Open Science and Open Education: Bringing social and technical disciplines into dialogue

Mojca Drevenšek (mojca.drevensek@consensus.si) and Iva Tajnšek
Consensus, Slovenia

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ABSTRACT

The concept of Open Science has gained more attention in recent years, including the European Commission's (EC) inclusion of the concept in its Horizon programme. Open Science provides a foundation for communicating science, connecting stakeholders, and supporting collaborations, as well as the uptake and re-use of the findings. For the successful uptake of Open Science and Open Education practices within research projects, a good technical, organisational and legal infrastructure needs to be established both by the EC and the educational/research institution themselves. These infrastructure include resources for skills development, providing researchers with an understanding of data ownership, and science/knowledge accessibility. Horizon projects, including the SSH CENTRE, should try to raise awareness of the benefits of Open Science and Open Education practices, and strive to make their findings easily accessible, open, and free to everyone, as well as offering the possibility for the open educational resources to be reused, retained, revised, remixed and redistributed (i.e. the 5Rs of OER).

SUMMARY

- Horizon Europe highlights the importance of Open Science and Open Education practices and integrates a more complete approach of the open science concept, including distinguishing between mandatory and recommended open science practices.
- Open science is a broad concept, describing practices and tools, such as open access, open journals, open data, open research, open science policies and open education, all linked by the principle of open access and availability to all.
- The main benefits related to Open Science and Open Education in SSH and STEM are the increased uptake, transparency and confidence in scientific research findings, exchange of knowledge and ideas, and increased accessibility and relevance of education in different fields of science.
- The European Commission should make Open Science skills an integral part of the work programmes with dedicated actions and funding to support and promote Open Science in Open Education both in SSH- and STEM-focussed projects, and especially in projects, aiming to bridge SSH and STEM.
- Educational institutions in SSH and STEM should support and encourage the development of skills, technical infrastructure, and organisational and legal frameworks for the development of Open Science and Open Education practices. This would benefit both SSH and STEM researchers.

KEY DEFINITIONS

Open science: Open science consists of principles and behaviours that promote transparent, credible, reproducible, and accessible science [1].

Open research: an openly collaborative approach, which includes developing relationships with, and working alongside, other researchers, often from other disciplines [2]..

Open Education: a way of carrying out education, often using digital technologies. Its aim is to widen access and participation to everyone by removing barriers and making learning accessible, abundant, and customisable for all [3].

Introduction

Open Science and all its principles can play a crucial role in communicating and sharing findings, as well as building upon existing research. Connecting various forms of openness (open science, open education, OER, open access, open data, open research, open policy etc.) can provide considerable added value, **enabling innovation, improvement of quality, and expansion of knowledge domains, not only for science but also for other stakeholders, such as business**. Specifically, the synergy between Open Science and Open Education has the potential to make scientific information available and shareable via OER (Open Educational Resources) and offer the application of these resources as open educational practices, open courses, open teaching etc. [6]. The importance of Open Science and Open Education principles is also highlighted by the European Commission (EC), who has integrated mandatory and recommended open science practices into the Horizon Europe programme [7].

This literature brief focuses on the coherence between Open Science and Open Education, and their synergistic overlaps. It focuses on how these overlaps can benefit both the SSH and STEM community to **overcome fragmentation on Energy, Climate and Mobility issues** by drawing upon a number of examples from research, projects, reports and toolkits, which help raise awareness on the energy-climate-mobility nexus and introduce system thinking about the interrelationships among these three fields and also their relation to other areas (socio-demographic trends, industry, forestry, agriculture, development of new technologies).

Current Understandings

Significant Findings to Date

Many types of 'openness' exist, for example open science, open education, open access, open-source software, and open innovation. They are all part of the open movement and are based on the same basic principles – to make scientific information available to interested stakeholders (including peer researchers from other fields, the business community, the educational ecosystem, the citizens). The connection of various 'open' areas can provide considerable added value, enabling innovation, improvement of quality, expansion of knowledge domains and development of new insights [8].

Open Science is supported by a number of tools, including open access, open journals, open data, open research and open science policies. By opening all steps of the research process and all research data, as well as open innovation, there are benefits for different stakeholders, including efficiency from reusing data, data quality due to wider evaluation and validation of data, opportunities for innovation and collaborative, and social benefits, particularly global collaboration and knowledge transfer. Stakeholders that benefit from Open Science include students undertaking research activities, institutions and companies developing new solutions, and governments drawing upon insights for policymaking [8]. Researchers, who make their research open access can develop and adapt their research in response to feedback, as well as gather inputs and information. An example of open research used to collect information is the 'Solar Energy' Massive Open Online Course (MOOC) by Delft University, who have, by developing a course, also gained a large research database for further research [9].

KEY DEFINITIONS (CONTINUED)

Open education resources (OER): learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright but have been released under an open license, that permits no-cost access, re-use, re-purpose, adaptation and redistribution by others [4].

FAIR Data Principles: Guidelines to improve the Findability, Accessibility, Interoperability, and Reuse of digital assets [5].

Initially, open education focused on the provision of open educational resources (OER) (such as open courseware) but the focus has shifted to the **application of OER** (including open educational practices, open courses, open learning pathways, certification and accreditation) [10]. The shift of focus provides new opportunities for synergies between SSH and STEM research findings, as open courses and learning pathways guide the learners through multiple research findings and research fields, rather than simply focusing on one particular educational resource. These diverse insights and cross-cutting understandings can be considered to strengthen the collaborative processes. They also offer opportunities to integrate open data and research practices, which can benefit the development of new research. Open Data provides the opportunity to discover and re-use other researchers' data in ways that validate outcomes and advance the research undertaken. This also supports future collaborations and can improve the speed at which important research can be conducted and disseminated [11].

While the previously mentioned examples mostly focus on the benefits of Open Science for researchers, the general public can also benefit from open practices, particularly OER and their application.

There is the need to better communicate the components of Open Science and its associated opportunities [12]. Understandings, and practices of Open Science, can be supported through the better provision of training opportunities for open access and open data. A survey of 1,277 researchers across Europe found that **75% of researchers surveyed had not participated in any open access or open data courses** but would like to [12]. These findings show, that to strengthen Open Education and Open Science practices, researchers and academics in all fields should be made aware of the concepts and their benefits. Additionally, platforms and other tools for open science should be readily available to researchers, to support and encourage them to embrace the principles.

Open Science and Open Education supports the **increased uptake, transparency, and confidence in scientific research findings, and increased accessibility and relevance of education** in both SSH, STEM and multidisciplinary (SSH-STEM combined) fields [GX].

Emerging Practices

The key challenge in relation to Open Science and Open Education between SSH and STEM is **how to support open approaches and how to find ways of agreement between all actors on how to implement 'open',** as found by several European and international projects (including ENCLUDE[1], DIAMOND[2], NDC ASPECTS[3], OE4BW[4]). Open Science and Open Education can be supported through the creation of alternative business models for journals to support Open Science and/or by motivating researchers, teachers, and other stakeholders to exchange knowledge and scientific findings [GX]. Open Science and Open Education can also be supported through the development of knowledge platforms which usually focus on specific topics and provide materials and outputs, related to that topic for its users. The format and structure of these platforms differs from case to case. For example, the SENSES project has developed the SENSES toolkit[5], a module-based open course about climate change scenarios [GX]. The FOSTER portal[6] is another knowledge platform which provides training resources addressed to those who need to know more about Open Science or need to develop strategies and skills for implementing Open Science practices in their daily workflows. The content targets different users - from early-career researchers to data managers, librarians, research administrators, and graduate schools.

One of the key messages of open principles is, that the resources and science should not only be open, but also findable. As humans rely on computational support to deal with data, due to the increase in volume, complexity, and creation speed of data, FAIR data principles and guidelines were developed. Their goal is to improve the **F**indability, **A**ccessibility, **I**nteroperability, and **R**euse of digital assets (FAIR) [5]. Research, investigating the meaning and potential impact of FAIR data principles in practice, includes the following significant findings, relevant to the planning and implementation of Open Science and Open Education activities in SSH- and STEM-related projects:

There are low levels of understanding around data ownership in the research community.

There is a diversity of data types across disciplines and variation in corresponding tools and systems to support data management, as well as in attitude to sharing and perceived individual benefits of sharing.

It is common across disciplines that the FAIR data principles are seen as 'going beyond' open access and are considered a helpful concept in bringing together various aspects of data management best practices [13].

Open Science and Open Education practices can improve the **intersectoral and multidisciplinary approach to different topics and areas**, especially those, where both SSH and STEM research is needed. This leads to a more comprehensive and integrated understanding of the topics, providing better leverage for decision-making, policy formation, and further research [9]. The open exchange of knowledge, research, and sources, as well as their integration in open processes (courses, databases), makes bridging the SSH and STEM barriers easier, more accessible, and more collaborative. Increased access to research and publications and open educational practices allows for an increase in national, European and global collaboration. This speeds up the transfer of knowledge between SSH and STEM, and assists in addressing issues that require a wider range of attention and multidisciplinary collaboration - such as energy supply, global warming and clean mobility.

From the viewpoint of key challenges, related to the engagement of researchers and other stakeholders in Open Science and Open Education practices, several emerging practices are observed by the experts [TU, GX] in relation to bridging SSH and STEM. The use of new open platforms and tools is one of the key developments of recent years. New knowledge platforms are developed for specific topics, including new open tools, such as courses and open research. These projects specifically concentrate on linking SSH and STEM research and provide an integrative overview of the selected topic to a variety of stakeholders.

The overall vision of ENCLUDE[7] (ENergy Citizens for inCLusive DEcarbonization) is to help the EU to fulfil its promise of a just and inclusive decarbonisation pathway through sharing and co-creating new knowledge and practices that maximize the number and diversity of citizens who are willing and able to contribute to the energy transition.

The research aims to operationalise the energy citizenship concept at multiple scales of policy and decision-making. Through the creation of the **ENCLUDE Academy for Energy Citizen Leadership**, new knowledge about energy citizenship, opportunities for the energy transition, along with strategies for collaborative decision-making and joint problem framing (based on both SSH and STEM insights) will be **shared with citizens and NGOs across the EU**. The aim is to help mobilize actions for decarbonization, including communities that normally do not or are not able to participate in these civic processes.

The goal of the Academy is to support citizens in becoming energy citizenship leaders in their respective communities by providing them with educational resources and design-thinking methodologies to help them develop and accomplish different citizen-led energy projects. As such, the main audience of educational resources are citizens. Note that the Academy has an almost equal number of participants from Africa and Europe and thus most educational materials were developed to be relevant for citizens within and outside Europe. (GX)

The ENCLUDE project provides a great example of **linking different types of research and providing different stakeholders with a comprehensive overview of insights**, rather than fragments of different research.

The DIAMOND[8] (Delivering the next generation of open Integrated Assessment MOdels for Net-zero, sustainable Development) project aims to **establish vibrant communities of practice to transparently 'open' model enhancements and to develop capacities by producing learning materials and easy-to-use applications, thereby lowering the entrance barriers to the established IAM community** [GX]. Not only will the project bridge SSH and STEM, but it will also take a step further and offer different stakeholders the opportunity

1 https://encludeproject.eu/
2 https://diamond-project.eu/
3 https://www.ndc-aspects.eu/
4 https://oe4bw.org/
5 https://climatescenarios.org/toolkit/
6 https://www.fosteropenscience.eu/
7 https://encludeproject.eu/
8 https://diamond-project.eu/

to apply and adapt these findings based on their needs and situations. Similar practices could be applied to all projects, exploring a different kind of (social) innovation.

Other emerging practices include new open repositories, such as Zenodo and OpenAIRE, which provide great opportunities for OER sharing to a larger, already established set of stakeholders. Open repositories also ensure scientific articles and research aren't hidden behind a paywall, benefiting the readers and other researchers, when searching for data and information. This makes the research – both SSH and STEM – more accessible to everyone. [14]

New learning programmes have also been developed, such as the Open Education for a Better World (OE4BW)[9]. The programme enrols mentees from all over the world to, under the guidance of internationally recognized Open Education experts (as mentors), to develop and implement OERs based on the UN Sustainable Development Goals. The process is person focused, led by the mentee, and supported by the mentor through dialogue. The role of the mentor is to help the mentee find their own solutions. Several Open Education projects have been developed related to SSH and STEM and specific issues related to energy, climate change and mobility. This programme supports the development of open practices around the world, which are then developed further after the project. This includes open libraries, knowledge platforms, open courses and other practices. They can be found in the OE4BW e-Library.

Open Education and Open Science practices are also included in educational programmes. The University of Nova Gorica in Slovenija has developed a Master's degree in Leadership in Open Education[10], which encompasses the design, management and performance of activities related to accessibility, flexibility, quality and sustainability of learning processes. The syllabus has a distinct interdisciplinary character, connecting SSH and STEM, such as information technologies, business studies, and educational sciences.

Learning programmes like this are useful for developing skills and knowledge needed, to further explore Open Education and Open Science practices. The basics of Open Education and Open Science could be included in all educational programmes, to ensure the growth of these practices.

Open Science and Education practices are needed in both SSH and STEM, not only for sharing findings and improving their uptake and application, but also to improve research practices. Open principles can be useful for researchers as they provide open databases and findings from other research, support the development of research principles and help identify research participants [9], as well as offering opportunities for new collaborations. Additionally, through open practices, researchers can increase the chance of the insights being implemented, whether by citizens, other researchers, the industry or policymakers.

Future SSH priorities

There has been a rise in the popularity of Open Science and other open principles, which we are expecting will rise even more in the future. Reasons why this might happen, especially in the EU environment, are the ever more prominent Open Science policies, developed and pushed by the European Commission[11]. The European Commission defines Open Science as one of its policy priorities and requires of the beneficiaries of research and innovation funding to make their publications available in open access and make their data as open as possible [15] Among the recommended practices, those recommendations related to involving all relevant knowledge actors including citizens, civil society and end users in the co-creation of Research and Innovation (R&I) agendas and contents (such as citizen science) are explicitly mentioned [7].

Due to this fact, we can expect further development of open practices in different Horizon projects and other funding programmes. The practices, expected by the projects, can then be further integrated into the researcher's work outside of the EU-funded projects. In SSH, this includes practices, such as:

- Development of open knowledge platforms, providing not only open access to existing materials but also OER, developed for disseminating and education about certain topics – e. g. open courses, webinars, infographics etc.
- Sharing open data, research practices and methods, protocols, research notes, engagement practices and other information, which could help develop further research.
- Sharing project materials and data on Open Repositories to provide maximum findability
- Using FAIR principles, to provide maximum findability.
- Opening research for maximum visibility, and credibility and improving the chances of implementation of the insights.

To support this, Open Science skills will have to be developed and open principles will have to be integrated into the education systems. Some actions might be required to get the maximum positive effects of Open Science principles, such as standardisation of data and research protocols as well as quality control. Additional incentives and rewards might be needed to support open science development [16].

9 https://oe4bw.org/

10 https://www.ung.si/en/schools/school-of-engineering-and-management/programmes/2NVOI/

11 https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en

Takeaways

Takeaways for the European Commission

In order to mainstream skills for Open Science and Open Education, the European Commission should encourage Open Science Policy on the EU level, including:

- Training in Open Science and Open Education skills (technical data management skills, Open Education literacy, legal skills, research integrity skills, business competences, etc.) should be an integral part of the European Commission's work programmes with dedicated actions and funding to support and promote them.
- There is the need for better support coordination across stakeholders providing Open Science and Open Education skills, with this combatting SSH and STEM fragmentation and possible duplication. The European Commission can play a role in the standardisation of a set of recognised skills, competencies and supports, which can then be coordinated across the current landscape utilising the expertise and networks of stakeholders.
- An integrated Open Science and Open Education roadmap should be developed, available to all SSH and STEM students, researchers and staff, with guidelines for integrating open principles into research and educational activities and as part of this roadmap, encourage FAIR institutional and/or funding guidelines to be implemented.

Takeaways for the educational institutions

- Future activities should focus on improving the quality and relevance of skills for Open Science and Open Education. The institutions should offer and promote both traditional and online career-level appropriate Open Science and Open Education training courses for researchers, with an appropriate level of accreditation and modularisation.
- Training courses are not enough to help researchers do Open Science and Open Education. There is the need to ensure adequate support is provided alongside Open Science and Open Education training, including technical infrastructure, data management practices, and appropriate legal frameworks.

Takeaways for the SSH CENTRE project

Planning and implementation of WP5 Evaluation and Synthesis, including the organisation of a *webinar* on the basics of Open Science and Open Education, creation of an *open online course* for ECRs and other stakeholders, and creation of a *digital guidebook* for Horizon Europe Cluster 5 projects on 'How to go Open, and the development of the *SSH Open Knowledge Platform* as part of WP6 should take into consideration the following:

- The benefits oof Open Science practices, particularly Open Access, Open Data, Open Education, Open Peer Review and Citizen Science; these benefits should be explained on both theoretical and practical grounds, integrating their added value on the levels of personal (researchers'), institutional and social benefits.
- The SSH CENTRE's key Open Science and Open Education deliverables, e.g. webinar, online course, digital guidebook and Open Knowledge Platform, should offer as many actual practical exercises as possible to motivate researchers to 'learn by doing' in the areas of knowledge exchange, collaboration and networking, research publishing and dissemination, teaching and supervision, and popularising science for the general public.

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