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Editorial

Special Issue: Engaging with Open Science in Learning and Teaching

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1. Introduction

Technology has impacted almost all aspects of our lives today, and education is no exception. Technology enhanced learning and teaching (TELT) has changed the way universities, in general, and learning and teaching specifically, operate today. The increasing adoption of TELT coupled with emerging philosophies of openness have brought additional opportunities and challenges to learning and teaching around the world. Openness is an overarching concept or philosophy that is characterised by an emphasis on transparency and free, unrestricted access to knowledge and information, as well as collaborative or cooperative management and decision-making rather than a central authority (Peters & Britez, 2008).

This new philosophy has encouraged the development of an open culture that is reaching scales never imagined before. Today, many stakeholders in education, such as governments, researchers, educators and students, have engaged in developing open initiatives, including open policies, open content, open education, open source software and so forth. Educators and learners have access to a large volume of open resources. Researchers have also benefited from having access to large volumes of data available in open access repositories all over the world – data that was previously held by only a few, now can reach anyone interested in using them and thus making new discoveries not only in science, medicine, but also in learning and teaching (European Commission, 2016; European Union, 2014).

One important element of openness is open science, which is the movement to make scientific research, data, process and dissemination accessible to all levels of an inquiring society, amateur or professional (Bartling & Friesike, 2014a, 2014b). It encompasses practices such as publishing open research, campaigning for open access, encouraging scientists to practice open notebook science, and generally making it easier to publish and communicate scientific knowledge. Although open science is

mostly seen as related to research, its philosophical foundations and dilemmas are very similar to other aspects of openness closely associated to learning and teaching, such as open education (Schuwer, 2017).

Recent developments and studies have realised the potential of open science to enhance many aspects of learning and teaching – some examples are Open Data as OER (Atenas & Havemann, 2015), Study on Open Science (Salmi, 2015), Open access scholarly publications as Open Educational Resources (OER) (Anderson, 2013b), Open science, open access and open educational resources: Challenges and opportunities (Vrana, 2015), (Open) Data in Education (Henty, 2015; Mouromtsev & d'Aquin, 2016). Despite those examples, the application of open science in learning and teaching is still very limited. In addition, most of the work conducted in open science is focused on data, infrastructure and publications rather than practices.

The lack of scholarly work linking open science and open education was the main rational for this Special Issue on *Engaging with Open Science in Learning and Teaching*. Through this call we were able to attract several interesting papers that readers will have the opportunity to access here. In this special issue, we called for contributions that explored and discussed approaches used to integrate open science and learning and teaching, including but not limited to philosophical and theoretical approaches to openness and open science in teaching and learning, students' perspectives on and students' roles in open science, examples of implementation of open science in learning and teaching, and beyond, open science and the scholarship of learning and teaching, capacity building for open science in education and so forth. Contributions in a range of formats (including case studies, empirical research, analyses, literature reviews and reflective pieces) were encouraged to include a diverse range of work. As a result, we received interesting and important contributions to this special issue, which we believe will further advance the body of work that aligns open science and open education.

In this paper, we discuss some of the literature that attempts to bring together these two different, but also overlapping elements of openness: open science and open education. We investigated these two topics and how they intersected with each other by conducting a desktop research with relevant topical terms in diverse information services. The coverage of topics in this literature sample gives first hints on current topics covered in research and papers that we think are relevant for further investigating potentials of interrelating open science and open education. We present the result of the desktop research in the next section. We then present and examine each of the five papers included in the special issue and finally, we make some recommendations regarding how institutions, educators and students can take advantage of and further advance open science in learning and teaching

1.1. Open science and open education

One of the key goals of open science is to make research processes open and transparent (European Union, 2016). Generally, this includes all kinds of research outputs.

The more prominent and represented claims are to make research publications and research data openly accessible and retrievable, followed by debates on openness in diverse research-related processes like peer review (Ross-Hellauer, 2017) or research software (Jiménez et al., 2017).

Following those activities to make research processes transparent and accessible, new programmes to teach researchers how to conduct and adopt open science have been developed. Training researchers, especially early career researchers, in open science practices is one important step to establish open processes in daily researcher work (Arabito & Pitrelli, 2015; Schönbrodt, 2019). Currently, there are many online resources such as handbooks and open science related MOOCs available worldwide to anyone, including researchers, interested in learning about open science concepts and practices (for example Open Science MOOC,[1] Open Science: Sharing Your Research with the World,[2] and Open Science Training Handbook).[3] However, some discipline-specific research practices do not allow, or are less inclined to use generic open science models, instead, they require specific models that meet their specific practices, domains and community's needs. In additional to requiring different approaches to open science, recent studies have also showed that researchers from different disciplines have different understandings of open science and its practices (Kim & Nah, 2018; Levin & Leonelli, 2017; Levin et al., 2016; Linek et al., 2017). Thus, general resources just give an overview of open science without explaining practices in detail. Those resources mainly focus on active researchers and lecturers who want to teach and practice open science. In accordance with those resources, the report of the open science policy platform emphasizes to expand open science skills and education not only for researchers at all stages, but as well for students at all levels (Mendez et al., 2020). The report speaks of fostering a "shared research knowledge system" (p. 4), however primarily with a focus on research and not on learning and teaching.

However, in addition to open science training for researchers and advocates, we see a growing tendency to adapt and apply open science in learning and teaching scenarios for students, specifically in higher education where students learn through research (Garde-Hansen & Calvert, 2016). Where a research culture is established and developed, open science may have the potential to improve learning and teaching.

Although it is important to raise awareness and understanding of the potential of open science and build capacity of researchers, educators and students, we hoped to find more examples and cases that combined open education and open science together, particularly those that would not be possible when they are considered as two separate fields. One clear example is to turn an open access paper into an OER when used in an educational context, and as previously mentioned, developing or

[1] https://github.com/OpenScienceMOOC.
[2] https://www.edx.org/course/open-science-sharing-your-research-with-the-world.
[3] https://www.fosteropenscience.eu/content/open-science-training-handbook.

utilising MOOCs to train researchers, collect research data or to disseminate results of research to a wider audience (Schuwer, 2017).

Open Education is not a new approach to learning and education. It was adopted by Open Universities worldwide to capture learning that takes place 'anywhere and anytime'. It also represented flexible learning structures such as open entry and alternative exit points which were the foundations of Open Universities and their correspondence and distance education models (James & Bossu, 2014, p. 81). Currently, there are a wide range of approaches and strategies to 'open-up' education and access to learning, including open content, open educational practices, open access (research and data), open learning design, open technologies, open policies, and also open governance (Bossu & Stagg, 2018) Open educational practices (OEP) in particular, is an approach that goes beyond developing OER It involves open pedagogical models, collaboration between teachers and students, amongst other aspects of supporting learning and learners (Ehlers, 2011a). In fact, a key aspect of OEP is the learners' freedom to determine their learning steps and participate in the development of new knowledge as co-producers of content. This aspect embraces the idea of the self-regulated learner, an idea often described in concepts of research-oriented learning (Brew, 2013; Heck & Heudorfer, 2018; Huber, 2014). Ehlers stresses that "the pure usage of these open educational resources in a traditional closed and top-down, instructive, exam-focused learning environment is not open educational practice" (Ehlers, 2011a).

Despite many similarities in their conceptualisations, it is unclear to us the reasons why there have not been more approaches and initiatives that combine both open education and open science. Schuwer (2017) expresses similar concerns, when he asks the question: "is that all there is?" He argues that instead of being an integrated approach, open science and open education are basically mirroring the split, differences and dilemmas of *research* and *learning and teaching* in higher education. This is because the reality is still that in many institutions, education and research are two separate branches with different processes, fund schemes and stakeholders. Although some open science initiatives include aspects of open education, for example the Citizen Science initiative, where there are connections with educational projects under the umbrella of open pedagogy (DeRosa & Robinson, 2017; Ehlers, 2011b), unfortunately, some initiatives do not combine these two aspects: open science and open education. However, despite their difference, both fields have been facing similar issues such as:

- Fear of commercial use of openly licensed resources
- Fear of misuse of openly licensed resources and datasets
- Lack of understanding of copyright and open licenses
- Fear of harming their career when involved in openness, because of possible quality issues (Schuwer, 2017; Bossu & Tynan, 2011).

The latter can also be looked at from a broader perspective, where in some institutions and countries, being involved in education is considered detrimental to for

one's scientific career, mostly because these activities do not count when applying for important research grants, for career progression and promotion (Schuwer, 2017).

In order to investigate more closely the links, overlaps and cross-overs between open science and open education in the current body of work available in education and open science, we conducted a systematic desktop review, which is discussed in detail in the next section.

1.2. Openness in learning and teaching

A growing amount of research papers exploring openness in science and education have emerged recently. In order to get a better understanding of current publications and research papers related to openness, open science and education, including open education, we conducted a broad web search in the Web of Science (WoS)[4] databases and in the German Education Portal (FIS)[5] databases. The latter is a cooperative database hosted by the Leibniz Institute for Research and Information in Education in Frankfurt or DIPF, with resources from the educational fields, including publications from ERIC, EBSCO host, the Library of Congress, among others.

We first did a scoping search to collect appropriate search terms. As some researchers do not tend to use terms such as open science and open education generally in their papers, we included additional terms researchers use when writing about aspects of openness in research and education (please see Table 1 for a full list of terms used in the search). In both databases, we restricted the search to the field "title" only and used search terms shown on Table 1. We included articles, proceeding papers and reviews as document types, and no temporal span. As FIS include resources from the educational field only, we did not refine the search with additional terms as in WoS. We also searched for German terms in FIS because the database includes many relevant German resources. Table 1 summarises our search and gives the total number of resources.

To get an overview of the topics covered within our retrieved documents, we applied a lexical term analysis on the titles of our documents, using the qualitative analysis software MaxQDA. For this, we first determined six major code concepts based on concepts used in our search and the relevant topics we relate to in this paper (Table 2). To automatically add those concepts to our documents and apply them as codes, we scanned the document titles and determined relevant terms that represent our code concepts, including English and German terms and various term spellings ($\pm$ hyphen). We then did automatically coding with those terms for all documents titles. Please note that we did not check the completeness of all references or delete duplicates of documents However, we manually checked all titles and eliminated 53 resources that were not fit for purpose for not having the relevant information for this

[4]http://apps.webofknowledge.com.
[5]https://www.fachportal-paedagogik.de.

Table 1
Search syntax and number of results

Search syntax	Number of resources
Web of Science databases TI = ("Open Science" OR "Open Data" OR "Open Access" OR "Open Methodology" OR "Open Source" OR "research transparency" OR "data reuse" OR "research data") **AND** TI = (education* OR teach* OR training OR learning OR "research-based" OR "research-led teaching" OR "research-oriented" OR "teaching and research") Refined to articles, proceedings, reviews	174
FIS database (Title: "Open Science" OR "Offene Wissenschaft" OR "Open Data" OR "Open Access" OR "Open Methodology" OR "Open Source" OR "research transparency" OR "data reuse" OR "research data" OR "Forschungsdaten")	673

Table 2
Frequency and distribution of codes for the 794 coded documents. Note that some documents have been assigned more than one code

Code concepts (bold) and their representing terms	# codes	Percentage
Education: Bildung, education, learn, Lehre, lernen, train, teach	335	42.19
Open source: open source, open-source	302	38.04
Open access: open access, open-access	297	37.41
Open data: Forschungsdaten, research data, offene Daten, open data, open-data	142	17.88
Open science: offene Wissenschaft, open science, open-science	29	3.65
Oer: Bildungsmaterialien, Bildungsressourcen, educational resources, OER	8	1.01
# total number of codes	**1113**	**100**

research. Finally, 794 titles were automatically coded. The frequency and distribution of codes related to the six code concepts is shown in Table 2.

The numbers in Table 2 give us a first indication of the topics covered in the literature set. Open source and open access were the most popular topics explored in these papers, followed by open data (see Table 2). As we were mostly interested in the papers that had links with and impact on learning and teaching, we then narrowed the search scope by including only articles that have any educational term in their title and excluding those that had no links with education. Table 3 shows the overlapping of related topics and education. We then concentrated the search scope on papers that had strong relation between open science and open education.

From the 794 papers initially included in our analysis, only eight papers were coded with *education* and *open science*. Half of them (4) did not fit our scope in relation to engaging with open science practices in educational scenarios (for example they focused on education as a research discipline and not practice), while one paper (Peters, 2009) shows the relation between openness in science and education, but with no concrete examples. The other three papers will be discussed next. One of the papers by Toelch and Ostwald (2018a) presents an "introductory course that guides students towards a reproducible science workflow", including also elements of good open science practices (Toelch & Ostwald, 2018a). With this, the authors bring open

Table 3
Matrix showing the relations of the six code concepts

Code concepts	Education	Oer	Open data	Open source	Open access	Open science
Education	–	7	56	**155**	**88**	8
Oer	7	–	1	0	6	0
Open data	56	1	–	0	1	0
Open source	**155**	0	0	–	1	0
Open access	**88**	6	1	1	–	2
Open science	8	0	0	0	2	–

science practices into the teaching of Master and PhD programs, which is a first step to make future researchers aware of open science. Similarly, the paper by Anagnostou et al. (2015) also stresses the importance of open science training to improve the quality of research. They stated that "a key step to achieve this goal [improve quality] is in the education of young researchers regarding the principles of open science, so as to make them understand its connections with scientific progress and appreciate the importance of transparency and trust in research" (Anagnostou et al., 2015).

In contrast, Scanlon (2011) does not refer to *open* in the sense of teaching open research practices to students, but instead to "the teaching of science at a distance" (Scanlon, 2011, p. 97) with the help of digital open tools, web-based projects and open educational resources. For example, conducting remote experiments that are dependent on public access to scientific apparatus or data, and shared resources. The author stresses the importance of innovative technology that enables this kind of open and distance learning and collaboration. This example shows that the meaning of *open* can be interpreted differently by researchers and that there are different ways in which researchers, practitioners and students have engaged with open science in learning and teaching.

With regard to the inter-relation between open science and education, we also had a look at the six papers coded with *OER* and *open access*, with the hope of finding additional relevant work to add to our discussion. Those papers explore mostly the relationship between open science and open educational practices with regards to openly licensed resources that are at no costs for users, i.e. open access research articles and open educational resources, including textbooks (Anderson, 2013a; Ebner et al., 2013; Elliott & Fabbro, 2015; Hatzipanagos & Gregson, 2015; Mruck et al., 2013; Okamoto, 2013). Although OER have open licenses, whereas open access research articles might be "free-to-read" only, all resources come at no costs. Further, both OER and research articles are relevant content specifically in higher education.

Papers coded with *open source* or *open data* often describe new technological tools and their application as an example of learning and teaching practices. Much of the literature we found explicitly refer to the engagement of openness in learning and teaching scenarios, without making any specific links to any science aspects.

The use and application of open source tools and software for different learning scenarios and topics (for example Auerbach et al., 2018; Dean et al., 2019) seem to be a relevant topic within education. The need to manage and use open data is addressed

in our literature sample as well. For example, one paper proposes a learning scenario based on problem-based learning to support lecturers in teaching the use of open government data (Camach et al., 2018). Another study with graduate students and postdoctoral researchers addresses challenges in data management with regard to data sharing and transfer via open formats. The authors of the study stress the importance of improving data management skills among university researchers to improve data storage and transfer practices according to good scientific practice standards (Wiley & Kerby, 2018). Other studies emphasise the need and importance of teaching students principles of transparent and reproducible research with the idea to raise awareness to open science (Jekel et al., 2020; Toelch & Ostwald, 2018b). This is in accordance of the recent recommendations of the open science policy platform that stresses the importance of teaching FAIR data principles and data management skills to students (Mendez et al., 2020).

Another approach to help students' engagement with open science, created by Redmann and Clark (2017) aimed at fostering student competencies in understanding open access publishing via learning to write and review open blog entries (Rebmann & Clark, 2017). The researchers' goal was to show students ways to support gold open access via blogging. According to the researchers, blogging has the potential to foster communication between students and researcher communities and to enable students participate in scientific communication. The authors concluded that blogging allowed students to collaborate and practice relevant research practices in scholarly communication.

In the following section, we introduce and discuss the contributing papers that were included this special issue. It is interesting to note that most of them reflect the topics and code concepts that emerged from our literature search discussed above.

2. Contributions in this special issue

As mentioned previously, the broad aim for this special issue was to contribute to the limited body of knowledge that explored and discussed approaches that integrate open science in learning and teaching. In this special issue we called for contributions that explore and discuss the impact of open science on learning and teaching, including new pedagogical approaches, strategies and policies, capacity building, and what opportunities and challenges they pose to educators, students and learning institutions. We invited papers from the Information and Communication Disciplines (ICD)[6] and beyond and from diverse educational systems. Submissions were double-blind peer reviewed and included literature discussion and analysis, conceptual and empirical

[6]Information and Communication Disciplines include Library and Information Science, Communication and Media studies, Journalism, Archival studies, Museum studies, Psychology, Cognitive science and Digital Humanities.

papers, case studies, quantitative and qualitative research. Although the selection of papers in this special issue shows a variety of approaches and activities that link open science and learning and teaching, we are aware that this represents a positive but small contribution to the overall work related to openness. Next we discuss the contributions each paper makes to the broad field of open science and learning and teaching.

The first paper of this special issue, entitled *Open Textbooks as a Route to Open Science: Results from the UK Open Textbooks Project* by Farrow et al., introduces the UK Open Textbook project and discusses some of its success factors with regards to promoting open practice and open pedagogy. Before delving into the project findings, the authors of this paper explore the literature related to Open Textbooks, which are "openly licensed academic textbooks and also an Open Educational Resource (OER)" (Clinton, 2018). The *UK Open Textbooks* project piloted several established approaches to the use and promotion of open textbooks (focusing on STEM subjects) between 2017 and 2018. Open textbooks have been very popular and gained a lot of traction in Canada and the US, and through dissemination and promotion, this project successfully raised the profile of open textbooks within the UK. Several case studies reporting existing examples of open textbook use in UK science were recorded. Project findings revealed that there was considerable interest and motivation to adopt open textbooks by UK academics. This was partly related to cost savings for students, but more significant factors were the freedom to adapt and develop textbooks and OER (Clinton, 2018). This is consistent with a range of research that has taken place in other countries and suggests the potential for impact on UK science education is high.

The paper by Schindler et al. on *Opening up Qualitative Research Practices in Teaching and Learning? Capacities and Boundaries of an Open Qualitative Research Environment* introduces an experimental set-up to apply an open digital research environment to teach students a qualitative research analysis method. The authors were motivated to build this environment due to a need of open tools to specifically support qualitative and mixed method research (Conrad, 2018). This tool was built to run analysis of objective hermeneutics, which is a method that can only be conducted in small researcher teams and cannot be done by a single researcher alone due to the principle of multi-perspective interpretation. The open tool allows objective hermeneutics to be conducted at any time and place, which gives greater flexibility to researchers involved. Furthermore, the tool stores the analysis process and makes it transparent for other researchers. Schindler et al. tested their tool in a research-based learning scenario, where students learned to apply the specific analysis method. Research-based or research-oriented learning has a student-centred approach (Reinmann, 2016), similar to concepts of open pedagogy (DeRosa & Robinson, 2017). The authors combine both ideas and want to support open analysis – a part of open science – within a learning and teaching context. Benefits for students are for example a more explicit methodological guidance given by the tool's structural design and the option to see the explicit analysis process for ongoing validation and reflection.

The digital storage of the analysis process helps lecturers as well in detecting how their students proceed and where they might need further support. Results (Schindler et al., 2020) from user studies with student participants show that the use of the research environment required little training and students found the design helpful to comprehend the analysis procedure. Despite positive feedback, students reported that while using the online tool more communication and agreement on working tasks and time is needed to proceed and finish the analysis process in a good manner. Despite challenges to be solved within pedagogical settings, open research infrastructures have the potential to support open analysis and foster new pedagogical approaches (Schindler et al., 2020).

Teaching Open Science and Qualitative Methods by Steinhardt is another paper that is part of this special issue, which describes the author's attempts to develop and deliver a seminar that was offered to undergraduate students in sociology in a university in Germany. The seminar combined practices and principles of both open science and open education in higher education, and adopted a project-based teaching approached, where students were asked to be involved in a qualitative research project about students' use and adoption of digital technologies for learning. During this project, students were required to engage in several research activities, which adopted strongly concepts of openness, including open data, open research design and procedures. Similar to Schindler's et al. (2020) work, this project has also generated an open science tool called KolloIn: Collaborative online interpretation to support student learning and transcription of interviews conducted by the students. The author's reflection at the end of the paper is very interesting, honest and presents the reality of many university teachers across higher education around the world. She points out that although the practical aspects of teaching open data and open science is not difficult, teacher and the students' digital literacy skills for learning and teaching were underdeveloped. She also highlighted that because students' engagement with open practices was not mandatory, students just contributed the bare minimum if anything at all. According to her, this was not surprising as the use of digital technologies and "the empowerment of learners are not part of the academic habitus in sociology" (Steinhardt, 2020). The same occurred for activities involving student co-creation of content and knowledge, as learning and teaching in Germany is still very traditional and adopts predominantly content driven and teacher-centred approaches to teaching.

In the following paper, entitled *Changes in Academic Libraries in the Era of Open Science* Tzanova (2020) discussed the impact of a university's adoption of open science, especially open data and open big data on the roles of academic libraries. Here authors explained that the role of open data as generator of new research increased dramatically in the last decade bringing new demands and challenges for academic libraries. They go on to explain that in order to support open data driven research, academic libraries re-invented themselves by embarking on expansions of traditional library services, adoption of new data science roles and expanding the library's educational and mediator functions. These processes have led to deep transformation in libraries themselves making them more technologically savvy, data

oriented and active participants in the research process. Indeed, academic institutions choose different approaches to ensure the support for open science, but in all instances the academic librarians are entitled to play a central role by providing leadership, information services, research data management services and even collaborating in research projects in their institutions. By sharing examples from CUNY the author illustrated how librarians can help to build capacity so that practitioners are able to make informed decisions about incorporating the open science in their teaching, learning and research processes.

The final paper of our special issue, by Heck et al (2020) discusses open science through the lenses of educational practices and resources and reports on a study that investigated the state of current educational practices from the perspective of open science in higher education in Germany. The authors believe that students should be introduced and exposed to the opportunities and elements of open educational practices and via open educational practices approaches, this would raise their awareness of future open science goals and teach them the skills needed to reach those goals. The study surveyed 210 participants with teaching responsibility at different higher education institutions in Germany. The results of the study revealed that although some teachers tried to adopt a more open learning and teaching approach, the majority applied the traditional teacher centred methods of teaching. Most participants (60%) have not used open educational resources before. In fact, many of them have never heard of OER, and as a consequence have not made their courses openly available to online learners. As similar studies revealed (Bossu et al., 2014), participants from this study were concerned with the quality and accuracy of open content and did not fully understand the benefits of open practices and their practicability and applicability. This paper adds to the general debate about open science practices and their adaptation into the learning and teaching in higher education and makes recommendations for improvements of open practice support and infrastructure. Perhaps the biggest contribution to this paper is the mapping and conceptualisation of some key components of openness that overlap and can be adopted in both open science and open education (see Fig. 1 in Heck et al., 2020, *Open Science Practices in Higher Education: Discussion of survey results from research and teaching staff in Germany*). Such aspects could also inform future research and educational practices more broadly.

3. Recommendations and conclusions

This special issue attempted to build on the limited body of knowledge that explores and discusses practices which integrate open science and learning and teaching. Despite some existing and prominent work, there seems to be some missing opportunities to combine aspects of open science and open education considering that the underpinning philosophy of both have many similarities. Before exploring the papers that are part of this special issue, we presented some findings of our systematic literature search which revealed that there is a growing number of papers written in

education related journals that explore open source, open access and open data. Open data is one of the main topics discussed and several papers show best practices on how to use open data for teaching. Teaching courses and online resources on open science seem to be currently one of the primary focus of researchers and advocates, who want to build capacity on open science. Lecturers have also began to develop learning scenarios for higher education (Jekel et al., 2020) and teaching students to apply open science principles in classroom projects and research. This trend is not surprising considering that 'education and training' is one of the eight pillars of open science development identified by the European Commission (Ayris et al., 2018). In fact, "raising awareness about Open Science and its potential benefits and providing skills training in Open Science practices are crucial to achieve the culture shift which is needed to open up universities to an Open Science culture" (Ayris et al., 2018, p. 16). The papers included in this special issue not only reflect some of the issues explored in the literature, but also make their own unique and contextual contribution to the progress of openness more broadly. Based on these papers, we collated some key recommendations for researchers, teachers and advocates of open science and open education to progress their work and the field. Our first recommendation is that you build your own capacity not only about open science, but also how to teach open science, basically the pedagogical side of it. As explained by Steinhardt (2020), her lack of experience teaching open science might have contributed to lack of students' engagement in her seminar. Steinhardt does not seem to be alone. As identified by the latest report from the European Commission on open science (Mendez et al., 2020), "there remains a deep lack of awareness of Open Science and the skills and roles required to deliver it" (p. 17). Perhaps through closer collaboration, governments, institutions and practitioners could develop "an accredited curriculum for Open Science skills training that fosters Open Science behaviours such as IT and data literacy, from primary school through the whole educational system" (Mendez et al., 2020, p. 17).

Our second recommendation is a plea that teachers and facilitators of such seminars and workshops adopt open textbook and open educational resources and make students aware of your approaches to teaching. As suggested by Farrow et al's (2020) research, students and teachers benefit from their adoption, which could reduce costs and increase students' satisfaction and engagement in learning. Another recommendation is that you use the resources and expertise of your university librarians (compare Ayris & Ignat, 2018), as they are equipped (or working hard to be) to provide advice and support regarding open science and open data (Tzanova, 2020). In fact, the potential role and assistance of university libraries "to support digital science is still undervalued" and more needs to be done to properly train, prepare and fund them (Mendez et al., 2020, p. 16).

Another key recommendation is that you should not assume that your students have the appropriate digital literacy skills to take on open science. Despite students' frequent use of technology in general, many do not have the skills and practice to use it to enhance their learning (Steinhardt, 2020). Lastly, but not least, all engaging in open science and/or open educational practices need to be aware of their infrastructure

capabilities and resources available before embarking on such projects to avoid frustrations and failure (Heck et al., 2020, Schindler et al., 2020, Mendez et al., 2020). Supporters of open science and education need to be aware of fostering open practice potentials in accordance with best practices developed by expert researchers and lecturers and their understanding of openness and good research and teaching. We encourage practitioners to continue supporting each other and building communities of practice so that research and teaching can have stronger links and come together to commonly establish best practices to progress in open science and open educational practices.

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