Open Science as an Instrument for Effective Research

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Openness is a key principle of science and research, creating new opportunities for participation by researchers, decision makers and the general public. The benefits extend to all branches of society. Open science has the potential to increase the quality and benefits of science by making science more reliable, efficient, and responsive to societal challenges. Open science also has the potential to enable economic growth and innovation through reuse of scientific information. However, we need to understand that some societal challenges are "wicked problems" that are hard or even impossible to solve through science and technology.

Digitalization and Openness of Research

Open science and research is intertwined with the digital research process, which is changing the way in which research is carried out. New research fields often lie in interdisciplinary settings, where the focus is on new methodologies, new protocols, new analytical instruments and new ways of evaluating areas of interest. Openness accelerates this process.

Digitalization requires new kinds of competences and the deployment of new skill sets. It would be a tall order to expect just one person to do all new things competently at the detailed level, but some in-depth knowledge in legal and ethical issues, workflows and practices, and general ICT literacy is needed. Open Science also requires investments in, for example, ICT interoperability, to become fully developed. The recent budget cuts in many countries, which affect research funding, will see an even greater interest in federating resources and infrastructures.

Openness is not black and white (Figure 1). For example, research that reuses materials subject to the *Personal Data Act* requires a data-protection guarantee.

The Open Science and Research Initiative

Finland's economy relies on research, innovation and expertise. Open science and research play a decisive role. For decision-makers, the availability of scientific and research results provides additional background material and is a prerequisite for rational decision-making. Industry gains access to research materials at the large scale. Citizens can benefit from increased transparency and increasing trust in science.

The Ministry of Education and Culture of Finland is responsible for the overall coordination of developing open science and research in Finland. *The Open Science and Research Initiative (ATT)* aims to make Finland the leading coun-

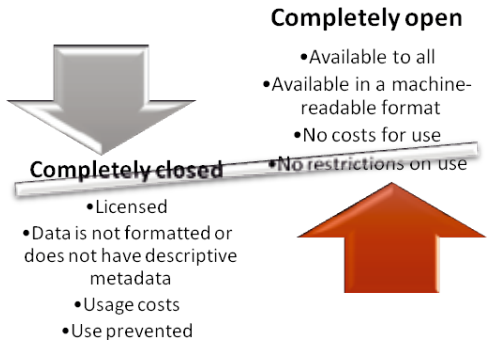

Figure 1: Levels of openness. Source: ATT initiative.

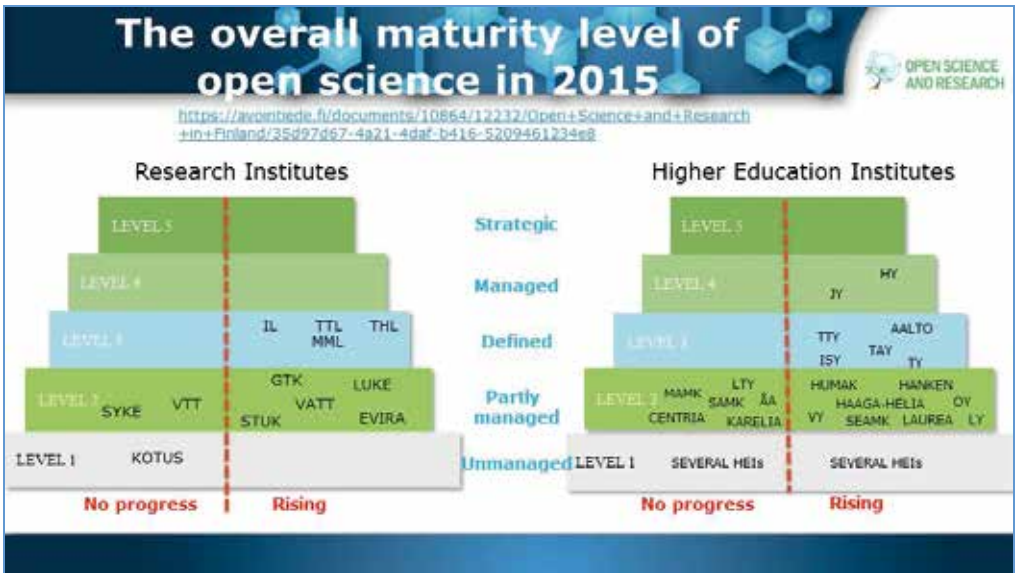

Figure 2: Hierarchy of operational culture maturity levels.

try for openness in science and research by 2017, and for the opportunities afforded by open science to be extensively harnessed in Finnish society [1]. The ATT initiative is executed in collaboration with research organizations, funding agencies and providers of services for research.

The Finnish National Research Data Initiative (TTA) was an important enabler for the current development in Finland, and this particular project was executed by the Ministry during 2011-2013. TTA was a broad-based co-operative network for the development of research data services and the promotion of open knowledge and interoperability.

The Finnish Roadmap 2014-2017

In 2014, the Ministry of Education and Culture of Finland released *The Open Science and Research Roadmap 2014–2017* [2] which sets the policy framework for the national efforts in the field. This document is also complemented with an *Open Science Handbook* [3] and a *Data Management Guide* [4] directed to Finnish researchers.

Dialogue in science and research is promoted on many levels in the roadmap, both nationally and internationally. The roadmap is implemented via four sub-objectives, which are:

- Reinforcing the intrinsic nature of science and research, so that openness and repeatability increase the reliability and quality of science and research.
- Strengthening openness-related expertise, so that those working in the Finnish research system know how to harness the opportunities afforded by openness to boost Finland's competitive edge.
- Ensuring a stable foundation for the research process, so that good, clear basic structures and services enable new opportunities to be harnessed at the right time and ensure a stable basis for research.
- Increasing the societal impact of research, so that open science creates new opportunities for researchers, decision-makers, business, public bodies and citizens.

A set of measures has been defined to achieve these sub-objectives. We gauge the success in achieving targets by monitoring the progress and impact of individual measures. Progress will also be promoted by increasing visibility, by analyzing shared sets of basic information, and through the required support functions and analyses.

Evaluating the Status of Openness

The status of research organizations open opera-

tional culture was evaluated in 2015 [5]. According to this analysis, no higher education institution has yet to reach the highest maturity level in openness.

The University of Helsinki and *the University of Jyväskylä* have reached the second-highest level. Five higher education institutions were placed at the third level, fourteen at the fourth level and nine at the lowest level. Of the research institutes, four were at the third level, seven at the fourth level and one at the fifth level. Over half of all institutions have been actively promoting openness.

In order to monitor progress, a similar analysis will be repeated annually until 2017. In 2016, funding organizations are also to be evaluated.

The *Academy of Finland* is currently implementing the practices outlined in the *Open Science and Research Roadmap* when providing funding for research projects. The Academy requires that academy-funded publications are made openly available [6]. The Academy also requires that applications include a data management plan, describing how the research data in the project will be used and re-used, how the rights of ownership and usage to the data used and generated by the project will be distributed, and how the data produced will be stored and subsequently made available within and outside the project both during the project and after the project has ended. Finally, the Academy recommends that the research projects also make their research data available through major national or international archives or storage services that are of relevance within their own fields.

How to Benefit from Openness?

To gain the benefits of open science, we need to make research materials (such as publications, data and methods) openly available (using an open licence) in accordance with the principles of research ethics and the judicial environment. We benefit from the opportunities afforded by open access, open peer reviews, and parallel archiving. In addition, we benefit from research materials openly available, but we need to ensure the availability of the required expertise, open-source software, and information about open standards and interfaces, as well as the solutions to implement them. Also, one needs to remember to cite and credit sources.

Open science and research offers many kinds of benefits such as:

- Faster progress: Use existing materials, resulting in faster development thanks to shared resources. Apply research results in real time.
- Awareness: Promote awareness of scientific methods and ways of working.
- Quality: Confirm and validate data quickly, improve repeatability of results, and gain transparency in research practices.
- Scientific literacy: The general public can access scientific results and methods.
- Impact: Businesses and decision-makers can harness research results and methods, enabling new kinds of businesses and innovations.

Different stakeholders benefit from open science and research in different ways (Figure 3). We need to work with these different viewpoints, and develop training and guidance in such a way that each stakeholder understands the requirements and benefits.

How to Support Openness?

The establishment of openness can be supported by:

- **Taking Care of Skills and Capabilities.** General information management exper-

Figure 3: Benefits to different parties. Source: ATT initiative.

Figure 4: Discussions at the ATT forum organized at the University of Tampere in November 2015. Source: ATT initiative.

tise has to be developed throughout the research system. The ATT initiative emphasizes the role of training in advancing open science and research, and organizes events targeted for different audiences based on their skills and expectations (Figure 4). In 2016 a big emphasis has been placed on training researchers in all phases of their studies.

- **Effective Information Management.** Effective information management is not easy. There are many systems to integrate, a huge range of needs to meet, and complex organizational (and cultural) issues to address. The ATT initiative promotes joint operating models for research organizations at national and international levels, linking information, developing science support processes and building shared or compatible services.
- **Building for Quality of Science.** Digital technologies play increasingly important roles, linking different research inputs and outputs and bringing new evidence to bear. Making research materials accessible does not simply facilitate validation, replication and reproducibility it also supports new research and innovation. *The FAIR principles* (findable, accessible, interoperable and reusable), put into practice and available as a service, form the foundation of quality in science.

We need to provide incentives to promote cultural change towards openness. Clear descriptions must be provided when rewarding or requiring openness (indicators, metrics, career impacts). We need to promote, enable and reward cooperation and interoperability by, for example, building cooperation platforms and enabling and rewarding cooperation.

We need to draw up clear policies and guidelines for openness for every party involved. Legislation that supports and encourages openness is also important.

A necessary role for openness is in developing research services and infrastructures, which should be planned with interoperability in mind (both nationally and internationally) and using open-source software, open interfaces and open standards whenever possible.

International Movement

International organizations are campaigning for open science. *OECD* has focused on harnessing open science in industry and innovation [7,8]. *UNESCO's* emphasis is in its use in education. In the EU, open science has been recognized as a driver for change. The European Commission believes in open information and the exchange of expertise to improve economic performance and by using information enhance the EU's ability to compete. *The European Commission's* funding mechanisms for science and research emphasize the widest possible availability of information.

Especially from the perspective of emerging countries open science is also a human rights issue, as noted in *Article 27 of the 1948 Universal Declaration of Human Rights*: "Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits." Therefore we should ensure that researchers working outside of established research infrastructures have equal opportunities for access to scientific information, such as publications, data and methods.

During the period of the Netherlands presidency (January - June 2016), the Council of the European Union has been writing conclusions on

the transition towards an Open Science system. The conclusions address the main barriers, namely the legal and financial barriers to access results of publicly funded research.

The *OECD directorate for science, technology and innovation committee for scientific and Technology and Innovation Committee for Scientific and Technological Policy* is setting up a *Survey of Scientific Authors on Access to Outputs of Scientific Research*.

In a pilot study in 2015, the main findings, based on study estimates of the incidence of open access, were:

- Approximately 50-55% of documents are openly available 3-4 years after publication. Documents in fields associated with a higher level of commercial funding of research are less likely to be available on an open access basis.
- Authors from emerging and developing countries tend to rely more on open access journals than their OECD counterparts. The use of repository-based access reduces OA differences across countries.
- Publisher and repository-based access to documents are intertwined. Their relative importance varies by field, and it is associated with the prevalence of major repositories for working papers.
- There is a considerable lack of knowledge about some aspects concerning access to documents, in particular with respect to embargo practices. Embargo length practices appear to be inversely related to citations by field, even though there was no evidence of this link within scientific domains.

Multitude of future benefits

Open science is the future, or in other words the sooner the better. We need to tackle challenges such as the cost increases of the publishing industry. Research funding will be more and more attached to the openness of the research output, and restricted access will remain a costlier choice.

Research organizations gain a multitude of benefits from open science and research. Realizing these advantages requires competences that need to be developed both at the organizational level and at the national level. A lot of development is already happening at the international level, but one needs to apply the results of this development work at the practical level of daily work of researchers and research groups. Thus, organizations need to target openness at the strategy level, and at the same time invest in training and guidance at the practical level. 🕮

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