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D1.3: Conceptual and normative framework for tackling the ethical, epistemic, disciplinary and RI-related challenges of advancing OS-practices

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Editors:

Project title: Responsible Open Science in Europe

Project acronym: ROSiE

Grant Agreement no.: 101006430
Lead contractor for this deliverable: UT, UiO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under GA No 101006430

Deliverable factsheet:

Project Number:	101006430
Project Acronym:	ROSiE
Project Title:	Responsible Open Science in Europe
Title of Deliverable:	D1.3 ROSiE conceptual and normative framework for tackling the ethical, epistemic, disciplinary and RI-related challenges of advancing OS-practices
Work Package:	WP 1
Due date according to contract:	February 28th, 2023
Editor(s):	Kadri Simm
Contributor(s):	Søren Holm, Rosemarie de la Cruz Bernabe, Kadri Simm, Mathieu Rochambeau, Jaana Eigi, Bjørn Hofmann, Francois Jost, Olivier Le Gall, Ivars Neiders, Signe Mezinska, Ana Sofia Carvalho, Maria Strecht, Nathalie Voarino
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ABSTRACT:	This framework provides guidance by establishing the normative foundations of OS, making explicit the ethical and epistemic issues of OS, raising epistemic/normative questions as guideposts for discussion, providing recommendations to stakeholders for addressing the challenges and offers a method for improving decision-making in the context of specific goals/tasks.
	Research ethics, research integrity, open science, open science principles, respect for persons, open science virtues, epistemology

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1.	Coordinator	University of Oslo	UiO	Norway
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4.	Partner	European Network of Research Ethics Committees	EUREC	Germany
5.	Partner	Federation of Finnish Learned Societies	TSV	Finland
6.	Partner	High Council for the Evaluation of Research and Higher Education	Hceres	France
7.	Partner	National Research Institute for Agriculture, Food and Environment	INRAe	France
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12.	Partner	Universitetet I Sorost Norge	USN	Norway

Revision history:

VERSION	DATE	Revised by	Reason
0.1	14-10-2022	D 1.2 was planned as the first draft of the D 1.3	
1.0	3-02-2022	D 1.3 draft	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under GA No 101006430

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Suggested normative framework on the discussion of challenges of OS

Introduction

Open Science (OS) raises a number of epistemic, ethical, and research integrity challenges. Below we propose a framework for addressing these challenges that arise in knowledge production within an OS context.

The *UNESCO Recommendation on OS*[1] defines OS as follows:

> *"OS is defined as an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible, and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community. It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open scientific knowledge, open science infrastructures, science communication, open engagement of societal actors, and open dialogue with other knowledge systems."*

Science as an activity and social practice is aimed at generating knowledge, and the most basic justification of OS as an overarching goal is that through the implementation of OS practices we will, as a global society, produce more and more reliable knowledge "for the benefit of science and society"[2]. It is also expected that this will enable the development of more and better evidence-based technologies and societal policies and contribute to public trust. Inherent in the view of science as an activity aimed at generating knowledge is a set of epistemic values or principles, and inherent in the view of science as a social practice is a set of ethical values or principles. The precise specification of these values or principles will always be a topic of contention, as will the precise justificatory relationship between different values and principles. Transparency can, for instance, be seen as an important freestanding value underpinning OS, or it can be seen as a prerequisite for other values like reproducibility, reliability, or accountability. It is not possible in this project to settle these contentious and ongoing discussions and we have therefore based the analysis and proposed framework on values and principles that are generally recognised to be important in relation to scientific activity. This suggested framework attempts to provide guidance:

- by providing the normative foundations (values and principles) of OS
- by making explicit the ethical and epistemic challenges of OS
- by raising epistemic and normative questions as guideposts for discussion

[1] UNESCO Recommendation on Open Science, https://en.unesco.org/science-sustainable-future/open-science/recommendation
[2] UNESCO Recommendation on Open Science, https://en.unesco.org/science-sustainable-future/open-science/recommendation

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- by providing recommendations to stakeholders for addressing the challenges
- by offering a method for improving decision-making in the context of specific goals/tasks (Appendix II, the method of moral imagination).

Normative Foundations

While OS is revolutionary in a number of aspects, it is also very much rooted in traditions of scientific research and therefore the normative framework of OS builds upon the numerous existing epistemic and ethical frameworks guiding science. It affirms the wisdom and the principles of research ethics (RE) and research integrity (RI) as enshrined in various declarations and guidelines, as well as the derived and increasingly widely agreed principles of OS.

OS, as well as RE and RI, have in common their foundation on the universality of human rights. In full alignment with the *Universal Declaration of Human Rights*, OS assumes and serves the principle that "All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood."

From this basic principle flows the RE principle enshrined in the *UNESCO Universal Declaration on Bioethics and Human Rights* which states that "Human dignity, human rights and fundamental freedoms are to be fully respected" and that "The interests and welfare of the individual should have priority over the sole interest of science or society." Additionally, article 27 states that "Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits", as well as "Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author".

OS is also rooted in RI, which, interpreted from the perspective of and founded on basic and generic respect for persons, defines good research practice as that which is based on the following fundamental principles, as stated in the *European Code of Conduct for Research Integrity*[3]:

> **Reliability** in ensuring the quality of research, reflected in the design, the methodology, the analysis and the use of resources. **Honesty** in developing, undertaking, reviewing, reporting and communicating research in a transparent, fair, full and unbiased way. **Respect** for colleagues, research participants, society, ecosystems, cultural heritage and the environment. **Accountability** for the research from idea to publication, for its management and organisation, for training, supervision and mentoring, and for its wider impacts.

From the perspective of research as a naturally collaborative practice, which includes LMIC (low- and middle-income countries) and HIC (high income countries) collaborations, OS is also rooted in principles governing research collaborations in resource-poor settings, as

[3] *European Code of Conduct for Research Integrity*, https://allea.org/code-of-conduct/

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elaborated in the *TRUST Global Code of Conduct for Research in Resource-Poor Settings*, specifically the principles of **fairness**, **respect**, **care**, and **honesty**.

OS, as much as it is rooted in the above-mentioned principles, must also be governed by the accepted foundations of the **principle of openness,** as reflected in the *UNESCO Recommendation on OS*: **Quality and integrity, collective benefit, equity and fairness, diversity and inclusiveness.**

Lastly, openness is supported and enabled by the following guiding principles, as stated in the *UNESCO Recommendation on OS***: transparency, scrutiny, critique, and reproducibility; equality of opportunities; responsibility, respect, and accountability; collaboration, participation, and inclusion; flexibility; sustainability.**

Challenges

The documents outlined above are not reducible to one particular normative theory. Rather they are a collection of important values and principles to guide researchers and they have their roots in various normative paradigms. Such pluralism, coupled with the highly abstract nature of the principles and values, creates challenges of interpretation and potential conflicts between two or more principles (for example when the values of open access and data sharing might endanger research participant privacy). There are often no simple rules for adjudicating between these conflicts but the values and principles highlighted here will offer some guidance and can be used as tools for articulating, debating and solving those challenges.

OS is a broad discourse accommodating a variety of objectives and values ranging from democratization of scientific processes to more effective use of public resources.[4] OS thus contains a number of sources of normativity – what counts as good or responsible OS – and this is one source of challenges in itself, i.e., in satisfying some objectives, it is seen as failing others. Cultural and political contexts can impact on how OS is approached, both on national as well as institutional levels. It has been argued that OS is a mindset, rather than a fixed framework[5] and this has consequences for the kind of norms that can realistically be formulated for a diverse and dynamic field.

A few general remarks regarding the nature of the challenges. Many of them have systemic aspects and cannot be adequately addressed by only one class of stakeholders in the science system. Not only researchers but also research performing organisations (RPOs), research funding organisations (RFOs) and all other types of stakeholders will have important

[4] Fecher B and Friesike S(2014). "Open Science: One Term, Five Schools of Thought". In: Bartling, S., Friesike, S. (eds) *Opening Science*. Springer, Cham. https://doi.org/10.1007/978-3-319-00026-8_2

[5] Hillyer et al (2017). „Framing a Situated and Inclusive Open Science: Emerging Lessons from the Open and Collaborative Science in Development Network". In Chan and Loizides (eds) *Expanding Perspectives on Open Science: Communities, Cultures and Diversity in Concepts and Practices.* IOS Press.

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obligations to discharge to meet the challenges fully. A number of challenges arise from the diversity and complexity of scientific practices. Their resolution lies less in the trumping of certain principles above others and more in the transparency about the goals of research and practice of open science and careful attention to the particularities of research context.

Epistemic challenges

Engendering public trust and epistemic standards

A significant assumption of OS, now supported by several studies[6], is that openness about the scientific process and projects will engender public trust in science and in research results. This leads to transparency being identified as one of the enabling values underpinning OS, although transparency (in relation to other researchers) is also a prerequisite for other OS values such as scrutiny, critique, and reproducibility, accountability, quality and integrity, among others.

While this is of course a largely grounded expectation it is, however, questionable whether full transparency, as an expression of the virtue of honesty, will always and automatically engender public trust - actual scientific processes are often messy and do not conform to the idealised processes that are written about in textbooks on methodology, or presented in the final scientific outputs in journals or more popular scientific writings[7]. There is also considerable evidence that the public's understanding of how science 'works' - 'folk philosophy of science' is very idealised, and that actual scientific practices are likely to fall significantly short of this idealised picture. Since scientific results are often complex and nuanced, there is the potential danger of "epistemic relativism" of many truths. Finally, dual-use risks and privacy concerns also complicate the value of transparency in OS. In some circumstances, opening up science and increasing transparency may therefore decrease trust[8], unless accompanied with significant contextualisation.

Transparency cannot be taken to be an unalloyed good in itself or a goal to be pursued in isolation, but needs to be conceptualised as one element of a multi-faceted and nuanced engagement with the public about how science works and the epistemic status of scientific knowledge claims.

In any case, transparency implies that science must be conducted according to golden RI/RE standards especially replication and validation, to avoid deceiving the readers and causing distrust.

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[6] For example, Rosman, T., Bosnjak, M., Silber, H., Koßmann, J., & Heycke, T. (2022). Open science and public trust in science: Results from two studies. *Public Understanding of Science*, *31*(8), 1046–1062. https://doi.org/10.1177/09636625221100686 ; Song, H, Markowitz, DM, Taylor, SH, Trusting on the shoulders of open giants? Open science increases trust in science for the public and academics, *Journal of Communication*, Volume 72, Issue 4, August 2022, Pages 497–510, https://doi.org/10.1093/joc/jqac017

[7] John, S (2018). Epistemic trust and the ethics of science communication: against transparency, openness, sincerity and honesty. Social Epistemology, 32(2), 75–87.

[8] John 2018.

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Recommendations are to[9]:

- Increase incentives to replicate studies to ascertain reliability and validity
- Adhere to strict validation procedures and make validation transparent
- Provide or enforce new institutional formats as well as new normative and legal frameworks for the production, circulation, appropriation, evaluation, and use of scientific knowledge
- In scientific communication, the nuances of scientific findings must be presented in a manner that is adapted to the intended audience. These communications must avoid unfounded, though not necessary untrue, conclusions (exaggerations or yet unfounded correlations must be avoided).
- Ensure that transparency is applied in a nuanced way within OS that takes account of the contextual factors that complicate its use (eg privacy concerns). Science governance structures as well as science communication partners have an important role in this.

Epistemic justice

Epistemic injustice occurs when knowledge claims are unfairly rejected, or when the knowledge possessed by certain types of knowers is excluded or not taken seriously because of prejudices about the knower[10], in violation of the principles of responsibility, respect, and accountability. Issues of epistemic injustice are common in science where research results published by well-known groups at prestigious universities, or by researchers in the "centers" (rather than margins) have often been evaluated as 'better' than publications from less well-known groups. Such bias goes against the principle of equality of opportunities.

In the OS context, these epistemic reception biases leading to epistemic injustice are likely to persist, possibly extending to open data. Thus, the envisioned advantage of OS in terms of quality and integrity and consequently more efficient knowledge production, for the benefit of all regardless of their current privilege or wealth status, might not materialise, rather the already existing advantages of the privileged will become even more entrenched.

These issues of epistemic injustice and bias can be 'converted' into issues of distributive injustice if RPOs and RFOs do not take the former into account when recognising or making decisions on the basis of an evaluation of research contribution (see section below on distributive justice issues).

Recommendations:

- Change the epistemic governance structure to ensure equal access, e.g., by actively adapting the incentive systems and funding requirements, and making adaptive adjustments to the assessment and impact metrics and peer review system.

[9] Numerous recommendations of this document originate from Bjørn Hofmann, 2022. "Open Science Knowledge Production: Addressing Epistemological Challenges and Ethical Implications," Publications, MDPI, vol. 10(3), pages 1-15, July.
[10] Fricker, M (2007). *Epistemic injustice: Power and the ethics of knowing*. Oxford: Oxford University Press.

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- Improve research infrastructures in order to address skewed infrastructure effects, e,g., by counter-framing and providing compensations.
- Promote good communication and clear premises for collaboration in order to ascertain coherence between the different conceptions of openness.
- Amend and develop anti- and debiasing approaches in order to avoid and compensate for biases in various parts of the project.

Data collection/procurement

Collection of research data is arguably one of the most challenging aspects of OS practice because it is most vulnerable to misconduct and most difficult to prevent.[11] Misconduct related to data collection can also be very costly to science and society. Trust is essential for successful and accountable collaborations thus training in RE/RI is crucial for ensuring that researchers from diverse fields, as well as citizen scientists, share an understanding of the data collection standards and research norms.

Data collection is an important part of research itself and the effort and resources involved in the procurement and standardisation of data need to be sufficiently acknowledged. Data is valuable and researchers are under pressure to publish which might hinder their willingness to share data or share it early enough (as it would work against their self-interest or the interests of their institution). This practice, however, should always be evaluated against the principle of openness with the aim to find the right balance between all the norms of OS.

Recommendations:

- Provide transparent and repeatable data acquisition protocols in order to increase trustworthiness and reliability.
- Revise or provide new measures for data quality assurance.
- Better acknowledge the merit of data collection in research evaluation. The promotion of publishing peer-reviewed data papers might help in this endeavor.
- Institutionalise and incentivise data sharing (open or FAIR data)
- Incentivise the sharing of highly interoperable data
- RPOs should provide services to make open or FAIR data sharing and reuse easily accessible to researchers.

Disciplinary/methodological challenges

Certain research methodologies and scientific fields, especially those that rely on large datasets and quantitative methods, are an especially good fit with OS[12]. Qualitative data, often impossible to anonymize completely, cannot be shared as easily without the risk of

[11] Hofmann, B (2022). "Open Science Knowledge Production: Addressing Epistemological Challenges and Ethical Implications," Publications, MDPI, vol. 10(3), pages 1-15, July.
[12] Leonelli, S (2022). Open Science and Epistemic Diversity: Friends or Foes? *Philosophy of Science*, *89*(5), 991-1001. doi:10.1017/psa.2022.45

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identifying (and therefore potentially stigmatizing or harming) research participants, thus potentially violating the principles of respect for persons and care.

Recommendation:

- Disciplinary and methodological constraints need to be taken into account, for example in research evaluation, where practicing OS is increasingly seen as an important criterion for academic career advancement.
- Investigate the probability of reidentification in the different fields and across fields.
- Establish guidance on data sharing based on evidence on probability of reidentification.

Ethical and research integrity challenges

Protecting research participants

The rights and interests of research participants lie at the core of RE and one of the major ethical challenges of practicing OS lies in how the goals of openness and data sharing can be fulfilled while also protecting the rights, dignity, and welfare of research participants.

While the privacy of individual research participants might be fully protected in some OS data sets that can be completely anonymised, for many types of data this is difficult or not possible and may decrease its research utility. Yet, even if absolute anonymization is not possible, it is nevertheless important to allow other researchers to use these datasets that might be unique (e.g. oral histories of participants in significant historical events or movements, genetic data, environmental data with individual implications, etc). In such cases, the researchers should be extremely careful not to violate the principle of respect of research participants and the openness and sharing of data needs to be refined accordingly.

Research participants in some contexts have enduring control interests in relation to the data they have provided to researchers, e.g., in relation to what the data is used for and who uses the data; and they may perceive some uses of their data as misuse. A common example in the literature is that a person might be happy for *bona fide* researchers to use their health data under conditions of broad consent for 'health related research' but might nevertheless find the use of the data in tobacco industry-sponsored research ostensibly on the health effects of smoking highly problematic[13].

Autonomy and privacy of research participants is a crucial value and ensuring this in OS potentially requires alternative modes of participant engagement and consent. The data governance mechanisms have therefore to recognize that participants may have no way to withdraw their data once they have been deposited as an open data set in a repository, or ensure their informed consent for further reuse in contexts unforeseeable at the time of data collection.

[13] Holm, S (2006). "Who should control the use of human embryonic stem cell lines: A defence of the donors' ability to control." *Journal of Bioethical Inquiry* 3, no. 1: 55-68.

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Recommendation:

- Develop other governance mechanisms that will allow research participants to protect their legitimate control interests.

Protecting the environment, ecosystems and cultural heritage

Openness is by definition the central principle of OS. At the same time, too much openness runs the risk of violating other important principles that are not considered less essential. In many cases, the availability of data about, for example, archaeological site might cause looting or information about habitats of biodiversity might draw unnecessary attention, therefore, threatening vulnerable species. In such cases, the principle of openness conflicts with the principle of respect and do no harm.

Recommendations:

- Respect for ecosystems and cultural heritage should be considered as a factor that may limit openness.
- To support development of further guidelines, the principle of openness should be further explored and elaborated according to the nuances of different research fields and research methods.
- All stakeholders (researchers, RPOs, research infrastructures etc.) should follow the principle "as open as possible and as closed as necessary"

Distributive justice in international knowledge production

OS is committed to the principle of openness expressed through the production of knowledge as a public good[14], and to data and code also being shared as public goods. Furthermore, in relation to researchers, OS practices are in principle reciprocal and symmetrical. Everyone contributes knowledge and data by making them openly accessible, and everyone can then use the knowledge and data for further research.

This egalitarian picture of OS is, however, highly idealised. Many OS practices, e.g. preparing and annotating a dataset to fully comply with FAIR ("Findable, Accessible, Interoperable, Reusable") standards require resources, as does utilising a data set made openly available by other researchers. The ability of a researcher or group of researchers to fully comply with OS ideals and mandates, and their ability to fruitfully exploit what others make openly available thus depends on their access to resources (financial and time-wise, also their technical and language resources). This issue is addressed in the case of indigenous people by the "FAIR and CARE" principles of action (CARE stands for "Collective benefit, Authority to control, Responsibility, and Ethics").[15]

[14] By 'public good' we mean a good that is non-rivalrous and non-excludable
[15] Carroll, S. R., Herczog, E., Hudson, M., Russell, K., and Stall, S. (2021). Operationalizing the CARE and FAIR Principles for Indigenous data futures. Sci Data 8, 108. doi: 10.1038/s41597-021-00892-0

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This means that researchers who are resource-poor, e.g. researchers in LMICs and in the scientific periphery in more affluent countries (including non-professional citizen scientists), are systematically disadvantaged in relation to realising the benefits of OS. While open access (OA) articles tend to be more cited,[16] publishing open access is often prohibitively costly, at least in the "gold open access" business model with expensive article processing charges. For researchers who are resource-poor, OS might therefore create a classic Matthew Effect of cumulative advantage[17].

It must be noticed that some OA models such as "green" or "diamond" are free to publish and to read.

This situation raises issues of justice and fairness that cannot be fully solved on a project-by-project basis, but needs a systemic solution. Researchers have obligations to act fairly in project collaborations, but other agents in the research system have obligations in relation to ensuring that resources are made available to researchers in LMICs and other less-favored contexts, that enable them to benefit fully of the opportunities offered by OS. The *Global Code of Conduct for Research in Resource-Poor Settings*[18] does currently not address the responsibilities and obligations that OS practices create for researchers, RPOs and RFOs.

Recommendations:

- RFOs, RPOs and public policies should promote OA models that incur no costs for the publisher, such as green or diamond.
- RFOs and publishers need to take into account the unequal opportunities that researchers from periphery and LMIC have in accessing and contributing to OS.
- Researchers from affluent countries could take the initiative in contributing to OS resources and practices, bearing much of the burden of associated costs.
- Extend the *Global Code of Conduct for Research in Resource-Poor Settings* with a section on the responsibilities and obligations that OS practices create for actors including researchers, RPOs and RFOs.

Citizen science

Citizen scientists are valuable partners in many OS projects and their collaboration, participation, and inclusion are crucial for achieving a number of broader OS goals (data, collection, public education, dissemination of research results, implementation of evidence-based policies etc). However, participation of citizen scientists also has its challenges, for

[16] Piwowar H, Priem J, Larivière V, Alperin JP, Matthias L, Norlander B, Farley A, West J, Haustein S. 2018. The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles. PeerJ 6:e4375 https://doi.org/10.7717/peerj.4375.

[17] Matthew effect is a pattern where the well-off/richer will, over time, benefit disproportionately, while the disadvantaged will get worse-off, meaning that the inequalities will deepen. Ross-Hellauer T, Reichmann S, Cole NL, Fessl A, Klebel T, Pontika N. (2022). Dynamics of cumulative advantage and threats to equity in open science: a scoping review. R. Soc. Open Sci. 9: 211032. https://doi.org/10.1098/rsos.211032

[18] *Global Code of Conduct for Research in Resource-Poor Settings*, https://www.globalcodeofconduct.org/the-code/

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example in terms of blurring of the research object/subject roles in research that have largely been kept separate in traditional RE guidance[19], or in terms of accommodating the activism of some citizen science with the more discovery-oriented stance and objectivity requirements of academic research[20]. Citizen science while often offering valuable opportunities for all involved, has in some cases[21] been associated with exploitation when citizen scientists are instrumentalised as a form of free labour and their contributions are not duly recognized (for example through authorship or ownership rights, if appropriate).

Scientific practice, while very diverse, still adheres to a set of basic research ethical norms intended to protect the participants and support the reliability and accountability of knowledge production. Data quality and integrity issues have been raised in this context as citizen scientists (1) have often not been trained in research ethics and methodologies, and (2) they may be motivated by personal interests in a way that would be considered as constitutive of a conflict of interest were the same persons in a professional situation.

Recommendations:

- To alleviate concerns around citizen science transparency regarding (1) the goals of research, (2) openness regarding the various roles and interests of (citizen) scientists, and (3)open data publication should be sought.
- RFOs, RPOs as well as researchers themselves have responsibilities in promoting and supporting citizen science and this includes providing access to RE/RI principles and training[22].

Proper recognition of research contributions – alternative metrics

Another aspect of distributive justice in OS knowledge production is related to the proper recognition of all contributions to the research processes, and a proper alignment of the scientific reward system with the overarching goals of OS. This has been recognised as a major challenge for some time, culminating perhaps with the wide adoption by individuals, RPOs and RFOs of the San Francisco declaration on research assessment (SF-DORA[23]) but practical progress in this area has been slow[24].

The lack of progress has both practical and more theoretical reasons. The main theoretical problem is that it is difficult to provide a principled account of how OS contributions, e.g.,

[19] Resnik, DB. (2019). Citizen Scientists as Human Subjects: Ethical Issues. Citizen Science: Theory and Practice, 4(1): 11, pp. 1–7, DOI
[20] Rasmussen, LM and Cooper, C (2019). Citizen Science Ethics. Citizen Science: Theory and Practice, 4(1): 5, pp. 1–3. DOI: https://doi.org/10.5334/cstp.235

[21] Resnik, DB., Elliott, KC, and Miller, AK. (2015). A framework for addressing ethical issues in citizen science. Environmental Science & Policy 54, 475–481. doi: 10.1016/j.envsci.2015.05.008.
[22] For example see the „Recommendation for Citizen Science“, authored by Open Science Coordination in Finland, Federation of Learned Societies (2022), https://edition.fi/tsv/catalog/view/445/362/1440-1
[23] See https://sfdora.org/
[24] Hatch, A., and Curry, S. (2020). Changing how we evaluate research is difficult, but not impossible. eLife 9, e58654. doi: 10.7554/eLife.58654.

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preparing a data set to FAIR standards and making it available equates to more traditional quantifiable contributions like authorship, citations, or grant success.

Stakeholders directly responsible for research evaluations and funding decisions should work on accommodating and supporting OS practices in such ways as to properly acknowledge and value them. Numerous research publishers have incorporated alternative metrics into their work but there is still room for further recognition of the diverse ways in which research makes a contribution and has an impact.

Recommendations:

- Make adaptive adjustments to accreditation systems, provide new modes of (qualitative) assessment, and connect money to metrics or provide alternative incentives
- Adjust assessment, acknowledgement, and accreditation systems.

Openness beyond publications, data and code

In relation to a consensus commitment to openness and an implementation of OS practices, most progress has been made in relation to open publication, data, and code. There are, however, many other elements of the research process that are not routinely shared openly and where there is no current consensus that they ought to be shared, despite a UNESCO recommendation.[25] This includes elements of the research process that are strictly necessary to reproduce particular research result (for example, highly specialised equipment and reagents, unique research sites, modified model organisms etc[26]). These elements are currently often 'traded' for collaborative opportunities or authorship, or kept as proprietary 'property' in order to exclude competitors from utilising them in their own research. The situation is thus very similar to the traditional way in which research data was conceived of and handled before OS became generally accepted in relation to data. However, there seems to be no good reason to exclude many of these research elements from the obligation to openness and sharing.

Many of these elements of the research process could be made public goods with a resource investment that is comparable to the investment necessary to make data FAIR. Their initial production clearly requires work, effort, intellectual input etc., but so does the production of any high-quality scientific data set. While there are numerous successful bottom-up approaches (e.g. researchers creating spaces for sharing data or preprints a la ArXiv), science policy governing bodies, RPOs, RFOs and other institutional stakeholders have an important role to play here.

Recommendation.

[25] UNESCO Recommendation on Open Science - UNESCO Digital Library Available at: https://unesdoc.unesco.org/ark:/48223/pf0000379949 [Accessed October 21, 2022].
[26] Gould, John, and Jose W. Valdez. "The Gollum effect: the issue of research opportunity guarding in academia." *Frontiers in Ecology and Evolution* (2022) 10: 543. https://doi.org/10.3389/fevo.2022.889236

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- Create new infrastructures that make storage, access and distribution possible and they also require discussions around the nature of Intellectual Property rights within OS.

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Appendices

The framework includes two appendices that provide a concise overview of some of the challenges, the recommendations and also a toolbox for further reflection (see below).

Appendix I provides a concise (table-based) overview of the various phases of OS knowledge production in relation to the challenges they raise as well as the recommendations (based on Hofmann 2022).

Appendix II focuses on using moral imagination for decision-making in the context of O S and provides a suggested framework for addressing the epistemic and ethical issues with OS. The framework is partly inspired by "The moral imagination framework" by Matthew Brown (2020)[27] and on ethical deliberation in clinical ethics, as well as on Hoffmann (2022)[28]

[27] Brown M(2020). Science and Moral Imagination: A New Ideal for Values in Science. Pittsburgh: University of Pittsburgh Press (available Open Access at https://upittpress.org/books/9780822946267/).
[28] Hofmann, Bjørn. 2022. "Open Science Knowledge Production: Addressing Epistemological Challenges and Ethical Implications" *Publications* 10, no. 3: 24. https://doi.org/10.3390/publications10030024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under GA No 101006430

Appendix I Table 1 Overview over various phases of O S knowledge production and risk of misconduct (FFP, fudging); whether knowledge is verifiable; whether errors or flaws are detectable, intentional and actionable (preventable). Dark grey boxes, level 3: the most challenging issues; medium grey, level 2: less challenging issues; light grey, level 1: least challenging issues.

Phase **Risk of**	**Data procure-ment**	**Analyzing data**	**Applying algorithms or models**	**Model parameters management**	**Producing raw results**	**Interpreting results**	**Synthesizing results**	**Presenting results**	**Envisioning implications**	**Documenting**
FFP	3	1	1	1	2	2	2	2	2	2
Fudging etc	3	2	2	2	2	2	2	2	2	2
Verifiability	3	1	1	2	1	2	2	2	2	2
Features										
Detectability	3	1	1	2	1	2	2	2	2	2
Intentionality	3	2	3	3	2	3	2	3	3	3
Actionability	3	1	1	1	1	2	2	2	2	2
Level	Individual, corporate	**Individual**, corporate	Individual, corporate	Individual, corporate	**Individual**, corporate	**Individual**, corporate	Individual, corporate	Individual, corporate	Individual, corporate	Individual, corporate

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Appendix II

Using moral imagination for decision-making in the context of OS

Most of the challenges described in this document are systemic and require systemic approaches. Nevertheless, individuals and small groups taking part in OS usually have at least some discretions when it comes to deciding how to realise specific goals or fulfil specific tasks. The method described below is offered as one possible approach for improving such decision-making ethically and epistemically. The worksheet meant as a decision aid and the method we describe for using it, are based on the ideal of "moral imagination" for scientific research developed by the philosopher of science Matthew Brown.[19]

This method is meant to be helpful in two interconnected ways:

1. helping ensure that one's research goal is realised/task fulfilled in a more responsible way ethically and epistemically by encouraging to think carefully about relevant values, norms, and stakeholders' interests;
2. helping ensure that one's goal is realised/task fulfilled as fully as possible by encouraging to think imaginatively about different options (to multiply options), given the goal/task on the one hand, and relevant values, norms, and interests on the other.

You can use this method on your own or in a small group; even if you do it alone, it may be helpful to have discussions with colleagues.

To use this approach, **start with the blank four-part table**: goal/task; options/alternatives; values; stakeholders. The arrows indicate that different parts of the table are interconnected and one needs to be revised in light of the others. (Tab. 1).

Begin filling in the table: the initial formulation of the task/problem; initial ideas about options for realising it; the most obvious relevant values/norms and stakeholders.

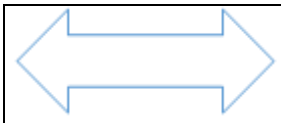
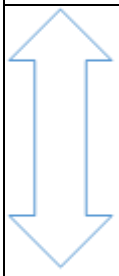
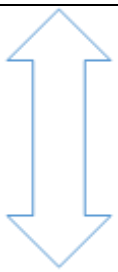
Return to the table at least once to see how it can be revised:

1. Think carefully about the relevant values/norms and stakeholders – do any need to be added? Are any of the included ones irrelevant/illegitimate and need to be removed? One of the aims of the normative framework is to attract attention to some less discussed considerations about values, normative issues, and stakeholders in OS.
2. Think imaginatively about options – are there any less obvious good options for realising the goal while respecting the relevant values, norms and stakeholders' interests? Are any of the options clearly problematic, given those values, norms and interests?
3. Think about the formulation of the goal/task – can it be helpful/feasible to reformulate it, given the relevant values, norms and stakeholders' interests on the one hand and the conceivable options on the other?

There is no set order to revising the table; there is no prescribed number of revisions – **do it as many times as is feasible and feels productive**.

Evaluate the list of options you have compiled. **Choose the option to pursue.** Is there one option that is clearly the best in the sense of being the most responsive to the relevant values and fair to the relevant stakeholders realizing the goal as fully as possible? Choose that. However, there may be no unique option like that and there may be reasonable disagreement about which is better or which trade-off are acceptable. In such cases, make whatever choice you feel is the most acceptable, all things considered.

Importantly, this method does not presuppose that there is always (or ever) one definite correct decision. The hope is that thinking carefully about the values and stakeholders in connection to the goal will spur more creative thinking about options and better options emerge than the option that first comes to mind or the most habitual one.

 **Goal/Task**	**Options/Alternatives**
 **Values** 	 **Stakeholders**

Tab. 1 Adopted from Matthew Brown (2020). Science and Moral Imagination: A New Ideal for Values in Science. Pittsburgh: University of Pittsburgh Press (available at https://upittpress.org/books/9780822946267/).

The steps of the process are summarized in Tab. 2.

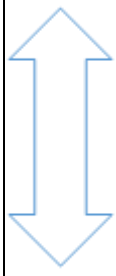
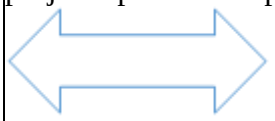
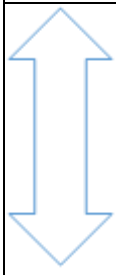
Goal/Task  Describe the specific goal/task and, briefly, its context	**Options/Alternatives** List the potential options for realizing the goal/fulfilling the task Evaluate each alternative in the light of the values, norms, principles, legal requirements and concerns that are relevant for the goal/task Evaluate each alternative as to its impact on different stakeholders  Evaluate each alternative as to how fully it realizes the goal/fulfills the task Choose the option you see as the best, all things considered
Values List the values, norms, principles, legal requirements and concerns that are relevant for the goal/task; consider both ethical and epistemic factors	 **Stakeholders**  List the relevant stakeholders and their rights, interests and preferences

Table 2.

A sample table for a specific task is provided in Tab. 3. It is not completed – you are invited to revise it before making the choice of the most suitable option.

Goal/Task	**Options/Alternatives**
Making the data from my current research project open in the spirit of Open Science  NB! I already know that the concerns about privacy, environmental protection, dual use or intellectual property etc. are not applicable/are resolved satisfactorily (If this is not the case, other relevant values need to be added – protection of privacy, public safety etc.)	Make data available on a website that does not require registration Make data available on a website that requires free registration Make data available on a website that requires free registration with an e-mail address from an academic institution Make data available as a downloadable supplement to a published Open Access article Make data available as a downloadable supplement to a published article that requires subscription Advertise the fact that data are available by personal request Make data available on a website that does not require registration and accompany it with a detailed commentary to provide context and prevent misinterpretation  Make data available on a website that requires free registration with an e-mail address from an academic institution; separately publish a popular article for non-specialists describing the project and data ….
 **Values** Transparency Reliability Replicability Reusability Accountability Collegiality Inclusivity	**Stakeholders**  Colleagues in the same and related fields: in the same country and abroad; abroad in low-income countries and in high-income countries Students and educators Researchers interested in replication, good statistical practices, machine learning etc. Science journalists Interested groups (e.g., social groups potentially affected by the research) Taxpayers

Trust … All these values support some degree of openness but making data open may also have unintended negative consequences – e.g., public trust may suffer if data are misunderstood or misinterpreted	General public …

Table 3.

Table 4 is a toolbox for addressing the epistemic and ethical issues with OS is shown partly inspired by "The moral imagination framework" by Matthew Brown (2020)29 and on ethical deliberation in clinical ethics as well as on Hoffmann (2022).

Goal/Task Describe the goal of the OS project Describe the specific tasks and their expected outcomes (endpoints) and contexts	**Stakeholders** Describe the stakeholders in the project/system Describe their roles, interests, and preferences
Normative issues 1. Describe the specific values, norms, principles, legal requirements, regulations that are relevant for the specific tasks. • Fairness, (epistemic) justice • Respect for autonomy, dignity • Beneficence • Confidentiality • Privacy • Collaboration • Participation and inclusion • Sustainability • Trust 2. Describe the epistemic issues relevant for the specific tasks, such as: • Replicability, reproducibility • Bias • Validity • Epistemic justice, • Epistemic relativism	**Options/Alternatives** 1. Describe the various alternatives for handling the specific tasks 2. Describe the various epistemic issues relevant for the various alternatives. 3. Describe how the various values, norms, principles, and rules/regulations support the various alternatives. 4. Discuss how the handling of the ethical and epistemic issues of the specific tasks add up for the OS project as a whole. 5. Based on 1-4, deliberate on which alternative that in total is the best option and document the process and the outcome

Table 4.

[29] Brown M (2020). Science and Moral Imagination: A New Ideal for Values in Science. Pittsburgh: University of Pittsburgh Press (available Open Access at https://upittpress.org/books/9780822946267/).