Open Science and the Future of Metrics

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Bio

Tamara Heck is Postdoc at the Information Center for Education at DIPF | Leibniz Institute for Research and Information in Education. She is responsible for research concerned with information management and infrastructures within the educational field. Her current research focuses on research behavior and the adaptation of open science practices, with the goal to disclose the development of scientific work and norms. These aspects include questions on the influence of open science on higher education and the development of open processes in learning and teaching, like applying open educational resources, open pedagogy and open infrastructures. Further research is concerned with information literacy and its implications on the adaptation of new information behavior and practices in work-related contexts.

ABSTRACT

Open science refers to a movement that discusses and investigates a shift in research practices toward being more open, inclusive and transparent. The overall goal is to improve research quality and output through better communication and collaboration among researchers.
With regard to open science developments, scientometrics might play an important role. Scientometrics enable displays of changes in research practices and possibly measurements of the impact of open science initiatives. Conversely, metrics influence researchers' practices and might be applied to achieve a wide-spread adoption of open science practices. This chapter discusses open science initiatives and goals, the establishment of policies and influences on researchers' practices. With regard to these developments, metrics will be discussed as an evaluation tool for open practices on the one hand, and as an incentive to foster open science on the other hand. The last part refers to the openness of metric analyses.

Keywords: open science, open metrics, incentives, research behavior, open access, open practices, responsible metrics

Introduction

The term "open science" refers to a discussion of research practices and norms that reaches from spotting a digital transformation in science to proclaiming a scientific revolution that will shift the entire research process. This umbrella term comprises ideas like open access to scientific publications, open data, open peer review, open education and citizen science (open participation). A concrete definition, specifically with regard to open science practices of researchers, has yet to be found. Alongside many bottom-up driven initiatives that mainly focus on single ideas of open science which were developed within research communities, larger top-down initiatives like those by the European Commission (European Commission 2016) contributed to the debates of opening up science and increased the visibility of the topic for researchers, infrastructure providers like libraries, political and commercial stakeholders, and society in general.

The transition to a new form of research practice was driven by the development of new digital technologies that offered new ways for researchers to communicate and disseminate their work and to collaborate with colleagues. Parallel to these changes, new forms of measuring and evaluating research became possible. As researchers started to use digital infrastructures of the Web 2.0 and more and more data was available related to scientists and their work, scientometricians and service providers were able to accumulate metrics about the activities of scientists and impact of research (Priem & Hemminger 2010; Priem et al. 2010).

In most cases, scientometricians followed the principle of measuring "what can be most easily measured" (Wilsdon et al. 2017, p 13). This lead to a variety of new metrics, which are subsumed under the term "altmetrics" (alternative metrics), and represent a counterpart of the more traditional bibliometrics. Measuring research activities on the Web, the question arises whether those metrics are suitable to measure open science practices and the impact open science intends to have.

Bibliometrics have not always been an indicator of demonstrating research practices, but reversely, they influence research practices. Thus, metrics can play an important role in achieving a wide-spread adoption of open science. Both perspectives are part of current discussions.

Open Science Goals

Open science is geared toward enforcing openness in all research processes. Initiators often use visualizations of a researcher circle to show those processes, like the one by Kramer & Bosman (2017). Processes include acts to facilitate the discovery of research results via sharing, disseminating and documenting, writing and publication processes via open access publications and open licenses, and assessment via open peer review and pre-registering studies. The options are as manifold as research practices and approaches. Science 2.0 as the term formerly used for the open science movement resembles the idea of using digital tools to make processes more open. Applying those tools and online services has been demonstrated in a large-scale survey (Kramer & Bosman 2016). To summarize the

idea of open science practice, it can be said that open science researchers move from publishing as early as possible to sharing as early as possible (European Union 2016).

Fecher & Friesike (2014) describe five perspectives that each set another focus on open science: open knowledge, open infrastructures, citizen involvement, efficient knowledge creation, and new measurements for science impact. Those perspectives show the multi-dimensionality and complexity of the idea as well as the linkage between the diverse aspects (Bartling & Friesike 2014). The establishment of new metrics is dependent on infrastructures and knowledge creation by researchers.

Open science is said to face current research challenges, which Franzen (2016a) labels the "credibility crisis of research". Relevant for research quality are reproducibility, validity, and comprehensiveness. Making data, methods and results – including none confirmed or negative results – open and accessible contributes to the enhancement of quality and thus credibility within the research community and in society.

Open Science Initiatives

It is interesting to note that the so-called second scientific revolution started to rebel against developments that have their origin in the first revolution, i.e. the establishment of the research journal publishing system in the 17th century. Many initiatives started by promoting open access publishing of journal articles. This resulted in diverse open access models, and journal publishers joined this trend[1]. Moreover, the idea of open access expanded to research output like data, source code, methods, and processes like peer-review.

Initiatives of the European Commission (European Commission 2016) include the Open Science Cloud for research data[2], the Open Science Policy Platform to promote and advise the application of open science principles[3] and Open Science Monitor to track open science trends[4]. OpenAIRE[5] is an EU-funded project that started with advice on open access publication, and is meanwhile engaged in several open science activities, like peer-to-peer learning. FOSTER[6] focuses on the teaching and learning of open science and respective awareness among researchers, librarians and other stakeholders. Similarly, the Open Science MOOC[7] launched in 2018 offers ten learning modules, including open learning and the use of open educational resources. The relevant supporting partners are university libraries, infrastructure providers for open research, open access publishers, and communities engaging in those topics.

[1] https://open-access.net
[2] https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud
[3] https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform
[4] https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/open-science/open-science-monitor_en
[5] https://www.openaire.eu/
[6] https://www.fosteropenscience.eu/
[7] https://opensciencemooc.eu/

In accordance with the EU activities, Go FAIR[8] is an initiative funded by the ministries of Germany, the Netherlands and France to support the development of research data services that follow the four principles research data should adhere to: findability, accessibility, interoperability and reusability (Wilkinson et al. 2016).

Besides the larger projects, many smaller research communities have raised awareness for open science. Initiators started to list further world-wide activities and community events[9] – as of summer 2019 there are over 55 entries for communities initiated by research institution offices or researcher groups at department level, with a local focus like a city or country, or with a research discipline focus.

Open Science Policies

Open science research policies are set to define guidelines and strategies to foster open science practices. Those policies are generally established by governments on a national level, research institutions, research funding bodies, or publishers. As it is still unclear what open science practices mean and which aspects should be included (Franzen 2016b), current policies focus on concrete sub-themes of open science, i.e. mostly data and publication. The SPARC analysis reports an increase in research data policies and declarations of intent to establish such (SPARC 2018). Five EU countries added a policy, which adds up to 13 EU countries that have a national policy. However, empirical studies have shown that open access or data policies are not commonly used by commercial publishers (Blahous et al. 2015; Ellison et al. 2019).

Policies either cover instructions on open data only, or as well cover guidelines on open access publication, infrastructure and software. Nosek et al. (2015), for example, suggest a policy model for journal publishers to set incentives for researchers to make their work more transparent. The model includes a range of aspects like sharing of data, methods (e.g. code), pre-registration and fostering replication studies. The types of policies differ from national plans to white papers, and even laws (France, Lithuania), i.e. guidelines are either highly imperative or rather encouraging (SPARC 2018). Those national policies are established on high levels, often involving ministries and national research funders. Policies act as "systematic incentives" (Friesike & Schildhauer 2015) to foster open science practice. Nevertheless, policy-makers are aware of the diversity of research institutions and their diverse needs for research data management and quality assurance, which makes it difficult to apply a one-policy solution on a national level.

Open Science Practices

Research practices do not seem to keep up with the speed and the enormous effort made by open science initiatives and policies. Data sharing seems to be dependent on individual personality (Linek et al. 2017) and academic reputation within a discipline (Kim 2018). Interviews with researchers give deeper

[8] https://www.go-fair.org/go-fair-initiative/
[9] https://docs.google.com/spreadsheets/d/1LNF5_bOkRV-RLIF4HYmu-gOemIa4IdfXEer89fM-Vy8/edit#gid=0

insights into researcher attitudes towards openness. Influencing factors are technical challenges to using open infrastructures, confusing guidelines to handle data sharing, and considerations of research impact and reputation (Levin & Leonelli 2017). Moreover, different research values and ethical considerations are factors that speak against openness on all levels, as researchers fear that open practices compromise their research integrity. Levin & Leonelli (2017) emphasize that current policies establish normative understandings of open science that do not reflect the heterogeneity of research and its contextual factors. Thus, the question is how researchers will practice open research in future, or more specifically how they will be able to practice according to contextual factors and their implied scientific values and ethos that guide their practice (Reichmann 2017)? We need to know more about the effects of open science initiatives and what influences research practice behavior.

Metrics – evaluating and incentivizing

For metrics research, the consequences of the open science movement are twofold. Metrics are instruments to evaluate research, and at the same time they are part of the scientific system and as such are applied to act as open science incentives.

Metrics and indicators are part of research evaluation, whereby the goals and uses vary. They can have an epistemological, controlling, or a public oriented function, for example, and may focus on research input or output processes (Hornbostel 2016). Hereby, we have to distinguish between data to be collected and its interpretation, which is applied to judgements on research performance and funding. The Research Core Dataset is a recent German approach to collect data for measuring research output, but it does not suggest concrete indicators (Biesenbender & Hornbostel 2016). In the Australian research assessment (ERA 2018)[10] information on open access research output was collected as an indicator to measure the open access trend. In the recent British research excellence framework[11] open access is even mandatory for journal articles and conference proceedings. Applying metrics as a controlling function with regard to research funding regulation as for example on open access publication means that we introduce new metrical indicators and approaches to assess the fulfillment of open science policies. As such, metrics can be applied as a controlling function for open science goals.

Bibliometrical approaches with an epistemological function are applied to measure the growth of open access publications on a country or discipline level for example. Recent studies have shown that the overall proportion of open access publications is growing (Piwowar et al. 2018). However, there are differences among disciplines. Bosman & Kramer (2018) summarize recent studies and introduce their own method to track open access output. Studies try to apply diverse data sources, i.e. traditional sources like the Web of Science and Scopus, and new services like oaDOI[12] that harvest data from relevant web sources.

[10] https://www.arc.gov.au/excellence-research-australia
[11] https://www.ref.ac.uk/
[12] https://oadoi.org/

Considering the multi-dimensionality of open science, altmetrics can include further indicators to measure research impact. There are diverse options, first of all new researcher activities in addition to authoring scientific publications, i.e. communicating about research (publications, but as well unpublished material) via social media platforms, commenting on colleagues' research. Second, any activities relating to a researcher's work can be measured, i.e. any persons reads, likes, downloads, or comments. As such, altmetrics may have a potential to measure social impact, i.e. open research participation, by any user online or in other words the society. Though in fact, researchers should be cautious while measuring the social impact of research (Tunger, Clermont & Meier 2018). Open research participation is hard to define. First of all, it is not clear what "open" means. Thus, online research activities can still be limited to the research community that is closed to the public. Second, "research participation" assumes that we claim online activities to be "meaningful" for research. However, "meaningful" and valuable is experienced differently by researchers (Levin & Leonelli 2017). They describe openness and open practices differently and prefer divers forms of openness, like a study on aspects of open peer reviews shows (Ross-Hellauer, Deppe & Schmidt 2017). If metrics are to contribute to monitoring open science, and those measurements are applied to evaluate openness, then we need to agree on what we measure and what value we put on those measured research actions.

The EU Open Science Monitor is a trial to aiming at establishing such metrics and indicators (Open Science Monitor Consortium Partners 2019).

Metrics as research evaluation tool are one perspective, another one considers the researchers' view and behaviour. Metrics are an effective way of guiding research practice, or more directly said to change behavioral practice. Similarly to policies and guidelines mentioned above, researchers are guided by metrics to improve their performance and reputation, and to assess peers. A researcher's reputation is highly dependent on the scientific communication system (Heise 2017, p 68), and this communication is represented by (alt)metrics like publications, citations, and social media activities like readership and downloads. As such, applying acknowledged metrics to measure open science practices by researchers can have positive effects. For example, infrastructures that allow the citation of shared research data or open research material increases researchers' reputation through acknowledged citation metrics. Additionally, systems may apply online badges for sharing open data to trigger the awareness of open science practice (Rowhani-Farid, Allen & Barnett 2017).

However, metrics can be misleading incentives. They are subject to "gaming" and studies showed that manipulating one's numbers to increase reputation is easily possible (Tunger, Clermont & Meier 2018; Orduna-Malea, Martín-Martín & Delgado López-Cózar 2016). Moreover, metrics tempting universities and research institutions to establish an "excessively managerial, audit-driven culture", leading actors to focus on things that can be measured only, herewith reduce diversity in research, and tempt researchers to pursue biased incentives (Wilsdon et al. 2017, p 6).

Open Metrics as Imperative

Discussions on the misuse of metrics and their interpretation put metrics themselves in the center of open science practices. Ràfols (2019) stresses that "[…] problems with current use of quantitative evidence [lie...] in the role that STI [science, technology and innovation] indicators play in STI governance" and that is about to change (p. 7). Currently, we see a change in norms and values that research and society embraces. Open science practices become more and more relevant and are required top-down by funders and policy makers and postulated bottom-up by research communities and initiatives. Furthermore, today's research needs to address its societal goals and impact. Future metrics should be framed with regard to this context and use and not be seen as isolated tools (Ràfols, 2019). They need to adapt to the shift in our norms. Moreover, we need to expand data sources to allow more diverse participation in the development of metrics, and to open up metrical processes to raise awareness on the obstacles and options metric come with (Ràfols 2019).

Open metrics need to show transparency with the data and objects they use, as well as with the algorithms applied to analyze these resources (Herb 2016). Infrastructures like for example Impactstory that support research activity analyses open up those processes for anyone, who wants to reproduce metrics (Konkiel, Piwowar & Priem 2014). The Leiden Manifesto, for example, summarizes those claims in ten principles, which guarantee open, transparent, and fair research evaluation (Hicks et al. 2015). Two aspects stressed are the context of evaluation and the need to consider quantitative metrics as well as qualitative evidence by experts.

The EU expert group on altmetrics (Wilsdon et al. 2017) picked up claims on the responsible use of research metrics stated by researchers and their initiatives like DORA[13], whose supporters aim at disposing journal impact factors for funding and promotion assessment in research. With regard to open science, they suggest indicator development for measuring the progress of open science, however, with an awareness on limitations and biases of single indicators.

To summarize, metrics do not come without risks and challenges, either in the sense of applying unfitting data and numbers, or of evoking inappropriate behavior like gaming. Those developments have led to initiatives and claims to introduce rules for applying metrics. One crucial factor is the openness and transparency of metrics themselves.

With regard to open science, metrics have the potential to foster the awareness and acceptance of open science practices. On the one hand, such indicators, properly established, can offer evidence for open science practices and show potentials of improving the support of such. On the other hand, metrics act as incentives to shape research behavior and communication.

It remains an open question to be solved whether we first should concretely define what we mean by Open Science practices and which practices we would like to foster – which we then can measure properly. Or whether we first should develop more robust and open sets of metrics to a) measure Open

[13] https://sfdora.org/

Science, and b) use them as incentives to foster Open Science practices among researchers. Currently, we are investigating both approaches, but we at least should be aware of their inter-dependencies and influences. Notwithstanding, both the discussion on metrics and Open Science have one important factor in common: We need to understand the meanings as well as our intended benefits and potential weaknesses of both metrics and Open Science. Quite possibly, this means that we might need to start more in-depth discussions on scientific values, and how we would like to practice and assess research in future.

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