Towards wide-scale adoption of open science practices: The role of open science communities

Authors

International Network of Open Science & Scholarship Communities

(INOSC)

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Abstract

Open Science (OS) increases the quality, efficiency, and impact of science. This has been widely recognised by scholars, funders, and policy makers. However, despite the increasing availability of infrastructure supporting OS and the rise in policies and incentives to change behavior, OS practices are not yet the norm. While pioneering researchers are developing and embracing OS practices, the majority sticks to the *status quo*. To transition from pioneering to common practice, we need to engage a critical proportion of the academic community. In this transition, Open Science Communities (OSCs) play a key role. OSCs are bottom-up learning groups of scholars that discuss OS practices, within and across disciplines. They make OS knowledge and know-how more visible and accessible, and facilitate communication among scholars and policy makers. By the same token, community members shape the transition to OS such that it is most beneficial for researchers, science, and society. Over the past two years, eleven OSCs were founded at several Dutch university cities, with approximately 700 members in total (at the time of writing). In other countries, similar OSCs are starting up. In this paper, we discuss the pivotal role OSCs play in the large-scale transition to OS and provide practical information on how to start a local OSC. We emphasize that, despite the grassroot character of OSCs, support from universities is critical for OSCs to be viable, effective, and sustainable.

Introduction

Over the past years, science has witnessed a shift towards openness, transparency, and reproducibility – a movement known under the umbrella term "Open Science" (OS)[1]. In response to increased awareness on existing challenges related to the reliability and accountability in scientific work, scholars[2] are motivated to increase the transparency of various aspects of their work, starting from the initial research and analysis plans to the dissemination of the final product (Bezjak et al., 2018; Munafò et al., 2017; Nosek et al., 2015, 2018; Stall et al., 2019). In parallel, expectations from journals, funders, and policy makers to improve the accessibility and transparency of scholarly products is steadily increasing (Aczel et al., 2019; Burgelman et al., 2019; Morey et al., 2016; Perkel, 2019; SPARC Europe, 2019; Teytelman, 2018), further feeding the upward spiral towards more transparent workflows.

By opening up their practices, scholars make their work less error-prone (Fosang & Colbran, 2015; Hales et al., 2019) and more visible, not only to peers from the same and other scientific disciplines – as evidenced by higher citation rates (Colavizza et al., 2020; McKiernan et al., 2016; Piwowar & Vision, 2013) – but also the general public, who can appreciate the economic benefits of knowledge dissemination (Fell, 2019). Moreover, engaging in OS practices facilitates the sharing and reuse of data, materials, and code in the scientific community (C. Allen & Mehler, 2019; Milham et al., 2018), contributes to enriched scholarly output and literacy, and increases trust in the scholarly process (Tennant et al.,

[1] In this document, we use the term "Open Science" following the result of the public consultation on Science 2.0 Science in Transition (https://tinyurl.com/sci2-2015; see also Burgelman et al., 2019), which popularized the term. Thus, the term 'science' is used in its broadest sense and includes humanities, social sciences, and engineering; that is, it more suitably refers to any form of scholarship.

[2] The term 'scholars' is used here as an umbrella term for all individuals who are in some way involved in research practices within academia as well as broader research areas.

2016), a strong *desideratum* in times of increased scrutiny and opinionated discussions over scientific findings (Baker, 2016; Cook et al., 2018; Jamieson et al., 2019). As such, adopting OS practices provides tangible benefits for individual researchers, the scientific community, and society at large.

This new drive towards openness and transparency has been accompanied by attempts to change how open workflows are facilitated. On the one hand, technological and methodological innovations are spearheaded by the research community and provide open solutions for individual scholars (e.g., the Open Science Framework[3], a project management platform for sharing data, code, and preprints). On the other hand, and possibly also as a reaction to bottom-up initiatives, OS is encouraged through changes in policy and reward structures, e.g., through badges for crediting OS practices (Aczel et al., 2019; Kidwell et al., 2016; Nosek et al., 2015), dedicated funding for replication research[4], or the Open Science Policy Platform established by the European Commission[5].

Yet, many OS events (e.g., workshops, conferences, symposia, discussion groups) often attract innovators and early adopters only, creating so-called "open science bubbles". While these scholars are central to the initial creation and adoption of innovative workflows, a critical mass is needed for wide-scale adoption; moving from OS advocacy to an actual change in behavior remains challenging when OS is not accepted as normative by the wider scientific communities (e.g., Houtkoop et al., 2018). In this paper, we showcase the role of OS communities (OSCs) as learning groups of scholars that facilitate effective adoption, and

[3] https://osf.io/
[4] https://tinyurl.com/NWO-replication
[5] https://tinyurl.com/EU-OSPolicy-Platform

thus normalization, of policy changes and technological innovation in contemporary science (Nosek, 2019).

The transition to OS

The rise of the OS movement comes with an increasing need for research environments to adapt to the new societal and technological realities of the past decade (Burgelman et al., 2019). For example, many OS practices are linked to the use of web-based technologies and social media networks, which are becoming regular tools for data collection, sharing, analysis, and collaboration (Voytek, 2017). There is no single definition or agreement on what the core components of OS practices are; it ultimately depends on the goals of the stakeholders affected by the changes (Fecher & Friesike, 2014). For example, for individual scholars, OS might come down to the skills and research practices themselves, as suggested in the training handbook of the FOSTER project (Pontika et al., 2015). For librarians, the priority might instead be the sustainable dissemination of information within the academic community (Deville et al., 2019), whereas policy makers might be more interested in quantifying the societal impact of scholarly output (Bornmann, 2017). In qualitative social science research, there is a long-standing interest in developing an ethical and mutually respectful relationship between researcher and participant, and in developing and promoting research that "make[s] a difference in everyday lives" (Denzin & Giardina, 2009, p. 13). As OSCs, we align with the European Commission and emphasize the collaborative aspect of OS: *"Open Science represents a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools. The idea captures a systemic change to the way science and research have been carried out for the last fifty years: shifting from the standard practices of*

publishing research results in scientific publications towards sharing and using all available knowledge at an earlier stage in the research process" (European Commission, 2016, p. 33).

Regardless of the role of each stakeholder, the transition towards OS can occur in two ways: bottom up and top-down.

Bottom up push: Innovators are adopting OS

Major OS applications frequently originate from individual (or small groups of) innovators. The history of software development offers particularly strong examples of wide-scale adoption of the work of individual innovators. In 1991, Linus Torvalds began developing the Linux kernel by building on top of the pioneering GNU open source project[6], which was further developed by a large internet community of volunteer developers (Raymond, 2001). Linux has since made a significant global impact in computational sciences with GNU/Linux being the operating systems of choice in high-performance computing; as of 2019, the world's 500 most powerful supercomputers use GNU/Linux (Henry-Stocker, 2020)[7]. To take another example, the open source Python plotting software *matplotlib* (Hunter, 2007) was developed by a single innovator, but has since matured into a global collaborative development community and even played a role in generating the first-ever image of a black hole (The Event Horizon Telescope Collaboration et al., 2019). A similarly successful individual OS initiative with broad application and influence among the computational biologists is the *Galaxy Community Hub*[8], a web-based platform for

[6] https://www.gnu.org/
[7] The count of supercomputing systems running on Linux can be viewed at: https://www.top500.org/statistics/details/osfam/1/
[8] https://galaxyproject.org

accessible, reproducible and transparent computational research that has supported over 10.000 publications since 2005[9].

Another example of bottom-up push towards OS comes from the practice of publicly sharing research outcomes before peer-review – i.e., publishing preprints[10]. Preprinting has been facilitated by the availability of publicly accessible preprint repositories. Preprints have been a common practice in the physics community since 1991, when the public preprint server *arXiv.org* was launched (Vale, 2015). In the biology community, although a precursor of a preprint system was proposed among individual researchers as early as the 1960s (Cobb, 2017), such practice has taken off substantially since 2013 with the launch of the *bioRxiv* server. Similar trends can now be observed in other disciplines, thanks to preprint infrastructures such as *PsyArXiv*, *SocArXiv*, *EarthArXiv*, *MetaArXiv*, *AfricArXiv*.

Apart from technical innovations, bottom-up initiatives also focus on promotion and curation of OS knowledge in novel formats. An example of a successful bottom-up initiative is the *ReproducibiliTea*[11] journal club, where scholars read and discuss papers and other documents on various OS topics (e.g., reproducibility, statistics, meta-science; Orben, 2019). At the time of writing, there are ReproducibiliTea journal clubs at more than 90 institutions in 25 different countries, predominantly led by early-career scholars. Similar initiatives include *Papers we love*[12], which uses open collaborative tools to help organise communities around reading and appreciating computer science papers, and *SciRate*[13], an open peer review archive

[9] https://galaxyproject.org/blog/2020-08-10k-pubs/
[10] Although publishing preprints is a core practice of OS, the one caution that should be taken into account is that this regards scientific products that have not yet undergone peer-review.
[11] https://reproducibilitea.org/
[12] https://paperswelove.org/
[13] https://scirate.com/

with an open-source rating and commenting system for preprints in the subfields of physics and computer science.

Bottom-up initiatives are also relevant for OS education and outreach. Notably, the Framework for Open and Reproducible Research Training (FORRT, 2019) revolves around open contributorship and aims to provide educators with a feasible pathway towards the adoption of principled teaching and mentoring practices, including open and reproducible research. It provides teachers with resources to include in their courses and tools to assess the current level of OS training that students receive. In moving beyond the openness for researchers alone, *The Pint of Science Festival*[14] and *SoapboxScience*[15] are examples of global platforms for engaging (female) researchers and explaining scientific topics to the broader audience in informal settings.

These examples show that bottom-up initiatives to facilitate OS can lead to technical, theoretical, didactical, and/or citizen-engaging solutions to the challenges of transitioning towards OS. By allowing research output to be shared and repurposed for novel uses, OS increases the efficiency, quality, and impact of science.

Top-down push: The role of policy makers and funding agencies

In concert with the adoption of OS by (individual) innovators, there has been a recent top-down push for OS by policy makers and funding agencies. In September 2018, the European Commission (EC), in collaboration with the European Research Council (ERC) and several international funders, launched an initiative called *Plan S*[16], which requires recipients

[14] https://pintofscience.com
[15] http://soapboxscience.org/
[16] https://www.coalition-s.org/

of research grants from European and national funding agencies to publish their research Open Access from 2021 onwards. This initiative is part of the overarching goal of funding agencies to stimulate OS. For example, the Dutch Research Council (NWO) provides information to scholars to make it easier to publish their work Open Access[17], and offers templates for data management plans that can be used to make their data accessible and reusable[18]. Similarly, Wellcome Trust[19] develops platforms for scholars to quickly and transparently publish and share their findings, offers several awards to stimulate open science practices, and allows scholars to include their preprints in funding applications. Moreover, these funding agencies continually monitor scholars' needs through large-scale surveys (e.g., van den Eynden et al., 2016).

In a recent perspective, the Directorate General for Research and Innovation of the EC has positioned OS as part of the vision to achieve a holistic science policy under the European agenda (Burgelman et al., 2019). For example, the new Horizon Europe 2021-2027 research and innovation programme will require open access to publications, data, and research data management plans, and will support the proliferation of findable, accessible, interoperable, and re-usable (FAIR) data (European Commission & Directorate-General for Research and Innovation, 2018). The proposed budget allocations for 2021-2027 Horizon Europe included €25.8 billion for research and infrastructure (Open Science Pillar) and additional €13.5 billion on innovation (Open Innovation Pillar).

These top-down policy initiatives send a clear and important message to European academic institutions: transparency and openness are not an afterthought, but an expected

[17] https://www.nwo.nl/en/policies/open+science/data+management
[18] https://dmponline.dcc.ac.uk/
[19] https://wellcomeopenresearch.org/

outcome of the research process. However, they risk having little tangible repercussions if not accompanied by a simultaneous restructuring of the reward system in academia. A well-known international initiative aimed at rewarding OS practices is the San Francisco Declaration on Research Assessment (DORA; Cagan, 2013). DORA recognises the need to improve the evaluation of scholarly output by refraining from using journal impact factors to judge individual scholars. Proponents and signatories of DORA advise, among others, to highlight the importance of the content of a paper rather than the journal in which it was published, and to consider all research output, including datasets, software, and other materials when evaluating research. In the Netherlands, there is an encouraging shift in priorities in this direction, as exemplified by the new national research evaluation protocol[20], recent agreements on the recognition and rewards system to further facilitate positive incentives toward OS[21], and by the universities that have started reserving funds for OS implementation in their strategic plans[22].

Although both bottom-up and top-down efforts and initiatives are promising, so far they have not had the fortitude to usher in a wide scale culture change in academia. Below we describe three challenges that this transition currently faces.

[20] https://www.vsnu.nl/files/documenten/Domeinen/Onderzoek/SEP_2021-2027.pdf
[21] https://tinyurl.com/room-talent
[22] See, for instance, recent strategic plans at Utrecht University (https://www.uu.nl/en/research/open-science/about-us), University of Twente (https://www.utwente.nl/en/organisation/about/shaping2030/), and Delft University of Technology (Haslinger, 2019).

Challenges in widespread adoption of OS

Reaching critical mass: From pioneers to common practice

Despite the presence of individual innovators and recent policy-, funding- and incentive-driven changes towards the adoption of OS, the challenge remains how to mobilise a critical mass of scholars to achieve this cultural change. On the one hand, only limited impact is achieved by individual innovations that do not reach widespread adoption by the community. On the other hand, policy changes cannot afford to bypass the sentiment of the communities in which they are adopted, else they risk being misdirected, ineffective, and possibly even counterproductive. Experts involved in central policy organs (such as the EC) responsible for encouraging OS from a top-down perspective may find it difficult to effectively reach scholars. Although there is likely no societal agent that can single-handedly solve the problem of widespread OS adoption (see Munafò, 2019 for a discussion on the role of institutions), we argue that bottom-up OSCs, due to their peer-based character and format, have the strongest leverage to reach a critical mass by giving voice to the scholars themselves.

The perceived costs of change

Whereas the advantages of OS may appear clear from a principled perspective, introducing and adopting change *in practice* can be met with some resistance. In a workshop report, Sholler et al. (2019) noted different sources of resistance among scholars. For example, those willing to adopt OS practices may encounter inertia from their collaborators or supervisors who prefer their established, closed, workflows due to their (perceived) past

efficiency. Additionally, reluctance may stem from fear of close scrutiny of their work, or from fear of getting scooped. Similarly, one can encounter unwillingness to adopt change because the immediate costs of the switch can be deemed too high relative to the potential long-term benefits. In some cases – and especially when a network of easily accessible information is not in place – it may seem costly or daunting to find out how to handle a situation. For instance, it is sometimes unclear whether publicly sharing data would pose a risk to vulnerable populations. This uncertainty could further increase the tendency to follow established routines (i.e., no data sharing). Such resistant behaviour finds fertile ground in local environments where OS practices are not seen as normative (Houtkoop et al., 2018). As mentioned above, innovation must thus be made both visible and rewarding for scholars. OSCs can aid in making OS practices visible through different platforms and workshops by creating a low-threshold exchange of knowledge, lowering the bar for scholars to adopt new workflows and find support from colleagues and mentors.

Disciplinary differences

Lastly, the need for adoption of OS practices varies across disciplines. For example, working with open data and materials is more customary in biomedicine than in psychology or other social sciences, while publishing open access is more popular in psychology (Hardwicke et al., 2019). In some disciplines, particularly the social sciences, principles that overlap significantly with those of OS have been associated with calls for civic engagement (McIlrath & Lyons, 2012), community-based research (Munck et al., 2014), and other activities that integrate transparency, reflexivity, and public engagement, such as service learning (Bringle & Hatcher, 1996; Giles & Eyler, 1994). Such diversity opens fruitful avenues to share best practices across disciplines. By virtue of their interdisciplinary

character and university-wide involvement, OSCs form the ultimate platform to combine multidisciplinary insights and knowledge and provide broad, but at the same time tailored, advice and knowledge exchange among scholars who have different backgrounds, questions, and needs.

Open Science Communities

The role of communities in shaping the transition

Incentivising OS policies and providing OS infrastructure for scholars are important steps in promoting scientific values such as transparency, reproducibility, accessibility, and inclusivity. In order to change the current research culture, however, it is crucial that the scholarly community *itself* aligns with these values and adopts OS practices as the new standard. As mediators between policy makers and scholars, local bottom-up networks play a central role in identifying obstacles that hinder scholars in opening up their workflows, and provide the support needed to foster cultural change at the institutional or organizational level (Nosek, 2019).

Through the wide variety of backgrounds and scientific expertise of their members, bottom-up networks create a learning environment where scholars can acquire the skills to conduct open, transparent, and reliable research, and are able to discuss OS practices among their peers. Moreover, local grassroot networks increase the visibility of these practices within their local communities, which in turn contributes to changing the descriptive norm of how research is conducted. As of today, more than 200 networks exist worldwide to increase transparency and accountability of scholarly products in various scientific fields[23]. The

[23] A crowdsourced list of grassroot initiatives is available at https://tinyurl.com/y2l9gpxc.

International Network of Open Science Communities (INOSC) constitutes a collaborative network that currently comprises eleven Dutch university cities (*Figure 1a*), one in Ireland, and a consortium of universities in Sweden (*Figure 1b*).

Figure 1. Overview of OSCs in Europe. A: OSCs in the Netherlands. OSCA is a collaborative effort of the University of Amsterdam, the VU Amsterdam, and the University of Applied Sciences Amsterdam. OSCN is a collaborative effort of Radboud University Nijmegen and the Max Planck Institute for Psycholinguistics. **B**: Overview of OSCs outside of the Netherlands.

Target audience: Early majority

Wide-scale adoption of innovation takes time, as individuals are not equally open to change. According to Rogers (2003), adopters of innovation can be categorized as innovators, early adopters, early majority, late majority, or laggards.

Early majority comprises individuals that are open and curious with regards to OS but, as of yet, have little to no experience with OS practices. They want to learn more, understand why it is important, and are willing to implement (some) OS practices in their daily workflow. While this audience may be interested, OS adoption is often not their first priority unless perceived as helpful for the success of their own research and, in the long run, their careers. An important segment of the early majority are undergraduate students and early-career researchers (ECRs). However, in periods of transition, students and ECRs can perceive the investment in novel OS practices as indirectly harming their career prospects (Schönbrodt, 2019). OSCs can mitigate the dilemma by connecting and collaborating closely with developers of local university curricula, e.g., by embedding OS training in research integrity courses for (under)graduates.

As opposed to the early majority, *the late majority* consists of individuals who are initially highly sceptical of innovation and will consider OS practices only after a critical mass of peers have adopted them (Rogers, 2003). Compared to the late majority, the early majority is more likely to form positive perceptions of innovation and can be more receptive

to change (Dedehayir et al., 2017). Encouraging adoption of OS by the early majority can facilitate a paradigm shift in research practices, and is therefore the needed step to engage the late majority in adopting OS practices. The *early majority* is thus the main target audience for OSCs.

We emphasize that, although the greatest opportunity to facilitate the transition to OS at a large scale lies within the early and late majorities, OSCs cannot provide the necessary knowledge, training, and help without the *innovators* and *early adopters* of OS practices. These people bring critical knowledge and skills to the table, so that the majority can benefit, contribute, and build upon them. At the same time, solutions developed by early adopters benefit from having a usage base that can test the effectiveness of proposed solutions and provide feedback for improvement. Such knowledge transfer and interaction is one of the key goals of OSCs.

Blueprint for an Open Science Community (OSC)

OSCs are typically initiated by scholars themselves as part of an institutional body (e.g., a university), and – at least to our experience so far – rarely by institutions. Such a bottom-up initiative contributes to the grassroots character of OCSs, and this might make it more approachable for other scholars to join. Nonetheless, support by institutions is very much needed for these bottom-up initiatives to be sustainable and rewarding (see *Box 1* for recommendations). To facilitate wide-scale adoption of OS practices, it is important to: 1) make OS knowledge more visible; 2) make OS knowledge more accessible; and 3) communicate effectively within (e.g., interactions among members) and beyond the OSC (e.g., with university support staff, policy makers, and research funders). In the following

section, we describe these basic elements of an OSC. A more elaborate description of the design of an OSC is provided in the INOSC Starter Kit[24]. Here we provide an overview of its central themes.

Box 1. Recommendations for institutions to support the activities of Open Science/Scholarship Communities (OSCs)

1. **Encourage creation of OSCs**

   Although OSCs are driven by communities of scholars, their jump-start and efficiency can be facilitated if they are welcomed at the institutional level. This can be as simple as words of encouragement for community creation from senior institutional management directed at institutional leaders in Open Science.

2. **Provide funding to sustain the activities of OSCs**

   Community coordination takes time and it is beneficial for long-term sustainability of OSCs if individuals providing support for community activities are funded to do so (e.g., through official posts of community coordinators). Communities will also benefit from funding to support their core activities (e.g., organisation of workshops, events, training sessions).

3. **Support OSCs in identifying local ambassadors within more granular institutional units**

   A network of ambassadors is an excellent way to connect with diverse research communities across the campus. Heads of departments/faculties may encourage interested researchers to dedicate a portion of their time to develop materials for OSC-related activities.

4. **Reward & recognise efforts invested in sustaining the OSCs**

   Include questions about Open Science education and research practices as part of regular progress review meetings. Include questions about Open Science practices in job adverts.

[24] https://doi.org/10.17605/OSF.IO/7VEZ3

Increasing the visibility of OS knowledge

A starting point to make OS more visible is to create a website to showcase the prevalence of interest and expertise in OS. Members who wish to do so can be displayed with their name and photo, together with a description of the OS knowledge they have and are willing to share, and/or what OS practices they would like to learn or need support with. Providing this information is important for innovators and early adopters who already gained experience in OS practices, as well as for the early and late majority who want to learn these practices. A member page can function as a 'marketplace of skills' where OS knowledge can be requested and offered among peers.

In addition, the website can be a resource for general information about OS (e.g., links, blog posts, publications) and become a starting point for people looking for (practical) information on (a specific aspect of) OS. A collection of resources will help members to take their first steps regarding OS practices. When setting up a website, it should be recognized that too much information about OS and the OSC may be quite overwhelming and perhaps discouraging. To avoid possible "freezing" behavior, OSCs can support people curious about OS by providing a clear starting point and a structured overview on their website.

Another way to create OS and OSC visibility is via social media and in print through banners and stickers. Currently, Twitter is widely used by most OSCs and can be an effective way to promote member initiatives and keep members updated on new OSC-related news, events, or activities. Banners and stickers can be used during events, local conferences, and member initiatives.

Increasing the accessibility of OS knowledge

The first and foremost way to increase accessibility to OS knowledge is by member initiatives, i.e., any OS-related event that a member of the community would like to initiate together with or for other members of the community. Member initiatives can come in different forms – workshops (i.e., getting hands-on experience with a specific aspect of OS, like preregistration), hack-a-thons aimed at tackling specific issues, talks, journal clubs, and symposia (i.e., multiple talks with room for discussion) – and are promoted via the OSC newsletters, website, and social media accounts. Examples of member initiatives are: a discussion on how to share data responsibly while taking into account the local university's security and privacy guidelines and facilities; a lecture on the philosophy behind the OS movement; a workshop on preregistration (or simply asking participants who have experience with preregistration to share tips and tricks); a ReproducibiliTea journal club; or a hack-a-thon where faculty students and staff put together a toolkit of resources for registered reports. Typically, members can submit a member initiative proposal to a general OSC email address and, if it gathers support within the OSC, can host the event under the *proviso* that the organizer(s) adhere(s) to the INOSC code of conduct.

In addition to member initiatives, OSCs can organize social gatherings such as OS Cafés or OS lunches. Furthermore, and provided that sufficient capacity and expertise is available, OSCs may also offer open office hours during which OSC members are available to provide assistance in applying OS practices to individual projects. OSCs, through their interdisciplinary breath and member diversity, have the added benefit of bringing together people that can help each other (e.g., support staff, experts on data sharing, open access

publishing, and bibliometrics often need to know researchers' needs in order to support them).

Communicating within and beyond the community

A regular newsletter is an effective way to inform the community about OS activities organized on a local, national, and international level. Such news can also be communicated via social media channels like Twitter and Facebook. One advantage of the use of social media over a newsletter is that it facilitates direct interaction and allows a broader (international) audience. Starting a podcast, e.g., *The Road to Open Science*[25] hosted by members of the Open Science Community Utrecht, is more time consuming but also a more entertaining way of informing people about OS.

To be able to function as connecting tissue, an OSC should be aware of their context and reach out to relevant stakeholders to build a collaborative network. Stakeholders within universities are, for example, Executive Boards, deans, the University Library, and research support staff. By investing in a collaborative network involving institutionalised bodies, OSCs create more credibility, strength, and embeddedness within the local context, e.g., to provide input to policy documents.

Governance and funding

The elements described above require time investment from the community (i.e., OSC activities are organized by and for the OSC members), preferably in combination with financial support from governing bodies. An OSC's success in facilitating the widespread adoption of OS practices depends on the amount of time people from the community are

[25] https://tinyurl.com/UYA-RoadOS

willing and able to invest voluntarily. Experience within the OSCs so far has shown that time investment from the community can be accelerated by appointing at least one OSC coordinator.

Funding is fundamental to the continuation of local OSCs. While OSCs have so far mostly started on a voluntary basis, the goal is to obtain specific funding (structural or otherwise) as soon as possible. Structural funding would mean that at least one OSC coordinator is explicitly paid (part- or full-time) to manage the OSC. An alternative solution is to embed the OSC coordinator in an existing academic unit (e.g., library, research support office) to provide formal support for the OSC. In this way, the OSC is part of a larger unit – which is then invested in the success of the project – rather than being isolated as an independent pilot. However, funders (e.g., faculty or university boards) may want to see the added value of a (local) community in relation to existing tools and courses (e.g., offered by support staff or the university library). Therefore, a strategic plan is advisable. For instance, the OSC coordinator could schedule an appointment with a faculty dean (or, if possible, the university president/rector and/or the executive board), explain the added value of an OSC to the existing local offers, and ask whether the faculty or university would be willing to fund such an initiative if it proves "successful" one year after kick-off. If needed, the RE-AIM planning and evaluation framework (Glasgow et al., 2019) may be used as an evaluation tool to evaluate the success of the initiative. For instance, the outcomes of measures taken to increase the visibility of OSCs may be measured through reach (i.e., the number of scholars that have enrolled in their local OSC communities), and surveys may be used to understand the adoption and/or perceived effectiveness of OS practices.

Inclusiveness

In line with the wider aims of OS, we believe OSCs should be open to people of all stripes. Researchers are the main target audience, but students, research support staff, and other individuals and communities interested in OS practices are equally welcome. To join the local OSC no prior knowledge about OS is needed, nor are members in any way required to commit to certain ways of transitioning towards OS.

To organize fruitful events, OSCs should seek to actively engage with representatives from all faculties, and in all positions in the academic hierarchy. This diversity can be quite rewarding as people in different fields and with different positions can have widely differing OS experiences. For example, we often see in our OSCs that ECRs generally tend to be more open to (and have more direct experience with) OS practices than senior researchers, which makes them good candidates to educate other members about the merits and potential downsides of these practices. However, as role models, senior researchers have the leverage to encourage such efforts and help broaden the network. When people from different fields meet during OSC activities, these different experiences can be successfully synthesized, thus leading to more widespread and diverse OS expertise. In addition, new collaborations can emerge because most problems are quite complex and require the combination of skills and know-how from a diverse set of disciplines.

OSCs are also encouraged to actively seek out collaborations with similar communities in the same region. The OSCs involved in this paper have connected to form INOSC, which greatly improves the reach of the movement by increasing learning opportunities and facilitating collaboration. These developments can also occur more locally: for instance, the

University of Amsterdam, the VU Amsterdam, and the University of Applied Sciences Amsterdam work together as OSC Amsterdam to increase the adoption of OS in their institutions.

Finally, to facilitate learning and trust among OSC members, OSCs should be dedicated to diversity, equity, inclusion, and the free expression of ideas. Therefore, they should provide an environment in which participants may learn, discuss, network, and enjoy each other's company in an environment of mutual respect. To safeguard such an environment, OSCs are required to draft a Code of Conduct, which can be adapted from the INOSC Code of Conduct[26].

Conclusion

Open Science (OS) is becoming an increasingly necessary and recognised *modus operandi* in scholarly environments, but actual adoption lags behind on the widely shared vision. Bottom-up innovations by pioneers, paralleled by top-down OS incentives and policies, are crucial steps in the direction towards change. However, a wide-scale adoption of OS practices requires a culture change that leads to normalisation among members of the scientific community. In this paper, we have identified three challenges that stand in the way of wide-scale adoption of OS practices: 1) reaching a critical mass; 2) the perceived cost of change; and 3) disciplinary differences. We have argued that a network of local Open Science Communities (OSCs) can overcome these challenges. OSCs play a central role in identifying obstacles that hinder scholars in opening up their workflows, hence providing the needed support to foster culture change at the institutional level. To spur the development of similar

[26] The INOSC Code of Conduct template can be found at https://osf.io/6gsye/.

OSCs globally, we have shared our experiences as coordinators of local OSCs and provided a blueprint to start new local OSCs. Together, we make science more open for the benefit of science and society.

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Contributions

Authorship is based on alphabetical order of the last names and does not necessarily reflect the relative contributions of authors. Author contributions are clarified below, using an adapted version of the CRediT taxonomy (L. Allen et al., 2014).

Conceptualization: LB, AE

Writing - original draft: KA, LB, AE, VEH, MM, ZS, AV, ASc, ORA

Writing - editing: KA (lead), ASc, LB, ZS

Feedback on draft: KA, LB, RC, AE, RFi, RFo, VEH, SH, WQK, MM, NM, AOB, ASa, ASc, HS, ZS, MT, ORA, AV, RZM

Figures: AE (licensed under CC BY-ND 3.0)

Competing interests

Most authors of this paper (KA, LB, RC, AE, RFi, RFo, VEH, SH, MM, ASa, ASc, HS, ZS, MT, ORA, AV, RZM) are involved as coordinators in local OSCs.

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