Inclusive Futures of Federated Digital Research Infrastructure (DRI)

A Scoping Review of Cultural Challenges to Federation

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This project is funded as part of the **National Federated Compute Services – NetworkPlus,** UK Research and Innovation (UKRI)

Table of Contents

Summary

With large investments being made into large-scale computing, national coordination has become crucial. Close attention has been paid to various technical and access issues. However, a critical challenge lies in bridging communities with distinctive *epistemic cultures* that shape how they respond to changes in their work. By 'epistemic cultures' we mean the unique and localised practices, tools, and ways of reasoning and communicating within different research fields (Knorr-Cetina, 1999). The aim of this project is to identify the cultural challenges that hinder the federation of DRI and to collaboratively develop pathways for more inclusive community building, which can inform the National Federated Compute Services (NFCS) roadmaps.

As a starting point, this scoping review maps existing research on the cultural dimensions of the digital transformation of research, paying particular attention to how large-scale computing resources are reshaping contemporary data regimes and reconfiguring practices, values and imaginaries. Drawing upon the PRISMA scoping review framework (Tricco et al., 2018), five themes have been thematically identified from the selected literature: 1) Disciplinary silos; 2) Epistemic diversity; 3) Trust and control; 4) Resistance; 5) Power asymmetries. We conclude this review by discussing the gaps in the literature, the notion of inclusiveness deployed, and the implications for the national federation of DRIs.

1. Introduction

1.1 Digital Research Infrastructure in the UK and the need for a cultural approach to culture

The UK's Digital Research Infrastructure (DRI) Landscape

The UK's Digital Research Infrastructure (DRI) ecosystem is undergoing a significant transformation. Led by UK Research and Innovation (UKRI), the £129 million DRI Programme aims to build a coherent, federated, and inclusive national infrastructure that connects researchers to the data, tools, compute, and skills needed for science. This includes:

- Large-scale compute and data services.
- Software and foundational tools.
- Interoperability, security, and sustainability frameworks.
- Professional skills and career pathways for DRI professionals.

The DRI programme's priorities – Interconnected, Human, FAIR and Sustainable DRI – reflect a growing recognition that infrastructure extends beyond technical issues to include social and cultural factors. It is recognised that these infrastructures must be inclusive, user-friendly, and community-driven to support the UK's ambitions in open science, AI-readiness, and global collaboration.

Emerging challenges: sustainability, complexity and fragmentation

As the DRI ecosystem evolves, new challenges emerge. The NetZero DRI Scoping Project, for example, highlights the urgent need to address the carbon footprint of digital infrastructure, from supercomputers to staff laptops. Projects like NetDRIVE aim to build a shared vision for sustainable digital research, recognising that the diversity of infrastructure and communities is both a challenge and an opportunity.

At the same time, the UK's DRI ecosystem encompasses a wide range of funders, users and providers. Each stakeholder brings unique capabilities and faces distinct needs. The federation of DRI – where all the infrastructure and services are connected – allows data sharing, resource pooling, communication and workload migration. Initiatives like the National Federated Compute Services NetworkPlus seek to overcome fragmentation by developing roadmaps for federated services, community-building strategies and governance models that support interoperability and equitable access.

The "cultural turn" in DRIs: cultivating cultures through cultural interventions

Technical and policy interventions alone cannot resolve the deeper cultural challenges around federation, net zero, data sharing, and effective communication and collaboration in the DRI ecosystem. Researchers' engagement with these issues is shaped by factors that cannot be addressed by short-sighted solutions or interventions.

This has been recognised by broader policy frameworks such as:

- UKRI's DRI Strategy emphasises human-centred design, community engagement, and FAIR principles;
- NetZero DRI and NetworkPlus initiatives promote sustainability, federation, and inclusive governance;
- UNESCO's Open Science Recommendations and Horizon Europe call for equity, openness, and global collaboration.

However, existing approaches often lack a "cultural" approach and lack ways to explore cultural challenges as DRI evolves. "Culture" is often treated as a behavioural or managerial problem, addressed through information, training and guidance. Although these approaches and interventions are critical for the development of the DRI ecosystem, they leave a fundamental gap in systems support that needs to be addressed.

Acknowledging this gap, the "FAIR Data Pilot Project: Cultivating Cultures of Data Sharing" (UKRI-DSIT funded and led by UCL-UKSRC) proposed a *cultural turn* in DRIs: the need to cultivate "Cultures" (e.g. data sharing culture) through *cultural interventions* (Chisholm et al., 2025). The project developed a framework that supports the identification of hidden social and cultural challenges, and the adoption of evidence-based approach to codesigning culture interventions. For DRI practitioners, these interventions focus on adopting values and mindsets that enable them to recognise cultural challenges and find ways to intervene. For researchers, scientists, and data professionals, these interventions focus on recognising hidden cultural factors, making visible emerging power dynamics, and imagining and valuing alternative futures, thus empowering them to engage more critically with the DRI ecosystem.

A cultural approach to DRI culture – or epistemic cultures – involves understanding DRI as a site of epistemic transformation – a space where systemic practices, values and social norms of research and innovation are contested, and alternative futures imagined. A cultural approach, therefore, focuses on the intersection of the *material* (e.g., existing standards, protocols, tools and infrastructures), *knowledge* (e.g., how to share data) and *meaning* (e.g., how federation is valued and framed) mobilised across DRIs and beyond.

The "meaning" dimension involves the exploration of "constellation of meanings" that orient the action of researchers, scientists, data professionals, and more. This constellation includes people's *emotions* (fears, concerns, beliefs) *moral evaluations* (ambivalences, ambiguities) and *imaginaries* (future states) that shape how they respond to changes and value certain practices. This approach points to a fundamental issue: each DRI community must address social and cultural barriers by using a cultural approach to contribute to the UK's leadership in inclusive and sustainable science.

2. Rationale for Review

Social and cultural challenges associated with technological developments in the workplace have been extensively documented over recent decades. These challenges often are linked to the emergence of new work practices, shifting knowledge and skills requirements, as well as evolving legal and governance structures and power relations. Together, these dynamics create challenges to the adoption of technologies and their associated practices. Previous research has also highlighted how the coming together of different epistemic cultures can generate tensions around trust and collaboration (Chisholm et al., 2025; Heidler, 2017; Knorr-Cetina, 1999).

At present, however, it remains unclear what kinds of evidence are available in the literature concerning the cultural challenges of *federated digital research infrastructures* – the evidence seems fragmented across disciplines and influenced by the understanding of federation and culture. The rapid advancement of digital technologies – and, in particular, the federation of large-scale compute services – demands an examination of new evidence about these cultural challenges. For these reasons, a scoping review was conducted to map the research in this area, as well as to identify any existing gaps in knowledge.

3. Objectives and questions

The main objective of this scoping review was to identify and synthesise existing research on cultural challenges that hinder collaboration in DRIs. Here federation is considered as extending beyond the technical requirements for access, authentication, security, and identity. Federation can lead to new forms of collaboration, communication, sharing and knowledge creation. Based on this assumption, this scoping review focused on the intersection of federation, culture, and collaboration.

Research questions:

- What cultural challenges to collaboration (linked to federation) in DRIs have been identified in the literature?
- How are inclusivity and diversity framed in relation to DRIs?
- What are the cultural conditions for a more inclusive national federated DRIs identified in the literature?
- What gaps exist in current knowledge about cultural challenges to collaboration?

4. Methods

The scoping review was conducted using the PRISMA framework (Tricco et al., 2018), first developed by Arksey and O'Malley (2005), and then enhanced by Levac et al. (2010). The review focused on literature on: 1) federated digital research infrastructure, 2) research collaboration and 3) power dynamics, equity and diversity in science.

Eligibility criteria

- *Population*: Researchers, institutions, scientific communities engaging with DRIs;
- *Concept*: federation, cultural challenges, inclusivity, scientific collaboration barriers, power dynamics;

- *Context*: Federated Digital research infrastructures (international and national cases).

Information sources

- Databases: Web of Science, Scopus, ACM Digital Library, SocINDEX, etc., accessed via UCL search engines platform.
- Grey literature: policy reports (OECD, EU, UNESCO, UKRI, Jisc).

Search strategy

The following keywords/Boolean strings were used:

- “e-science” AND “collaboration” and “culture”.
- “research infrastructures” AND “collaboration” AND “culture”:
- “digital research infrastructures” AND “federation” AND “culture”.
- “digital research infrastructures” AND “culture”.
- “research infrastructures” AND “cultural change”.
- “scientific collaboration” AND “research infrastructure” AND “culture”.
- “scientific collaboration” AND “culture”.
- “digital research infrastructure” AND “development”
- “federated infrastructure” AND “development”

Selection of sources

44 documents were selected for the review, including journal articles and books (see appendix 1). This is a non-exhaustive but fresh evidence review of the literature. It is worth mentioning that one paper included a literature review of the barriers to scientific collaboration in e-science, bringing together more than 150 papers.

Data charting

Extracted items include cultural challenges of federation of DRI and/or research collaboration, the framing of inclusivity, and recommendations. Each document was analysed using Copilot, which extracted key information based on predefined prompts. Summaries of each document, as generated by Copilot, are provided in Appendix 1. Using this information, we then conducted a *thematic analysis* to identify key patterns across the documents.

5. Results

5.1. Cultural Challenges in Federating Digital Research Infrastructures

Federated Digital Research Infrastructures (DRIs) aim to support large-scale, multidisciplinary, and geographically distributed collaborations. However, the literature reveals that cultural challenges, rooted in disciplinary norms, institutional practices, and interpersonal dynamics, pose significant barriers to their effective implementation. Five themes were identified:

1. Disciplinary silos.
2. Epistemic diversity.
3. Trust and control.
4. Resistance.
5. Power asymmetries.

Summary of themes

Themes	Description
Theme 1: Disciplinary silos	• Many disciplines operate in isolation, with distinct vocabularies, methodologies, and data practices (e.g., libraries versus museums; humanities versus computational sciences). • These silos hinder interoperability and collaboration, especially in federated systems that require shared standards and mutual understanding. • Bringing together different disciplines require effort termed “boundary work” and the development of “relational expertise”.
Theme 2: Epistemic diversity	• Federated access systems (e.g., MyAccessID) often enforce rigid role-based access tied to institutional hierarchies, which may not reflect the diversity of existing and new research roles or collaborative models. • This rigidity can exclude non-traditional actors (e.g., community partners, citizen scientists) and limit flexibility in participation. • Moreover, a gender gap still persists in the design, development, and deployment of research infrastructures.
Theme 3: Trust and control	• Researchers express discomfort with data sharing due to fears of misuse, of being “scooped”, loss of control, and lack of recognition. • In federated infrastructures, trust must be built across institutions with varying governance models, technical capacities, and ethical standards.
Theme 4: Resistance	• Resistance to interdisciplinary collaboration is often rooted in entrenched epistemic traditions, particularly in humanities and some social sciences. • Some disciplines exhibit cultural resistance to digital tools, viewing them as incompatible with traditional practices.

	• Automation in biosciences, for example, disrupts embodied routines and tacit knowledge, leading to emotional and ethical tensions.
Theme 5: Power asymmetries	• Smaller institutions, community archives, and researchers in low and middle income countries often lack the resources to participate in federated infrastructures. • Dominant institutions and actors shape standards, governance, and narratives, reinforcing epistemic hierarchies and exclusion. • Data sovereignty concerns are especially pronounced in Global South contexts, where geopolitical restrictions and infrastructural inequities persist.

Narrative synthesis of thematic mapping

Theme 1: Disciplinary silos

Federated DRIs often aim to bridge disciplinary boundaries, yet entrenched epistemic cultures and siloed practices pose significant barriers. Across domains – from life sciences to digital humanities – researchers operate within distinct traditions of knowledge production, validation, and collaboration. For example:

- In collection-based infrastructures, libraries, museums, and archives exhibit divergent cataloguing and metadata standards, complicating interoperability and aggregation efforts (Humbel et al., 2024).
- Astronomy and high-energy physics, despite shared goals, clash over collaboration styles and epistemic strategies: experimentation versus observation, or formalism versus idiography (Heidler, 2017).
- Synthetic biology teams struggle to reconcile *tacit lab knowledge* with the explicit programming required for automation, leading to friction and inefficiencies (Meckin, 2019).
- Environmental research infrastructures face friction when academic and private sector cultures collide: knowledge advancement versus market-driven deliverables (Chabbi et al., 2017).

These misalignments hinder the development of shared infrastructure, since federated systems must accommodate diverse ontologies, workflows, and expectations.

Theme 2: Epistemic diversity

Structural inequalities shape how researchers engage with infrastructure, collaboration, and digital tools. These gaps that are reflected in governance and organisational structures can obstruct federation.

- Short-term funding cycles and precarious employment in arts and humanities research undermine long-term infrastructure planning and retention of skilled staff (Beavan et al., 2025)
- In federated HPC systems, rigid role-based access tied to institutional hierarchies limits flexibility and inclusivity (Alam et al., 2024). This rigidity can exclude people, communities and practices.
- A gender gap still persists in the design, development, and deployment of research infrastructures (Guariglia Migliore et al., 2025)
- Doctoral students and early-career researchers often lack institutional support for digital collaboration, facing fragmented governance and weak incentives (Koschtial et al., 2021).
- Open Science initiatives often privilege dominant Northern epistemologies, marginalising exploratory or context-sensitive methods (Leonelli, 2022; Rafols, 2024).

Federated infrastructures must navigate these gaps in participation (and therefore types of practices), designing systems that recognise diverse institutional logics and practices while promoting interoperability.

Theme 3: Trust and control

Trust is foundational to collaboration, yet federated infrastructures often challenge traditional notions of control and ownership.

- Researchers express discomfort with data sharing due to fears of misuse, of being scooped, loss of control, and institutional restrictions (Morrison-Smith, 2019; Chisholm et al., 2025).
- In federated health data infrastructures, building trust among partners required intensive communication and consensus-building (González-García, 2021).
- Open data mandates conflict with private sector needs for proprietary control, especially in environmental science (Chabbi et al., 2017).
- In some astronomy communities, epistemic obedience and data conformism reflect deeper colonial dynamics, where local actors align with global observatories at the expense of autonomy (Lehuedé, 2023).
- FAIR data principles often fail to account for geopolitical restrictions and infrastructural inequities, creating misleading impressions of accessibility (Shanahan & Bezuidenhout, 2022).

Federated DRIs must embed mechanisms for equitable governance, transparent access control, and recognition of diverse data sovereignties.

Theme 4: Resistance

Despite the promise of digital transformation, many researchers resist automation and digital tools due to epistemic, emotional, and cultural concerns.

- In synthetic biology, automation disrupts embodied routines, leading to frustration and ethical concerns about invisible labour (Meckin, 2019).
- Arts and humanities researchers often view computational methods as incompatible with traditional interpretive practices (Beavan et al., 2025).
- Web 2.0 tools remain underutilised in scholarly contexts due to privacy concerns, disciplinary inertia, and lack of perceived utility (Koschtial et al., 2021) .
- Machine learning systems impose normative constraints on scientific goals, privileging prediction over explanation and marginalising human epistemic agency (Ratti, 2025).

Federated infrastructures must be designed not just as technical transformations but as reconfigurations of practice, requiring training, reflexivity, and cultural sensitivity.

Theme 5: Power asymmetries

Federated infrastructures risk reproducing global and institutional hierarchies:

- Community archives and small institutions lack the resources to participate in centralised aggregation projects, leading to digital inequities (Humbel et al., 2024).
- Open Science platforms often reinforce Northern dominance, excluding marginalised epistemologies and researchers from the Global South (Leonelli, 2022; Rafols, 2024; Couldry & Mejias, 2023).
- Intellectual humility is essential for equitable collaboration, yet academic norms reward assertiveness and individualism (Palmer, 2023).
- Emotional labour and informal leadership in scientific teams are undervalued, despite their centrality to collaboration (Lopez Carrasco & Belli, 2023).
- Platform capitalism and corporate control over infrastructure exacerbate exclusion and surveillance, particularly in LMICs (Couldry & Mejias, 2023; Shanahan & Bezuidenhout, 2022.

Federated DRIs should be based on inclusive governance models, recognise invisible labour, and challenge epistemic hierarchies to foster truly equitable collaboration.

Conclusion

Federating digital research infrastructures poses cultural issues – the access and use of DRI is a deeply cultural and political endeavour. Addressing disciplinary silos, exclusionary practices, trust dynamics, resistance to automation (viewing resistance as a productive practice rather than a barrier or obstacle), and power asymmetries requires a holistic and reflexive approach. Successful federation depends on designing infrastructures that are not only interoperable but also inclusive, cultural sensitive, and epistemically just.

5.2. Enabling conditions and recommendations for inclusive federated DRIs

Literature often recommends ways to move forward. In this section, these recommendations are summarised.

Relational and reflexive infrastructure design

- Infrastructure should be co-designed with diverse stakeholders, recognising local contexts, epistemic cultures, and power dynamics.
- Relational infrastructure emphasises trust, care, and mutual recognition over purely technical interoperability.

Flexible governance and roles

- Federated systems must allow dynamic role switching and accommodate non-traditional contributors.
- Governance models should support inclusive decision-making and equitable access to infrastructure and data.

Recognition and reward structures

- Academic incentives must evolve to value data sharing, collaboration, and invisible labour (e.g., curation, stewardship).
- Recognition systems should account for diverse contributions, including those from marginalised communities and interdisciplinary teams.

Capacity building and cultural bridging

- Training programs should bridge technical and humanistic skills, fostering shared language and collaborative norms.
- DevSecOps and participatory design cultures require institutional support and mindset shifts.

Decentralisation and ethical frameworks

- Decentralised models (e.g., linked data, community-led repositories) can empower local actors and reduce centralisation risks.
- Ethical frameworks (e.g., CARE principles, feminist ethics of care) should guide data governance and infrastructure development.

5.3. Framing of inclusivity and diversity

The literature reveals that the notion of inclusion and diversity in (federated or not) DRI is shaped by epistemic cultures, technical requirements, and infrastructural constrains. Across multiple studies, inclusivity extends beyond issues of access to include forms of recognition, representation, and equitable participation in the design, governance, and use of DRIs. This framing focuses on “access and institutional inequities”; “geographical and resource disparities”; “invisible labour, recognition and representation”.

This means that inclusion and diversity focus mainly on the human aspect of DRI. Although this is crucial, the growing interconnection between humans and non-human entities, such as computer services, AI, and data storage, requires the idea of inclusion and diversity be expanded to cover these increasingly complex interactions. This does not necessarily mean developing new conceptualisations, but rather illuminating current concerns by adding more nuanced interrelationships.

2.1 Gaps in literature

The following gaps were identified in the literature:

Limited theorisation of cultural and epistemic dynamics in Federation DRIs

There is a need for frameworks that integrate key theoretical concepts into federation design and development. The cultural and epistemic implications of federation remain under-theorised. For example:

- A focus on key concepts from STS, philosophy of science and sociology like “epistemic diversity”, “meta-work”, “trading zones”, “relational expertise”, “interactional expertise”, “agency”, “identity negotiation”, etc., is missing when analysing digital research infrastructures.
- The diversity of epistemic cultures within specific disciplines is rarely considered in the design of federated systems, leading to misalignment between infrastructure and practice.

Inadequate attention to power asymmetries

Research is needed to explore inclusive governance, horizontal collaboration, and decolonial approaches to federation. Federated DRIs often reproduce existing institutional and geopolitical inequities:

- Smaller institutions and LMICs face barriers to participation due to lack of infrastructure, technical capacity, and federation membership (Hofman, 2015; Shanahan & Bezuidenhout, 2022).
- Data colonialism and epistemic obedience persist in federated collaborations, especially in Global South contexts (Lehuedé, 2023; Couldry & Mejias, 2023).
- Access inequities are exacerbated by reliance on commercial platforms and restrictive governance models.

Fragmented understanding of interdisciplinary and cross-sector collaboration

There is a gap in understanding how federated infrastructures can facilitate epistemic translation, boundary work, and interactional expertise across sectors and disciplines. Federated DRIs are intended to support interdisciplinary and cross-sectoral research, yet:

- Disciplinary silos and divergent metadata standards hinder interoperability (Humbel et al., 2024).
- Collaboration architectures are rarely optimized for epistemic disruption or innovation (Zheng, 2025).
- Public-private partnerships in federated DRIs face cultural and structural misalignment (Chabbi et al., 2017).

Lack of longitudinal and comparative studies

Most studies focus on pilot projects or single-use cases (e.g., stroke care in JA-InfAct), limiting generalizability. There is a need for longitudinal research on the sustainability and evolution of federated DRIs; and comparative studies across disciplines, regions, and governance models to identify best practices and pitfalls.

Underdeveloped metrics for evaluating cultural change

While technical performance is often measured, cultural transformation within federated DRIs is not systematically assessed. Existing frameworks (e.g., Value Creation Framework) offer starting points, but diverse types of metrics for epistemic justice and relational infrastructure are still emerging. Future research should develop mixed-method evaluation tools that capture both technical and cultural dimensions of federation.

6. Conclusion

Literature has identified some evolving cultural challenges around the adoption of new digital technologies and the federation of research infrastructures. However, there are still some fundamental questions that need to be addressed to drive the discussion around federation. For example:

- How are users involved in decisions about governance of the national federation of DRI?
- Whose voices are heard in setting policies and roadmaps: large research universities versus teaching-oriented and non-traditional institutions?
- Is there support for institutions that are less well-resourced, so that participation is equitable?
- Could there be subtle, unintended, and hard-to-detect exclusionary practices embedded in the way key aspects of federation are defined?
- Epistemological disputes: will universities continue to be the central space where science is validated?
- How inclusive will the governance of the national federated DRI be?
- How does the federation interact with broader debates about surveillance, data privacy, and autonomy, especially in the context of staff being identified everywhere digitally?

These questions – and more! – are important to the development of the roadmap of federated DRI. Addressing them is crucial to ensure the federation remains inclusive and sensitive to varied epistemic and institutional cultures.

7. References

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8. Appendix

8.1. Appendix 1: Summary of selected literature (the synthesis was conducted using Copilot)

Paper/ book/ chapter	summary
1. Towards a National Research Software Engineering Capability in Arts and Humanities Research: a Roadmap (by Beavan et al., 2025)	**Key Findings** • The report outlines a strategic plan to establish a national, people-centred Research Software Engineering (RSE) Capability for Arts & Humanities (A&H) research in the UK. • It identifies a critical shortage and uneven distribution of RSEs, especially those skilled in A&H contexts. • There is a lack of institutional support, training, and career pathways for both RSEs and A&H researchers engaging in digital methods. • The roadmap proposes a UK-wide RSE Directory, training programmes, matchmaking mechanisms, outreach, and an incubator for innovation. **Social and Cultural Barriers Identified** **1. Fragmented Academic Cultures** o Many institutions operate in disciplinary silos, which hinders collaboration between RSEs and A&H researchers. o There is a lack of shared language and understanding between technical and humanities professionals, making interdisciplinary work difficult. **2. Low Awareness and Recognition of RSE Roles** o A&H researchers often do not understand the value or role of RSEs, and RSEs may lack familiarity with A&H research methods. o This mutual unfamiliarity creates barriers to collaboration and limits the integration of digital methods. **3. Short-Term Funding and Precarity**

	- A&H research is typically funded for short durations, making it hard to plan long-term collaborations or retain skilled staff. - This contributes to instability in RSE careers, especially within A&H contexts. **4. Cultural Resistance to Digital Methods** - Some A&H disciplines exhibit resistance to adopting computational approaches, viewing them as incompatible with traditional methodologies. - There is a perceived divide between "technical" and "humanistic" research cultures. **5. Geographical and Institutional Inequities** - RSEs are concentrated in certain institutions, leaving others—especially smaller or less research-intensive universities—without access to digital expertise. - This creates regional disparities in digital research capacity. **Contextual Factors** • The roadmap is informed by prior studies and surveys (e.g., iDAH, SSI, AHRC reports) that highlight systemic issues in digital A&H research. • It builds on existing initiatives like King's Digital Lab, The Turing Institute's Data/Culture project, and UKRI's NetworkPlus programmes. • The Capability is designed to be inclusive, distributed, and collaborative, aiming to overcome the barriers through structured support and community-building. **Implications for Practice and Policy** • **Policy Recommendations:** - Funders should prioritise long-term investment in digital A&H infrastructure and RSE career development. - Institutions should formalise collaboration mechanisms and provide incentives for interdisciplinary work. - National coordination (via the RSE Directory and Capability team) should

	facilitate equitable access to digital expertise.
	• **Practice Recommendations:**
	  ○ Develop training pathways that bridge technical and humanistic skills.
	  ○ Promote mentorship and outreach to foster a culture of collaboration.
	  ○ Encourage open-practice collaboration and knowledge exchange across disciplines.
	
	Gaps and Limitations in the Analysis
	• While the roadmap is comprehensive, it relies heavily on existing initiatives and assumes their scalability.
	• The cultural change required is acknowledged but not deeply theorised; more work is needed to understand disciplinary resistance.
	• The metrics for success are still under development and may need refinement to capture nuanced social and cultural shifts.
	• The roadmap does not fully address intersectional issues (e.g., gender, race, class) that may affect access to digital research opportunities.

2. Socio-cultural challenges in collections digital infrastructures by Humbel et al., 2024	**Key Findings** • The paper explores the experiences of libraries, archives, museums, and heritage organisations (collectively referred to as collections-holding organisations) in contributing to digital infrastructures. • It argues that technical and legal challenges, while important, are often overemphasized, and that social and cultural factors play a critical but underexplored role in shaping digital infrastructure development. • The study is based on semi-structured interviews with 18 individuals from 10 organisations, including national institutions, community archives, and international aggregators. **Social and Cultural Barriers Identified** **1. Disciplinary Silos and Divergent Traditions**

	◦ Different sectors (e.g. libraries vs museums vs archives) have distinct cataloguing practices, metadata standards, and descriptive conventions. ◦ These differences complicate efforts to unify collections at scale and hinder interoperability. **2. Aggregation Fatigue and Institutional Memory** ◦ Many organisations have participated in multiple aggregation projects with limited long-term sustainability, leading to scepticism and reluctance to engage in new initiatives. ◦ There is a perception that projects often "reinvent the wheel" without learning from past efforts. **3. Power Asymmetries and Resource Disparities** ◦ Smaller organisations, especially community archives, lack the technical capacity, funding, and staff to digitise collections or participate in aggregators. ◦ Competitive funding models favour large, well-resourced institutions, reinforcing digital inequities. **4. Inherited Infrastructural Conventions** ◦ Legacy systems and entrenched practices lock organisations into outdated workflows, making it difficult to adopt new technologies or standards. ◦ Infrastructure development often imposes dominant models that marginalise local or less powerful actors. **5. Ethical and Cultural Sensitivities** ◦ Digitisation and aggregation can reproduce colonial and cultural injustices, especially when metadata or images are shared without community consent. ◦ Legal frameworks (e.g. copyright) do not adequately address ethical concerns around sensitive or contested collections. **6. Centralisation vs Decentralisation**

	◦ There is growing scepticism about centralised aggregation models; many interviewees favour linked data and decentralised approaches that respect local contexts and practices. ◦ However, decentralised models require technical expertise and infrastructure that many organisations lack. **Contextual Factors** • The paper is situated within the UK's Towards a National Collection (TaNC) programme and broader international efforts to unify digital collections. • It critiques the dominant focus on technological innovation and calls for a shift toward socially embedded, sustainable, and inclusive infrastructure development. • The authors draw on infrastructure studies and critical archival theory to frame their analysis. **Implications for Practice and Policy** **Practice** • Invest in cataloguing and metadata quality, especially in under-resourced institutions. • Support cross-sectoral collaboration that respects disciplinary differences. • Develop lightweight, accessible tools for data sharing and exploration. **Policy** • Funders should prioritise sustainability over novelty, supporting existing infrastructures rather than creating new ones. • Establish inclusive networks where collections-holding organisations, tech providers, and users can co-design infrastructure. • Address ethical and cultural concerns through frameworks like CARE principles and feminist ethics of care. **Gaps and Limitations in the Analysis** • While the paper offers rich qualitative insights, it does not propose concrete models for decentralised infrastructure or linked data implementation.

	• The voices of community stakeholders (e.g. Indigenous groups, local users) are represented indirectly through institutional perspectives. • The study focuses on UK and EU contexts; broader international comparisons could enrich the findings.
3. Federated Single Sign-On and Zero Trust Co-design for AI and HPC Digital Research Infrastructures by Alam et al., 2024	**Key Findings** • The report presents a federated Identity and Access Management (IAM) and Zero Trust Architecture (ZTA) implementation for the UK's Isambard-AI and HPC Digital Research Infrastructures (DRIs). • The system is designed to balance seamless access for researchers with strict cybersecurity and regulatory compliance, using federated login (MyAccessID), multi-factor authentication (MFA), and role-based access control (RBAC). • The architecture is segmented into zones (Access, Management, HPC, Security), each with distinct access protocols and monitoring systems. **Social and Cultural Barriers Identified** **1. Federation Limitations and Institutional Inequities** • The federated IAM system (MyAccessID) is limited to institutions within the federation. Users from non-member organisations (e.g. vendors, government bodies) must use an "Identity Provider of Last Resort," which lacks federation and broader trust assurances. • This creates access inequities, especially for interdisciplinary or cross-sector collaborations. **2. Role-Based Access and Institutional Hierarchies** • Access is tightly linked to institutional roles (e.g. PI, Researcher, Admin), which may not reflect the diversity of user needs or collaborative models in research. • The system enforces strict role boundaries, potentially limiting flexibility in project participation and knowledge sharing. **3. Cultural Expectations Around HPC Access**

	• Some users, especially those accustomed to traditional HPC workflows, found the cloud-like interface unfamiliar or confusing. • This reflects a cultural gap between legacy HPC practices and emerging cloud-native, security-first paradigms. **4. DevSecOps Adoption and Team Culture** • The report notes the need to cultivate a DevSecOps culture to support secure, agile development and operations. • This cultural shift requires training, mindset change, and institutional support, especially in environments historically focused on performance over security. **Contextual Factors** • The work is driven by UKRI's vision for a national digital research infrastructure and the UK Government's AI Safety Institute. • It responds to global cybersecurity mandates (e.g. NIST, UK NCSC) and aims to support open research while meeting compliance requirements. • The system was developed rapidly (within 6 months) and tested at scale during RSECon24. **Implications for Practice and Policy** **Practice** • Institutions must invest in user onboarding and training to bridge cultural gaps in access models. • Adoption of open standards and open-source tools supports interoperability and sustainability. • Role-based access must be flexible and inclusive, especially for interdisciplinary and non-traditional research roles. **Policy** • Broader international federation efforts are needed to expand trusted identity access beyond current R&D institutions. • Policymakers should support DevSecOps capacity-building in research infrastructure teams.

	• Funding models should account for the costs of secure access, not just hardware and compute. **Gaps and Limitations** • The reliance on MyAccessID excludes non-federated users, limiting inclusivity. • The system's complexity (e.g. zoning, segmentation) may challenge scalability and user comprehension. • Encryption and secure access are well-implemented for IAM workflows but less mature in HPC subsystems (e.g. parallel file systems), which may pose future risks.
4. Integrating Environmental Science and the Economy: Innovative Partnerships between the Private Sector and Research Infrastructures by Chabbi et al., 2017	**Key Findings** • Environmental Research Infrastructures (ERIs) are critical for understanding ecological processes and addressing global environmental challenges. • Despite their scientific value, ERIs face challenges in securing sustainable funding and translating research into actionable, market-driven solutions. • The paper advocates for innovative public-private partnerships to bridge the gap between environmental science and economic development. • Two models are proposed: university-based innovation incubators and value-added service models (e.g., NCAR's Engineering for Extreme Climate Partnerships). **Social and Cultural Barriers** **1. Institutional and Structural Misalignment** • ERIs are structured like academic institutions, while private enterprises operate under market-driven, profit-oriented models. • This misalignment creates friction in collaboration, especially around timelines, deliverables, and expectations. **2. Cultural Differences in Motivation and Language**

	• Scientists prioritize knowledge advancement and publication; entrepreneurs focus on competitive advantage and profitability. • Lack of a shared language and understanding of roles leads to confusion and missed opportunities in joint ventures. **3. Trust and Legitimacy Issues** • Public trust in science and government institutions has fluctuated, especially post-2008 financial crisis. • Environmental data is often politicized, undermining its legitimacy and complicating its use in commercial contexts. **4. Intellectual Property and Data Sovereignty** • Open data mandates for publicly funded ERIs conflict with private sector needs for proprietary data and competitive advantage. • Managing IPR and data sovereignty across geopolitical boundaries remains a persistent challenge. **5. Resistance to Formal Business Practices** • ERIs are often slow to adopt project management, business planning, and commercialization tools. • This limits their ability to engage effectively with private sector partners and justify long-term investments. **Contextual Factors** • The paper is situated in a landscape of increasing environmental risks, political volatility, and economic uncertainty. • Governments and funding agencies are pushing for ERIs to demonstrate societal relevance and economic impact. • The UN Sustainable Development Goals and global climate initiatives provide a framework for aligning ERI efforts with broader policy agendas. **Implications for Practice and Policy** **Practice** • ERIs should adopt formal project management and business planning tools to improve accountability and strategic alignment.

	• Hybrid models combining university incubators and service-oriented analytics can foster innovation and scalability. • Synthesis centers can facilitate stakeholder engagement and co-design of solutions. **Policy** • Governments should support flexible funding mechanisms and incentives for public-private collaboration. • Policies must address IPR and data sovereignty to enable cross-sector innovation while maintaining public access. • Strategic roadmaps should include ERIs as key players in environmental decision-making and economic resilience. **Gaps and Limitations** • The paper acknowledges the lack of a universal model for public-private collaboration and the need for tailored approaches. • It does not provide detailed case studies or metrics for evaluating success in partnerships. • The proposed models require further testing through pilot projects and adaptive learning.
5. Changing Infrastructural Practices: Routine and Reproducibility in Automated Interdisciplinary Bioscience by Meckin 2019	**Key Findings** • The paper explores how automation in synthetic biology—particularly robotics and software-enabled design—reconfigures routine scientific practices. • It introduces the concept of infrastructure as practice, arguing that mundane, embodied routines (e.g., pipetting, curating frozen materials) are central to knowledge production and are often disrupted by automation. • These disruptions require creative problem-solving and adaptation, which in turn reshape epistemic cultures and collaborative dynamics. **Social and Cultural Barriers** **1. Tacit Knowledge vs. Explicit Programming** • Manual lab practices (e.g., pipetting) rely heavily on tacit, embodied knowledge. • Automation demands that this tacit knowledge be made explicit and codified, creating friction and requiring new skills and understandings.

	2. Disciplinary Misalignments • Interdisciplinary teams (e.g., biologists, computer scientists, technicians) often have differing expectations and practices around reproducibility, data management, and collaboration. • These differences can lead to misunderstandings and inefficiencies, especially when automating processes that were previously manual. **3. Temporal Disjunctions** • Automation accelerates some aspects of research (e.g., design), but others (e.g., DNA synthesis, material curation) lag behind. • This uneven pace creates bottlenecks and complicates reproducibility and data integrity. **4. Changing Emotional and Ethical Engagements** • Researchers express frustration with machines ("robots are stupid"), reflecting emotional shifts in how they relate to their tools and tasks. • Ethical concerns arise around valuing certain practices over others, especially when automation renders previously central routines invisible or obsolete. **Contextual Factors** • The study is based on ethnographic research in a UK synthetic biology center aiming to build a "pipeline" for faster, reproducible microbial engineering. • The center integrates robotics, machine learning, and interdisciplinary collaboration, reflecting broader trends in the bioeconomy and engineering biology. • The work is situated within STS (Science and Technology Studies) debates on infrastructure, practice, and epistemic cultures. **Implications for Practice and Policy** **Practice** • Automation should be approached as a reconfiguration of practice, not just a technical upgrade. • Teams must invest in training, documentation, and collaborative problem-solving to bridge

	disciplinary divides and preserve reproducibility. • Routine practices (e.g., pipetting, data curation) should be recognized as infrastructural and valued accordingly. **Policy** • Funding and strategic planning should account for the hidden labor and adaptation required to implement automation. • Policies promoting reproducibility must consider the diverse ways it is practiced across disciplines. • Infrastructure development should include mechanisms for tracking and supporting evolving practices, not just technologies. **Gaps and Limitations** • The study focuses on a single case and does not generalize across other synthetic biology or interdisciplinary contexts. • It does not offer prescriptive solutions for managing infrastructural change but rather highlights the complexity and fluidity of such processes. • The concept of infrastructure as practice, while compelling, requires further empirical testing and theoretical refinement.
6. Towards a Federated Infrastructure for the Global Data Pipeline by Hofman (2015)	**Key Findings** • The paper proposes a **federated infrastructure** to support global data pipelines in logistics, enabling seamless interoperability across diverse platforms and stakeholders. • It introduces **platform services and protocols** to facilitate real-time data sharing, visibility, and transaction support, especially for **Small and Medium-sized Enterprises (SMEs)**. • The approach is grounded in **action design research** across EU-funded projects, aiming to overcome fragmentation in logistics data systems. **Social and Cultural Barriers** **1. Trust and Reluctance to Share Data**

	• Organizations are hesitant to share data due to **commercial sensitivity**, **liability concerns**, and **privacy risks**. • Cultural norms around **data ownership** and **control** vary widely, creating friction in collaborative environments. **2. SME Constraints** • SMEs, which make up ~80% of the logistics market, often lack sophisticated IT systems and rely on **manual interfaces**, making interoperability difficult. • Their limited resources and technical capacity pose a **cultural and structural barrier** to adopting federated solutions. **3. Fragmented Governance and Standards** • The absence of unified **data governance frameworks** and **semantic standards** leads to siloed systems and closed solutions. • Cultural differences in how organizations interpret and implement interoperability standards exacerbate this fragmentation. **Contextual Factors** • The chapter is situated within the broader push for **digital transformation in logistics**, including initiatives like the **Physical Internet** and **synchromodal planning**. • It draws on **European Union projects** and Living Labs to validate technical solutions, emphasizing the need for **open systems** and **cross-border collaboration**. **Implications for Practice and Policy** **Practice** • Develop **semantic services and ontologies** to standardize data interpretation across platforms. • Support SMEs with **smart device applications** and **cloud-based solutions** to reduce entry barriers. • Implement **privacy-enhanced technologies** (e.g., role-based access control, homomorphic encryption) to address data sensitivity concerns. **Policy**

	• Establish **interoperability protocols** and **data governance models** that accommodate diverse stakeholder needs. • Promote **standardization efforts** and **certification services** to build trust and accountability. • Encourage **community-based data sharing frameworks** to balance openness with control. **Gaps and Limitations** • The paper does not deeply explore **user-centric design** or **stakeholder engagement strategies**, especially for SMEs. • There is limited empirical analysis of **cultural resistance** or **organizational change dynamics**. • The proposed technical solutions require further **real-world validation**, particularly in **non-European contexts**.
7. Coping with interoperability in the development of a federated research infrastructure: achievements, challenges and recommendations from the JA-InfAct by González-García (2021)	**Key Findings** • The JA-InfAct project developed a federated research infrastructure (FRI) to support cross-border health data analysis in Europe, particularly for population health and health system performance. • The infrastructure was built using a process-mining methodology and open-source tools, enabling partners to analyze their own data locally and share aggregated results. • The project successfully addressed the four layers of interoperability defined by the European Interoperability Framework (EIF): legal, organizational, semantic, and technical. **Contextual Factors** • The initiative involved 40 partners across 28 EU and associated countries. • The federated approach was chosen to respect national data governance laws and avoid transferring sensitive health data across borders. • The stroke care pathway was used as a case study to test the infrastructure, involving partners from Spain, Italy, Croatia, and Latvia.

	Social and Cultural Barriers **1. Organizational Trust and Collaboration** • Building trust among partners was essential but labor-intensive. • Continuous communication and consensus-building were required to align expectations, roles, and responsibilities. • Cultural differences in institutional readiness and technical capacity created uneven participation. **2. Capacity and Skills Gaps** • Some partners lacked IT expertise to deploy the infrastructure, requiring intensive support from the Coordination Hub. • The need for domain experts, data scientists, and system administrators was evident, but not uniformly available across institutions. **3. Data Governance and Local Practices** • Local data access procedures, governance models, and ethical standards varied significantly. • Partners had different interpretations of GDPR compliance, requiring tailored support and training for Data Protection Officers (DPOs). **4. Semantic Misalignment** • Differences in coding systems (e.g., ICD-9 vs ICD-10) and definitions of clinical concepts (e.g., stroke types) posed challenges. • Harmonizing data semantics required iterative refinement and negotiation, reflecting diverse healthcare practices and terminologies. **Implications for Practice and Policy** **Practice** • Federated infrastructures must include robust support mechanisms for partners with limited technical capacity. • Open-source tools and transparent methodologies enhance trust and reproducibility. • Continuous capacity-building and training (especially for DPOs and IT staff) are essential. **Policy**

	• EU-wide standards for semantic interoperability and data governance should be promoted. • Investment in institutional readiness and digital infrastructure is needed to ensure equitable participation. • Federated models should be integrated into broader initiatives like the European Health Data Space and HealthyCloud. **Gaps and Limitations** • The pilot was limited to a small number of nodes and a controlled use case (stroke care), which may not generalize to more complex or diverse scenarios. • The reliance on manual processes (e.g., dashboard sharing via email) limits scalability. • The social dynamics of collaboration (e.g., power asymmetries, institutional incentives) were not deeply analyzed. • The infrastructure's sustainability and long-term governance model remain underdeveloped.
8. Synergy, not size: How collaboration architecture shapes scientific disruption by Zheng (2025)	**Key Findings** • The study analyzes over 14 million papers across 19 disciplines (1960–2020) to understand how collaboration architecture—not just team size—affects scientific disruption. • It introduces a novel metric, the "synergy factor," to quantify the cost-benefit dynamics of collaboration. • Four distinct knowledge production modes are identified: 1. Elite-driven 2. Baseline 3. Heterogeneity-driven 4. Low-cost • The presence of "key authors" (those with high disruption, citation, or productivity metrics) significantly increases the disruptive potential of scientific output—especially when they occupy leadership roles. **Contextual Factors**

	• The study is situated in the context of increasing team-based science and interdisciplinary collaboration. • It draws from cooperative game theory, hypergraph modeling, and citation network analysis. • The work responds to longstanding debates about the role of team size, individual excellence, and diversity in scientific innovation. **Social and Cultural Barriers** **1. Disciplinary Norms and Collaboration Traditions** • Humanities disciplines (e.g., Philosophy, Art, History) show minimal synergy gains from collaboration and often favor solo work. • These fields exhibit suppression effects, where collaboration may hinder disruption due to the deep individual reflection required. **2. Resistance to Interdisciplinary Collaboration** • Despite its benefits, interdisciplinary collaboration faces cultural resistance in some fields due to entrenched epistemic traditions and methodological silos. • Coordination challenges and lack of shared language or norms can reduce the effectiveness of diverse teams. **3. Leadership Structures and Role Expectations** • The impact of key authors is highly position-dependent: first-author roles amplify disruption, while last-author (supervisory) roles do not. • This suggests cultural expectations around hierarchy and authorship may limit the potential of exceptional individuals in certain team configurations. **4. Diversity and Team Composition** • Age, gender, and productivity heterogeneity have mixed effects depending on discipline. • In social sciences, age diversity may impede collaboration, while in life sciences it enhances it—highlighting cultural differences in how diversity is valued and managed. **Implications for Practice and Policy** **Practice**

	• Research teams should strategically structure collaborations to match disciplinary norms and innovation goals. • Institutions should support diverse team configurations and recognize the value of placing key authors in leadership roles. • Evaluation systems should move beyond citation metrics to better capture disruptive potential. **Policy** • Funding agencies should tailor support mechanisms to different collaboration modes and disciplinary needs. • Policies promoting interdisciplinary research must also address cultural and coordination barriers. • Science policy should incorporate synergy metrics to guide team formation and resource allocation. **Gaps and Limitations** • The synergy factor is inferred from observed patterns, not directly measured—potentially missing informal or qualitative aspects of collaboration. • The study focuses on publication data, not the actual collaborative processes or interpersonal dynamics. • Propensity score matching controls for observable confounders but cannot eliminate all selection biases. • Cultural and institutional factors influencing collaboration (e.g., norms around authorship, power dynamics) are acknowledged but not deeply explored.
9. Collaboration, participation and transparency: the promise of digitizing academic research by Friesike and Fecher (2016)	**Key Findings** The authors identify three major opportunities enabled by digitization in academic research: 1. Collaboration: Digital tools facilitate co-authorship, data sharing, and modular research practices across disciplines. 2. Participation: Crowdsourcing and volunteer engagement (e.g., SETI@home, ARTigo, Polymath Project) allow researchers to tackle resource-intensive problems.

	3. Transparency: Open sharing of data, methods, and results enhances reproducibility, public engagement, and interdisciplinary reuse. These opportunities promise to accelerate discovery, improve research quality, and democratize knowledge production. **Contextual Factors** • The chapter is situated within the broader transformation of academia in the digital age. • Despite the availability of digital tools and infrastructure, adoption remains slow due to entrenched academic norms. • The authors argue that academia functions as a "reputation economy," where incentives are tied to traditional outputs like journal publications. **Social and Cultural Barriers** **1. Collaboration Barriers** • Data sharing is undervalued: Unlike co-authorship, sharing datasets does not contribute to career advancement and may even pose risks (e.g., being scooped or misinterpreted). • Fear of misuse: Researchers worry about others falsifying results or misusing data. • Lack of modular collaboration norms: Most collaborations are limited to co-authorship; sharing intermediate products like code or data is rare unless mandated by top-down initiatives. **2. Participation Barriers** • Lack of expertise in participatory design: Few researchers know how to effectively engage volunteers or sustain their motivation. • Quality control concerns: Ensuring data reliability from volunteers requires mechanisms like redundancy or seniority, which are not universally applicable. • Ownership conflicts: Tensions may arise between volunteers' expectations of open access and researchers' desire to publish and retain control over data. **3. Transparency Barriers**

	• Ethical and legal risks: Public sharing of sensitive data (e.g., firm interviews, endangered species locations) can have unintended consequences. • Poor documentation practices: Even when data is shared, it is often unusable due to lack of clarity or annotation. • Communication challenges: Researchers are not trained to engage non-expert audiences, limiting the effectiveness of public-facing science communication. **Implications for Practice and Policy** **Practice** • Researchers should adopt collaborative tools and practices that go beyond co-authorship. • Training in participatory research design and science communication should be integrated into academic curricula. • Institutions should support replication studies and interdisciplinary collaboration. **Policy** • Funders: Reward transparent and participatory research through grants and recognition (e.g., data publication prizes). • Universities: Educate researchers on data management, legal/ethical sharing, and public engagement. • Research Institutes: Value methodological contributions and collaborative impact over publication counts. • Individual Researchers: Established scholars should lead by example in adopting open and participatory practices. **Gaps and Limitations** • The chapter acknowledges that digitization has not transformed academia as expected, largely due to misaligned incentives. • There is limited empirical research on best practices for participatory research and volunteer engagement. • Ethical and legal frameworks for data sharing remain underdeveloped and inconsistently applied.

	• The communication gap between researchers and broader audiences persists, with few institutional mechanisms to address it.
10. Coopetition, Where Do You Come From? Identification, Categorization, and Configuration of Theoretical Roots of Coopetition by Klimas (2023)	**Key Findings** • The paper systematically reviews and categorizes the theoretical foundations of coopetition—a strategic approach where firms simultaneously cooperate and compete. • It identifies 10 core theories underpinning coopetition, including: o Game theory o Resource-based view (RBV) o Network theory o Transaction cost economics o Institutional economics o Strategic learning o Dynamic capabilities o Resource dependence theory o Tension management o Mutual trust • These theories are grouped into three functional categories: 1. Construction theories – help firms adopt coopetition. 2. Development theories – support the expansion and implementation of coopetition. 3. Maintenance theories – sustain long-term coopetitive relationships. • The authors propose a configurational framework that maps these theories across the coopetition lifecycle: initiation, development, and maintenance. **Contextual Factors** • Coopetition is increasingly relevant in complex, hyper-competitive environments where firms must balance rivalry and collaboration. • Despite its growing popularity, the field lacks theoretical coherence and integration, which hampers empirical rigor and conceptual clarity. • The review spans literature from 1987 to 2019, covering 67 key articles across disciplines such as management, strategy, and organizational studies.

	Social and Cultural Barriers **1. Conceptual Ambiguity and Fragmentation** • Coopetition is paradoxical and often misunderstood due to its dual nature—cooperation with competitors. • The lack of shared definitions and theoretical clarity creates confusion and resistance in both academic and managerial contexts. **2. Trust and Tension Management** • Social and psychological factors such as trust, fear of opportunism, and tension between partners are critical but difficult to manage. • Cultural differences (organizational and national) influence how coopetition is perceived and practiced, affecting openness and willingness to engage. **3. Institutional and Normative Constraints** • Formal institutions (e.g., legal frameworks, industry norms) may either facilitate or hinder coopetition. • Informal institutions (e.g., cultural norms, managerial mindsets) often resist paradoxical strategies due to ingrained competitive thinking. **4. Cognitive and Behavioral Challenges** • Managers may struggle to reconcile the conflicting logics of competition and cooperation. • Coopetition requires ambidextrous capabilities and a shift in mindset, which is not always culturally supported within firms. **Implications for Practice and Policy** **Practice** • Managers should tailor coopetition strategies to the lifecycle phase and select appropriate theoretical lenses (e.g., trust for maintenance, RBV for development). • Training in paradox management, trust-building, and dynamic capabilities is essential for sustaining coopetition. **Policy** • Institutions can promote coopetition by creating supportive environments (e.g., innovation ecosystems, collaborative platforms).

	• Funding agencies and industry bodies should recognize and reward coopetitive behaviors, especially in sectors where collaboration is essential for innovation. **Gaps and Limitations** • The review is literature-based and may suffer from selection bias and theoretical over-dispersion. • Some theories are underdeveloped or inconsistently applied, leading to classification challenges. • The framework does not cover the evaluation phase of coopetition, which could benefit from further theoretical exploration. • Future research should explore underutilized theories (e.g., proximity, co-innovation) and examine coopetition in diverse cultural and institutional contexts.
11. Connecting Infrastructures: The Physical Sciences Data Infrastructure (PSDI) in the UK by Bicarregui (2023)	**Key Findings** • The PSDI initiative aims to build a socio-technical data infrastructure for the UK physical sciences, enabling better data discovery, access, integration, processing, curation, and publication. • It seeks to connect existing experimental and computational facilities across disciplines and techniques. • The initiative is part of the broader UKRI Digital Research Infrastructure (DRI) Programme and has progressed through a Statement of Need (SoN), a pilot phase, and current pathfinder activities. **Contextual Factors** • The physical sciences community in the UK is diverse and fragmented, comprising four major pillars: 1. Large national facilities and hubs 2. Medium-scale national research facilities 3. Computational initiatives 4. Research institutions and laboratories

	• Compared to life sciences and particle physics, physical sciences lag behind in integrated data infrastructure and global collaboration. • The pilot phase revealed strong community support and identified 13 recommendations across four areas: infrastructure, data, people, and technology. **Social and Cultural Barriers** **1. Fragmentation and Siloed Practices** • Existing infrastructures are discipline-specific and often operate in isolation, limiting cross-disciplinary collaboration. • Researchers are accustomed to bespoke systems and workflows, which hinders interoperability and standardization. **2. Lack of Incentives for Data Sharing** • Cultural resistance to open data persists, especially where data is seen as proprietary or competitive. • Researchers may lack motivation or resources to make data FAIR (Findable, Accessible, Interoperable, Reusable). **3. Skills and Professionalization Gaps** • Data roles (e.g., data managers, curators) are undervalued and under-supported. • There is a need for community training, recognition, and governance structures to professionalize data stewardship. **4. Limited Awareness of Global Standards** • Unlike life sciences, physical sciences lack widespread adoption of global data standards and repositories. • This impedes international collaboration and reuse of data across borders. **Implications for Practice and Policy** **Practice** • Researchers should be supported to adopt FAIR principles and integrate data from diverse sources. • Institutions must invest in training and infrastructure to enable sustainable data practices. • Community coordination and co-creation are essential to ensure relevance and uptake.

	Policy • Funders (e.g., EPSRC, UKRI) should prioritize long-term support for data infrastructure beyond individual projects. • Policies should incentivize data sharing, reuse, and professional development in data roles. • National and international alignment with other initiatives (e.g., PDB, CERN) is critical for scalability and impact. **Gaps and Limitations** • The initiative is still in early phases; long-term sustainability and integration remain uncertain. • The pilot focused on scoping and consultation, with limited implementation of technical solutions. • Broader engagement with international partners and standard-setting bodies is needed. • The evaluation of impact and adoption across the four pillars is yet to be fully assessed.

12. Effects of Digital Transformation in Scientific Collaboration. A Bibliographic Review by Belli (2019)	**Key Findings**
	• The study reviews 162 scientific papers to explore how digital transformation has reshaped scientific collaboration.
	• Key dimensions include:
	    ○ The shift from physical to digital journals.
	    ○ The rise of Open Access (OA) and Open Science (OS).
	    ○ The integration of digital tools (e.g., cloud storage, collaborative writing platforms).
	    ○ The emergence of digital infrastructures and e-infrastructures.
	• Digital transformation has enabled more efficient, inclusive, and global scientific collaboration, especially through platforms like ORCID, Google Drive, and Twitter.
	
	Contextual Factors
	• The review is situated within the broader context of the EU-CELAC relations and Horizon 2020 funding.

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It highlights disparities between developed and developing countries in access to digital tools and scientific knowledge.
Latin America is used as a case study to illustrate both the promise and challenges of OA and OS in regions with limited infrastructure and restrictive copyright policies.

Social and Cultural Barriers
1. Digital Divide

ICTs are unevenly distributed, especially in emerging and least developed countries.
Researchers in these regions face limited access to journals, data, grants, and networks.
Copyright restrictions further exacerbate access issues, particularly in Latin America.

2. Knowledge Colonization

The dominant scientific communication model favours developed countries, creating asymmetries in knowledge production and dissemination.
OA is framed as a political tool for decolonizing knowledge and promoting equity.

3. Resistance to Open Practices

Many researchers are reluctant to share data due to:

Fear of misuse or scooping.
Lack of incentives or recognition.
Concerns about data quality and reproducibility.

4. Infrastructure and Capacity Gaps

Developing countries often lack the infrastructure to support digital collaboration (e.g., reliable internet, digital repositories).
There is a need for tailored digital infrastructures that reflect disciplinary and regional needs.

Implications for Practice and Policy
Practice

Researchers should be trained in digital tools and open practices.
Institutions must support collaborative platforms and data-sharing norms.
OA and OS should be integrated into research workflows to enhance visibility and impact.

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	Policy
	• Governments and funding bodies should:
	    ○ Promote OA and OS through mandates and incentives.
	    ○ Invest in digital infrastructure, especially in underserved regions.
	    ○ Support regional and international collaborations to bridge capacity gaps.
	
	Gaps and Limitations
	• Despite the growth of OA in Latin America, restrictive copyright policies persist.
	• There is limited uptake of Open Data practices, with only 36% of researchers agreeing to public data access.
	• The review calls for stronger global standards and governance to ensure equitable digital transformation in science.

13. Engaged in collaborative research? Try a touch of intellectual humility by Palmer (2023)	**Key Findings** • Intellectual humility — recognizing one's cognitive limitations and valuing others' perspectives — is essential for fostering effective interdisciplinary and cross-cultural scientific collaborations. • Researchers who approach partnerships with humility are more likely to build trust, encourage open dialogue, and co-create meaningful research outcomes. • Intellectual humility is linked to improved learning, critical thinking, and openness to diverse viewpoints, all of which are vital in collaborative science. **Contextual Factors** • The article draws on examples from global research contexts, including collaborations in the Philippines, Finland, Australia, and Indigenous communities. • It highlights the tension between academic norms (e.g., competition, publishing pressure) and the need for humility in collaborative settings. • The piece is informed by the University of Connecticut's "Humility & Conviction in Public

	Life" project and recent psychological research.
	
	Social and Cultural Barriers
	1. Academic Arrogance and Hierarchies
	• Academia often rewards confidence and assertiveness, discouraging openness to alternative viewpoints.
	• Early-career researchers may fear that showing uncertainty could jeopardize funding, publication, or career progression.
	2. Paternalism in Cross-Cultural Research
	• Researchers from dominant institutions or countries may approach collaborations with a "missionary" mindset, assuming they know best.
	• This can alienate local or Indigenous communities and undermine trust.
	3. Marginalization of Indigenous Knowledge
	• Traditional ecological knowledge is often dismissed as folklore or fiction, despite its empirical value.
	• Indigenous perspectives are frequently excluded from research design and decision-making processes.
	4. Lack of Early Engagement and Co-Design
	• Scientists often define research questions without consulting communities, treating them as afterthoughts.
	• This leads to missed opportunities for co-created and contextually relevant research.
	
	Implications for Practice and Policy
	Practice
	• Researchers should:
	    ○ Begin collaborations by listening and acknowledging others' expertise.
	    ○ Co-design projects with communities from the outset.
	    ○ Embrace fallibility and encourage feedback within research teams.
	    ○ Recognize and integrate diverse forms of knowledge, including Indigenous epistemologies.
	Policy
	• Institutions and funders should:

	◦ Provide cultural sensitivity and humility training. ◦ Support guidelines for ethical collaboration with Indigenous communities (e.g., Kaupapa Māori framework, CSIRO's "Our Knowledge, Our Way"). ◦ Promote inclusive research practices that value non-Western knowledge systems. **Gaps and Limitations** • While the article offers compelling narratives and practical advice, it does not provide systematic data on the prevalence or impact of intellectual humility in research. • There is limited discussion on structural reforms needed to shift academic incentives toward humility and collaboration. • The piece focuses primarily on qualitative insights and case studies, which may not generalize across all disciplines or regions.
14. Epistemic Collaborations: Distributed Cognition and Virtue Reliabilism by Palermos (2022)	**Key Findings** • The paper introduces a hybrid epistemological framework called Distributed Virtue Reliabilism, combining virtue epistemology with the hypothesis of distributed cognition. • It argues that epistemic collaborations (e.g., scientific research teams, Transactive Memory Systems) produce knowledge that is irreducibly social, not merely aggregative. • Knowledge generated through collaborative interaction is a collective epistemic property—it arises from the group's self-organization and self-regulation, not from individual contributions alone. • Such collaborations can qualify as epistemic group agents, capable of both reliability and epistemic responsibility. **Contextual Factors** • The paper draws on examples from cognitive psychology (Transactive Memory Systems) and philosophy of science (scientific research teams).

	• It critiques traditional epistemological models that focus on individual belief aggregation, proposing instead that collaborative knowledge emerges from continuous reciprocal interactions. • The framework is grounded in Dynamical Systems Theory (DST), which helps distinguish between mere social interaction and genuine distributed cognition. **Social and Cultural Barriers** While the paper is primarily philosophical and conceptual, several implicit social and cultural barriers are discussed or implied: **1. Epistemic Individualism** • Traditional epistemology often assumes that knowledge is individually held and produced. • This bias can obscure the value of collaborative, socially embedded knowledge processes. **2. Recognition of Group Agency** • There is resistance within mainstream epistemology to recognizing groups as epistemic agents. • This reluctance may stem from cultural norms that prioritize individual achievement and accountability. **3. Undervaluing Informal and Non-Hierarchical Collaboration** • The paper highlights how scientific knowledge often emerges from informal interactions (e.g., “meetings after the meeting”), which are culturally undervalued in formal academic structures. • Such informal spaces are crucial for distributed cognition but may be overlooked due to rigid institutional hierarchies. **4. Challenges in Attribution and Credit** • Collaborative knowledge production raises questions about how credit and responsibility are distributed. • Cultural norms in academia often struggle to accommodate non-individualistic models of epistemic success. **Implications for Practice and Policy**

	Practice
	• Researchers and institutions should recognize and support collaborative epistemic practices as legitimate and valuable.
	• Scientific teams should foster environments that encourage reciprocal interaction and shared cognitive responsibility.
	Policy
	• Funding bodies and academic institutions should:
	    o Develop frameworks for recognizing group epistemic agency.
	    o Support collaborative infrastructures (e.g., shared labs, interdisciplinary teams).
	    o Reconsider metrics of success that overly emphasize individual output.
	
	Gaps and Limitations
	• The paper is largely theoretical and does not empirically investigate how social or cultural barriers manifest in real-world collaborations.
	• It does not address how power dynamics, inclusion/exclusion, or cultural diversity affect epistemic collaboration.
	• While it defends the concept of epistemic group agents, it does not explore how such agents navigate institutional constraints or social norms.

15. FAIR Data Accelerator Project: Cultivating Cultures of Data Sharing by Chisholm et al. (2025)	**Key Findings**
	• The project identifies and reframes social and cultural barriers to data sharing within the UK Digital Research Infrastructure (DRI) ecosystem.
	• Two major themes emerged from ethnographic analysis:
	    o Epistemic uncertainties: fear of judgment, fear of losing control over data (especially with AI).
	    o Cultural reluctance: entrenched academic norms that deprioritize data sharing, lack of recognition, and disengagement from leadership.
	• These barriers are deeply embedded in professional identity, disciplinary traditions,

	and symbolic exchanges rather than technical limitations. **Contextual Factors** • The pilot is part of the DSIT/UKRI Research Data Cloud initiative, aiming to test the need for a national research cloud. • The project draws on sociology of scientific knowledge, science and technology studies, and professional learning to understand how data sharing is shaped by social structures, cultural dynamics, and individual agency. • Ethnographic methods (interviews, observations, workshops) were used to explore lived experiences across diverse research communities and roles. **Social and Cultural Barriers** **1. Fear of Judgment and Loss of Control** • Researchers worry about data quality and errors being exposed. • Concerns about how data might be used or misinterpreted, especially in automated systems. **2. Lack of Recognition and Incentives** • Data sharing is not adequately rewarded in academic career structures. • Traditional metrics (e.g., publications) dominate over collaborative or open practices. **3. Disciplinary Silos and Communication Gaps** • Epistemic diversity is often undermined by privileging certain types of data or expertise. • Interdisciplinary collaboration is hindered by lack of shared language and norms. **4. Epistemic Injustice and Positioning** • Marginalised groups face exclusion from recognition and credit. • Informal judgments link identity to the perceived value of knowledge claims. **5. Invisible Meta-Work** • The work that enables data sharing (e.g., curation, stewardship) is often invisible and undervalued. **Implications for Practice and Policy** **Practice**

	• Cultivate cultures of data sharing through co-designed learning experiences. • Support professional identity negotiation and agency cultivation. • Recognize and reward invisible work and diverse forms of expertise. **Policy** • Develop strategic leadership forums to shape research culture. • Fund collaborative data communities and reuse initiatives. • Expand social science-informed frameworks like the Applied Learning Programme (ALP). • Promote relational infrastructure to foster trust and collaboration across disciplines. **Gaps and Limitations** • While the project offers rich qualitative insights, broader quantitative validation across disciplines is needed. • Structural reforms (e.g., funding models, career progression) are acknowledged but not deeply explored. • The long-term sustainability of cultural change initiatives remains uncertain without institutional embedding.
16. Epistemic Cultures in Conflict: The Case of Astronomy and High Energy Physics by Heidler (2017)	**Key Findings** • The paper analyzes the epistemic conflict between astronomy and high energy physics (HEP) following the discovery of dark energy and the accelerating expansion of the universe (AEU). • It introduces a theoretical framework combining Knorr-Cetina's concept of epistemic cultures with Whitley's theory of strategic and functional dependencies between disciplines. • The conflict is rooted in deep differences in epistemic cultures—how knowledge is produced, validated, and socially legitimized in each field. • The discovery of AEU triggered a sudden increase in mutual dependency between astronomy and HEP, leading to tensions over

	collaboration styles, data access, instrumentation, and disciplinary identity. **Contextual Factors** • The discovery of AEU in 1998, awarded the Nobel Prize in 2011, was a scientific breakthrough that affected both disciplines profoundly. • Two competing research groups—Supernova Cosmology Project (SCP, rooted in HEP) and High-z Supernova Search Team (HZT, rooted in astronomy)—played central roles in the discovery. • The epistemic cultures of these groups differed in theoretical orientation (nomothetic vs. idiographic), collaboration style (formal vs. informal), and disciplinary composition (physicists vs. astronomers). **Social and Cultural Barriers** **1. Epistemic Strategy Divergence** • HEP emphasizes experimentation, reductionism, and formalism. • Astronomy relies on observation, complexity, and idiographic approaches. • These differences led to skepticism and resistance, especially from HEP, toward the implications of the AEU discovery. **2. Collaboration Style and Group Structure** • HEP teams are large, hierarchical, and formally organized. • Astronomy teams are smaller, more informal, and heterarchical. • These structural differences created friction in joint projects and affected recognition and authorship norms. **3. Access to Instruments and Data** • Astronomy favours open access to telescopes and data via peer-reviewed proposals. • HEP traditionally maintains exclusive control over instruments and data. • This disparity led to debates over fairness, transparency, and scientific openness. **4. Social Legitimacy and Public Engagement** • Astronomy enjoys high public and media interest, often supported by philanthropy.

	• HEP derives legitimacy from political prestige and technological leadership. • These differing sources of support influence how each field navigates funding and public communication. **5. Identity and Moral Economy** • The conflict raised existential questions for researchers: "Who am I?" and "What is my discipline?" • Scientists became reflexive about their epistemic cultures, leading to debates over disciplinary boundaries and values. **Implications for Practice and Policy** **Practice** • Encourage interdisciplinary collaboration through mutual respect for differing epistemic cultures. • Develop hybrid models that integrate observational and experimental approaches. • Promote open data practices across disciplines to reduce friction and foster trust. **Policy** • Funders and institutions should recognize and support diverse collaboration styles. • Policies should facilitate equitable access to instruments and data across disciplines. • Strategic planning should consider the sociocultural dynamics of interdisciplinary research, especially in large-scale projects. **Gaps and Limitations** • The study is retrospective and based on document analysis, interviews, and bibliometrics rather than ethnographic observation. • It focuses on a single case (AEU discovery) and may not generalize across all interdisciplinary conflicts. • While it identifies tensions, it does not offer concrete mechanisms for resolving epistemic conflicts or fostering long-term integration.
17. Liquid Science and Digital Transformation: How Knowledge	**Key Findings**

between Researchers Flows in Their Scientific Networks by Belli (2022)	• Digital transformation has significantly reshaped how researchers collaborate, communicate, and share knowledge. • Researchers increasingly rely on digital tools (e.g., email, cloud platforms, videoconferencing) to maintain and expand scientific networks. • Despite the benefits of digital tools, analogical interactions (e.g., phone calls, face-to-face meetings) remain essential for trust-building, emotional nuance, and effective collaboration. • The concept of "liquid science" describes a flexible, digitally mediated research environment where knowledge flows across boundaries, disciplines, and geographies. **Contextual Factors** • The study was conducted as part of the EULAC Focus project, with a sample of 305 researchers from 18 countries, primarily in Latin America and Europe. • Mixed methods were used: surveys and semi-structured interviews explored digital practices, collaboration styles, and communication tools. • The majority of respondents were affiliated with universities and worked in medium-sized research teams (3–6 members). **Social and Cultural Barriers** **1. Geo-social Asymmetries** • Researchers in developing countries face unequal access to digital infrastructure, scientific databases, and collaboration opportunities. • Limited internet connectivity and lack of technical resources hinder participation in global scientific networks. **2. Gender and Age Inequities** • Female researchers, especially in emerging economies, face cultural constraints that limit access to digital tools and networking opportunities. • Younger researchers tend to have more favorable access to digital networks. **3. Digital Communication Challenges**

	• Lack of face-to-face interaction leads to misunderstandings, emotional detachment, and difficulty in decision-making. • Informal digital tools (e.g., WhatsApp) blur boundaries between professional and personal life, causing stress and "information anxiety." **4. Information Overload and Multitasking** • Researchers struggle to manage the volume of digital communication and data, which can reduce time for deep thinking and writing. • The fast pace of digital interaction is often incompatible with the slow, reflective nature of research. **5. Access and Cost Barriers** • Many digital tools and services are costly, creating financial obstacles for researchers in resource-poor settings. • Technical failures (e.g., poor internet, software issues) disrupt collaboration and meetings. **Implications for Practice and Policy** **Practice** • Encourage hybrid collaboration models that combine digital and analogical interactions. • Promote training in digital literacy and soft skills to navigate digital tools effectively. • Recognize the emotional and cognitive dimensions of digital collaboration. **Policy** • Invest in digital infrastructure and equitable access to research tools in developing regions. • Support open access initiatives and reduce financial barriers to scientific databases. • Address gender and age disparities in digital participation through inclusive policies. **Gaps and Limitations** • The sample is skewed toward Ecuador and Latin America, limiting generalizability. • The study may be biased toward digitally active researchers due to its online survey method. • It does not assess the scientific impact or competitiveness of the networks studied.

	• Further research is needed to explore long-term effects of digital transformation on research quality and equity.

18. Mapping communication and collaboration in heterogeneous research networks by Heimeriks (2003)	**Key Findings**
	• The study develops a methodological framework to analyze communication and collaboration across three layers of research networks:
	  1. Scholarly communication (journal publications)
	  2. Project-based collaboration (EU-funded research projects)
	  3. Web-based dissemination (hyperlink networks)
	• These layers serve different functions and involve different actors, structures, and content.
	• The overlap between actors in scholarly and project networks is limited, indicating distinct communities and purposes.
	• Web-based networks are the least connected and most heterogeneous, primarily serving local and educational functions rather than research collaboration.
	
	Contextual Factors
	• The study focuses on three Mode 2 research fields: Biotechnology, Artificial Intelligence, and Information Science.
	• Mode 2 fields are characterized by interdisciplinary, application-oriented research involving university–industry–government collaborations (Triple Helix model).
	• Data sources include:
	  ○ Journal Citation Reports (SCI/SSCI)
	  ○ EU Cordis project database
	  ○ Web crawlers for hyperlink and content analysis
	
	Social and Cultural Barriers
	1. Fragmentation Across Communication Media
	• Different media (journals, projects, websites) serve different audiences and purposes, leading to fragmented communication ecosystems.

	• Limited overlap between actors in scholarly and project networks suggests siloed communities. **2. Institutional and Disciplinary Silos** • Universities dominate scholarly communication, while project networks include more diverse actors (industry, government). • Industrial participation varies significantly across disciplines, with less involvement in biotechnology compared to AI and information science. **3. Localism in Web-Based Communication** • Hyperlink networks are weakly structured and often reflect national or linguistic proximity rather than thematic or collaborative ties. • Web content is oriented toward general or educational audiences, not scientific collaboration. **4. Barriers to Integration** • Lack of thematic clustering and low density in web networks suggest missed opportunities for cross-sectoral knowledge exchange. • Differences in codification and terminology across media hinder interoperability and mutual understanding. **Implications for Practice and Policy** **Practice** • Encourage cross-media integration to bridge gaps between scholarly, collaborative, and public-facing communication. • Promote thematic coherence and deeper linking in web-based dissemination to support research visibility and collaboration. **Policy** • Support infrastructure that enables interoperability across journals, projects, and web platforms. • Foster inclusive collaboration models that engage diverse actors beyond academia. • Invest in tools and standards for harmonizing organizational data across databases. **Gaps and Limitations**

	• The study focuses on broad fields; finer-grained analysis of subfields could yield more actionable insights. • Web crawling was limited to two levels deep, potentially missing deeper thematic connections. • The methodology requires extensive data cleaning and standardization, which may not be feasible at scale. • The analysis does not fully explore the dynamics of power, access, or equity in these networks.
19. Science friction: Data, metadata, and collaboration by Edwards (2011)	**Key Findings** • Interdisciplinary scientific collaboration is increasingly data-driven, but data sharing is impeded by “science friction”—the social, technical, and organizational resistance encountered when data move across disciplinary boundaries. • Metadata, often seen as a solution to data interoperability, can itself become a source of friction—especially when treated as a static product rather than a dynamic process. • The authors propose a shift from viewing metadata as fixed descriptors to understanding it as a form of scientific communication—a process that requires negotiation, repair, and shared understanding. **Contextual Factors** • The study draws on ethnographic research from three major scientific projects: 1. The Dycore Workshop (climate modeling) 2. The Center for Embedded Networked Sensing (CENS) 3. The Long-Term Ecological Research (LTER) program • These projects span environmental sciences, engineering, and computer science, and involve large, distributed teams with diverse disciplinary backgrounds. • The rise of “e-science” and “cyberinfrastructure” has created new

	expectations for data sharing, reuse, and interoperability across disciplines. **Social and Cultural Barriers** **1. Disciplinary Vocabulary and Conceptual Misalignment** • Collaborators often use different terms for the same concepts, leading to confusion and misinterpretation. • Establishing “common ground” requires time-consuming negotiation and repair. **2. Metadata as Burden** • Scientists see metadata creation as an unfunded mandate, often disconnected from their core research goals. • Metadata standards (e.g., EML) are complex, difficult to implement, and poorly supported by tools. **3. Fragmented and Divergent Practices** • Metadata are often created ad hoc, inconsistently, and stored in multiple formats (e.g., spreadsheets vs. portals). • Lack of coordination leads to duplication, loss of links between data and metadata, and reduced usability. **4. Local vs. Global Priorities** • Researchers prioritize local use and immediate collaborators over broader community needs. • Incentives for contributing to shared metadata systems are weak or absent. **5. Informal Communication as Metadata** • Emails, conversations, and annotations often carry crucial metadata, but are ephemeral and hard to capture. • In cases like “Climategate,” informal communications were misinterpreted when taken out of context. **Implications for Practice and Policy** **Practice** • Recognize metadata as a communication process, not just a product. • Support informal, iterative, and context-sensitive metadata practices. • Design tools that align with scientists’ workflows and reduce friction.

	Policy • Avoid unfunded mandates for metadata compliance; instead, provide resources and incentives. • Foster interdisciplinary training to build shared vocabulary and understanding. • Develop flexible metadata standards that accommodate diverse research cultures. **Gaps and Limitations** • The study focuses on environmental and Earth sciences; findings may not generalize to all disciplines. • It does not offer a concrete framework for integrating metadata-as-process into existing infrastructures. • The tension between precision (standardization) and lubrication (flexibility) remains unresolved.
20. Sociotechnical Imaginaries of Sharing and Emerging Postdigital Meaning-Making Practices in the Astronomy Community by Duran del Fierro et al., (2024)	**Key Findings** • The development of the Square Kilometer Array Observatory (SKAO) and its associated infrastructure is reshaping the astronomy community's practices, particularly around data sharing, collaboration, and meaning-making. • A dominant sociotechnical imaginary—centered on sharing (data circulation, storage, archiving, and reuse)—has emerged, influencing how astronomers conceptualize and conduct research. • Two major shifts are identified: 1. Astronomers must now negotiate research questions and methods collaboratively in large, interdisciplinary teams. 2. The increasing reliance on digital tools and algorithms is transforming how astronomers define what counts as relevant evidence. **Contextual Factors** • The SKAO is a global, distributed infrastructure involving multiple telescopes, regional centers, and data processing systems.

	• The scale and complexity of SKA data necessitate new forms of collaboration, epistemic trust, and algorithmic mediation. • The study draws on document analysis and 18 interviews with astronomers across career stages, disciplines, and geographies. **Social and Cultural Barriers** **1. Epistemic Trust and Dependency** • Astronomers must rely on data processed by others (including automated systems), which challenges traditional norms of data ownership and validation. • Trust in algorithms and in the expertise of engineers and data scientists becomes essential, yet difficult to establish due to physical and disciplinary distance. **2. Loss of Copresence and Communication Challenges** • The postdigital condition reduces opportunities for face-to-face interaction, complicating interdisciplinary communication and collaboration. • Differences in terminology, values, and epistemic cultures (e.g., between scientists and engineers) lead to misunderstandings and friction. **3. Governmentality and Identity Transformation** • The sociotechnical imaginary of sharing acts as a form of governmentality, requiring astronomers to reshape their scientific selves to align with new norms of openness and data-intensive inquiry. • This transformation affects how astronomers perceive their roles, priorities, and professional identities. **4. Inequality and Vulnerability** • The shift toward data analysis privileges astronomers with computational expertise, potentially marginalizing those focused on theory or data collection. • Open data may democratize access, but disparities in skills, infrastructure, and institutional support persist. **5. Algorithmic Agency and Epistemic Filtering**

	• The push for "perfect algorithms" to process SKA data introduces concerns about what gets filtered out as "uninteresting," potentially shaping scientific discovery in opaque ways. • This raises questions about responsibility, transparency, and the limits of automation in scientific reasoning. **Implications for Practice and Policy** **Practice** • Foster interdisciplinary training to bridge epistemic cultures and improve communication. • Support collaborative governance models that recognize diverse contributions and mitigate power imbalances. • Encourage reflexivity around algorithmic design and its epistemic consequences. **Policy** • Ensure equitable access to infrastructure, training, and funding across roles and regions. • Develop policies that balance openness with recognition of sociocultural diversity and ethical concerns. • Promote inclusive imaginaries that reflect the lived realities of all research community members. **Gaps and Limitations** • The study focuses on the astronomy community; broader generalization to other disciplines requires further research. • While the paper identifies key tensions, it does not offer concrete strategies for resolving them. • The concept of resistance to sociotechnical imaginaries is raised but not explored in depth.
21. The coloniality of collaboration: sources of epistemic obedience in data-intensive astronomy in Chile by Lehuedé (2023)	 **Key Findings** • The article critically examines how data collaborations in astronomy—particularly in Chile—can reproduce global hierarchies and epistemic obedience, despite appearing egalitarian.

	• A “collaborative subject position” has emerged among Chilean actors, aiming to establish reciprocal, technical partnerships with data-rich observatories. However, this position often reinforces dependency and suppresses critical reflection on whose knowledge matters. • Three sources of epistemic obedience are identified: 1. Dis-embedding of data producers: Treating observatories as neutral data factories obscures their agendas and power. 2. Erosion of local ties: Chilean actors prioritize vertical collaboration with international institutions over horizontal collaboration within the local community. 3. Data conformism: Focus on reusing existing datasets limits the capacity to generate locally relevant data and research questions. **Contextual Factors** • Chile hosts ~70% of the world’s terrestrial astronomical infrastructure, yet most observatories are controlled by US and European institutions. • Chilean astronomers are guaranteed 10% of observation time, but new data-intensive telescopes (e.g., LSST) challenge this arrangement by automating data collection and reducing exclusive access. • The shift to data-intensive astronomy has prompted Chilean actors to reposition themselves from passive recipients (“collectors”) to active collaborators, seeking proximity to global observatories. **Social and Cultural Barriers** **1. Coloniality and Epistemic Hierarchies** • The collaborative stance often masks underlying power asymmetries, reinforcing the idea that knowledge from the Global North is universal, while local knowledge is peripheral. • Chilean actors internalize the language and metrics (e.g., KPIs) of international

	observatories, aligning with their productivity goals rather than questioning their epistemic frameworks. **2. Fragmentation and Lack of Local Coordination** • There is limited dialogue and coordination among Chilean institutions, leading to competition and “atomization” rather than collective strategy. • Local initiatives are often criticized or misunderstood, while international observatories are rarely questioned. **3. Instrumental vs. Epistemic Autonomy** • The focus on accessing and analyzing existing data sidelines efforts to develop local instruments or methodologies. • This limits the ability to ask novel questions or pursue research aligned with local needs and visions. **Implications for Practice and Policy** **Practice** • Encourage reflexivity in data collaborations: who benefits, whose questions are prioritized, and what epistemologies are embedded. • Support horizontal collaboration among local actors to build shared visions and reduce dependency. **Policy** • Revisit agreements with international observatories to ensure equitable access to data and infrastructure. • Invest in local instrumentation and capacity-building to foster epistemic autonomy. • Recognize and address the colonial legacies embedded in scientific collaboration frameworks. **Gaps and Limitations** • The study focuses on Chile and may not generalize across the Global South, though it offers valuable insights into broader dynamics of data colonialism. • The analysis is primarily discursive; material practices are still emerging and speculative due to the ongoing nature of data-intensive astronomy.

	• While the article critiques epistemic obedience, it does not fully explore strategies for resistance or alternative models of collaboration.

22. Rivals: How Scientists Learnt to Cooperate by Daston (2024)	**Key Findings**
	• Scientific collaboration has evolved over 350+ years through distinct phases: the Enlightenment's Republic of Letters, 19th-century internationalism, and the 20th-century scientific community.
	• Despite fierce competition, national rivalries, and personal egos, scientists have repeatedly imagined and constructed collective frameworks to enable cooperation.
	• Successful collaborations often hinge on:
	    o Shared standards (e.g., cloud classification, star mapping)
	    o Face-to-face interactions and trust
	    o Disciplinary governance
	    o Strategic use of national prestige to secure funding
	
	Contextual Factors
	• The book traces scientific cooperation from the 17th century to the present, focusing on astronomy and meteorology as case studies.
	• Key historical moments include:
	    o The transits of Venus expeditions (1761, 1769)
	    o The Carte du Ciel star-mapping project (1887–1970)
	    o The International Cloud Atlas (1896)
	    o The transformation of the International Meteorological Organization into the UN-affiliated World Meteorological Organization (1951)
	• Technological advances (e.g., printing, telegraphy, photography, digitalization) and geopolitical shifts (e.g., wars, colonialism, Cold War) shaped the possibilities and limits of collaboration.
	
	Social and Cultural Barriers
	1. Rivalry and Ego

- Early scientists were fiercely competitive, often engaging in public polemics and personal attacks.
- Recognition was a scarce resource, and collaboration often required suppressing individual ambition.

2. Nationalism and Political Interference

- Scientific collaboration was frequently disrupted by wars, boycotts, and ideological divides (e.g., exclusion of German scientists post-WWI).
- Governments both enabled and hindered collaboration, depending on political agendas.

3. Exclusivity and Elitism

- Scientific communities were historically dominated by elite, male, European figures.
- Women and marginalized groups were often excluded or relegated to behind-the-scenes roles.

4. Lack of Institutional Continuity

- Many early collaborations depended on charismatic individuals and collapsed when they died or lost influence.
- Institutions often lacked the durability to sustain long-term projects.

5. Fragmentation and Disciplinary Silos

- Scientific governance remains largely disciplinary, with limited cross-disciplinary coordination.
- The term “scientific community” masks deep diversity in norms, practices, and values across fields.

6. Metric-Driven Governance and Integrity Risks

- The rise of proxy indicators (e.g., citation counts, impact factors) has led to gaming, misconduct, and erosion of trust.
- Peer review systems are under strain due to the exponential growth of publications and researchers.

Implications for Practice and Policy

Practice

- Foster face-to-face interactions to build trust and shared norms.

	• Prioritize standard-setting collaborations, which are more resilient to political and institutional disruptions. • Encourage inclusive governance structures that reflect disciplinary diversity and global representation. **Policy** • Governments should support science without micromanaging research agendas. • International organizations (e.g., ISO, WMO) offer models of non-sovereign governance that balance expertise and neutrality. • Funding mechanisms should recognize the long-term nature of scientific collaboration and avoid short-termism. **Gaps and Limitations** • The book focuses primarily on Western scientific traditions and elite institutions; perspectives from the Global South and marginalized communities are underrepresented. • While rich in historical detail, the analysis is less prescriptive about how to reform current governance structures. • The role of digital platforms and virtual collaboration is acknowledged but not deeply explored.

23. The Geography of Scientific Collaboration by Olechnicka et al. (2020)	**Social and Cultural Barriers to Scientific Collaboration**
	1. Trust and Misconduct
	• Barrier: Lack of mutual trust among collaborators, especially in large or international teams.
	• Examples:
	    o *Korean stem cell scandal* (2005): Fraud by Woo-suk Hwang undermined collaborators' reputations (e.g., Gerald Schatten).
	    o *Paul Kammerer case* (1926): Alleged data fabrication led to suicide, highlighting the emotional toll of broken trust.

	• Implication: Trust must be managed both affectively (personal bonds) and cognitively (reputation, reliability). Formal controls help but cannot eliminate risk.
	2. Communication and Language Barriers
	• Barrier: Misunderstandings due to linguistic, cultural, and disciplinary differences.
	• Examples:
	    o *NASA's Mars Climate Orbiter* failure (1999): Unit mismatch due to poor communication.
	    o Disciplinary semantics: e.g., "map" means different things in geography vs. other fields.
	• Implication: Collaboration requires shared understanding and clear communication protocols, especially in interdisciplinary or international settings.
	3. Cultural and Institutional Differences
	• Barrier: Divergent norms, expectations, and organizational structures.
	• Examples:
	    o *China*: Confucian hierarchy and guanxi networks hinder open collaboration and trust in returnees.
	    o *US vs. EU*: Americans more mobile and institutionally flexible than Europeans.
	• Implication: Policies must be sensitive to cultural contexts and institutional diversity to foster effective collaboration.
	4. Authorship and Recognition Conflicts
	• Barrier: Disputes over credit, order of authorship, and contribution recognition.
	• Examples:
	    o *Schatten's role* in Hwang's papers: Lack of oversight and unclear responsibility.
	    o *Matilda Effect*: Gender bias in recognition; women's contributions often undervalued.
	• Implication: Clear authorship policies and contributorship statements are essential to ensure fairness and transparency.
	5. Collaboration Saturation and Inequity
	• Barrier: Over-collaboration can lead to diminishing returns and unequal benefit distribution.

	- Examples: - Hyperauthorship (e.g., 5,154 authors on Higgs boson paper) dilutes individual recognition. - Peripheral countries often play subordinate roles in global collaborations. - Implication: Collaboration policies must address equity, ensuring fair benefit sharing and avoiding exploitation. **Key Findings** - Collaboration is increasingly the default mode of scientific production. - International collaboration correlates with higher citation impact, but benefits are unevenly distributed. - Proximity facilitates collaboration formation; distance enhances impact. - Cultural and institutional factors significantly shape collaboration dynamics. **Contextual Factors** - Globalization: Facilitates collaboration but also introduces complexity. - ICT and Mobility: Reduce transmission costs but not transaction costs (e.g., tacit knowledge exchange). - Policy Environment: Varies by country (e.g., US collaborative culture vs. China's bureaucratic fragmentation). - Disciplinary Norms: Influence collaboration intensity and authorship conventions. **Implications for Practice and Policy** **Policy Design:** - Must integrate collaboration policy with broader science policy. - Should balance place-based and place-neutral approaches. - Need to support both local engagement and global excellence. **Equity Measures:** - Encourage strong-weak partnerships with fair benefit sharing.

	◦ Address gender and regional disparities in recognition and access. • **Infrastructure and Tools:** ◦ Invest in ICT, shared facilities, and mobility programs. ◦ Promote transparency in authorship and contribution tracking. **Gaps and Limitations** • **Under-researched Areas:** ◦ Impact of geographic distance on citation outcomes. ◦ Long-term effects of collaboration saturation. ◦ Role of informal networks and tacit knowledge in collaboration success. • **Measurement Challenges:** ◦ Difficulty in quantifying weak collaboration and informal contributions. ◦ Ambiguity in geolocating collaborators and interpreting co-affiliations. • **Policy Blind Spots:** ◦ Limited attention to collaboration equity and power asymmetries. ◦ Insufficient integration of collaboration tools across policy levels.
24. e-Science: Open, Social and Virtual Technology for Research Collaboration by Koschtial et al. (2021)	**Summary with Emphasis on Social and Cultural Barriers** **1. Context and Scope** • The volume explores the evolving concept of e-science, emphasizing its technological, organizational, and socio-cultural dimensions. • It includes empirical studies, conceptual frameworks, and case analyses from Germany (especially Saxony), focusing on digital research collaboration, doctoral education, and infrastructure development. **2. Key Social and Cultural Barriers Identified** **A. Resistance to Digital Collaboration**

	• Academic reluctance to adopt digital tools (e.g., social media, collaborative platforms) due to:
	    o Concerns over data security, intellectual property, and reputation.
	    o Low trust in open platforms and fear of oversimplification of scientific content.
	    o Disciplinary cultures that favor traditional methods (e.g., handwritten work, face-to-face interaction).
	B. Governance and Organizational Challenges
	• Virtual organizations require trust-based governance rather than traditional hierarchical control.
	• Lack of social control mechanisms (shared norms, rituals, joint training) hinders effective collaboration.
	• Fragmented institutional structures and temporary project funding limit long-term collaboration.
	C. Uneven Adoption of Digital Tools
	• Web 2.0 tools (e.g., microblogs, social bookmarking) are underutilized, especially in engineering and social sciences.
	• Utilitarian motivations dominate tool adoption (efficiency, practicality), while social and ethical dimensions are less emphasized.
	D. Communication Barriers in Research Networks
	• Scientists struggle to simplify complex knowledge for external stakeholders.
	• Ambiguous terminology (e.g., “sustainability”) and abstract content reduce accessibility.
	• Limited engagement with civil society and media due to lack of strategic communication planning.
	
	3. Key Findings and Conceptual Contributions
	A. The Fish Model (Mohamed & Köhler)
	• Conceptual framework for understanding online research collaboration among doctoral students.
	• Identifies four dichotomous factors:
	    o Tasks/Time
	    o Beliefs/Activities
	    o Support/Context
	    o Incentives/Ethics

	• Empirical validation shows beliefs and incentives are significant predictors of collaboration, while time and context are not.
	B. Digital Tool Adoption (Science 2.0 Survey 2013)
	• Majority of scholars use digital tools like Wikipedia, online archives, and mailing lists.
	• Web 2.0 tools remain niche; adoption varies by discipline and region.
	• Qualitative interviews reveal that collaboration, mobility, and efficiency are key drivers of change.
	C. Governance in Virtual Organizations
	• Social control (trust, shared culture) is more effective than behavioral/output control.
	• Case studies (Saxony portals, e-Science network) show mixed success in sustaining virtual collaboration.
	D. Strategic Communication in Research Networks
	• Effective knowledge transfer requires tailored content, stakeholder involvement, and open-access formats.
	• Advisory boards and opinion leaders play a crucial role in bridging gaps between science and society.
	
	4. Implications for Practice and Policy
	A. Institutional Support
	• Universities and research institutions should:
	    o Invest in training for digital literacy and collaborative tools.
	    o Develop clear governance models for virtual organizations.
	    o Encourage open-access publishing and data sharing.
	B. Strategic Communication
	• Research networks must:
	    o Design targeted communication strategies for diverse stakeholders.
	    o Use digital media effectively to disseminate knowledge.
	    o Involve non-academic actors in co-creation and dissemination.
	C. Infrastructure Development
	• Policies should support:

	○ Interoperable metadata standards (e.g., CMDI, Dublin Core). ○ Secure and sustainable IT infrastructure. ○ Legal frameworks for copyright and data protection. **5. Gaps and Limitations in Analysis** • Limited generalizability: Most empirical data comes from Saxony and TU Dresden. • Underexplored citizen engagement: Few studies assess public/media involvement in research communication. • Lack of longitudinal data: Adoption trends and cultural shifts need long-term tracking. • Insufficient focus on interdisciplinary dynamics: More analysis needed on how different fields interact in digital collaboration.
25. On the Entanglement of Science and Europe at CERN: The Temporal Dynamics of a Coproductive Relationship by Mobach and Felt (2022)	**Key Social and Cultural Barriers Identified** **1. Ambiguity and Contestation of 'Europeanness'** • Europe is portrayed in multiple, sometimes contradictory ways: as a cultural unity, a political entity, a collaborative model, and a geographical region. • The lack of a fixed definition of Europe created tensions, especially in early debates about membership (e.g., British resistance to defining CERN as exclusively European). **2. Universalism vs. Particularism** • Early visions of science as a universal language were used to justify European unity, but this universalism was paradoxically rooted in European cultural superiority. • This created a barrier to truly inclusive global collaboration, as non-European partners were expected to adopt European norms and governance models. **3. Governance and Power Dynamics** • The shift from European collaboration to global participation introduced tensions around governance. • Non-European partners contributed to CERN's infrastructure but had limited influence over

strategic decisions, reinforcing a European-centric power structure.

4. Cultural Narratives and Institutional Identity

- CERN's identity was shaped by affective (spirit, heart), trajectorial (historical progression), and utilitarian (organizational competence) registers.
- These narratives often masked underlying exclusions and reinforced a Eurocentric worldview, limiting alternative visions of scientific collaboration.

Key Findings

Temporal Dynamics of Coproduction

- **The relationship between science and Europe at CERN evolved in two phases:**
    1. Making Europe through Science (1950s–1980s): Science was used to justify and build postwar European unity.
    2. Using Europeanness as a Resource for Global Science (1990s–present): Europeanness became a model for global collaboration, with CERN positioned as a "laboratory for the world."

Narrative Infrastructure

- CERN's identity was maintained through recurring narratives that adapted to changing political and scientific contexts.
- These narratives enabled continuity while allowing for strategic shifts in positioning.

Organizational Layering

- CERN developed a layered structure where European member states retained control over infrastructure, while global partners participated in experiments.
- This structure preserved European dominance while enabling global participation.

Contextual Factors

- Postwar European reconstruction: Science was seen as a neutral, unifying force.
- Cold War geopolitics: Influenced membership debates and visions of collaboration.

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Globalization of science: Increasing scale and cost of experiments necessitated broader collaboration.
Cancellation of the US SSC: Boosted CERN’s global role and attracted non-European partners.

Implications for Practice and Policy
1. Rethinking Science Diplomacy
Policymakers should critically assess how narratives of collaboration may obscure power asymmetries and cultural exclusions.
2. Inclusive Governance Models
Future global scientific infrastructures should consider more equitable governance structures that go beyond Eurocentric models.
3. Reflexive Institutional Narratives
Institutions like CERN should reflect on how their identity narratives shape participation and inclusion, and adapt them to changing global contexts.
4. Temporal Sensitivity in Policy Design
Understanding the temporal dynamics of coproduction can help design policies that are responsive to shifts in scientific and political landscapes.
Gaps and Limitations in the Analysis

Limited engagement with non-European perspectives: The article focuses on CERN’s internal narratives and European actors, with less attention to how non-European partners perceive and negotiate CERN’s Europeanness.
Underexplored material dimensions: While narrative infrastructures are well analyzed, the material and economic implications of governance structures are less developed.
Focus on elite discourse: The analysis centers on official documents and leadership interviews, potentially overlooking grassroots or dissenting voices within the scientific community.

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<tr><td></td><td>Social and Cultural Barriers Identified</td></tr>
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26. European Scientific Cooperation and Research Infrastructures: Past Tendencies and Future Prospects by Papon (2004)	**1. Fragmentation of National Interests** • Despite shared scientific goals, national agencies often prioritize local projects over European ones. • This leads to duplication of facilities (e.g., multiple synchrotron radiation centers) and hinders coherent infrastructure planning. **2. Lack of Unified Governance** • Research infrastructures are governed by diverse legal frameworks (e.g., intergovernmental organizations, EU institutions, private entities). • This diversity complicates coordination and policy alignment across Member States. **3. Limited Cooperation in Certain Disciplines** • Fields like oceanography, engineering sciences, and atmospheric research suffer from weak or nonexistent European-level cooperation. • Cultural and administrative differences among national agencies impede joint ventures. **4. Resistance to EU Involvement** • Member States have historically opposed transferring responsibility for research infrastructure to the European Commission. • Concerns include loss of national control and skepticism about the EC's effectiveness (e.g., criticism of the Joint Research Centre). **5. Inertia and Bureaucratic Barriers** • Institutional inertia and bureaucratic complexity slow down the development of shared infrastructure and dual-use policies (civil-military collaboration). • This is particularly evident in the slow uptake of collaborative models in IT and data-sharing. **Key Findings** • Europe has built a robust and diversified system of research infrastructures, often outside the formal EU framework. • Successful cooperation is most evident in disciplines with clear objectives and high capital costs (e.g., particle physics, space science).

	• Flexibility and "variable geometry" (i.e., tailored participation models) are strengths of the European approach. • The EU's Framework Programmes have gradually increased support for infrastructure, especially for access and networking. • Economic impact studies show mixed results; large facilities may enhance regional prestige but do not guarantee local economic development. **Contextual Factors** • Post-WWII reconstruction and political integration (Treaty of Rome, EURATOM) catalyzed scientific cooperation. • The rise of megascience and distributed infrastructures (e.g., genome research, climate studies) increased the need for transnational collaboration. • Enlargement of the EU to Central and Eastern Europe introduced new challenges related to funding, capacity, and integration. • The Lisbon Strategy (2000) and the European Research Area initiative marked a turning point in recognizing infrastructure as central to competitiveness and cohesion. **Implications for Practice and Policy** **1. Need for Strategic Coordination** • Establish mechanisms (e.g., European Strategic Forum for Research Infrastructures) to assess needs and guide investment. • Encourage multidisciplinary expert panels to evaluate proposals. **2. Support for Access and Networking** • Expand programs that facilitate access to national facilities for researchers from smaller or less-resourced countries. • Promote data standardization and interoperability across disciplines. **3. Encourage Dual-Use and Industry Collaboration** • Develop policies for shared civilian-military infrastructure use, especially in oceanography and materials science.

	• Foster industry consortia (e.g., Sematech-style models) to co-invest in generic technologies. **4. Strengthen EU Role** • Consider EC participation in infrastructure consortia, with proportional funding responsibilities. • Use structural funds and European Investment Bank loans to support infrastructure in less-developed regions. **Gaps and Limitations in the Analysis** • The paper lacks detailed analysis of cultural and institutional resistance within Member States beyond general observations. • There is limited discussion of how social sciences and humanities can be integrated into infrastructure policy. • The economic impact assessments are referenced but not critically evaluated or compared across regions. • The role of public engagement and societal value of infrastructures is underexplored.
27. Understanding collaboration in the research life cycle by Chung et al. (2016)	**Social and Cultural Barriers Identified** **1. Hierarchical Culture and Seniority** • Korean hierarchical norms influence collaboration dynamics. • Junior researchers often feel exploited or undervalued in credit-sharing, leading to reluctance to collaborate with senior scientists. • Cultural expectations discourage open discussions about authorship and contribution. **2. Competitive Tensions** • Scientists fear being "scooped," leading to reluctance in sharing lab notes, data, or ideas—even with collaborators. • Collaboration is often seen as a temporary alliance that may turn into competition. **3. Trust and Personal Compatibility** • Trust is essential but difficult to establish, especially across institutional or disciplinary boundaries. • Collaborators are often selected from known social or academic networks, limiting diversity and openness.

	4. Security Concerns in Information Sharing
	• Preference for traditional communication methods (face-to-face, phone, email) over digital tools due to concerns about data security.
	• Social media and cloud-based platforms are avoided, even when they could enhance collaboration.
	
	Key Findings
	• Collaboration is not limited to the early stages of research; it occurs dynamically across all phases.
	• Motivations for collaboration vary by phase:
	  ○ Idea generation: inspiration and intellectual synergy.
	  ○ Funding: institutional or grant requirements.
	  ○ Experimentation: access to expensive equipment or specialized expertise.
	  ○ Research product: enhancing publication impact.
	• Scientists define collaboration narrowly—primarily as coauthorship.
	• Partner selection is based on trust and subject expertise, often within existing networks.
	• Communication and information-sharing practices are shaped by psychological and cultural factors, especially concerns about competition and data security.
	
	Contextual Factors
	• The study is situated in Korean scientific culture, which emphasizes hierarchy and seniority.
	• Funding structures in Korea often require collaboration, influencing researchers' behaviour.
	• The fields of bioscience and nanoscience are inherently interdisciplinary and resource-intensive, making collaboration both necessary and complex.
	
	Implications for Practice and Policy
	1. Cyberinfrastructure Design

	• Systems should support dynamic collaboration formation at any phase of the research life cycle. • Tools must address security concerns and allow creator-controlled access to shared data. • Phase-specific features (e.g., idea generation vs. data analysis) should be built into collaborative platforms. **2. Policy Reform** • Evaluation systems should recognize diverse forms of collaboration beyond coauthorship. • Policies should promote equitable credit-sharing and transparency in authorship. • Institutions should foster inclusive collaboration cultures that mitigate hierarchical pressures. **3. Training and Support** • Researchers need training in ethical collaboration, data sharing, and authorship negotiation. • Support structures should help junior researchers navigate power dynamics in collaborative settings. **Gaps and Limitations** • The study is geographically and culturally bounded to Korea; findings may not generalize globally. • It focuses on bio- and nanoscientists, limiting applicability to other disciplines. • The narrow definition of collaboration (coauthorship) may overlook other valuable forms (e.g., mentoring, data sharing). • The role of institutional policies and international collaborations is underexplored.
28. Back and forth" between the individual and the group: collaboration and emotional leadership in science by Lopez Carrasco and Belli (2023)	**Summary with Emphasis on Social and Cultural Barriers** **Overview** This qualitative study explores the emotional dimension of leadership and collaboration within high-performance scientific research groups, particularly those funded by the European Research Council (ERC). It examines how principal investigators (PIs) manage interpersonal dynamics, emotional tensions,

	and organizational structures to foster collaboration, balancing individual autonomy and group cohesion.
	
	Social and Cultural Barriers Identified
	1. Hierarchical Norms and Power Dynamics
	• Traditional academic hierarchies often conflict with the collaborative ethos.
	• PIs struggle to balance authority with participatory, horizontal leadership.
	• Junior researchers may feel undervalued or constrained by rigid structures.
	2. Emotional Ambivalence and Informality
	• Emotional closeness can foster trust and creativity but also lead to favoritism, conflict, or blurred boundaries.
	• PIs must navigate between warmth and detachment, often suppressing personal affinities to maintain fairness and professionalism.
	3. Individualism vs. Collectivism
	• Scientific culture promotes individual achievement (e.g., publications, grants), which can undermine group collaboration.
	• Researchers may prioritize personal goals over team objectives, creating tension and competition within groups.
	4. Lack of Institutional Support for Emotional Leadership
	• There are few formal spaces for training or reflecting on emotional leadership and collaboration.
	• Emotional labour is often invisible and undervalued, despite its centrality to team functioning.
	
	Key Findings
	• Collaboration is a dynamic “back and forth” movement between individual and group work.
	• Two leadership styles were identified:
	  ○ Ego-centered leadership: emphasizes individual control, authority, and ownership of research.
	  ○ Group-centered leadership: promotes shared decision-making, recognition, and collective identity.
	• Emotional leadership involves both:

	◦ Affective activation: fostering motivation, trust, and group cohesion. ◦ Affective deactivation: maintaining boundaries, controlling egos, and enforcing formal structures. • Informal interactions (e.g., coffee breaks, social outings) play a crucial role in building trust and facilitating collaboration. • Formal rituals (e.g., scheduled meetings) help regulate emotional intensity and maintain professionalism. **Contextual Factors** • The study focuses on Spanish ERC-funded research groups, which have high resources and productivity expectations. • The findings are shaped by the specific institutional culture of Spanish academia. • The ERC funding model encourages collaboration but also intensifies competition and performance pressures. **Implications for Practice and Policy** **1. Leadership Development** • Institutions should provide training and reflective spaces for emotional leadership and collaborative management. • PIs need support in navigating the emotional complexities of team coordination. **2. Organizational Design** • Research groups should balance formal structures with opportunities for informal interaction. • Recognition systems should value both individual contributions and collective achievements. **3. Policy Reform** • Evaluation metrics should account for emotional labor and collaborative dynamics, not just outputs. • Funding bodies could incentivize inclusive and emotionally intelligent leadership practices. **Gaps and Limitations**

	• The study focuses exclusively on high-performance ERC-funded groups; findings may not generalize to less-resourced teams. • Cultural specificity (Spain) limits cross-national applicability. • The analysis centers on interpersonal and organizational scales; broader systemic factors (e.g., global academic norms) are underexplored. • Interviewees may have presented idealized views of collaboration due to social desirability bias. • Gender, disciplinary differences, and career stage effects on leadership styles are acknowledged but not deeply analyzed.
29. Crowd science: The organization of scientific research in open collaborative projects by Franzoni and Sauermann (2014)	**Summary with Emphasis on Social and Cultural Barriers** **Overview** This paper explores the emerging phenomenon of “crowd science”—scientific research conducted through open, collaborative projects involving large numbers of contributors, often outside traditional academic institutions. It analyzes the organizational features, benefits, and challenges of crowd science, comparing it to traditional science, crowdsourcing, and innovation contests. **Social and Cultural Barriers Identified** **1. Tensions with Traditional Scientific Norms** • Traditional science emphasizes individual recognition and priority in discovery, which conflicts with the collective, open ethos of crowd science. • Scientists may be reluctant to share intermediate inputs (e.g., data, heuristics) due to competitive pressures and career incentives. **2. Authorship and Credit Attribution** • Crowd science challenges conventional authorship norms. Some projects use pseudonyms or collective credit, which may deter professional scientists who rely on publications for career advancement.

	• Lack of clear credit mechanisms can create disincentives for participation, especially among academics.
	3. Motivation Conflicts
	• Contributors have diverse motivations—ranging from intrinsic interest and curiosity to professional advancement or commercial gain.
	• Reconciling these motives within a single project is complex and may lead to tension or disengagement.
	4. Limited Inclusion of Professional Scientists and Firms
	• Due to open data sharing and lack of financial rewards, crowd science may struggle to attract contributors with specialized skills or commercial interests.
	• Firms may be hesitant to participate without mechanisms to protect intellectual property or derive financial benefit.
	5. Quality Assurance and Scientific Rigor
	• Projects led by non-professionals may lack methodological rigor.
	• Open platforms and non-traditional publication channels raise concerns about peer review and validation.
	
	Key Findings
	• Crowd science is defined by two core features:
	    ○ Open participation: Anyone can contribute.
	    ○ Open sharing of intermediate inputs: Data, methods, and discussions are publicly accessible.
	• These features distinguish crowd science from traditional science, crowdsourcing, and innovation contests.
	• Crowd science offers:
	    ○ Access to diverse knowledge and skills.
	    ○ Scalable labor for data collection and problem solving.
	    ○ Enhanced transparency and reproducibility.
	    ○ Non-pecuniary motivation (e.g., curiosity, social interaction, contribution to science).
	• Challenges include:

	◦ Coordination and integration of contributions. ◦ Sustaining engagement. ◦ Managing diverse motivations. ◦ Ensuring scientific quality and rigor. **Contextual Factors** • The rise of digital platforms (e.g., Zooniverse, Foldit, Polymath) enables large-scale participation. • Projects span disciplines from astronomy and biology to mathematics and medicine. • Citizen scientists play a central role, often driven by personal interest or altruism. • Funding agencies increasingly support open science and data sharing, aligning with crowd science principles. **Implications for Practice and Policy** **1. Infrastructure Investment** • Support for multi-project platforms (e.g., Zooniverse) can lower barriers to entry and improve scalability. • Preservation of intermediate inputs (e.g., logs, data) is essential for cumulative science. **2. Licensing and Governance** • Development of standardized licenses can help reconcile conflicting motivations and protect contributors' rights. • Lessons from open source software may inform governance models. **3. Recognition and Incentives** • New models for credit attribution (e.g., modular authorship, contributor badges) are needed. • Funding mechanisms could include stipends or grants for key contributors. **4. Quality Assurance** • Platforms may need to embed scientific rigor into tools and workflows. • Certification or advisory roles for professional scientists could enhance credibility. **Gaps and Limitations** • The study is largely conceptual and based on qualitative case analysis.

	• Empirical data on efficiency, scalability, and output quality are limited.
	• The role of crowd science in democratizing access to research remains underexplored.
	• More research is needed on:
	  ○ Motivation dynamics.
	  ○ Integration mechanisms for complex tasks.
	  ○ Cross-sector collaboration (e.g., academia-industry).
	  ○ Long-term sustainability and impact.

30. Understanding Equity, Diversity and Inclusion Challenges Within the Research Software Community by Chue Hong et al., (2021)	**Summary with Emphasis on Social and Cultural Barriers** **Overview** This chapter explores how online communities can be integrated into citizen science frameworks, particularly in hydrology and environmental monitoring. It proposes a conceptual model linking citizen science participation typologies (contributory, collaborative, co-created) with online community behaviors (sharing, cooperation, collective action), drawing on theoretical insights and practical applications. **Social and Cultural Barriers Identified** **1. Hierarchical Expert-Led Structures** • Citizen science often remains expert-driven, with volunteers relegated to data collection roles. • This limits genuine co-production and reinforces traditional power dynamics between scientists and citizens. **2. Unequal Access and Representation** • Volunteers vary widely in education, cultural background, and motivations. • Marginalized groups (e.g., ethnic minorities, local associations) may be underrepresented or excluded unless explicitly targeted. **3. Limited Digital Inclusion** • While ICTs and social media expand participation, not all communities have equal access or digital literacy. • This creates barriers to engagement in virtual citizen science platforms.

	4. Fragmented Participation Models
	• Many projects fail to move beyond basic data sharing (contributory models), missing opportunities for deeper collaboration or co-creation.
	• Lack of structured frameworks for transitioning volunteers into more active roles.
	5. Weak Integration of Online Communities
	• Despite the rise of digital platforms, online communities are often peripheral to citizen science initiatives.
	• Their potential for collective action and knowledge co-production is underutilized.
	
	Key Findings
	• The authors propose a tripartite model aligning:
	    o Contributory citizen science ↔ Sharing in online communities
	    o Collaborative citizen science ↔ Cooperation
	    o Co-created citizen science ↔ Collective action
	• Online communities can support all phases of citizen science—from problem definition to data collection and analysis—if properly engaged.
	• Hydrology and water resource management offer rich case studies for integrating digital tools and participatory models.
	• Social media and mobile apps facilitate low-cost, wide-scale data collection and stakeholder engagement.
	• Stakeholder analysis and communication strategies are essential for building durable, inclusive citizen science communities.
	
	Contextual Factors
	• The chapter is situated within environmental sciences, focusing on hydrology and water management.
	• Advances in ICTs (e.g., mobile apps, social media) have transformed how citizen science is conducted.

	• The authors draw on practical examples and literature from participatory water monitoring and flood risk communication. **Implications for Practice and Policy** **1. Design Inclusive Participation Models** • Move beyond expert-led data collection to co-created frameworks that empower volunteers. • Recognize and accommodate diverse volunteer profiles and motivations. **2. Leverage Digital Platforms Strategically** • Use social media and apps not just for data collection but for dialogue, coordination, and collective decision-making. • Ensure accessibility and usability for all community members. **3. Institutional Support and Training** • Provide training for both experts and volunteers to foster mutual understanding and collaboration. • Institutions should facilitate the integration of online communities into formal research processes. **4. Stakeholder Mapping and Role Definition** • Conduct stakeholder analysis to assign roles, define levels of engagement, and build cohesive communities. • Use network analysis to understand interactions and optimize communication flows. **Gaps and Limitations** • Theoretical and empirical gaps remain in understanding how online communities can be fully integrated into citizen science. • Most current initiatives focus on field-based activities; digital engagement is often secondary. • There is limited research on how volunteers acquire knowledge and develop awareness through participation. • More comparative studies across disciplines and regions are needed to generalize findings.
	Overview

31. Rethinking Open Science: shifting from access to connections to care for equity and inclusion by Rafols (2024)	This commentary critically examines the current trajectory of Open Science (OS), arguing that its dominant focus on digital access to research outputs is failing to deliver on promises of equity, inclusion, and societal impact. Instead, the author advocates for a shift toward contextualized knowledge exchange and care-centered practices that prioritize epistemic justice. **Social and Cultural Barriers Identified** **1. Inequitable Access Models** • The pay-to-publish Open Access model privileges researchers in wealthy institutions, exacerbating global inequalities. • Researchers in low-resource settings often lack the infrastructure or funding to publish or utilize open data effectively. **2. Platform Capitalism and Corporate Control** • Dominant OS infrastructures are increasingly controlled by oligopolistic publishers (e.g., Elsevier, Springer-Nature), mirroring the extractive dynamics of surveillance capitalism. • These platforms shape representations of science that reinforce Global North hegemonies in terms of language, disciplines, and values. **3. Misalignment with Local Needs** • Open Science often assumes that digital access equals usability, ignoring the need for translation, adaptation, and contextual relevance. • Marginalized communities may lack the capacity to engage with scientific outputs without tailored support and participatory processes. **4. Technocratic Focus Over Participatory Inclusion** • OS policies emphasize technological platforms and data sharing, sidelining citizen science and other participatory approaches that foster genuine societal impact. • The emphasis on outputs (e.g., articles, datasets) neglects the relational and processual dimensions of knowledge exchange.

	Key Findings • Current OS practices are not inherently equitable or impactful; they often benefit those with existing resources and capacities. • The societal impact of OS is more likely to emerge through participatory interactions (e.g., citizen science, stakeholder engagement) than through open access alone. • There is no singular OS future—different visions (efficiency, access, participation) lead to divergent trajectories, some of which conflict. • Alternative models (e.g., diamond OA, community-led platforms like La Referencia or OCSDNet) offer more inclusive and justice-oriented pathways. **Contextual Factors** • The analysis is situated within global debates on science policy, equity, and digital infrastructure. • It draws on UNESCO's 2021 Recommendation on Open Science, which frames science as a global public good. • The commentary is informed by experiences in both the Global North and South, highlighting disparities in access, infrastructure, and participation. **Implications for Practice and Policy** **1. Shift Focus from Access to Connection** • Prioritize processes of knowledge exchange over mere dissemination of outputs. • Support relational, context-sensitive engagement between researchers and communities. **2. Invest in Inclusive Infrastructures** • Promote diamond OA and community-led platforms that do not rely on pay-to-publish models. • Ensure that digital tools are accessible, adaptable, and responsive to diverse user needs. **3. Recognize and Support Translation Work**

	• Fund and value the creation of materials that make scientific knowledge usable for non-experts. • Encourage participatory formats that allow communities to co-produce and interpret knowledge. **4. Challenge Corporate Dominance** • Develop governance models that resist monopolistic control of research infrastructures. • Advocate for public and collective ownership of scientific platforms and data. **Gaps and Limitations** • The commentary is conceptual and reflective, not empirical; it calls for further research on the actual impacts of OS practices. • It does not provide detailed case studies or metrics to evaluate alternative OS models. • While it critiques dominant OS trajectories, it offers limited guidance on how to operationalize care-centered approaches at scale.
32. Rethinking the A in FAIR Data: Issues of Data Access and Accessibility in Research by Shanahan and Bezuidenhout (2022)	**Overview** This paper critically examines the "Accessibility" component of the FAIR (Findable, Accessible, Interoperable, Reusable) data principles, arguing that current implementations often overlook real-world barriers to access—especially those rooted in geopolitical, infrastructural, and socio-economic contexts. The authors present empirical evidence showing that access to FAIR data is not universally equitable and call for a rethinking of how accessibility is defined and operationalized. **Social and Cultural Barriers Identified** **1. Geopolitical Restrictions and Geoblocking** • Researchers in sanctioned countries (e.g., Iran, Syria, Cuba) face blocked access to key Open Science platforms like GitHub due to financial sanctions and geolocation-based restrictions. • These restrictions are often enforced by commercial entities hosting research

	infrastructure, which are bound by national laws. **2. Unequal Distribution of Repositories** • The majority of trusted digital repositories are located in high-income countries (HICs), with minimal representation in low- and middle-income countries (LMICs), especially in Africa. • This geographic concentration reinforces global research inequalities. **3. Connectivity and Infrastructure Challenges** • Researchers in LMICs face unstable internet connections, frequent time-outs, and prohibitively high mobile data costs. • These "last-mile" issues hinder access to large datasets and participation in online collaborations. **4. Risk of VPN Use** • VPNs are often suggested as a workaround for access restrictions, but their use can be illegal or dangerous in repressive regimes. • Reliance on VPNs shifts the burden to individual researchers and does not address systemic inequities. **5. Misleading FAIR Scores** • Automated FAIR assessment tools (e.g., FUJI, FAIR-Checker) evaluate accessibility based on metadata and repository infrastructure, not actual user experience. • This creates a false sense of universal access and obscures the lived realities of marginalized researchers. **Key Findings** • Accessibility in FAIR is often interpreted narrowly, focusing on technical protocols and repository standards. • Actual access varies significantly by geographic location due to sanctions, infrastructure, and political controls. • The FAIR ecosystem is shaped by commercial actors whose compliance with national laws can restrict access. • There is a disconnect between FAIR principles and the broader goals of Open Science, particularly in terms of equity and inclusion.

	Contextual Factors • The study uses VPN-based simulations to test access to 2,781 Open Science-related URLs from 14 countries, including both HICs and LMICs. • The analysis reveals significant disparities in access, with countries like Syria, Cuba, and Sudan experiencing frequent blocks or time-outs. • The paper is situated within broader discussions on Open Science, digital divides, and global research equity. **Implications for Practice and Policy** **1. Redefine Accessibility in FAIR** • Move beyond technical definitions to include user-centered perspectives and geopolitical realities. • Recognize that metadata availability does not guarantee equitable access. **2. Integrate FAIR with Open Science Equity Goals** • FAIR discussions must be aligned with infrastructure investment and policy reforms aimed at reducing global disparities. • Accessibility should be treated as a dynamic, context-sensitive principle. **3. Avoid Overreliance on VPNs** • VPNs are not a sustainable or safe solution for researchers in repressive contexts. • Infrastructure and policy changes are needed to ensure safe and equitable access. **4. Expand Repository Networks** • Support the development of repositories in LMICs to decentralize data storage and access. • Encourage regional Open Science clouds and community-led data initiatives. **5. Reform FAIR Assessment Tools** • Incorporate geographic and user-experience metrics into FAIR scoring systems. • Avoid reinforcing inequities through misleading indicators. **Gaps and Limitations**

	• Current FAIR frameworks lack mechanisms to account for geopolitical and infrastructural barriers. • FAIR assessments are overly reliant on repository metadata and do not reflect real-world access conditions. • There is limited empirical data on user experiences of FAIR data in LMICs—this study begins to address that gap. • Further research is needed to explore alternative models of accessibility and to develop inclusive FAIR standards.
33. To share or not to share: Incentivizing data sharing in life science communities by Bezuidenhout (2019)	**Overview** This paper explores the complex landscape of data sharing in life sciences, particularly in low- and middle-income countries (LMICs), using empirical evidence from biochemistry laboratories in Kenya and South Africa. It applies the Thomas Theorem—"If men define situations as real, they are real in their consequences"—to argue that scientists' perceptions of their research environments significantly shape their data sharing behaviors, regardless of objective realities. **Social and Cultural Barriers Identified** **1. Perceived Resource Deficits** • Scientists often view their environments as lacking the infrastructure, funding, and support necessary for data sharing. • Even when resources (e.g., institutional repositories) exist, they are underutilized due to lack of awareness or perceived irrelevance. **2. Connectivity and ICT Limitations** • Poor internet access, outdated hardware, and lack of institutional support for software hinder online data sharing. • Researchers rely on personal devices and limited bandwidth, making uploading or accessing data difficult. **3. Positional and Institutional Constraints** • High student turnover and lack of standardized data management practices result in data loss or fragmentation.

	• Supervisors struggle to curate and preserve student-generated data. **4. Cultural Perceptions of Openness** • Data sharing is often seen as a “Western” practice, disconnected from African research realities. • Scientists perceive themselves as outsiders to the Open Data movement, reinforcing disengagement. **5. Fear of Exploitation and Lack of Protection** • Concerns about being “scooped” by better-resourced researchers in high-income countries (HICs) are widespread. • LMIC scientists feel vulnerable due to perceived lack of legal and institutional support. **6. Lack of Recognition and Incentives** • Data sharing is not rewarded through promotion, teaching buy-out, or institutional recognition. • Fee waivers and support schemes are poorly understood or mistrusted, reinforcing perceptions of exclusion. **Key Findings** • Scientists support the idea of data sharing but rarely practice it due to contextual disincentives. • Perceptions of the research environment—whether accurate or not—strongly influence behavior. • Incentives must address both practical barriers and subjective interpretations of the research context. • Without community engagement and culturally sensitive policies, data sharing will remain peripheral in LMICs. **Contextual Factors** • The study is based on ethnographic research in four African biochemistry labs. • Interviews and observations reveal a disconnect between global Open Data norms and local realities.

	• The Thomas Theorem is used to frame how subjective perceptions shape objective outcomes. **Implications for Practice and Policy** **1. Rethink Incentivization Strategies** • Move beyond "carrots and sticks" to culturally embedded, context-sensitive incentives. • Recognize that perceptions of risk, exclusion, and irrelevance must be addressed alongside technical barriers. **2. Engage Local Communities** • Co-design policies with scientists in LMICs to reflect their lived experiences and aspirations. • Support bottom-up initiatives that build trust and relevance. **3. Improve Infrastructure and Training** • Invest in ICT resources, data management training, and institutional support. • Ensure that repositories and platforms are accessible and usable in low-bandwidth settings. **4. Promote Visibility and Recognition** • Showcase successful LMIC data sharing examples to build confidence and community norms. • Integrate data sharing into promotion and evaluation criteria. **Gaps and Limitations** • Lack of empirical data on African research environments and data sharing practices. • Absence of clear evidence showing benefits of data sharing for LMIC scientists. • Global Open Data initiatives often assume universal applicability without local validation. • More research is needed to understand how perceptions can be shifted to enable sustainable change.
34. Beyond the digital divide: Towards a situated approach to open data by	**Overview** This paper critiques the dominant "digital divide" framing in Open Data (OD) discourse, arguing that it oversimplifies the challenges faced by researchers in low- and middle-income countries (LMICs). Drawing

Bezuidenhout et al., (2017)	on fieldwork in Kenya and South Africa, the authors propose a shift toward a "capabilities approach" (CA) that emphasizes the conditions under which researchers can meaningfully engage with data—not just access it. **Social and Cultural Barriers Identified** **1. Misleading Binary of 'Have' vs. 'Have Not'** • The digital divide framing reduces complex realities to simplistic access/no-access binaries. • It ignores the nuanced social, institutional, and epistemic factors that shape data engagement. **2. Lack of Institutional Support and Infrastructure** • Researchers often work with outdated equipment, unreliable internet, and frequent power outages. • Institutional repositories and proxy servers are underdeveloped or inaccessible off-campus. **3. Cultural Perceptions and Marginalization** • Data sharing is perceived as a "Western" practice, alien to local research cultures. • Scientists fear their data will be undervalued due to its origin or the use of older methodologies. **4. Fear of Exploitation and Lack of Protection** • Concerns about being "scooped" by better-resourced researchers in high-income countries. • Lack of legal and institutional mechanisms to protect intellectual property rights. **5. Epistemic Isolation** • Niche research topics (e.g., medicinal plants, water purification) are strategically chosen but poorly represented in global datasets. • This limits opportunities for reuse and collaboration. **6. Economic Constraints** • Researchers self-fund equipment and data bundles, limiting their ability to engage with OD platforms. • Fee-based access to journals and data repositories remains a barrier. **Key Findings**

	• Access to data does not equate to usability or meaningful engagement. • Conversion factors—personal, communal, organizational, infrastructural, epistemic, and economic—shape researchers' ability to use data. • OD initiatives must move beyond resource provision to capability strengthening. • The current OD discourse risks reinforcing inequalities by ignoring the heterogeneity of research environments. **Contextual Factors** • The study is based on qualitative fieldwork in four biochemistry departments in Kenya and South Africa. • These labs are not part of international consortia and represent "homegrown" research efforts. • Despite being "online," researchers face multiple barriers to effective data engagement. **Implications for Practice and Policy** **1. Shift from Access to Capability** • Policies should focus on enabling researchers to use data, not just access it. • This includes training, mentorship, infrastructure, and institutional support. **2. Contextualize Open Data Initiatives** • Recognize the diversity of research environments and avoid one-size-fits-all solutions. • Design platforms and policies that are inclusive of low-bandwidth and non-Western contexts. **3. Address Epistemic and Cultural Marginalization** • Promote recognition of diverse research topics and methodologies. • Ensure that data sharing platforms do not privilege HIC norms and aesthetics. **4. Rethink Metrics and Incentives** • Move beyond citation-based incentives to include community relevance and local impact. • Support researchers in building visibility and credibility within their own contexts. **Gaps and Limitations**

	• OD discourse lacks empirical engagement with LMIC research environments. • There is insufficient data on how researchers in LMICs perceive and use open data. • The digital divide framing obscures the continuum of access and capability. • More research is needed on poorly resourced labs within HICs to challenge geographic binaries.
35. Open Science and Epistemic Diversity: Friends or Foes? By Leonelli (2022)	**Overview** This paper critically examines the conceptualization and implementation of Open Science (OS), arguing that current approaches often overlook epistemic diversity and risk reinforcing existing inequities in research. Through three case studies and philosophical analysis, Leonelli highlights how OS practices can unintentionally privilege dominant research cultures, marginalize others, and exacerbate global disparities. **Social and Cultural Barriers Identified** **1. Inequitable Access and Recognition** • Researchers in low-resourced environments (especially in the Global South) face barriers to contributing and benefiting from Open Data due to lack of infrastructure, visibility, and recognition. • Platforms like GISAID attempt to address these asymmetries by requiring credit attribution, but are criticized for not being “open enough.” **2. Technological Stigma and Publishing Bias** • Use of open-source software is stigmatized in some contexts, with researchers fearing that editors and reviewers perceive it as low-quality. • Preference for proprietary tools (e.g., MatLab, Mathematica) is driven by reputational concerns, not scientific merit. **3. Reproducibility as a Gatekeeping Mechanism** • Standardized notions of reproducibility (e.g., randomized controlled trials) are used to demarcate “good science,” disadvantaging

	research that relies on exploratory, field-based, or context-sensitive methods. • This reinforces methodological conservatism and excludes diverse epistemic approaches. **4. Dominance of Northern Repertoires** • OS infrastructures and standards are often shaped by institutions in the Global North, embedding their values and assumptions. • This creates systemic bias in what is considered credible, publishable, or fundable research. **Key Findings** • OS, as currently implemented, risks privileging entrenched systems of practice and marginalizing alternative approaches. • Epistemic diversity—variation in methods, goals, tools, and contexts—is essential for robust science but is often undermined by universal OS policies. • Philosophical insights from pluralism suggest that OS must account for: 1. Specificity to local conditions 2. Degree of entrenchment in existing repertoires 3. Permeability to newcomers 4. Demarcation strategies for scientific credibility **Contextual Factors** • The paper draws on empirical examples from global data sharing (GISAID), software use in LMICs, and reproducibility debates. • It is situated within broader discussions on scientific pluralism, epistemic justice, and the politics of knowledge production. • The author emphasizes the need for context-sensitive OS policies that reflect diverse research environments and practices. **Implications for Practice and Policy** **1. Rethink OS Principles** • Move away from one-size-fits-all standards and embrace procedural, context-aware definitions of openness.

	- Recognize that openness may require constraints (e.g., credit attribution) to ensure equity. **2. Support Diverse Systems of Practice** - Encourage development of locally relevant methods, tools, and infrastructures. - Avoid imposing dominant repertoires as universal models of good science. **3. Reform Evaluation and Reward Systems** - Challenge publishing and funding biases that favor Global North norms. - Promote inclusive criteria for assessing research quality and impact. **4. Foster Transdisciplinary Dialogue** - Engage researchers across disciplines and geographies to co-design OS policies. - Ensure that demarcation strategies are transparent and inclusive. **Gaps and Limitations** - OS discourse often lacks fine-grained analysis of epistemic diversity beyond disciplinary boundaries. - There is limited empirical data on how OS practices affect marginalized research communities. - More work is needed to understand how digital tools and infrastructures can be adapted to diverse contexts.
36. Epistemic control and the normativity of machine learning based science by Ratti (2025)	**Overview** This paper explores the concept of epistemic control in the context of machine learning (ML)-based science. It critically engages with Paul Humphreys' pessimistic view that ML systems push human scientists out of the epistemological loop due to their opacity and autonomous functioning. Ratti proposes a more nuanced framework for understanding epistemic control, emphasizing the role of human values, methodological choices, and the normative influence of ML systems on scientific practice. **Social and Cultural Barriers Identified** **1. Epistemic Opacity and Representational Alienation**

	• ML systems, especially deep neural networks (DNNs), often produce internal representations that are implicit and distributed, making them difficult for human scientists to interpret. • This opacity undermines tracing (understanding how outputs are generated) and tracking (ensuring outputs align with accepted epistemic standards), especially in disciplines like biology or psychiatry. **2. Value Conflicts and Specification Challenges** • ML systems are shaped by value-laden decisions, including both cognitive (epistemic) and non-cognitive (social, ethical) values. • Scientists face dilemmas in specifying and choosing values (e.g., data quality vs. representativeness), which are often influenced by the technical constraints of ML systems. **3. Normative Constraints Imposed by ML Tools** • ML systems bring their own normativity, subtly shaping what scientific goals are feasible or prioritized (e.g., prediction over explanation). • This can lead to epistemic misalignment, where scientific communities are nudged toward goals that may not align with their disciplinary values or societal needs. **4. Marginalization of Human Perspective** • The dominance of ML's internal logic and representational style can marginalize human epistemic perspectives, especially in contexts where interpretability and mechanistic explanation are valued. • This raises concerns about scientific autonomy, especially in fields where ML tools dictate methodological norms. **Key Findings** • Epistemic control in ML-based science is not entirely lost but is partial and conditional. • Human scientists retain control through value-laden design and oversight, but ML systems impose constraints that shape scientific aims and practices. • The normativity of ML systems—how they implicitly prescribe certain scientific

	behaviors—must be acknowledged and critically examined. • ML's opacity is problematic primarily for explanatory goals, but less so for predictive or classificatory tasks, where epistemic control can still be maintained. **Contextual Factors** • The analysis is situated within philosophy of science and draws on examples from biology, psychiatry, and cancer genomics. • It engages with debates on automated science, machine epistemology, and value-laden methodologies. • The paper builds on interdisciplinary literature, including work on inductive risk, mechanistic explanation, and AI ethics. **Implications for Practice and Policy** **1. Design ML Systems with Epistemic Transparency** • Encourage practices that enhance interpretability and traceability, especially in high-stakes domains like healthcare and biology. **2. Recognize and Deliberate Value Trade-offs** • Develop frameworks for value specification and choice, ensuring that scientific communities consciously navigate trade-offs (e.g., accuracy vs. fairness). **3. Address Normative Influence of ML** • Acknowledge that ML tools shape scientific norms and goals; policies should support critical reflection on these influences. **4. Foster Human-Centered Oversight** • Maintain human epistemic agency by embedding discipline-specific standards and methodological pluralism into ML workflows. **Gaps and Limitations** • The paper focuses primarily on epistemic rather than social or political dimensions of control. • It does not deeply explore institutional or regulatory mechanisms for mitigating ML's normative impact.

	• Further empirical research is needed to understand how different scientific communities experience and negotiate epistemic control in practice.
37. The decolonial turn in data and technology research: what is at stake and where is it heading? By Couldry and Mejias (2023)	**Overview** This article surveys the emergence of a “decolonial turn” in critical data and technology studies. It argues that contemporary data practices—especially those driven by Big Tech—represent a new form of colonialism, termed data colonialism, which continues and extends historical patterns of resource extraction, dispossession, and epistemic violence. The authors position their own “data colonialism thesis” within a broader landscape of decolonial scholarship and critique. **Social and Cultural Barriers Identified** **1. Epistemic Violence and Knowledge Hierarchies** • Data systems reproduce colonial hierarchies by privileging Western epistemologies and marginalizing indigenous, feminist, and Global South perspectives. • Algorithms and AI often encode racial, gendered, and class-based biases under the guise of neutrality and objectivity. **2. Global Asymmetries in Data Infrastructure and Sovereignty** • Big Tech platforms (e.g., Facebook’s Free Basics) create dependencies in the Global South, limiting technological sovereignty and reinforcing neo-colonial control. • Data extractivism disproportionately targets marginalized communities, both in the Global South and within disadvantaged populations in the Global North. **3. Racial Capitalism and Algorithmic Discrimination** • Technologies normalize surveillance and control of racialized bodies, echoing colonial practices of domination. • The ideology of “artificial whiteness” (Katz, 2020) and critiques by Benjamin (2019) and Noble (2018) highlight how data systems perpetuate systemic racism.

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4. Exclusion from Governance and Policy Debates

Indigenous and marginalized communities are often excluded from shaping data governance, standards, and ethical frameworks.
Resistance movements must contend with entrenched power structures in both corporate and state institutions.

Key Findings

Data colonialism is not merely metaphorical—it represents a new stage of colonialism where human life is appropriated as a resource through data extraction.
The decolonial turn offers a transhistorical lens that connects contemporary data practices to centuries of colonial and capitalist exploitation.
Decolonial critiques challenge the dominant narratives of technological progress and innovation, exposing their complicity in global inequality.
Resistance must be both local and global, material and epistemic, and inclusive of diverse voices and imaginaries.

Contextual Factors

The article draws on interdisciplinary scholarship from media studies, critical data studies, postcolonial theory, and political economy.
It situates the decolonial turn within broader critiques of platform capitalism, surveillance capitalism, and digital extractivism.
The authors engage with critiques of their own data colonialism thesis, emphasizing the need for nuanced, context-sensitive analysis.

Implications for Practice and Policy
1. Rethink Data Governance

Policies must address the colonial roots of data systems and prioritize data sovereignty for marginalized communities.
Ethical frameworks should be informed by decolonial, feminist, and indigenous epistemologies.

2. Support Non-Aligned Technological Movements
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	• Initiatives like the Non-Aligned Technologies Movement (NATM) advocate for alternatives to Silicon Valley and Chinese techno-authoritarianism. • Strategies include divestment from Big Tech, reappropriation of data, and promotion of public education and citizen research. **3. Foster Inclusive Resistance** • Decolonial resistance must include Queer, Trans, Two-Spirit, Black, Indigenous, and People of Color communities. • Design justice and abolitionist tech movements offer models for participatory, community-led alternatives. **4. Challenge Data Universalism** • Avoid assuming that data practices are universally applicable or beneficial. • Recognize the diversity of local contexts and resist the imposition of Western technological rationalities. **Gaps and Limitations** • The article acknowledges critiques that the data colonialism thesis may risk overgeneralization or insufficient attention to local specificities. • There is limited empirical research on how data colonialism manifests in different regions, especially outside the Global North. • More work is needed to explore the intersection of data colonialism with gender, class, and disability.
38. Postcolonial Computing: A Lens on Design and Development by Irani (2010)	**Overview** This paper introduces the concept of postcolonial computing as an analytical lens for understanding the cultural, historical, and power-laden dimensions of technology design, especially in contexts labeled as "developing." It critiques conventional approaches in Human-Computer Interaction for Development (HCI4D) and proposes alternative frameworks rooted in postcolonial theory and Science and Technology Studies (STS).

	Social and Cultural Barriers Identified **1. Static and Taxonomic Views of Culture** • Design practices often rely on simplified, static models of culture (e.g., Hofstede's dimensions), which fail to capture the fluid, dynamic, and multi-sited nature of cultural identity. • These models reinforce "otherness" and obscure the hybrid, transnational realities of users, especially in diasporic or globalized contexts. **2. Problematic Development Narratives** • Development projects frequently frame poverty as a technical problem solvable through Western-designed products, ignoring political and structural causes. • NGOs and corporations often impose solutions that reflect donor interests rather than local needs, leading to mismatches and disempowerment. **3. Uneven Economic Relations and Intellectual Property Norms** • Global power asymmetries shape what counts as legitimate design, innovation, and authorship. • Cases like Brazil's Unitron and Peru's open-source movement show how Western IP norms marginalize local practices and redefine creativity. **4. Epistemic Incommensurability and Knowledge Hierarchies** • Western design methods assume knowledge is portable and abstract, while many cultures view knowledge as situated, embodied, and relational. • Indigenous knowledge systems challenge assumptions about who can speak, what can be known, and where knowledge can be shared. **Key Findings** • Design is always culturally situated and shaped by histories of colonialism, even in "neutral" or "technical" contexts. • Postcolonial computing reframes design as a process of engagement, articulation, and

	translation, emphasizing mutual learning and power awareness. • Cultural specificity is not a problem to be solved but a reality to be embraced in design practice. • Hybrid knowledge systems and design practices emerge from intercultural encounters and should be recognized as legitimate and valuable. **Contextual Factors** • The paper draws on case studies from India, Brazil, Peru, and Australia, as well as corporate and NGO design settings. • It critiques dominant HCI4D paradigms and situates them within broader global flows of capital, labor, and knowledge. • The authors are interdisciplinary, combining expertise in informatics, women's studies, and computing. **Implications for Practice and Policy** **1. Rethink Design Methodologies** • Move beyond user-centered design to models that foreground community engagement, cultural epistemologies, and historical context. • Recognize that design methods themselves are culturally and politically situated. **2. Embrace Hybrid and Situated Knowledge** • Support design practices that integrate indigenous, local, and non-Western ways of knowing. • Avoid universalizing Western design norms and instead co-create methods with communities. **3. Address Power and Participation** • Design engagements should be mutual, reflexive, and attentive to who is included or excluded. • Articulate design needs with awareness of political and economic commitments embedded in technology. **4. Challenge Development Orthodoxy** • Question the assumption that Western technologies are inherently empowering or progressive.

	• Support infrastructural and political solutions alongside technical interventions. **Gaps and Limitations** • The paper critiques dominant paradigms but does not offer a fully developed alternative design methodology. • It focuses primarily on qualitative and ethnographic insights; more empirical studies could strengthen its claims. • While rich in theory, the paper could benefit from more concrete guidance for practitioners navigating intercultural design challenges.
39. Embedding Digital Infrastructure in Epistemic Culture by Merz (2006)	This chapter introduces the notion of a "disunity of e-science:" It posits that different epistemic cultures privilege different forms of digital infrastructure, integrate them into their practice in historically and culturally specific ways and assign to them distinct functions, meanings and interpretations. Based on an ethnographic case study of theoretical particle physics, the chapter demonstrates how digital infrastructures are firmly embedded and deeply entwined with epistemic practice and culture. The case is made, firstly, by investigating the practice of distributed collaboration and how it is sustained by e-mail-based interaction and, secondly, by analyzing the practice of preprinting and how an electronic preprint archive has turned into a central element of the scientists' culture. In its conclusion, the chapter cautions against techno-deterministic views of how digital infrastructure might align sciences and turn them into a homogenized "e-science."
40. New Infrastructures for Knowledge Production: Understanding E-Science by Hine (2006)	**Overview** This edited volume, led by Christine Hine, explores the emergence of e-science—the use of digital infrastructures to support collaborative, data-intensive scientific research—through the lens of Science and Technology Studies (STS). It critically examines how these infrastructures are shaped by, and in turn shape, scientific practices, disciplinary cultures, and institutional norms. **Social and Cultural Barriers Identified**

	1. Disciplinary Cultures and Epistemic Diversity
	• Scientific disciplines vary in their mutual dependence and task uncertainty, which affects their readiness to adopt e-science tools.
	• Fields like high-energy physics show centralized coordination and rapid uptake of digital infrastructure.
	• In contrast, social/cultural geography and corpus-based linguistics exhibit fragmented practices and resistance to standardization.
	2. Technological Determinism and Misalignment
	• Grand visions of e-science often assume universal applicability, ignoring the specific needs and practices of different epistemic cultures.
	• For example, women's studies scholars emphasize reflexivity, contextual interpretation, and writing as knowledge-making—practices not easily supported by computational tools.
	3. Institutional Constraints
	• Promotion and tenure (P&T) systems discourage interdisciplinary and digital scholarship, especially in the humanities.
	• Scholars avoid publishing in electronic journals due to concerns about recognition and legitimacy.
	4. Inequities in Access and Participation
	• The SIBIS survey (2003) reveals persistent disparities in internet access and use among scientists based on gender, age, discipline, and country.
	• Kerala case study shows how patrifocal social structures limit women's mobility and networking, though the internet offers partial circumvention.
	5. Strategic Resistance and Appropriation
	• Disciplines like systematics in biology respond strategically to computerization movements by:
	    o Embracing digital tools while highlighting limitations.
	    o Stressing existing efforts and lobbying for funding.
	    o Disaggregating grand visions into practical, discipline-specific actions.

Key Findings

- E-science is not monolithic: Adoption and impact vary widely across disciplines.
- Digital infrastructure is deeply embedded in scientific cultures, but its meaning and use are context-dependent.
- Interdisciplinary collaboration requires deliberate negotiation of epistemic, institutional, and technological boundaries.
- STS perspectives offer valuable insights into the social shaping of e-science and the reflexive potential of new technologies.

Contextual Factors

- The UK's £250M e-science initiative (2001–2006) catalyzed interest in digital infrastructure.
- The National Computational Science Alliance (USA) illustrates challenges in organizing labor and expertise for interdisciplinary IT development.
- Historical documents (e.g., Lax 1982, Hayes 1995, Cerf 1993) show evolving visions of computational science and collaboratories.

Implications for Practice and Policy

1. Infrastructure Design

- Must be informed by disciplinary practices, epistemic cultures, and user needs.
- Avoid one-size-fits-all solutions; support customization and co-design.

2. Institutional Reform

- Revise P&T criteria to recognize interdisciplinary and digital scholarship.
- Support long-term maintenance of infrastructure, not just innovation.

3. Equity and Inclusion

- Address gender, regional, and disciplinary disparities in access and participation.
- Preserve advantages of open networking while mitigating structural exclusions.

4. Reflexive Engagement

- Use STS and ethnographic methods to interrogate assumptions and guide development.

	• Encourage dialogue between developers, users, and policy makers. **Gaps and Limitations** • Overemphasis on computational fields: Humanities and qualitative social sciences are underrepresented in e-science initiatives. • Limited empirical data on long-term impacts of digital infrastructure on knowledge production. • Insufficient integration of STS insights into infrastructure design and policy. • Assumption of linear progress: Need for more nuanced understanding of resistance, adaptation, and hybrid practices.
41. Infrastructuring digital humanities: On relational infrastructure and global reconfiguration of the field by Pawlicka-Deger (2022)	**Overview** The article critically examines the global development of Digital Humanities (DH) through the lens of infrastructure studies, particularly from Science and Technology Studies (STS). It argues that infrastructural inequalities—in terms of connection, standardization, and access—are central barriers to inclusive and equitable global DH. **Social and Cultural Barriers Identified** **1. Connection** • Digital divide: Nearly half the global population lacks reliable internet access, exacerbating exclusion from digital scholarship. • Materiality of infrastructure: Physical infrastructure (e.g., broadband cables, electricity) is unevenly distributed, especially between the Global North and South. • Political control: Internet shutdowns (e.g., Gujarat, India) illustrate how connectivity is subject to state control, creating “disconnected subjects.” • Invisibility of local DH: Many initiatives (e.g., in India) are absent from global DH maps, leading to underrepresentation. **2. Standardization** • Language dominance: English-centric platforms and tools marginalize non-English languages (e.g., Arabic, African languages).

	• Platform monopolies: Commercial tools (e.g., Zoom, Microsoft) dominate academic communication, sidelining open-source alternatives. • Homogenization risk: Standardization can suppress diverse epistemologies and methodologies, reinforcing Western norms. **3. Access** • Paywalls and affordability: High costs of academic resources and publishing fees exclude scholars from low-income regions. • Open access paradox: While open access aims to democratize knowledge, models like Plan S may disadvantage those unable to pay article processing charges (APCs). • Neocolonial dynamics: Open access may reinforce North-South asymmetries by privileging Northern knowledge dissemination over local knowledge production. **Key Findings** • Infrastructure is relational and political: It reflects and reinforces global power dynamics in knowledge production. • Global DH is not monolithic: It comprises diverse, locally situated practices that are often excluded from dominant narratives. • Infrastructuring is a process: Building inclusive DH requires participatory, ethical, and community-led design of infrastructure. • STS offers critical tools: Concepts like co-production and infrastructuring help interrogate the socio-technical entanglements of DH. **Contextual Factors** • COVID-19 pandemic: Highlighted both the potential and fragility of digital infrastructures, exposing inequalities in access and connectivity. • Grassroots initiatives: Feminist, decolonial, and multilingual DH projects challenge dominant infrastructural paradigms. • Global movements: Open access efforts (e.g., RedALyC, CLACSO) in Latin America exemplify community-driven alternatives to commercial publishing.

	Implications for Practice and Policy **For DH Scholars and Institutions** • Foster inclusive infrastructuring: Design tools and platforms that support diverse languages, formats, and epistemologies. • Promote open scholarship: Share resources under Creative Commons licenses and support local digitization efforts. • Ensure sustainability: Maintain long-term access to digital projects and cultural heritage data. • Encourage collaborative networks: Build bridges across regions and disciplines through shared vocabularies and mutual understanding. **For Policymakers and Funders** • Support local infrastructure development: Invest in electricity, internet, and digital tools in underserved regions. • Rethink open access models: Avoid pay-to-publish systems that exclude Global South scholars. • Address language equity: Fund development of multilingual tools and platforms. **Gaps and Limitations** • Technical analysis deferred: The article focuses on social dimensions, leaving technical infrastructure for future study. • Limited empirical data: While rich in conceptual framing, more case studies and quantitative data could strengthen the analysis. • Global DH mapping challenges: Existing maps are incomplete and risk reinforcing exclusion if not critically interpreted.
42. e-Science: Open, Social and Virtual Technology for Research Collaboration by Koschtial (2021)	**Overview** This edited volume explores the evolving concept of e-science, focusing on how digital technologies, virtual collaboration, and open infrastructures are reshaping research practices. It includes empirical studies, theoretical models, and case analyses across Germany and Europe, with particular attention

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to doctoral education, digital tool adoption, and research infrastructure.

Social and Cultural Barriers Identified
1. Digital Divide and Tool Adoption

Web 2.0 tools (e.g., blogs, microblogs, social media) are underutilized in scholarly contexts, especially in Germany.
Barriers include:

Lack of perceived utility.
Privacy concerns and data protection regulations.
Institutional inertia and limited support for digital literacy.
Disciplinary cultures resistant to change (e.g., engineering vs. humanities).

2. Collaboration Challenges

Doctoral students face difficulties in establishing meaningful online collaboration due to:

Limited incentives and ethical concerns.
Weak institutional support and context-specific constraints.
Time management and task fragmentation.

Fish Model shows that beliefs and ethics are stronger predictors of collaboration than institutional context or task/time factors.

3. Infrastructure Inequities

Small institutions struggle with:

High costs of IT infrastructure.
Lack of green IT strategies.
Limited legal expertise in copyright and data protection.

Collaboration across institutions is often informal and lacks standardized governance.

4. Communication and Knowledge Transfer

In large research networks (e.g., Sustainable Land Management), communication is hindered by:

Abstract content not tailored to stakeholders.
Lack of professional communication design.
Limited integration of citizen science and media outreach.

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	Key Findings • Digital tools are widely adopted for basic scholarly tasks (e.g., Wikipedia, mailing lists), but Web 2.0 tools remain niche. • Beliefs and ethics significantly influence collaboration; institutional context and time/task factors are less impactful. • Virtual organizations require social control mechanisms (trust, shared culture) rather than traditional governance. • Metadata standards (CMDI, Dublin Core) and open formats (XML, TEI) are essential for sustainable digital infrastructure. • Future research may be shaped by Global Expert Systems (GESs) and Brain–Computer Interfaces (BCIs), raising ethical and epistemological questions. **Contextual Factors** • Geographic focus: Germany, especially Saxony. • Timeframe: Surveys and interviews conducted between 2012–2013; publication in 2021. • Funding: European Social Fund (ESF), Saxon State Ministry of Science and Culture, Horizon 2020. • Disciplinary variation: Humanities show higher adoption of collaborative tools; engineering and sciences lag behind. **Implications for Practice and Policy** **For Institutions** • Invest in open access infrastructure and digital literacy training. • Support interdisciplinary collaboration through flexible governance models. • Develop strategic communication plans for research networks. **For Policymakers** • Encourage standardization of metadata and formats. • Address legal barriers to data sharing and reuse.

	• Promote inclusive digital research environments, especially for early-career researchers. **For Researchers** • Reflect on ethical dimensions of digital collaboration. • Engage with open innovation platforms (e.g., MOVING, CLARIN-D). • Advocate for transparent and sustainable infrastructure policies. **Gaps and Limitations** • Empirical scope: Mostly limited to Germany; broader international comparisons needed. • Disciplinary bias: Overrepresentation of technical fields in survey samples. • Tool usage data: Lacks longitudinal tracking to assess trends over time. • Collaboration models: Need further validation across diverse institutional contexts.
43. Understanding scientific collaboration in the research life cycle Chung (2016)	**Key Social and Cultural Barriers Identified** **1. Hierarchical Culture and Seniority Norms** o Korean scientific culture emphasizes seniority, which can lead to unequal credit sharing and discourage junior researchers from collaborating with senior colleagues. o Younger scientists reported feeling exploited or undervalued, limiting their willingness to collaborate outside their peer group. **2. Trust and Personal Compatibility** o Trust was a critical factor in collaborator selection, often outweighing technical expertise. o Scientists preferred collaborators from known networks (e.g., same alma mater), reflecting cultural preferences for familiarity and loyalty. **3. Competitive Tensions** o Collaboration coexists with competition. Scientists feared being "scooped" and were reluctant to share sensitive data or lab notes.

- This competitive mindset hindered open communication and information sharing, especially in high-stakes research environments.

4. **Credit Sharing Conflicts**
    - Disputes over authorship and recognition were common, especially in the research product phase.
    - Cultural reluctance to discuss credit allocation openly exacerbated tensions and led to collaboration breakdowns.
5. **Security Concerns in Communication**
    - Despite the availability of digital tools, researchers preferred traditional communication (face-to-face, phone, email) due to concerns about data security and confidentiality.
    - Social media and cloud-based tools were avoided, reflecting anxiety about information leakage.

Key Findings

- Collaboration is not limited to the early stages of research; it occurs dynamically across all phases: idea generation, securing funding, experimentation/analysis, and publication.
- Motivations for collaboration vary by phase:
    - Idea generation: inspiration and intellectual synergy.
    - Funding: institutional and agency requirements.
    - Experimentation: access to expensive equipment and specialized skills.
    - Publication: increasing visibility and impact.
- Scientists select collaborators based on trust and subject expertise, often from personal networks.
- Communication and information-sharing practices are shaped by psychological and cultural factors, not just technological availability.
- Barriers such as competition, priority misalignment, and hierarchical norms can derail collaboration even when technical and intellectual alignment exists.

	Contextual Factors • Study conducted in South Korea with 24 bio- and nanoscientists. • Data collected via in-depth interviews and a follow-up focus group. • Participants included principal investigators, postdocs, and graduate students across bioscience and nanoscience disciplines. • Korean cultural norms (e.g., Confucian respect for hierarchy) significantly influenced collaboration dynamics. **Implications for Practice and Policy** **For System Designers (e-Science Platforms)** • Design collaboration tools that accommodate dynamic collaboration formation across research phases. • Incorporate secure, creator-controlled communication and data-sharing features. • Enable flexible credit attribution mechanisms to reduce authorship conflicts. **For Policy Makers** • Reevaluate evaluation and funding systems to reduce pressure-induced collaboration and promote genuine intellectual partnerships. • Address cultural barriers by promoting transparency in credit sharing and encouraging cross-hierarchy collaboration. **For Research Institutions** • Foster environments that support trust-building and equitable collaboration. • Provide training on ethical collaboration and authorship norms. • Encourage interdisciplinary and cross-cultural collaboration through institutional support. **Gaps and Limitations** • Cultural specificity: Findings are rooted in Korean scientific culture; generalizability to other contexts may be limited. • Sample size: 24 participants, mostly from bioscience and nanoscience, may not represent broader scientific communities. • Focus on coauthorship: Collaboration was narrowly defined by participants, potentially

	overlooking other forms of scientific cooperation. • Lack of longitudinal data: The study captures snapshots of collaboration but not long-term outcomes or evolution.
44. E-Science Collaborations in the Life Sciences: Challenges and Design Opportunities for Technology and Coordination" by Sarah Morrison-Smith (2019)	**Key Social and Cultural Barriers Identified** **1. Differences in Work Culture and Practices** o Collaborators from different institutions or disciplines often have divergent methodologies, expectations, and definitions of quality. o These differences can lead to mistrust, miscommunication, and delays due to the need to redo experiments or reformat data. **2. Trust and Control Over Data** o Researchers expressed discomfort with sharing data due to concerns about control, misuse, and institutional restrictions. o Trust issues were exacerbated by lack of transparency in data-sharing platforms and fear of accidental sharing. **3. Perceived Prioritization and Engagement** o Researchers often struggled to gauge whether collaborators were prioritizing the project, especially in distributed teams. o This uncertainty led to frustration, extra work, and sometimes disengagement. **4. Technical Language Barriers** o Multidisciplinary teams faced challenges in establishing common ground due to jargon and differing terminologies. o Misunderstandings could affect coordination, data interpretation, and overall project success. **5. Competitive vs. Cooperative Cultures** o Territorial behavior emerged when collaborators had overlapping expertise, leading to competition rather than cooperation. o This undermined morale and collaboration efficacy.

	6. Geographical and Perceived Distance o Physical separation reduced informal interactions and awareness of collaborators' activities. o Perceived distance (subjective sense of closeness) was found to be more impactful than actual geographical distance. **Key Findings** • Collaboration is essential in biological e-science due to the complexity and scale of research questions. • Coordination challenges include managing large, diverse teams, maintaining engagement, and aligning goals. • Data sharing is hindered by technical limitations (e.g., file size), lack of expertise, and institutional constraints. • Researchers often rely on computational experts, but access is limited, leading to constrained research scope. • AmbientInvolvement, a system designed to visualize collaborator activity, showed promise in improving perceptions of prioritization and motivation. **Contextual Factors** • Study involved interviews with 30+ life science researchers across institutions in the US, Canada, Australia, and China. • Participants worked in fields such as microbiology, epidemiology, plant biology, and bioinformatics. • Research projects ranged from small teams to large, multi-institutional collaborations. **Implications for Practice and Policy** **For Technology Designers** • Design for transparency: Make data-sharing controls understandable and visible. • Support fine-grained access control: Allow nuanced permissions for collaborators. • Facilitate scientific discussion: Include tools for informal and formal communication.

	• Enable role switching: Allow dynamic leadership based on expertise. • Visualize activity effectively: Use binary indicators and clear time scales to show engagement. **For Research Institutions and Funders** • Recognize coordination costs: Provide support for managing large, diverse teams. • Promote interdisciplinary training: Help researchers navigate technical language and cultural differences. • Support infrastructure for secure data sharing: Invest in platforms tailored to large, sensitive datasets. **For Researchers** • Establish common ground early: Discuss terminology, methodology, and expectations upfront. • Document workflows: Maintain records of computational steps and decisions. • Foster mutual respect: Acknowledge diverse contributions and maintain engagement across project phases. **Gaps and Limitations** • Reliance on self-reported data: Findings are based on interviews, which may be subject to recall bias. • Limited observational data: Future studies could benefit from ethnographic or longitudinal methods. • Focus on life sciences: Findings may not generalize to other e-science domains (e.g., physics, astronomy). • Small-scale evaluation of AmbientInvolvement: Tested in small teams; broader validation needed.