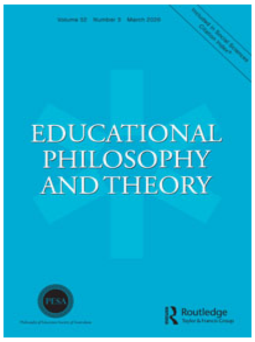

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Citizen science and ecological democracy in the global science regime: The need for openness and participation

Michael A. Peters

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EDITORIAL

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1. The emergence of global science regime

The emerging political economy of global science is a significant factor influencing development of national systems of innovation, and economic, social and cultural development, with the rise of multinational actors and a new mix of corporate, private/public and community involvement. It is only since the 1960s with the development of research evaluation and increasing sophistication of bibliometrics and webometrics that it has been possible to map the emerging economy of global science, at least on a comparative national and continental basis. The question of the political economy of world science and its geographic distribution cannot be easily separated from its measurement and evaluation or the pattern of journal ownership.

Increasingly, emphasis has fallen on the economics and productivity of science in both firms and higher education institutions, as policy-makers and politicians seek to foster innovation and to draw strong links between scientific performance and emerging economic structures. In science policy, the accent often falls on measuring scientific productivity, on 'intellectual property' and the codification of knowledge, and on research collaboration, partnership and cooperation in regional, national and international contexts. Investment in science, engineering and technology has received strong attention from governments as the basis of the 'knowledge economy' and most governments now look to their international science policy strategy to emphasize national competitive advantage and to encourage research collaboration in global science projects. Education at all levels has become an integral part of an emerging global knowledge system that starts with elementary learning and builds on nation sp - national research systems focused on universities and borderless private–public partnerships.

Indeed, it is the age of *global science*, but not primarily in the sense of 'universal knowledge', which has characterized the liberal meta-narrative of 'free' science since its early development, where scientific findings or results are open to peer review, and public scrutiny and, in principle, are reproducible by others following the same procedures. It is the age of global science but not necessarily in the sense of 'international' collaboration (part of the same liberal meta-narrative) as, say, the incipient norms of free exchange of ideas, free inquiry and collaboration developed during the so-called 'scientific revolution' and period of classical science when 'scientists', particularly within Europe, travelled to meet one another and to share their ideas. This was the period when learned societies were established and the first journals flourished with the growth of publishing during the 17th and 18th centuries, helping both to generate the international exchange of theories, concepts, methods and discoveries, and to aid the processes of research collaboration.

This (older) liberal meta-narrative of science has now been submerged by official narratives based on an economic logic linking science to national purpose, economic policy, and national science policy priorities. In the era of 'post-normal' science (Funtowicz & Ravetz, 1992), where globalised corporate science dominates the horizon and scientific 'outputs' differ from the traditional peer-reviewed published scientific papers, quality assurance replaces 'truth' as the new regulative ideal. In contemporary science, policy regimes outputs often take the form of patents, unpublished consultancy, 'grey literature' or are covered by legal arrangement and 'lawyer-client confidentiality'. As a result, there are expressed concerns about the fate of scientific publishing. The rise of digitized publications has led to a counter-revolution in scholarly publishing where actual sales are recast into licences and commercial publishers are taking advantage of the growth of open archives. The Select Committee on Science and Technology in the United Kingdom Parliament (2003), for example, has urged the adoption of a new government strategy to address the problem of increasing journal prices imposed by commercial publishers, recommending 'that all UK higher education institutions establish institutional repositories on which their published output can be stored and from which it can be read, free of charge, online'. Lyotard (1984) raised similar questions a generation ago (Peters, 1995; Peters & Besley, 2006).

Open access publishing has a new momentum after the launch of 'Plan S' by Science Europe in 2018, an initiative of 'cOAlition S' that is a consortium of national research agencies from 12 European countries: 'Plan S is an initiative for Open Access publishing that was launched in September 2018. The plan is supported by cOAlition S, an international consortium of research funders. Plan S requires that, from 2020, scientific publications that result from research funded by public grants must be published in compliant Open Access journals or platforms' (https://www.coalition-s.org/). Signatories to Plan S holds that OA is 'foundational to the scientific enterprise':

> Universality is a fundamental principle of science (the term "science" as used here includes the humanities): only results that can be discussed, challenged, and, where appropriate, tested and reproduced by others qualify as scientific. Science, as an institution of organised criticism, can therefore only function properly if research results are made openly available to the community so that they can be submitted to the test and scrutiny of other researchers. Furthermore, new research builds on established results from previous research. The chain, whereby new scientific discoveries are built on previously established results, can only work optimally if all research results are made openly available to the scientific community. (https://www.coalition-s.org/why-plan-s/)

Paywalls are seen to disrupt this universality principle – 'no science should be locked behind paywalls!' (ibid)

Global science as a term to describe the emerging *geography of scientific knowledge and collaboration* as an aspect of globalization and its new interconnectedness within a globalized world is a distinctly new phenomenon, although, judging by scholarly criteria, it still reflects a strong Western control and bias and is still heavily nationalistic and seen as a vital part of national culture and state economic policy. In modern Baconian statecraft, science belongs to a knowledge economy and is the source of innovation and growth in productivity. To a large extent, the developing infrastructure of global science is an outgrowth of earlier historical conditions, particularly, the industrial-military research complex established during the two world wars and extended through nuclear escalation and the space race of the Cold War, and the incipient infrastructure provided by 'colonial science' of the European expansionist era (arguably the *first* globalization of science). On one reading, the term global science reflects an extension of the 'old' liberal (as opposed to the market-driven neo-liberal) ideology of 'universal free knowledge' based on exchange and peer review that developed with the emergence of the modern research university in the nineteenth century. Yet it is also clear that it also smacks of 'imperial science'—science in the service of the empire—which strongly motivated Francis Bacon's new philosophy and the views of the founders of the Royal Society in the seventeenth century during the early institutionalization of British science. At the same time, the emergence of 'global science' also reflects new global exigencies, new global problems and an enhanced global network of science communicative practice. Today, 'big science' projects require massive state and intergovernmental funding support in an era of intense international competition for knowledge assets, which has forced governments and institutions to collaborate with one another on certain issues. Global science in the form of international science agencies also recognizes the need for cooperation on a number of pressing common global issues that run across borders, such as global warming and other ecological problems, AIDS/HIV, other global diseases and virus outbreaks, natural species extinction, preservation of biomass features, etc.

2. Open science as a new participatory model

The open science economy is an alternative growing sector of the global knowledge economy utilizing open source models and its multiple applications (open access, open archiving, open publishing, open repositories, etc.) in distributed knowledge and learning systems that encourage innovation-smart processes based on the radical non-propertarian sharing of content, cloud data sourcing, and leveraging of cross-border international collaborations. Open science provides an alternative to the intellectual property approach to dealing with difficult problems in the allocation of resources for the production and distribution of information). Rich-text, highly interactive, user-generated, and socially active Internet (Web 2.0) activity has seen linear models of knowledge production giving way to more diffuse, open-ended, decentralised and serendipitous knowledge processes. Distributed peer-to-peer knowledge systems rival the scope and quality of similar products produced by proprietary efforts where the speed of diffusion of open-source projects is an obvious advantage. The successful projects occur in both software and open-source biology. Open science economy can play a complementary role with corporate and transnational science and implies a strong role for governments. Increasingly, portal-based knowledge environments and global science gateways support collaborative science (e.g. Science.gov & Science.world). Open science economy demonstrates an 'exemplar of a compound of 'private-collective' model of innovation' that contains elements of both proprietary and public models of knowledge production (Von Hippel & von Krogh, 2003). Powerful new cognitive tools and Web 2.0 and 3.0 platforms enabled by the Internet are changing the practice of science and greatly accelerating scientific discovery (Peters & Roberts, 2011; Nielsen, 2011). Open science encourages a distributed, collaborative, de-centralized model of research culture that is genuinely participatory involving the wider public and amateur scientists along with experts in the social mode of open knowledge production (OpenScienceSummit.com; http://www.opensciencegrid.org/). The new model highlights the prospect of this growing aspect of the knowledge economy with the prospects of: (i) expanding the size and scope of the open science economy and its significance for future participatory knowledge and science, especially in schools and universities; (ii) enhancing the science education infrastructure in the digital age by providing opportunities for promoting closer linkages between schools and university science through portals and engines of open science; and (iii) creating conditions for national debate concerning the production of public science goods and the role of science in a more democratic science culture. The interdisciplinary study and integrated nature of open science can determine the greater integration of the logic of digital distribution to realise a closer alignment of school science.

3. Citizen science and ecological democracy

In science, sustainability science, post-normal science and science-in-transition is gaining strength representing a recognition of multiple ways of being (ontological pluralism) and knowing (epistemological pluralism) and the inevitability of complexity, ambiguity and uncertainty. In society, the call for living more lightly and equitably on the Earth is leading to transitions in energy (away from fossil fuel and centralized energy systems), food (away from agri-business and industrial farming towards more localized and sustainable food systems), economics (away from profit and growth oriented capitalist systems towards economies of sharing and meaning), and health care (away from centralized and privatized care systems towards localized cooperatives).

Muki Haklay (2015) provides a comprehensive report on how citizen science can significantly contribute to policy formation especially in environmental monitoring and decision-making. He makes the case this way:

> The past decade has witnessed a sustained growth in the scope and scale of participation of people from outside established research organizations, in all aspects of scientific research. This includes forming research questions, recording observations, analyzing data, and using the resulting knowledge. This phenomenon has come to be known as citizen science. While the origins of popular involvement in the scientific enterprise can be traced to the early days of modern science, the scale and scope of the current wave of engagement shifts citizen science from the outer margins of scientific activities to the center—and thus calls for attention from policymakers.

An emerging challenge of citizen science is its deployment in education at all levels to promote participatory scientific practices integrating school, STEM education and environmental science and green studies at university to promote DIY science for local communities that encourages committed and objective, disinterested research based on rigorous and systematic data collection on the one hand, and, on the other, environmental responsibility for an action agenda—an indissoluble link carrying an ethical and political obligation to act on results. Indeed, we might better characterize the action imperative as a result of the shift from the industrial science model to an ecological systems view that recognizes the interconnectivity of all things and problematizes the disinterested scientist and spectator theories of knowledge.

The European Commissions' *Green Paper on Citizen Science* entitled 'Citizen Science for Europe: Towards a better society of empowered citizens and enhanced research' (2014) puts the argument powerfully in terms that readily carry educational and pedagogical possibilities:

> ICT facilitates a shift of paradigm, with a more open research process sharing good and bad experiences through digital media and collaboration e orts. These new participative and networked relationships promote the transformation of the scientific system, allowing collective intelligence and new collaborative knowledge creation, democratizing research and leading into emergence of new disciplines and connections to study emerging research questions and topics. While doing this, participatory approaches contribute to long-term inclusive education, digital competences, technology skills and wider sense of initiative and ownership.

We are at the beginning of a new era characterized by the cooperation of amateur and professional scientists where enhanced computing and computation power along with big and linked data signal an exciting mix of local and global, humans and machines, humans and nature in the transgressive pedagogical paradigm that moves beyond the industrial scientific model of applied science.

In the introduction to a special issue on citizen science in *Conservation Biology* Dillon et al. (2016) introduce a particular strand of citizen science that fits well with the idea of ecological democracy. They speak of 'transition-oriented civic science' to emphasize that not the questions and concerns of scientist are the point of departure of collaborative inquiry but rather those of concerned citizens. In other words, it is not so much about citizens supporting science but rather about science supporting citizens. The 'transition-oriented' suggests a normative stance towards a shift away from unsustainable routines and systems that tend to lead to the earlier global systemic dysfunction (e.g. planned obsolescence, built-in inequality, fossil fuel dependency, loss of identity and sense of place, etc.). This relatively new approach can be traced back to a post-normal science perspective, which assumes that: citizens have or need to have agency, there are multiples ways of knowing and different types of knowledge that all are relevant (e.g. indigenous knowledge and local knowledge) and that improving a 'wicked' sustainability challenge requires social learning between the multiple stakeholders/actors affected by an issue (scientists being one of many).

In their conclusion Dillon et al. (2016, p. 454) write:

> … our civic-science version of citizen science calls for expanding public participation beyond the volunteers who normally populate citizen science projects, shifting the role of scientists to one of the stakeholders (but with recognized important technical expertise), and engaging all stakeholders as co-creators and co-learners in a deliberate and systematic process of knowledge building. An important part of this process is treating emerging goals and knowledge as tentative and subject to revision based on ongoing critical and collaborative dialogue, inquiry, and action.'

Recursion is one of the keys of science. The history of science is reveals how science itself has changed over time. Kevin Kelly[1] has chronicled a sequence of new recursive devices in science from earliest times:

2000 BC – First text indexes

200 BC – Cataloged library (at Alexandria)

1000 AD – Collaborative encyclopedia

1590 – Controlled experiment (Roger Bacon)

1600 – Laboratory

1609 – Telescopes and microscopes

1650 – Society of experts

1665 – Repeatability (Robert Boyle)

1665 – Scholarly journals

1675 – Peer review

1687 – Hypothesis/prediction (Isaac Newton)

1920 – Falsifiability (Karl Popper)

1926 – Randomized design (Ronald Fisher)

1937 – Controlled placebo

1946 – Computer simulation

1950 – Double blind experiment

1962 – Study of scientific method (Thomas Kuhn)

To this list we can '1995 – The Emergence of Open Science' and '2005 – Citizen Science'. These participatory models are particularly powerful in the 'new biology', in astronomy, in mathematics and physics, and in ecological science. In the future, there will be accelerated change especially in the cross-overs of science and computing such as bioinformatics, and new ways of knowing will emerge with distributed instrumentation and experiment that will yield smart-mob, hive-mind science, based on greater interconnectivity at the global level that offers the prospect of integrating science in schools more closely with research.

Note

1. http://www.kk.org/thetechnium/index.php

Disclosure statement

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Michael Peters and Tina Besley
Faculty of Education, Beijing Normal University, Beijing, China
tbesley@bnu.edu.cn