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Open Science Practices in Higher Education: Discussion of survey results from research and teaching staff in Germany

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Abstract

Aspects of open science and scholarly practices are often discussed with a focus on research and research dissemination processes. There is currently less discussion on open science and its influence on learning and teaching in higher education, and reversely. This paper discusses open science in relation to educational practices and resources and reports on a study to investigate current educational practices from the perspective of open science. We argue that offering students opportunities via open educational practices raises their awareness of

future open science goals and teaches them the skills needed to reach those goals. We present online survey results from 210 participants with teaching responsibility at higher education institutions in Germany. While some of them try to establish more open learning and teaching settings, the majority applies rather traditional ways of learning and teaching. 60 % do not use open educational resources – many have not even heard of them – nor do they make their courses open for an online audience. Participants' priority lies in resource accuracy and quality and we still see a gap between the benefit of open practices and their practicability and applicability. The paper contributes to the general discussion of open practices in higher education by looking at open science practices and their adaptation into the learning and teaching environment. It formulates recommendations for improvements of open practice support and infrastructure.

Keywords: open educational resources, open science, open education, survey

Introduction

Open science and open education are strongly connected through the concept of 'openness', but they approach this concept from different perspectives: Open science – here we mean as well open research, i.e. referring to natural sciences, social sciences and humanities likewise – mostly refers to research and researchers as well as aspects connected to the scientific enterprise such as scientific communities, publications, and research impact (Bartling & Friesike, 2014a; Herb, 2015). In contrast, open education is concerned with open strategies and approaches to learning and teaching in various settings like for example schools, higher education, vocational education, informal learning. Open educational resources is a key element of open education and well explored by the literature in this area (Hylén, van Damme, Mulder, & D'Antoni, 2012). Most research discusses openness in either science or education and lacks the interrelation of both fields, specifically in higher education environments where a large number of employees are concerned with both, research as well as learning and teaching. Moreover, discussions within both movements, openness in science and education, mostly

concentrate on how to facilitate and secure access to their products, such as scientific publications and open educational resources. This results in countless open access initiatives, guidelines, and progress reports. Those activities overlook an important and integral part on the way to more openness, which is that open practices include more than open access to final products of science and education. Our goal is to understand how educational practices in higher education reflect diverse forms of practices discussed within the open science movement, which might foster a better integration of open science practices of future researchers.

We conducted a study, which used a quantitative online survey to ask academic staff teaching at higher education institutions in Germany about their use of digital media, tools and OER, and their teaching practices. Results consider practices of teaching staff including resources, technologies and activities that relate to currently discussed aspects of open science. The leading research question is:

- Which open science related practices are currently applied in German higher education?

In this paper, we briefly introduce aspects of open science and open education before we lay out opportunities of open practices. Afterwards, we report on our quantitative survey that provides a view on current practices of teachers. We summarize the survey findings and compare them to similar studies before we draw conclusions.

Aspects of Open Science

Open science or open research stands for a movement which suggests openness in all phases of the research lifecycle (European Union, 2016; Förstner, Hagedorn, Koltzenburg, Kubke, & Mietchen, 2011). It considers not only the use of new technologies in areas like content access, shared ideas and collaboration, but advances

further discourses, some of which stand for a radical change in research behaviour, like open peer review (Ross-Hellauer, 2017), open grant writing and open evaluation. As such, in open science researchers move from publishing as early as possible to sharing as early as possible (European Union, 2016). Some researchers even talk of a second "scientific revolution" (Bartling & Friesike, 2014b; Friesike, Widenmayer, Gassmann, & Schildhauer, 2015; Nielsen, 2013). Researchers and stakeholders of the scientific enterprise, such as funders and institutions of higher education have established proper infrastructures for making research more open, like open access repositories and professional research data archiving centres. Herewith, libraries and information infrastructures centres see a change to position themselves to a new area of responsibility (Fecher, Friesike, Peters, & Wagner, 2017; Fender, 2015). There seems to be a tendency towards open access publishing (Bosman & Kramer, 2018), with publishers offering more open access options and funders support open access publishing. Recent practices and business models within the publishing landscape have their potential and drawbacks, and are discussed controversially by different authors, often debating the affordance of open access (Green, 2019). This discussion is beyond the scope of this paper.

Besides infrastructure development, large initiatives have emerged to support the Open Science moment and developed guidelines to apply open practices and guarantee high quality of open data. One example of such initiative is a larger EU project named FOSTER (fosteropenscience.eu) that offers courses and online materials for researchers to learn about open practices. Another one is the Go FAIR initiative (go-fair.org), which suggests that any open data should be findable, accessible, interoperable and reusable (Wilkinson et al., 2016). Its concrete application is relevant for data producers such as

researchers and metadata editors and for infrastructure developers that give access to this data.

Larger bibliometric studies (Piwowar et al., 2018) analyse open access publishing and show a positive trend – however there are still great differences among diverse disciplines (Bambey, 2016).

Other recent studies aim at finding explicit explanations for researchers open practice behaviour. such as the study by Moksness and Olsen that shows attitudes and social norms as predictor for publishing open access (Moksness & Olsen, 2017). Other surveys showed that external factors like a researcher's institution or their personality influence the adoption of sharing one's research data openly (Kim & Nah, 2018; Kim & Stanton, 2016; Linek, Fecher, Friesike, & Hebing, 2017). Moreover, researchers define "openness" in different ways, which influence their practices (Levin, Leonelli, Weckowska, Castle, & Dupré, 2016), specifically in relation to their research impact in society and good research practices guaranteeing research quality (Grubb, Easterbrook, & Biondi-Zoccai, 2011). However, some other studies show that some researchers are still sceptical of sharing their data (Blahous et al., 2015). One reason for this might be the lack of incentives and resources, as well as a not so well stablished reputation for the use of open data. A recent survey showed that attitudes differ with regard to how open peer reviewing should be handled (Ross-Hellauer, Deppe, & Schmidt, 2017) – for example some researchers prefer an open process where reviews are accessible immediately, others want reviews to be accessible after paper acceptance. Another positive influencing factor of adopting open science practices seems to be open science policies (Levin et al., 2016), framed for example by research funders and journal publishers that now want researchers to share their data. Despite diverse attitude and recent practices among researchers with regard to open practices, most researchers show

a positive attitude towards the goals of open science as the study of Kramer and Bosman (Kramer & Bosman, 2016) showed, where over 80 percent of the respondents agreed to the goals of open science.

Aspects of Open Education

Open education shall decrease learning inequalities and support lifelong learning (Blessinger & Bliss, 2016a; UNESCO, 2012). A core element of open education is open educational resources (OER). There is a common understanding of the nature of open educational resources – although there might be some disagreement on best practices and types of licensing to adopt. OER are educational resources and materials that users are able to retain, reuse, revise, remix and redistribute (Wiley, Bliss, & McEwen, 2014). OER include all kinds of educational resources, including learning material, tools and software. "Access is fundamental to open education. [However] Open education goes beyond access" (Blessinger & Bliss, 2016a, pp. 13–14), practices need to include "the construction of new pedagogies and learning activities" (Kaatrakoski, Littlejohn, & Hood, 2016). Increasing the use of OER and at the same time adapting open pedagogies leads to an increase in open educational practices (Albion, Jones, Jones, & Campbell, 2017; Ehlers & Stracke, 2012) and fosters open education. Cronin (Cronin, 2017) expands this definition: "OEP …[are] collaborative practices that include the creation, use, and reuse of OER, as well as pedagogical practices employing participatory technologies and social networks for interaction, peer-learning, knowledge creation, and empowerment of learners." Similarly to discussion on OER and aspects of open practices, our study asked about the use and creation of OER and additional open practices referring to derived scenarios in science and education.

Studies on open education practices focus on applying OER (Bossu, Brown, & Bull, 2013; Boston Consulting Group, 2013a) or open textbooks (Seaman & Seaman, 2018), or discuss any influencing factors like policies and their potential to foster OER use and creation (Bossu & Stagg, 2018; Cox & Trotter, 2016). Researchers see potential in current initiatives, but see a need for improvements (Stagg & Bossu, 2016; Udas, Partridge, & Stagg, 2016). Kaatrakoski, Littlejohn and Hood (2016) still see tensions in practices between individual's needs and institutional policies, educators' amount of teaching responsibility and institutional accountability, and cost efficiency and learning objectives. In her qualitative study, Cronin describes four levels which educators can be distinguished with regard to their open practices: macro (will I share openly?), meso (who will I share with?), micro (who will I share as), and nano (will I share this) (Cronin, 2017). Cronin states that educators are influenced in adopting open practices by diverse factors such as the use and creation of OER that has a positive influence (compare (Wiley, 2015)). Reversely, open practices like networking foster the awareness or OER (Cronin, 2017).

Stagg (2014) discusses not only open educational resources use, but practices like enabling an open environment for students (discussion options, options to share ideas and one's work), and formal credit, meaning that students' open behaviour find its way into the formal assessment process. With regard to open pedagogies, research discusses concepts of research-oriented learning, with forms of openness referring levels of student autonomy (Brew, 2013; Heck & Heudorfer, 2018). In this study, our understanding of practices refers to activities, behaviours and attitudes of teachers that contribute to more or less open learning and teaching environments, similar to prior discussions (Stagg, 2014; Väänänen & Peltonen, 2016), with the aim to get first insights into teachers' practices and their levels of openness.

Adopting Open Practices in Teaching and Learning

There seems to be several commonalities between open practices in science and in education. One of these similarities is presented by Väänänen and Peltonen (2016) who draw a connection between the concept of openness in research, learning and teaching in higher education. In higher education where research and learning meets, an open environment including access to research and OER, fosters open science. Moreover, the authors state that fostering competitive research "while preserving accessible and shared materials and knowledge is essential to OER" (Väänänen & Peltonen, 2016). So, the higher education field seems to be an environment where open science and open educational practices can meet on shared commonalities of the concept of openness. More explicitly, open science and open education are related through their actors such as researchers in higher education, who not only do research, but teaching as well. The current version of the open science training book ("Open Science Training Handbook") summarises this fact: "In many cases open educational resources are built upon research findings. If you are an Open Science practitioner it makes sense that your educational resources maintain the level of openness of your research".

Figure 1 was developed to show some key components of openness in open science that overlap with open educational practices scenarios. Moreover, those aspects could also be related to research and education practices more broadly.

One component are tools, i.e. systems and services – mostly digital – that support communication and collaboration in science. Openness in this sense might refer to a tool's accessibility, its costs or its compatibility with other services. Many researchers refer to open source tools and software as services that are accessible, modifiable and have freely (re)-usable code ("Open Science Training Handbook"). Thus, open source research tools

are easy and affordable to use for learning and teaching and can facilitate access to research data and sources for learners.

The second component are activities such as personal behaviour and interactions of researchers like communication and collaboration in research communities. Activities can be visible to all, restricted to specific groups, or closed like blind peer review processes. Adapting those to teaching and learning scenarios, activities can refer to either the behaviour of teachers or the behaviour of learners. Relevant aspects for learners are options to create and share own content, and to discuss with peers.

The third component are resources such as data, books or scientific articles. Scientific resources freely available for everyone, or even openly licensed, is one goal of open science supporters. Similarly, freely available and openly licensed educational resources like open educational resources are the goal of the open education movement. They allow learners fully and non-restricted (no costs, no restricting file formats) access to relevant learning materials. Those three aspects, which are discussed with focus on open science practices in research, and with focus on open resources and pedagogy in education informed our survey.

Fig 1. Open practices relevant for research and education.

Survey on Open Practices

We conducted an online survey to investigate the status openness in higher education based on components of openness in open science that overlap with open educational practices scenarios (Figure 1). We did not ask about any pedagogical designs like research-oriented learning or other concept applied in learning and teaching scenarios, but focused on practical implementations of aspects of open science.

Method

This is an explorative study that aimed at questioning current issues and ideas to implement open science practices in education. The target participants were any academic, professional and researcher with teaching responsibility at German higher education institutions, including universities and universities of applied sciences. As higher education systems and educational roles differ globally, we did not aim at designing this survey to be used internationally. However, we think that the design of the contextual questions (in contract to demographic questions) is adaptable and a comparative study in other countries would be beneficial.

Regarding our study, we aimed at doing a purposive sampling and involving people from current groups and communities that engage in discussions and activities about open science and open education. To reach them we sent the survey to diverse institutional-internal and external mailing lists and via personal contacts. We also included mailing lists that were discipline-based, derived from higher education and higher education didactic communities as well as lists from open science, Science 2.0 and open educational resources communities. Additionally, personal e-mails were sent to presidents and contact persons from those communities, and Twitter was used to disseminate the survey. We collected data anonymously and survey participation was voluntary. Thus, we did not seek approval by an ethics committee. Potential participants were informed about the study, data usage and its goals on the online survey landing page. They were informed that they give consent for their anonymous data being used for scientific purposes when starting the online survey. The survey was online from February 6 to March 3, 2017.

The survey structure and data is openly available (Heck et al., 2017b; Heck et al., 2017a). It includes 20 topical questions which were separated into five major topics: demographics (4 questions), material used in courses (4 questions), open educational

resources awareness, usage and development (6 questions), collaborative tools used in courses (1 question), assessment and participation options (5 questions). The question types differed, with mostly single choice questions, multiple choice where applicable (choice of applied tools), and 5-point-likert scale when participants had to rate the importance of resource characteristics (Fig 2). We offered a comment field when participants clicked the NO-answer and at the end of the survey. As well, participants had the option to add additional answers, e.g. tools they use that we did not list.

Questions on OER regard use and creation of OER and reasons for this behaviour. Data from earlier studies revealed that academics were confused about the proper definition of OER. Some seemed to understand OER as free resources, or only refer to open source software (Seaman & Seaman, 2018). Other studies (Seaman & Seaman, 2018) decided to give a broad explanation of OER, avoiding details to not tempt the participant to claim "awareness". However, there is a danger of having a bias when giving an explanation. We decided not to give an explanation to participants about the definition of OER, but keep this question simple. We assume that either someone knows about OER or not. If they had not heard of the term before, they do not properly use OER (at least not consciously) or create them.

Demographic questions asked about the current professional position, the discipline, birth year and gender. The classification of research disciplines was adapted to general disciplines at German higher education institutions without any sub-classes. The job position classification refers to common positions in Germany: Professor (all with German professor title, includes associate, full and affiliate professors), special education teacher (staff with specific teaching responsibility like teaching literacy skills), academic (staff with research and teaching responsibility), lecturer (with teaching responsibility only), student assistant (supports teaching and research).

We used SPSS (v23) for statistical analysis, and provide descriptive analysis for all variables. We got 360 responses, whereof 210 were completes and 150 incompletes. Results are based on the 210 complete cases. Significance tests (Chi-Square) considering the job position were done with 207 cases, where we left out two student assistants (not representative for group) and one case with an unclear job position. Two researchers analysed and checked open text questions. We show the most relevant results on specific questions in tables and figures below and discuss them in the subsequent section.

Limitations of the Survey

Using self-selective online sampling and a purposive dissemination of the questionnaire (Creswell, 2013) – that is aiming at open educational resources and open science communities in Germany – the results are not representative for German teaching staff at higher education institutions. Compared to German micro census data (Statistisches Bundesamt, 2016), we have a higher percentage of professors, lower percentage of academic staff (usually over 60 %) and slightly higher percentages of special education teachers and lecturers. We have a few more male respondents (55 %), where females should have a percentage of 51 %. In addition, some disciplines are under-represented (Table 1), whereas the Arts and Humanities discipline is overrepresented. Despite this, we think our explorative study gives critical insights into the status of openness in higher education in Germany, with implications for further research in other countries.

Results

Table 1 summarizes the demographic data from 210 cases. The majority of participants was about 40 years old. Please note that this field had to invalid entries. Participants had a multiple choice option for their discipline and some felt to belong to two disciplines,

i.e. *n* is larger than 210 cases. The Art and Humanities group is slightly overrepresented which might be due to the mailing lists where we promoted our survey.

Table 1. Participant demographics.

	#	*n*
Age (as of 2019)		*n* = 208
> 24 years	97 %	
> 40 years	70 %	
> 60 years	13 %	
Gender		
Female	94	*n* = 210
Male	116	
Current position		*n* = 210
Professor	63	
Academic	81	
Lecturer	42	
Spec. Edu. Teacher	21	
Student Assistant	2	
Unknown	1	
Discipline		*n* = 252
Natural Sciences	39	
Arts/Humanities	111	
Economics	51	
Law	4	
Medicine	6	
Technics/Computer Science/Engineering	41	

Table 2. Values for the question on relevant criteria for resources choice.

Criteria	**M**	**SD**
Currency material	1.70	.929
Ease of access	1.89	1.077
Recommendations	2.49	1.191
Expenses for learners	2.58	1.364
Open educational licenses, e.g. CC-BY	2.73	1.343

Figure 2 shows the boxplots for the question on criteria considered for resource choice. The boxplots and the means (Table 2) show that all criteria are important for the participants, with means a rated value less than three (1 = very important). Currency of material and ease of use are the most important criteria for selecting resources for teaching, with also the lowest standard deviation. Open licenses are least important, with a high standard deviation. Table 3 shows the number on open resources use and its creation and sharing. There are no significant differences between the use of open resources and a person's position or discipline, except for the discipline economics where less people than statistically expected use open resources (χ^2 (1) = 4.42, $p < .05$, N = 210). There is a difference regarding gender and open resources usage, female respondents use open educational resources more often (χ^2 (1) = 5.66, $p < .05$, N = 210). 46 out of 94 females use open resources, while only 38 out of 116 males use these resources. Regarding the creation of open resources, there is no significant difference. Here, academics seem to be the most creative, with a number slightly above the statistically expected number and over half of them (21 out of 36 that use open resources) creating open resources.

Table 3. Open educational resources use and creation (n = 207).

Current position	Use educational resources	Create and create open educational resources
Professor		
%	30.2	12.7
n	19	8
Academic		
%	44.4	25.9
n	36	21
Lecturer		
%	35.7	16.7
n	15	7
Spec. Educ. Teacher		
%	57.1	23.8
n	12	5
Natural Sciences		

%	36.8	15.8
n	14	6
Art/Humanities		
%	44.5	24.5
n	49	27
Economics		
%	27.5	13.7
n	14	7
Law		
%	0.0	0.0
n	0	0
Medicine		
%	16.7	0.0
n	1	0
Technics/Computer Science/Engineering		
%	40.0	17.5
n	16	7
Total		
%	39.6	19.8
n	82	41

Fig 2. Boxplots showing criteria for resource choice. Survey question: "What criteria do you consider when choosing your learning resources?", Likert-scale 1 (very important) to 5 (not important at all).

Regarding collaborative tools used in courses, we asked the participants to distinguish if they use tools only for the provision of course resources, only for communication and collaboration between lecturers and students, or for both of the pre-mentioned tasks. Participants had the option to state that they do not use any tool. Distinguishing between usage and non-usage, most participants used two collaborative tools (Fig 3). The tools used most often (Fig 4) are email and institutional learning platforms, both tools are also coming first and second with each other tool combination. They are followed by file-sharing and open tools. However, the top two tools are used twice as much as open tools. For example, open tools like open blogs or forums are used by 70 out of 210 participants (30 %).

Fig 3. Number of collaborative tools used per participants.

Fig 4. Tools used.

There is a tendency that professors and academics use "traditional academic tools" (such as reference management tools) more often than special education teachers and lecturers. Special education teachers and lecturers tend to use non-academic tools like blogs (over 23 % compared to less than 15 % for both academics and professors) and editing tools like Google Docs (over 36 % compared to 26 % for academics). One reason might be that not all lecturers and special education teachers have access to academic tools (e.g., some reference management tools require licenses). Usage numbers for Wikis and open forums are quite similar over all positions and lie between 28-35 % (Wikis) and 27-38 % (open forums).

The top tools used for course resource provision are file sharing tools and institutional learning platforms that are used more than twice as much (both are marked 47 times, 22 %) as other tools) (Fig 5). The top tool for communication and collaboration by far is email, mentioned 102 times (49 %). Institutional learning platforms (50 %) and email (37 %) are also also tools often used for both, provision of resources and communication and collaboration, whereas open tools (15 %) and closed wikis (14 %) follow on third and fourth ranks. We found a tendency that lecturers and special education teachers use tools like blogs and Google Docs more often.

Fig 5. Tools used distinguishing between purposes.

The last part of the survey investigated questions around student participation, sharing and assessment, i.e. aspects mentioned with regard to open educational practices and pedagogy (Table 4). Although academics are the largest group supporting resource sharing, they do not explicitly require it from their students. Contrary, there are exactly twice as many professors who do require in-course sharing than those who only offer sharing options. Require in-course sharing from students was the most popular answer

for all job positions except with academics. We asked if participants assess students sharing, that is if students' grading is dependent on sharing materials. Professors, who require sharing in their teaching more often, also assess students' sharing activities (48 %). Over one-third of special education teachers assess sharing, within the lecturers and academics group it is less than 25 %. In addition, 68 % of the participants stated that they offer opportunities for students to co-create and determine course content (Table 5). The behaviour significantly correlates with the use of OER (χ^2 (1) = 7.07, p < .01, N = 210), although not with its creation.

Participants that opt for student co-creation said that most of the course content is predetermined with options to consider students' interests (50 %) or that the course basics are predetermined, but specific foci are determined together with students (43 %). Only 6 % of the participants opt for a more radical answer stating that course content derives out of discussions and determinations together with students during a running course. Here, special education teachers and lecturers were more likely to choose the latter version, being 13 % and 12 % compared to less than 4 % for academics and professors.

Table 4. Student work and material sharing and assessment (n = 207). Single choice, participants should state on their most commonly situation.

Current position	I do not want to see my students sharing their work with others	I offer options for students to share their work, but I do not explicitly require sharing	My students shall share their work with other students in the class	My students shall share their work with other students from my institution	My students shall share their work with other students as well as with the open online community	I request my students to share their work and consider it for my assessment of each student
Professor						
%	17.5	22.2	44.4	7.9	7.9	48.1
n	11	14	28	5	5	25
Academic						
%	8.6	45.7	32.1	2.5	11.1	23.0

n	7	37	26	2	9	17
Lecturer						
%	9.5	31.0	45.2	7.1	7.1	23.7
n	4	13	19	3	3	9
Spec. Educ. Teacher						
%	14.3	28.6	38.1	9.5	9.5	38.9
n	3	6	8	2	2	7
Total						
%	12.1	33.8	39.1	5.8	9.2	31.9
n	25	70	81	12	19	58

Table 5. Student co-creation in courses (n = 141). Yes/No answer, 2nd question (single choice) answered by 141 participants, who allow co-creation.

Current position	Yes, students are allowed to co-create course content	My course plan is mostly set, but I leave room for my students' interests.	I have a course plan and topics in mind, but determine specific topics and foci together with my students.	I really consider my students' interests. Thus, I determine my course plan and topics together with them after the class has started.
Professor				
%	58.7	54.1	43.2	2.7
n	37	20	16	1
Academic				
%	67.9	52.7	43.6	3.6
n	55	29	24	2
Lecturer				
%	78.6	45.5	42.4	12.1
n	33	15	14	4
Spec. Educ. Teacher				
%	76.2	43.8	43.8	12.5
n	16	7	7	2
Total				
%	68.1	50.4	43.3	6.4
n	141	71	61	9

Discussion

In the following, we discuss the highlight-findings, grouped in 1) open educational resources, 2) tools and activities, and draw upon challenges and opportunities for open

practices.

Open Educational Resources: Awareness and Use

Overall, our findings match the results on open resources use that were reported earlier (Bossu et al., 2013; Boston Consulting Group, 2013b; Seaman & Seaman, 2018). The survey showed that four out of ten respondents (is it 40%) use open resources which is slightly less than found by recent other studies. A recurrent U.S. study shows an increase in the awareness from 34 % in 2014-2015 to 46 % in 2017-2018 (Seaman & Seaman, 2018). This trend indicates a rising awareness among teaching staff in the US. However, our study shows that 60 % of all respondents do not use OER, which is still a high number. Please note that we did not explicitly ask respondents if they use OER or not, but we asked if they were at least aware of them. A survey sent to staff at Australian universities revealed that 60% of the participants were aware of open resources (2013).

Our study shows that there are challenges that might hinder open resources usage: Participants stated that they have not heard of open educational resources (46 %, Table 3), and that there is a lack of material available for their discipline that promotes OER (53 % compared to 49 % in (2017)). Some participants neither see a need nor a benefit to open resources, nor do they assume that they could create open resources on the basis of their teaching material. Others have difficulties in finding resources. In addition, participants commented that they have "no time to go through all the materials". Similarly to other study results (2017), 45 % of the participants criticize that there is no resource catalogue. Those results show that work needs to be done to facilitate an easy way of searching and finding open resources and systems that consider them with regards to the needs of diverse disciplines.

Half of our respondents who know open resources also produce and share them (Table 3). Those that do not produce them find it both too laborious and time-consuming, or they do not know how to do that. This confirms the reasons for not producing open resources as found by (2013), although this applies to less respondents from our sample.

Our answers suggest that the digitality of learning and teaching material, that provides options for easy access and distribution, is considered a more important aspect than openness. This may be an indication that the concept of open resources and the properties belonging to it are not fully understood or not valued equally. As proof for the latter we can look at the drivers behind resource selection. Although 77 % of the respondents know the license which determines a resource's options for reuse, the selection of teaching and learning resources is mainly driven by their currency and ease of access as well as by their relevance for the topic taught and their quality (Fig 2, Table 2). Open licenses, on the other hand, are neglected by the majority of respondents when choosing learning and teaching material. Respondents even stated: "Quality of content is key: whether I have to pay for it or not" and "negligible in as much as students have access".

There is a substantial number of respondents who do not use open resources (60 %) because they are either not aware of them or do not know what they mean, although we have not explicitly asked about the latter. These seem to be common problems faced by the OER movement, as demonstrated by other similar studies (Bossu et al., 2013). This finding is remarkable, though, despite major efforts from a range of stakeholders, national and international, to increase awareness and to provide access to open resources and promote activities via large initiatives. This still remains an considerable issue to be addressed, and perhaps one way to address this problem would be to increase capacity building and training of university teaching staff could.

Open Tools and Activities

It seems that there is a tendency that professors and academics prefer established academic tools such as literature reference tools. Special education teachers and lecturers tend to use non-traditional academic tools such as editing pads or open wikis. One reason may be that the latter group do not have proper access to academic tools, for example because of license restrictions. Despite this tendency, email is still the tool most used (Fig. 4 and 5).

Results may be influenced by how the survey questions were formulated, though. We asked participants to state the current tool usage and did not ask them to state whether they have ever used those tools, whether they just do not know them, or whether they have particular reasons to not use them. It would be interesting to study whether their choice of tools is influenced by external factors – like institutional regulations, restricted options in designing a course – or if participants did test diverse tools in the past and came up with their personal favourites as a matter of best practices that also fit the current educational environment best. More research has to be done considering the teaching staff's opinion on and choice of good teaching practices and use of open technologies and pedagogy, specifically with regard to their specific educational contexts.

We were also interested in which ways teaching staff integrates and fosters open practices in education and what serves as incentives. We assumed that teachers do not feel too comfortable with using the technology (2008) and expected a conflict to occur between openness, collaboration, and assessment in class (2012). Our study reveals similar results regarding the use of tools defined as open Web 2.0 tools. Only 33% do use them. However, over half of the respondents require students to share their works using any kind of digital technology (Table 4). We asked them, in which form students should share

their work. One of ten respondents said they engage students to share work openly on the web.

Brown's (2012) study revealed that some academics have difficulties in finding "an appropriate balance between assessment and student collaboration via Web 2.0" (Brown, 2012, p. 56). Outcomes from our survey reveal not a resistance against open practices in general, but a kind of helplessness in practical applications and handling. Reasons for not using open resources and comments like "I miss further training in this field" or "I would appreciate a better search for open resources and open licenses" show that teaching staff needs more support to adapt to open practices.

Comparing the related studies with our survey results, we also see that to overcome challenges of open practices, different levels of openness must be considered and discussed, for example openness within class, openness within an institutional learning platform, and openness within the web that potentially reaches the entire public. This differentiation seems to be reasonable in order to introduce open practices, to respect institutional and social requirements and to increase chances that open practices will be applied. This, however, also shows that, further infrastructures and support are needed to enable full embracement of openness.

Opening up science comes with similar difficulties. Practicality concerns may hinder research to fully adopt open practices. As well do external requirements (like publishing in non-open-access Q1-journals) and concerns of research impact – although open access publication do get more citations (Piwowar et al., 2018). If teaching and learning becomes more open and offers ways for students to access content, to participate and to co-create, this fosters a way towards openness in research, i.e. research that opens its community for students and is able to raise awareness of those critical issues beyond internal borders. Our study shows a relation between the use of OER and supporting student co-creation.

Here, positive synergies can be used. Raising OER awareness, specifically via improving search, findability and accessibility with proper infrastructures, can support open educational practices and open science.

In addition, to adopt open practices strong incentives are needed, which confirms the results of Brown's study (2012). One participant stated: "Potential of open educational resources is overestimated. Students are busy and just want to pass the course." Academics are especially keen about sharing the works of students. The main reason for this seems to be that due to academics wanting to prepare students for a future academic and professional career that increasingly entails aspects of open science and surely requires knowledge about open practices. However, the statement also reveals some disappointment about the clash of good intentions and their practical implementation. Hence, almost 30 % of the teaching staff uses grades to incentivize sharing and along with it open practices among students, like co-creation of course content.

Regarding the latter aspects through an openness lens, we also must distinguish between levels of collaboration regarding diverse study and course forms. To teach courses with a high openness, like high levels of co-creation and communication options, might overstrain early semester students, whereas more experienced students in their Masters can benefit from those. Survey participants stated that the level of student experiences and skills influence their practices.

Challenges and Opportunities for Openness in Higher Education

Our survey did not explicitly ask what kind of support or infrastructures teaching staff needs to facilitate open practices. However, the explanations on why participants are reluctant towards open practices revealed fundamental issues in this regard. A majority

of participants lack the knowledge to include open practices and are willing to seek for assistance: “I need more help in this area: What is available? How to do it?” This finding confirms earlier recommendations to offer training to teaching staff so that they can master the technology needed in future(2008). Although there are larger service-like projects that collect and share information about OER and open practices and offer practical support, like FOSTER (fosteropenscience.eu) and OERInfo (open-educational-resources.de) to name only two for the European and German region, it seems that educators lack awareness of those offerings. Many services and infrastructures are established by now, or are in the developing phase, and proper communication about those is needed. In contrast, research shows that personality and external factors influence the adoption of open practices in science (Kim & Stanton, 2016; Linek et al., 2017) and education (Bossu & Stagg, 2018) and that we need to find out more about those constraints.

In addition, open practices literacy has to be improved, i.e. literacy on the current state of open resources and open pedagogies (compare Ehlers and Stracke [Ehlers & Stracke, 2012]). We may even assume that as soon as open practices are mediated in the most natural way the learners will take them as a matter of course and will fully embrace them. This is a major point that will help fostering open practices: Taking away personal and practical boundaries for future researchers is essential to make open science a default.

Technical support and easy to use infrastructures are needed to support open practices. Concrete demands were formulated from our survey participants: “Filter for CC licenses and open resources in library systems are needed”. Here, one important fact became apparent again: local support and infrastructures such as libraries (Bueno-de-la-Fuente, Robertson, & Boon, 2012) are the major facilitators and drivers of OER. They can provide

the fruitful ground and incentives (such as open practice awards) that teaching staff needs for adopting OER and additional open educational practices.

Based on our understanding of open practices and their implementation in the education environment, we think those practices can foster further openness in science and research (Table 6). Offering students opportunities via open educational practices raises their awareness of future open science goals and teaches them the skills needed to become a researcher that successfully conducts open science in the future.

Table 6. Open Educational Practices to foster Open Science

Open Educational Practices	**Contribution to Open Science**
	Awareness of and skill development for…
Use and create open educational resources	…open access publishing of research outcomes
Use of open tools for sharing resources	…tools and techniques to share research like data and methods
Options for open communication and collaboration	…open research communication, like open peer review
Options for co-creation	…research community and research method practices

Our survey built on our understanding of open practice and gives first insights on the status of those practices in Germany. Although we cannot generalize our findings, we showed how a broader view on open educational practices might look like and which implications might be possible. More research has to be done to understand the context and influence of different education environments (like higher education, vocational education) and country-dependent regulations (like open resources policies, copyright laws).

Although not focus of our study, we would like to make the point that where the interrelation and potential fruitful coaction between research and education become

obvious. Pedagogical concepts of research-oriented learning focus on students as researchers and teaching research skills (Brew, 2013). “Learning through research” aims at letting students participate and engage in a research process. They need the opportunity to formulate research questions and co-design and reflect on research aspects (Reinmann, 2016). Aspects like student engagement and participation discussed within concepts of research-oriented learning are similar to those discussed within open science and education and would easily complement each other (Heck & Heudorfer, 2018). The open education concept emphasizes the importance of students being allowed to actively participate in the scientific community to understand what research is about and to apply this knowledge in their studies. “Indeed, one of the goals of open education is to move learners closer to the centre of a community of practice, specifically through providing opportunities and infrastructure for participation and collaboration” (Blessinger & Bliss, 2016b, p. 14). Brown (2012) emphasizes the high potential to build a bridge between teaching and current research, it allows students to become a member of a “knowledge creating collective” (Brown, 2012, p. 56), where they benefit from and contribute to the research community.

Conclusion

We discussed the interrelatedness between open practices in education and science and claimed that open science need to be fostered by educational practices that refer to goals in open science. We conducted an online survey to shed light on the status of those practices in German higher education institutions.

Our results point out that open practices have not yet been fully achieved in higher education. Open resources are not popular, and prevailing email as a digital teaching tool does not contribute to open practices that foster a community awareness and belonging.

Respondents undertake activities related to openness like encourage students to share their content and be co-creators of resources, but those activities are not common place. Here, we still see challenges in bringing open practices and existing higher education practices together. However, independently from our aim to relate practices in science and education, we need to investigate what benefits and learning outcomes open practices in context of science and education will have. In addition, answers showed that teaching is very diverse and has different needs depending on the form and discipline of teaching. Further research should investigate as to how far open practices can be integrated in different scenarios and environments and what support educators require.

Regarding our survey results that show the current state of practices in German higher education institutions, further research has to be done to better understand the motivations and attitudes of lecturers (Weller, 2014), specifically those that practices teaching and research and are able to bridge both fields. In addition, we need to investigate benefits of open practices with regard to pedagogical aims as well as aims intended in the open science movement. This again is an argument to investigate further open practices in relation to research and education.

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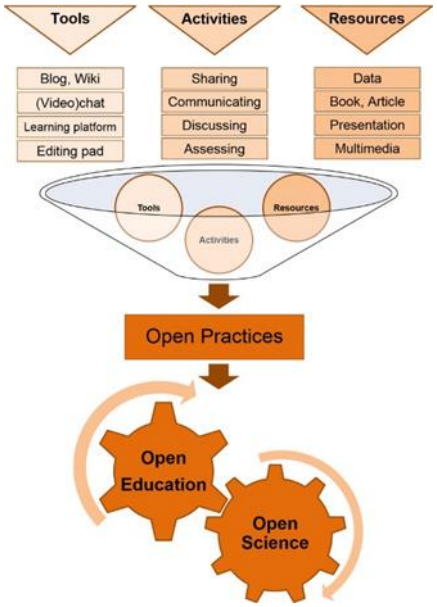

Figure 1. . Open practices relevant for science and education.

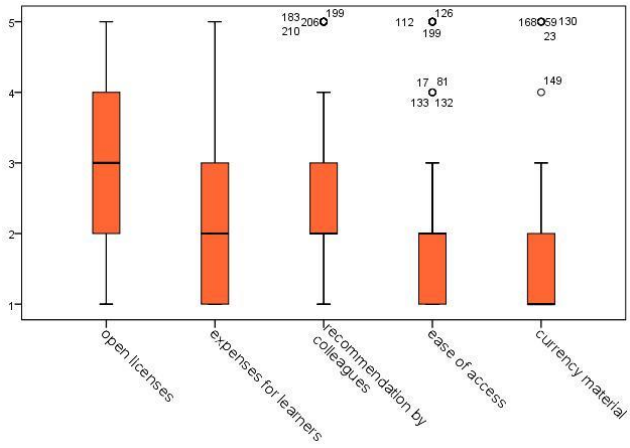

Figure 2. Boxplots showing criteria for resource choice: "What criteria do you consider when choosing your learning resources?", Likert-scale 1 (very important) to 5 (not important at all).

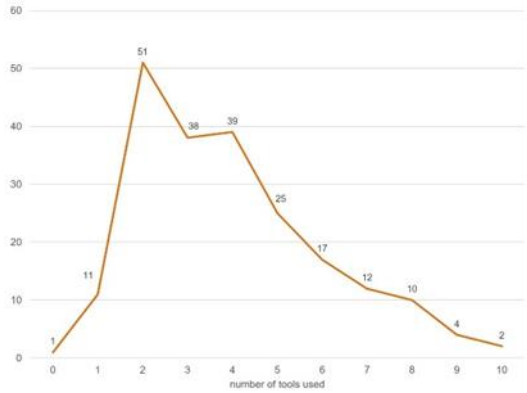

Figure 3. Number of collaborative tools used per participants.

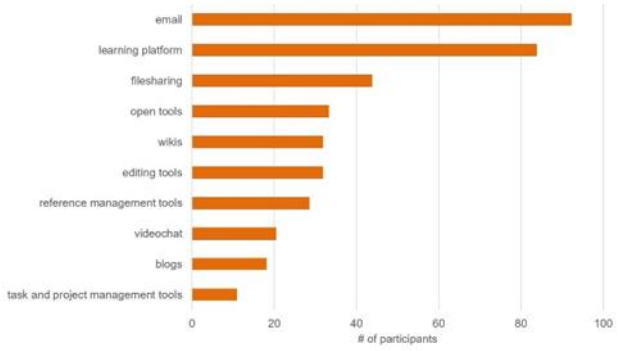

Figure 4. Tools used.

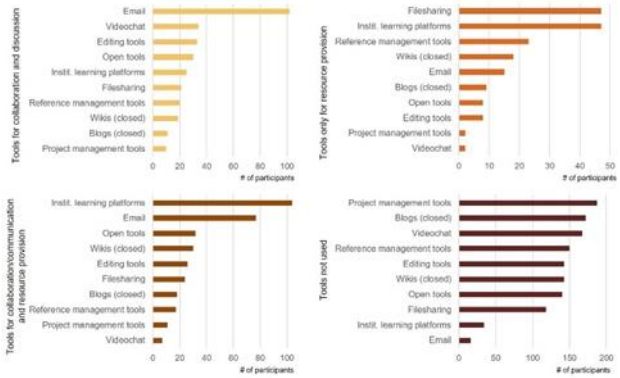

Figure 5. Tools used distinguishing between purposes.