The day when science is truly open

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How will the web change the practice of science in the next 25 years?

Network peer-review via the web and enhanced data crunching power are two of the defining changes recently bestowed upon 21st century science. While the term Science 2.0, like Web 2.0, means different things to different people, many appeal to transparency as its defining characteristic. In fact, results of the European Commission's public consultation on Science 2.0 published in May 2015 reveal that stakeholders voted to replace Science 2.0 with open science in any further proceedings of the Commission.

Yet, Science 2.0 holds in store many other new issues for researchers to confront, such as changes in the style and means of collaborating and obtaining funding. Sophisticated algorithms now allow scientists to produce and analyse data in new and faster ways. In addition, the web has opened up ways for citizens to interface with various stages of the scientific process--from funding to data production.

But the overarching question of whether the web will accelerate research and innovation in the next 25 years still remains to be answered. Nonetheless, Science 2.0, in its many connotations, has great potential to establish a more reliable scientific process, with greater transparency and accountability. And that alone is an exciting prospect.

A Call for Transparency

So how should the scientific process evolve towards greater transparency? Experts agree different disciplines must have different standards for openness. "There is no one-size-fits-all," says Eva Méndez, an associate professor of

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library and information science at Carlos III University of Madrid in Spain, who was involved in the Commission's Science 2.0 consultation. Today, calls for greater transparency have progressed more smoothly in fields like high-energy physics than in biomedicine because of the relatively extreme competition pervading the latter, adds Caroline Lynn Kamerlin, who is chair for Young Academy Europe (YAE)--a pan-European bottom-up initiative of a dynamic group of recognised European young scientists--and who also took part in the Commission's consultation.

Regardless of discipline, all agree any move towards greater transparency in the scientific process has a higher potential for success if it comes from the top-down. Policy makers, publishers and funders first need to create incentives for scientists to be more open, says Kamerlin who is also associate professor of structural biology at Uppsala University in Sweden. Kamerlin remains skeptical about using force to further greater transparency though; especially in cutthroat fields like biomedicine. "It's an invitation for data-vandalism," she says.

But the research process has already started becoming more transparent. Today open journals provide access to papers free-of-charge--as it is the authors of the work who bear the cost of publication. Multiple publishers now also encourage--or even require--researchers to publish their raw data with their findings. With the publication of raw data, cases of fraud or simple mistakes can be caught before publication and researchers can more easily replicate or reuse the data in future studies, experts say. To test this idea, the European Commission has implemented a pilot action for open access to raw data under Horizon 2020.

Nothing left private

Greater transparency may eventually find its way into the earliest stages of the scientific process as well; through documents outlining the step-by-step formulation of a scientific theory or experiment. In the future, open laboratory notebooks may allow anyone--including the public, companies and other scientists--access to researchers' daily notes.

But open lab notebooks might be a thing of the far future, though not because of any failure in technological advancement. Any researcher could easily publish his or her notes to the web today, but worries about intellectual property and patenting laws might prevent them from doing so, says Thomas Crouzier, an advocate of open science in every sense of the term, who is also a French assistant professor of biomaterials. Crouzier says he will probably not force members of his new lab at the Royal Institute of Technology in Stockholm, Sweden to share their notes with the world just yet.

Still, he argues implementing open lab notebooks would have advantages, if the culture of science and industry was different. "You could have a little helper that figures out where you're having difficulties [in an experiment] and how you could be helped by others; perhaps by selling you a service or connecting you with colleagues," says Crouzier.

However, the idea of an open lab notebook is a bit too Orwellian for Kamerlin. But she also admits the next generation of scientists--who are digital natives--might not feel that way. Since young people today grow up "sharing every aspect of their lives" on the web, they will probably be "more prone to sharing every aspect of their scientific lives" as well, she adds.

Better credit, altered peer-review

Any step towards greater openness "has to be coupled with a system that clearly identifies authorship," Crouzier emphasises. Others stakeholders involved in the Commission's consultation concur. "I think one of the biggest changes will be the way scientists get credit for their research," adds Méndez.

Today a scientist's worth is mainly based on the number of papers he or she publishes in peer-review journals, which are ranked by impact factor. But Méndez argues scientists need "mechanisms to legitimise alternative ways of communicating research." For example, via blogs, tweets or discussions on social media networks for scientists such as Mendeley or ResearchGate.

Besides, if researchers had more exposure to the complex, "sociological factors that influence their world"-- perhaps through connecting to the wider public through a blog -- they might realise "relying upon simple, singular forms of

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evaluation" will remain problematic, adds Brian Wynne, a professor of science and technology studies at Lancaster University in the UK.

But creating a standardised system for comparing and assessing the quality of blogs or Twitter feeds is easier said than done, he adds. "The attractive aspect of the traditional peer-review model, albeit completely inadequate and misleading, is that at least it's unified and recognisable," allowing for easy comparison.

The best model, all agree, could involve combining elements of traditional peer review with features associated with community-based evaluation via altmetrics. Today altmetrics primarily entail measuring the impact of an individual paper by monitoring when, where and how much it is downloaded by the community. In the future, network-based peer-review might involve large numbers of scientists voting via the web on whether a paper is published in a journal. Given their influence on both transparency and peer-review in science, Crouzier believes publishers are guiding and will continue to guide any changes that occur in these domains. They have to, if they want to survive, he adds.

The move towards massive data

Beyond increased transparency and improved credit, the concept of Science 2.0 also implies how technology is widely influencing the way researchers handle their data. Indeed, scientists can now produce, store and share large amounts of data with ease. Even simple web-based file hosting services, like Dropbox and Google Docs, are having significant impacts on the way researchers share their data, says Kamerlin. Since much of science is no longer a solo enterprise, "having efficient ways to share large volumes of data is absolutely crucial," she adds. This is especially the case in fields like climatology, genomics and high-energy physics, where author lists can reach the hundreds, even the thousands.

Longer author lists also correlate to the growth of data sets across all scientific disciplines. "Our data sets are exploding," says Kamerlin. "People talk about big data, but I always say, it's not big – it's massive," agrees Méndez. In 2014, Méndez and 24 other experts in science, publishing and law gathered to write the Hague Declaration: a call for greater openness with data with the aim of utilising the full potential of text and data mining technology. By combining and analysing much of existing data, the declaration claims, scientists will be better equipped to find answers to climate change, global epidemics and economic strife.

While many call the 21st century the Age of Big Data, producing bigger data sets may not be better if scientists cannot find ways to also organise and understand their data, says Wynne. Today, "the average academic is already feeling massively overwhelmed by the amount of information being thrown at them," adds Kamerlin. But like a snake biting its tail, the Web also provides some answers to the problem of information overload with academic paper recommendation sites, such as PubChase, ScienceScape or Nowomics.

Due to the growth of data sets across all disciplines, both Méndez and Kamerlin believe more and more researchers will devote their entire careers solely to finding new ways to analyse data, carving new research disciplines. "I don't think that a few decades ago you would have thought people would devote their careers developing algorithms for the meta-analysis of data," adds Kamerlin. But even today, this is the case.

Last word

With more adequate data management, web-based technologies have undoubtedly had a beneficial impact on science by helping researchers more easily and swiftly share and communicate their work. However, experts say it is still too early to tell whether the web will lead to optimal transparency and accountability; qualities at the crux of Science 2.0. "The web has the potential to open minds, open education, open the government and open research," says Méndez. But like any tool, the web's promise for improving science lies in the hands of its users.

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