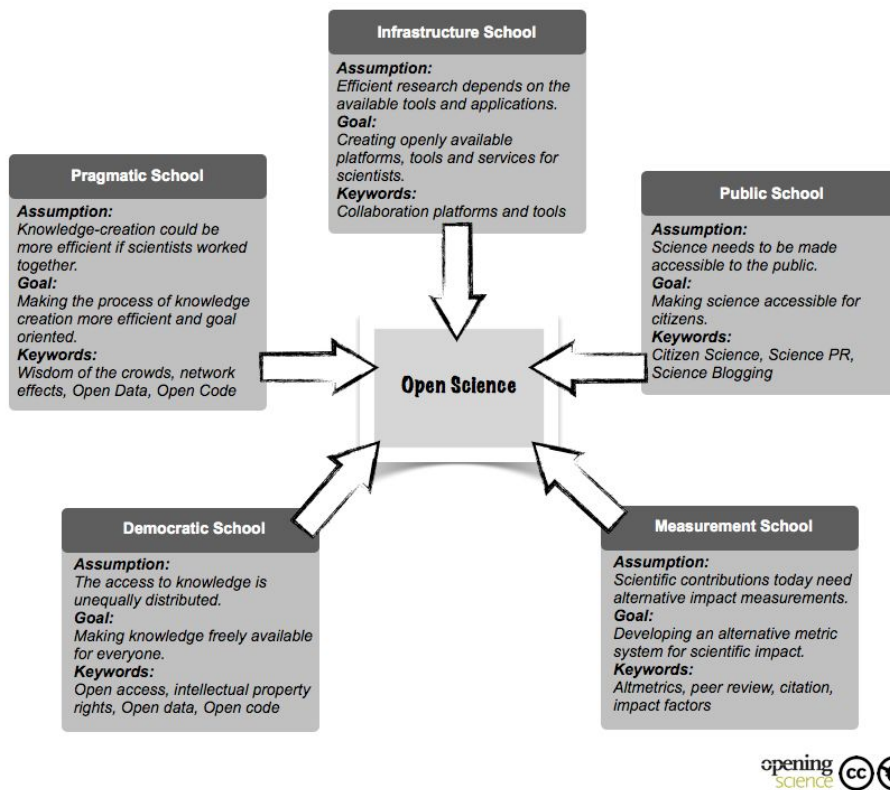


Fig. 4 - Fecher & Friesike Five Schools

Fecher and Friesike’s framework proposes that these five approaches encompass most of the aspirations of open science. Libraries working in this area tend to lean toward one or maybe two of these schools, often based on the character of the university they are attached to and the specific strengths of the librarians employed there. For example, NC State University, a land-grant, STEM-focused university with deep connections to the state of North Carolina through our cooperative agriculture extension program, fits squarely in the Pragmatic School, invested in efficient and collaborative work. Florida State University, my alma mater and former place of employment, would fit much more comfortably in the Democratic School, as etched in stone above Dodd Hall, “The half of knowledge, is to know where to find knowledge.” The “five schools” model offers a flexible suite of definitions for understanding what open science does and where it applies.

The Knowledge Exchange, a think tank of European researchers, developed an “open scholarship framework”, proposing that any open activity could be situated in between three dimensions: Arena, Research Phase, and Level (Fig. 5). For example, a post-doc’s software development project could be technological and focused on dissemination at a micro level, while simultaneously being part of a larger research group’s work that is challenging the social fabric of discovery across their discipline. While feeling a bit sterile and conceptual, this model is helpful for visualizing another important aspect of what open science does, as alluded to above;

open science is a spectrum, affecting change in many ways concurrently, changing how researchers perform daily work, how universities value new forms of scholarly outputs, and also how governments invest in and extract value from higher education as an industry.

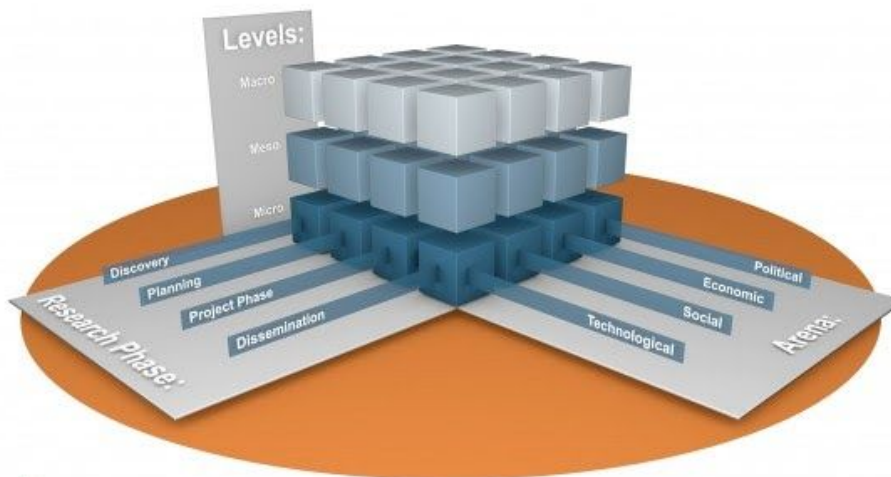


Fig. 5 - KE Open Scholarship Framework

Another important framework for understanding what open science does and applies to is the history of other “open” movements. A valuable trait in this history is that the predecessors of open science took care to document and refine their definitions over time, leading to a nice building block approach using common terms and ideas across the years.

The precepts of open science arose from a few “open” movements that had several established framing definitions:

- [Free Software](#) (1986): “Free software” means software that respects users' freedom and community. Roughly, it means that the users have the freedom to run, copy, distribute, study, change and improve the software. Thus, “free software” is a matter of liberty, not price.
- [Open Source definition](#) (1998): Includes qualities and characteristics for something to be called open source, including: free redistribution, access to the source code, allow and encourage modified and derivative works, some progressive claims about anti-discrimination.
- [Open Access](#) (2002-3): ...open access refers primarily to scholarly literature that is “digital, online, free of charge, and free of most copyright and licensing restrictions. What makes it possible is the internet and the consent of the author or copyright-holder.”⁹

⁹ <http://legacy.earlham.edu/~peters/fos/brief.htm>

- [Open Definition](#) (2005): “Open means anyone can freely access, use, modify, and share for any purpose (subject, at most, to requirements that preserve provenance and openness).”

Building from this history, UNESCO issued a first draft of recommendations on open science in late 2020, following a six month long period of global comments and discussion including 2900 participants from 133 countries¹⁰, underlining and responding to the need for a worldwide open science defining framework. Helpfully, that recommendation offered a mega-definition, affirming that open science is:

“an umbrella concept that combines various movements and practices aiming to make scientific knowledge, methods, data and evidence freely available and accessible for everyone, increase scientific collaborations and sharing of information for the benefits of science and society, and open the process of scientific knowledge creation and circulation to societal actors beyond the institutionalized scientific community.”¹¹

Gesturing backwards to history again, the UNESCO authors hedge their bets and say the open science is “a complex of at least the following elements...” listing out lengthy definitions for open access, open data, open source hardware/software, open science infrastructures, open evaluation, open educational resources, open engagement of societal actors, and openness to diversity of knowledge.

Approaching open science through these frameworks, or others like them, has allowed a breadth of people to claim ownership in the term and utilize it as is helpful to describe their innovations in how they work, why they chose one perspective over another, and in what ways they distribute and invite others into their work. Teased in the introduction, and aligning with the trajectory toward a more equitable and inclusive research environment, a remaining barrier for open science is the “science” part of that phrase. If the distilled version of open science is an evolutionary movement in the culture and behaviors of how academic ideas are created, shared, and used, it's clear that many other people who do not identify as scientists also have purchase in that movement. What we can best glean from the five schools, the three dimensions, and the mega-inclusive global concept is that open science is changing things, rapidly, and hopefully, toward a more equitable data, information, and knowledge future.

III. Characteristics

The principles of open science, according to the National Academies report mentioned earlier, work together to “increase transparency and reliability, facilitate more effective collaboration, accelerate the pace of discovery, and foster broader and more equitable access to scientific

¹⁰ <https://en.unesco.org/science-sustainable-future/open-science/consultation>

¹¹ <https://unesdoc.unesco.org/ark:/48223/pf0000374409.locale=en>

knowledge and to the research process itself.” Taken individually, these principles in practice provide a loose set of qualities (not all encompassing) that we can look for in a research project or a scholar’s portfolio. While not a win/lose checklist, these characteristics can be helpful in identifying open interventions that one could encourage in partnerships, consultations, or collaborative projects. Open science is greater than what it is, and being aware of core principles can help us get closer to describing more clearly what it does.

Deepening the list the National Academies proposed, the Open and Collaborative Science in Development Network (OCSDNet) proposed in their Open Science Manifesto¹² that open science:

- Enables a knowledge commons where every individual has the means to decide how their knowledge is governed and managed to address their needs
- Recognizes cognitive justice, the need for diverse understandings of knowledge making to co-exist in scientific production
- Practices situated openness by addressing the ways in which context, power and inequality condition scientific research
- Advocates for every individual's right to research and enables different forms of participation at all stages of the research process
- Fosters equitable collaboration between scientists and social actors and cultivates co-creation and social innovation in society
- Incentivizes inclusive infrastructures that empower people of all abilities to make, and use accessible open-source technologies
- Strives to use knowledge as a pathway to sustainable development, equipping every individual to improve the well-being of our society and planet

Practically then, the chart below attempts to pair some open science practices to open science principles, in an effort to show what open might look like in action.

Practice	Principle
Documenting data workflows	increases transparency by allowing the process of research to be more visible.
Equitably apportioning credit across a research project	advocates for every individual's right to research and enables different forms of participation at all stages of the research process.

¹² <https://ocsdnet.org/manifesto/open-science-manifesto/>

Sharing research ideas through pre-prints or video abstracts early in the research process	accelerates the pace of discovery by circulating new knowledge.
Producing non-technical, non-technological things (art works, community events, translations/interpretations, etc.)	recognizes cognitive justice, the need for diverse understandings of knowledge making to co-exist in scientific production.
Clearly indicating copyright and licenses for the things you produce (data, articles, posters, graphics, software), and advocating for author-favored licensing in publishing	facilitates more effective collaboration by allowing anyone who encounters your work to immediately understand how they can use, build on, and re-share it.
Advocating for revised tenure and promotion guidelines	practices situated openness by addressing the ways in which context, power and inequality condition scientific research.
Resisting corporate monopolization of academic tools and systems (like major publishing companies owning open access repository software)	enables a knowledge commons where every individual has the means to decide how their knowledge is governed and managed to address their needs.

These characteristics, and the many not detailed in this chapter, are a snapshot of the kinds of actions a researcher or research collective might take to illustrate their commitment to open science. There is no shortage of articles, blog posts, conference presentations, or listicles on

Vienna PRINCIPLES

a vision for scholarly communication

- | | | |
|-------------------|---------------------|-----------------------|
| 1 Accessibility | 5 Transparency | 9 Evaluation |
| 2 Discoverability | 6 Understandability | 10 Validated Progress |
| 3 Reusability | 7 Collaboration | 11 Innovation |
| 4 Reproducibility | 8 Quality Assurance | 12 Public Good |

how to be an open researcher, indicating a growing shift in behavior. However, the culture of research production, steeped in the traditions of pre-digital higher education, is slower to recognize, value, and provide credit for many open practices. As open science practices become more commonplace the expectation is that systems like tenure and promotion will adapt to account for it. Looking ahead to that time, statements like the [Vienna Principles](#) or the [San Francisco](#)

[Declaration on Research Assessment](#) offer a vision of “cornerstones of the future scholarly communication system” and “the need to improve the ways in which researchers and the outputs of scholarly research are evaluated.”

The characteristic practices of open science are not confined to the empirical research that is often stereotyped in the hard sciences. Advancements in applied fields like education, sociology, public history, and fine arts can also connect and reaffirm goals and principles like those outlined above. A modern and progressive researcher might then talk about their work

using familiar disciplinary terms (e.g. cultural heritage artifact) while also connecting to the increasingly common language of open science (e.g. FAIR data), effectively tying their work to this next phase of how we produce new knowledge.

IV. Horizon(s)

In the end it's perhaps more important to point to the increasing speed of developments towards open science, than worry about the exact definition of it. Returning to the trans-atlantic perspective that opened this chapter, the latter years of the 2010's have produced a groundswell of open science advancements, from individuals and communities building and aligning, to full-scale university programs, and perhaps most impactful, governmental and research funder policies shifting to full-throated support.¹³ Concurrently, the global connectivity of research, riding the waves of open access and open educational resources thanks in large part to the maturity of the internet, has solidified the realization that an open science for North America and Europe is not open at all.

In an essay for *The Geopolitics of Open*, Chen, Mewa, Albornoz, and Huang urge caution in the spread of open science from the northern to the southern hemisphere, writing, that if it is not respectful and inclusive of local and diverse knowledge systems, "we will continue to witness the strengthening of systems that seek to be global and "open" research infrastructures, yet continue to limit wider and equitable participations from researchers in less powerful regions and institutions."¹⁴ They continue, acknowledging work of critical theory scholars studying the spread of open knowledge, "an uncritical uptake of "openness" that does not actively work to redress power imbalances in the current system of academic knowledge production - such as the primacy of knowledge written in colonial languages in historically dominant institutions and validated by international academic journals (Chan 2011; Czerniewicz 2015; Canagarajah 2002) - threatens to replicate and amplify them."¹⁵ Knowing this, there is an implicit responsibility in claiming open science to be aware of defining its boundaries precisely.

Kramer and Bosman rightly point out that open science does not develop in a vacuum and is part of a broader movement towards open knowledge. They clarify that nicely, writing that open knowledge and within that open science should be open to the world, offering: translations, plain language explanations, outreach beyond academia, open to questions from outside academia, curation and annotation of non-scholarly information, actionable formats, and participation in public debate.¹⁶ The near horizon is to think globally and act locally; the distant horizon is to erase the barriers between the academy and the public. A broadly defined, principled,

¹³ See: [Global Young Academy](#), [University of Utrecht - Open Science Platform](#), [Plan S](#), [Open Research Funders Group](#)

¹⁴ Albornoz, D., Chen, G. (Zhiwen), Huang, M., Mewa, T., Cota, G. M., & Solís, Á. O. Á. (2018). *The Geopolitics of Open*. <https://hcommons.org/deposits/item/hc:19819/>

¹⁵ *ibid*

¹⁶ <https://im2punt0.wordpress.com/2017/03/27/defining-open-science-definitions/>

action-oriented open science movement may be part of realizing that vision for a more equitable, open knowledge environment.

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