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OPEN SCIENCE TRAINING AND EDUCATION: CHALLENGES AND DIFFICULTIES ON THE RESEARCHERS' SIDE AND IN PUBLIC ENGAGEMENT

Open science

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Abstract

Open science is the most recent paradigm shift in the practice of science. However, it is a practice that has emerged relatively recently and as such, its definition is constantly-shifting and evolving. This commentary describes the historical background of open science and its current practice, particularly with reference to its relationship with public engagement with research.

Keywords

Public engagement with science and technology

Openness is what makes us scientists; it is 'arguably the great strength of the scientific method' [Neylon and Wu, 2009, p. 540]. Through this culture of sharing we are able to examine, criticise, refine, improve — or even reject — our models and theories. The philosophy of the Enlightenment, which covered the period when the first scientific journals were published (the Royal Society's *Philosophical Transactions* in the U.K. and the *Journal des sçavans* in France), focussed attention on the sharing of models and practices that became a fundamental element of scientific culture. Before this paradigm shift, many natural philosophers were loath to share their painstakingly acquired wisdom, whether for fear that someone else would claim it [Hull, 1985], to protect it against from adulteration or to safeguard their source of income [McMullin, 1985].

However, we should bear in mind that such sharing as does exists has largely remained within the accredited community [Hull, 1985], giving the outward appearance of closed-ness even though its practice was not. Peer-reviewed journals, conferences and symposia are primarily media for peer to peer communication; very few members of the public attend scientific conferences or have access to learnèd journals.

Moreover, much scientific communication is, by and large, done after the fact. The classic peer-reviewed paper is 'effectively just [a] snapshot of what the authors have done and thought at [one] moment in time' [Waldrop, 2008-01-09]. However, in science, the process is at least as important as the results:

> The creativity and invention [of research] comes in the process of laboratory work and demonstration and if we are to judge a scientist's artistry fully, it

> must be by watching him or her in the laboratory with its retorts, tubes and compounds, timing, weighing and testing; or in front of a monitor interpreting the brainwaves and scans of a willing subject. [Hamilton, 2003, p. 267]

The emerging practice of 'open science', which Nielsen defines as the sharing of 'everything — data, scientific opinions, questions, ideas, folk knowledge, workflows and everything else as it happens' [Nielsen, 2009, p. 32] offers us precisely this ability to peer over the researchers' shoulders as he or she goes about their work. However, his definition focusses on what parts of the process may be opened up, not how it is made open nor with whom it might be shared. Indeed, although some writers view open science through an economic lens [Willinsky, 2005; Cribb and Sari, 2010], the open science community concentrates on the importance of open access to data [Murray-Rust et al., 2010]. Science Commons [n.d.] and Fry, Schroeder and den Besten [2009] describe four elements as essential to open science: open access to research literature, free and open access to the research tools used, open access to the research data and their delivery through an open and non-exclusive cyber-infrastructure.

I acknowledge that these are very purist views of what constitutes open science. Open science, as a practice and concept, is still in an experimental period of rapid evolution and diversification. Grubb and Easterbrook [2011], in a small-scale qualitative survey, showed that even among scientists who identified themselves as advocates of openness, there was a low degree of consensus on precisely what it comprised. This diversity may arise from a variety of causes; the different circumstances in which people work, for example in a large research group or alone, or publicly or privately funded. There is a spectrum in how openness is conceptualised and practised, but fundamentally, open science has considerable potential to reveal the workings of science and scientists through its presentation of the complete record of research activity [Grand, 2012].

Although one of the earliest mentions of open science in the literature came in a special issue of *Science, Technology and Human Values* in 1985, the commentaries focussed on institutional secrecy and traditional concepts of sharing [La Follette, 1985]; that is, openness in its dictionary definition of 'unrestricted, unconcealed or being in public knowledge' [OUP, 1993, p. 2003], rather than openness as way to do science. 'Open science' in the sense I am using it in this commentary is a creation of the early twenty-first century; a practice that is only possible because of the Internet and the existence of freely accessible websites.

Since the beginnings of the Internet, from about 1972, complemented by the development of of the World Wide Web from the early 1990s [Leiner et al., 2011], scientists — along with members of almost every discipline and profession — have made use of new modes of collaboration as they have evolved. From email and simple-to-transmit document formats such as PDF, to blogs, wikis and social media, new mechanisms for co-operation, conversation and dissemination have become part of the scholarly landscape.

But the Internet is more than a route to more efficient and effective communication. It also makes possible new ways of working. The laboratory is no longer a lonely place, inhabited by eccentric boffins pursuing a solitary path through long dark nights [Leadbeater, 2009]; rather, researchers work together in 'collaboratories',

in which they 'use remote libraries, collaborate with remote colleagues, interact with remote instruments, analyze data and test models' [Wulf, 1993, p. 854] in communities that might span multiple laboratories, multiple institutions and multiple countries. And even where the lone genius persists in their garret, they in turn can draw on the accumulated wisdom and knowledge of the networked world.

The Internet, and especially Web 2.0 tools, are the driving forces behind open science; tools that enable scientists to break through the laboratory wall and work under the tenets of 'openness and community that were supposed to be the hallmark of science in the first place' [Waldrop, 2008-01-09, p. 5]. In open science, research diaries become blogs, lab notebooks become wikis, journal clubs are conducted via micro-blogging, data are automatically gathered and transmitted, collaborations 'span continents, and the smallest details of what is happening in a laboratory can be shared' [Neylon and Wu, 2009].

As Trench [2008, p. 185] noted, the Internet has 'made more completely porous the boundaries between professional and private communication, [facilitated] public access to previously private spaces and thus [turned] "science communication inside-out"'. Although it is possible for Internet-based communication among collaborating scientists to be deliberately made private, if those scientists choose — as a matter of principle — to conduct their research 'in the open', it follows that there are no boundaries to preclude people from outside that collaboration from following, analysing, engaging with and contributing to the research process. Not only does open science allow anyone to watch the scientist at work from the moment of creating the research question and throughout the process, it also allows science to reach new audiences 'beyond the borders of the scientific community' [Suleski and Ibaraki, 2010, p. 112]. In its direct access and lack of mediating 'angels' acting between publics, professionals and institutions [Bauer, 2009], open science challenges existing modes of interaction between the actors in the research process, in that can facilitate direct public engagement with science as it is happening, rather than with scientists, scientists' personalities, scientific issues, science communicators, science policy-makers, or government decision-makers.

However, as Borgman [2003, p. 165] wrote, making 'digital laboratories useful to multiple audiences requires simple analytical structures, more common vocabulary and user interfaces that demand minimal domain knowledge'. In other words, scientists, if they commit to maintaining a continuous and full record of questions, methods, notes, data, publications and results to open archives, may need to develop new skills (such as setting up and managing a blog), face new challenges (such as making their handwriting readable!) and will certainly need to dedicate time. While this might be seen as time that should be used for 'real work', open practice could also be a way for scientists to create and maintain their digital reputation, something which concerns significant numbers of scientists [Reich, 2011].

Scientists are not alone in possibly needing to develop new skills; those from outside the professional community may also need to develop new skills of gaining access, interpreting, understanding and navigating the data torrents of modern science [Grand et al., 2014].

Fittingly, even this drawing of a boundary between different communities — professional and non-professional — may be subverted by open science. The

Internet facilitates the emergence and sustenance of dynamic, self-organised and shifting networks of people; groups that Hess [2010] described as counter-publics, who use alternative paths and emerge from novel social arenas. Today, we cannot assume that scientists are exclusively found in universities or industry; they may be part of a civil organisation, belong to no organisation or move among a variety of situations. They might not be professional scientists but instead emerge from a community organisation or interest group [Hess, 2010]. This is not a new phenomenon; neither Hooke nor Darwin were professional researchers and history has many other examples of the contribution of the skilled amateur. In fields such as astronomy and archaeology, where a keen and well-trained eye is needed, rather than expensive equipment [Silvertown, 2009], many significant discoveries have been made by so-called 'pro-ams'; that group of engaged and intellectually very competent amateurs who work to professional standards [Leadbeater and Miller, 2004, p. 4]. The open questions, data and methods made available by open practice may themselves be a route to 'encourage and provide paths to those with enthusiasm but insufficient expertise to gain sufficient expertise to contribute effectively' [Neylon, 2010].

We should recognise that, for all its merits, practising open science brings with it its own difficulties. For those inculcated in the traditional scientific culture, being required to be open can feel as if they are 'throwing out some of the most important elements of science and making deep, long-term research more difficult [Johnson, 2011, p. 1]. Some scientists are concerned that they may be scooped [Wald, 2009-04-09]; that others may re-use their data to take precedence in publication. More information can also create grounds for criticism and concern; increasing rather than lessening controversy; more discussion, through analysis of positions, may lead to the breaking down of debate rather than effective deliberation [Jasanoff, 2003; Irwin, 2006]:

> [there are] Dangers from [...] mixing of contexts for discussions among experts and pedagogical discussions with lay people; weakening of the roles of accreditation, reputation and authorship in disciplining scientific discourse [Smolin, 2008]

Where a commitment to open science is made for pragmatic reasons — for example, as a condition of receiving funding, and without deep and clear-sighted commitment — what I often refer to as "signing up without signing on" — the practice of openness may be a tortured one [Lloyd, 2008]. And commitment must go beyond the personal; open science requires the complete support of colleagues, supervisors, research leaders and institutions; this is particularly true for people the beginning of their careers, rather than the well-established [Johnson, 2011]. Furthermore, committing to opening up the whole scientific process means sharing failure as well as success. For scientists of the social media age, this can be a daunting prospect. While there may be sound practical and economic arguments for sharing failure:

> At present, scientists often share only the results of successful experiments. [...] This practice condemns others who have the same idea to waste time, money and animals' lives in duplicating the failed experiment. [...] Endlessly re-running failed experiments helps nobody. [The Economist, 2009]

others will call to mind the travails of the scientists involved in the so-called 'Climategate' affair, when media-literate climate change-deniers selectively used hacked information to criticise the work of climate scientists and support their cause [Holliman, 2011]. Here people's expectation of open information ran head-on into the apparent closed-shop of the scientific circle. However, as increasing numbers of people become 'digital residents' — people who see the Internet as a location, a place where they can express opinions, form relationships, develop an identity and belong to a community [White and Le Cornu, 2011] — then the expectation that information is will be freely available and instantly communicated can only grow.

The current demand for publicly-available information is well-illustrated by the hydra-headed broadcast and print media. No book, radio programme, magazine, newspaper seems to come without an accompanying website, blog and links to background, educational and other material. However, while these websites do facilitate access to the scientific paraphernalia of journal papers, data files and other information, those using such facilities also routinely encounter blocked access, pay walls, non-existent websites, subscription requirements, abstracts and summaries, which inevitably creates disappointment and lowers expectations. Science can no longer allow itself the luxury of locking itself and its components away behind ivory walls: members of the public increasingly demonstrate a willingness to engage with science, funders demand engagement is part of scientists' practice and even without these compulsions, science is demonstrating a willingness to engage with the public.

Conclusion

Open science has the potential to lift the lid on the dynamic, argued and constantly changing state of science as its participants seek after truth. For members of the public, this means adapting to recognise that no science is ever perfect and no knowledge complete; that science is uncertain and tentative, full of set-backs, detours, disagreements, new discoveries and new directions for exploration that constantly change the questions being asked. For scientists, open science means becoming less afraid to demonstrate that constant turmoil beyond their community: to be, as Mary Midgley [1992] writes, more ready to open up the 'myths, metaphors, images and the other half-conscious apparatus' of the scientific imagination.

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