Open Access and Open Science

Abstract

Openness has become a defining paradigm in contemporary knowledge creation, governance, and technological development. Yet openness is often treated as fragmented domains—Open Access, Open Data, Open Source, Open Standards—rather than a unified ecosystem. This write-up integrates multiple conceptual frameworks and empirical insights to articulate a comprehensive **Open Ecosystem Model** consisting of layered infrastructures, cultural practices, governance mechanisms, and frontier technologies. Central to this model is **Open Science**, which acts as the coordinating logic that activates and connects the integrity of each layer. The write-up highlights evidence on distortions arising within Open Access (e.g., APC-driven inequities, predatory journals, licensing failures) and traces how these distortions cascade into Open Educational Resources (OER) and the broader openness ecosystem. Combined with international frameworks (UNESCO, OECD), reproducibility scholarship, and layered openness analyses, the write-up suggests a unified theory of openness that supports equity, sustainability, interoperability, and trustworthy AI.

1. Introduction

Openness today shapes how societies produce knowledge, govern institutions, and build technologies. Movements such as Open Access (OA), Open Data, Open Source Software (OSS), and Open Educational Resources (OER) emerged from struggles for equitable information access and reproducible science (Suber, 2012; UNESCO, 2021). More recent global commitments to Open Science emphasize transparency, reproducibility, participation, and inclusivity across the research lifecycle (Fecher & Friesike, 2014; OECD, 2021).

However, discussions of openness often focus on isolated components—for example, OA publishing or OA mandates—without explaining how these components interlock within a larger ecosystem. A layered perspective clarifies how technical infrastructures, cultural norms, legal frameworks, policy structures, and emerging technologies mutually reinforce or undermine one another.

This write-up synthesizes:

- the **10-layer openness model** (Open Access → Open AI)
- Open Science as an integrated cross-layer practice
- empirical work on OA distortions and OER vulnerabilities
- legal-technical analysis of the "Free, Permanent, Open, Online" criteria
- cultural and collaborative enablers
- governance frameworks and AI transparency

The result is a unified framework for understanding openness as a systemic, interdependent ecosystem.

2. Foundations: Core Infrastructures of Openness

2.1 Open Access (OA)

Open Access eliminates price and permission barriers to scholarly literature (Suber, 2012). Evidence shows that OA increases citation impact, accelerates knowledge diffusion, and supports global research equity (Piwowar et al., 2018).

However, OA is not inherently equitable. APC-based models create financial barriers, leading to geographic and institutional stratification (Klebel & Ross-Hellauer, 2023; Smith et al., 2021). Hybrid and "pseudo-open" models—free to read but not legally reusable—further erode the integrity of openness.Thus, OA must satisfy four conditions:

- **Free** – no reader/payment barriers
- **Permanent** – preserved long-term
- **Open** – licensed for reuse, modification, redistribution
- **Online** – digitally accessible and interoperable

When these criteria fail, openness becomes nominal rather than genuine.

2.2 Open Source Software (OSS)

OSS enables transparent, modifiable, and redistributable software development (Raymond, 1999). Modern infrastructures—cloud computing, AI frameworks, cybersecurity—depend on OSS communities (Fitzgerald, 2006). OSS also enhances reproducibility in scientific workflows by exposing computational logic (von Hippel & von Krogh, 2003).

2.3 Open Data

Open Data makes research datasets accessible, reusable, and interoperable. FAIR principles (Findable, Accessible, Interoperable, Reusable) guide high-quality data sharing (Uhlir, 2012). Open Data supports reproducibility, policy innovation, and AI development (Janssen et al., 2012).

2.4 Open Licensing

Licenses such as Creative Commons, GPL, and MIT operationalize openness. They grant legal clarity for use, adaptation, and redistribution (Lessig, 2004). Licensing failures—e.g., publishing OA materials without reuse rights—undermine OER creation, scientific transparency, and AI dataset integrity.

3. Collaborative & Cultural Layer

3.1 Open Collaboration

Open Collaboration describes distributed, transparent, multi-stakeholder work—exemplified by Wikipedia, Linux, and citizen science. It enhances creativity and collective intelligence (Benkler, 2006; Chesbrough, 2003).

3.2 Open Mind

This cultural foundation represents humility, curiosity, and inclusivity—traits essential for open research, cross-cultural collaboration, and scientific critique. Without an open mindset, infrastructural openness remains underutilized.

3.3 Open Review

Open peer review improves transparency, accountability, and scholarly trust (Ross-Hellauer, 2017). Platforms such as F1000 and eLife demonstrate how open reports and reviews strengthen evaluation integrity.

4. Governance & Standardization

4.1 Open Policy

Open Policy establishes mandates, funding rules, and institutional governance structures to sustain openness. It aligns public value with research incentives (OECD, 2021; Kitchin, 2014). Examples include Plan S, national OA mandates, and open government data policies.

4.2 Open Standards

Standards ensure technical interoperability and long-term preservation (David & Shurmer, 1996). Persistent identifiers, non-proprietary formats, open protocols, and metadata schemas are essential for discoverability and cross-platform integration.

5. Open AI

Open AI represents transparent, accountable, equitable development of artificial intelligence. It depends on—and stress-tests—the entire openness ecosystem:

- open datasets → reproducible training
- open models → auditability
- open evaluation protocols → verifiable claims
- open standards → interoperability
- open policy → responsible governance

Without openness, AI risks opacity, bias, and unaccountable decision-making (Brundage et al., 2020; Whittaker et al., 2018).

6. OA Distortions and Their Systemic Ripple Effects

Based on Frank et al. (2022), several distortions undermine the openness system.

6.1 APC-Driven Inequities

High APCs exclude LMIC researchers, early-career scholars, and unfunded academics (Klebel & Ross-Hellauer, 2023). OA thus becomes skewed toward well-funded institutions, distorting the knowledge base that OER and AI models draw from.

6.2 Predatory and Low-Quality Journals

Predatory outlets publish unvetted work, injecting noise into the open corpus (Beall, 2012). OER creators and AI training pipelines risk absorbing misinformation without proper curation (West et al., 2021).

6.3 Algorithmic Amplification

Search engines and LLMs preferentially surface OA materials, magnifying biases within the OA corpus (Lindemann, 2024). This creates a feedback loop: whatever is open becomes more visible, regardless of quality.

6.4 Licensing Errors

Incorrect or restrictive licenses create "pseudo-open" materials—free to read but not legally reusable—breaking OER workflows and limiting scientific reproducibility.

6.5 Preprint Misinterpretation

Unreviewed preprints can be mistaken for authoritative literature, especially when incorporated into OER or ingested by AI models (Frank et al., 2022).

Collectively, these distortions show that **openness without quality, legality, or preservation is fragile**.

7. Open Science as the Coordinating Logic

Open Science sits at the center of the ecosystem:

- It **uses** foundational infrastructures (OA, data, code).
- It **depends on** cultural practices (collaboration, open mind, open review).
- It **requires** policy and technical governance.
- It **shapes** frontier technologies (Open AI).

Open Science is therefore not just another "open"—it is the **ecosystem** that integrates all layers.

When foundational openness is incomplete or distorted:

- reproducibility collapses (Munafò et al., 2017)
- public trust erodes
- AI becomes opaque and unaccountable
- OER becomes biased or inaccurate
- inequity widens

When foundational openness is strong, Open Science amplifies quality, sustainability, and global participation.

8. Conclusion

A comprehensive open ecosystem requires more than access or transparency alone. It requires durable infrastructures, lawful permissions, cultural norms, governance systems, and responsible technological design. Open Science acts as the coordinating logic that binds these layers into a coherent system.

The **Free, Permanent, Open, Online** framework clarifies the difference between cosmetic and genuine openness.

Global frameworks (UNESCO, OECD) provide policy direction.

Empirical research reveals distortions and inequities that must be addressed. Further, emerging technologies like Open AI depend fundamentally on the integrity of the layers beneath them.

Building a resilient, equitable, and trustworthy knowledge society demands strengthening all layers—technical, cultural, legal, policy, and technological—and ensuring they reinforce, rather than undermine, each other.

References:

Benkler, Y. (2006). *The wealth of networks: How social production transforms markets and freedom*. Yale University Press.

Beall, J. (2012). Predatory publishers are corrupting open access. *Nature, 489*, 179.

Brundage, M., Avin, S., Clark, J., Toner, H., Eckersley, P., Garfinkel, B., … Anderson, H. (2020). Toward trustworthy AI development: Mechanisms for supporting verifiable claims. *AAAI Conference on Artificial Intelligence*, 34(09), 13645–13648.

Chesbrough, H. (2003). *Open innovation*. Harvard Business School Press.

David, P. A., & Shurmer, M. (1996). Formal standards-setting for global telecommunications and information services. *Telecommunications Policy, 20*(10), 789–815.

Fitzgerald, B. (2006). The transformation of open source software. *MIS Quarterly, 30*(3), 587–598.

Fecher, B., & Friesike, S. (2014). Open science: One term, five schools of thought. In S. Bartling & S. Friesike (Eds.), *Opening Science* (pp. 17–47). Springer.

Frank, F., Foster, J., & Pagliari, C. (2022). Open access publishing – noble intention, flawed reality. *Social Science & Medicine, 315*, 115592.

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data. *Information Systems Management, 29*(4), 258–268.

Kitchin, R. (2014). *The data revolution: Big data, open data, data infrastructures and their consequences*. Sage.

Klebel, T., & Ross-Hellauer, T. (2023). The APC-barrier and stratification in open access. *Quantitative Science Studies*.

Lessig, L. (2004). *Free culture*. Penguin.

Lindemann, N. F. (2024). Chatbots, search engines, and the sealing of knowledges. *AI & Society*.

Munafò, M., Nosek, B., Bishop, D., et al. (2017). A manifesto for reproducible science. *Nature Human Behaviour*, *1*, 1–9.
OECD. (2021). *Enhancing access to and sharing of research data*. OECD Publishing.
Piwowar, H., Priem, J., Larivière, V., et al. (2018). The state of OA. *PeerJ*, *6*, e4375.
Raymond, E. S. (1999). *The cathedral and the bazaar*. O'Reilly Media.
Ross-Hellauer, T. (2017). What is open peer review? *F1000Research*, *6*, 588.
Smith, A. C., Merz, L., Borden, J., et al. (2021). APCs and geographic diversity. *Quantitative Science Studies*.
Suber, P. (2012). *Open access*. MIT Press.
Uhlir, P. (2012). The value of open data sharing. National Academies Press.
UNESCO. (2021). *UNESCO Recommendation on Open Science*. UNESCO.
von Hippel, E., & von Krogh, G. (2003). Open source software and innovation. *Organization Science*, *14*(2), 209–223.
West, J. D., Bergstrom, C. T., et al. (2021). Misinformation in and about science. *PNAS*, *118*(32), e2102659118.
Whittaker, M., Crawford, K., et al. (2018). *AI Now Report*. AI Now Institute.