D5.1 - RECOMMENDATIONS TO ENHANCE SWAFS AND OPEN SCIENCE ACROSS ARQUS WPs AND FOR INNOVATIVE RESEARCH IMPACT ASSESSMENT

December 2022

Work Package: 5 – Open Science Agenda

Arqus Research & Innovation Project
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1. Introduction to the report

This report represents the first deliverable of Work Package 5 (WP5) "Open Science Agenda'' from the Arqus Research and Innovation project (Arqus R.I.). It thus refers to Open Science implementation processes in Arqus European University Alliance (Arqus Alliance) and is an official Arqus Alliance document. The target groups of the recommendations included are on the one hand the Arqus Alliance and the partner universities, because they are required to provide adequate conditions, support, rewards and infrastructures for practising Open Science, and on the other hand the researchers, who face an increasing number of requirements regarding Open Science and are main drivers of the current changes in the research system.

The report starts with an introduction on the topic of Open Science (chapter 2) and the work of WP5 (chapter 3). The targeted recommendations are based on three pillars - current situation on Open Science at Arqus Universities, literature on the topic and an Arqus-wide questionnaire among researchers - which are presented in chapter 3.2. These pillars inspired the proposed actions in this report that would make Open Science more practicable for researchers and promote the Open Science movement. For this, three main challenging fields were identified and overarching recommendations formulated (chapter 4), which are followed by concrete measures for action.

Open Science is a complex process and none of the above recommendations can be tackled in isolation. In the concluding reflections (chapter 5), the relevance of the holistic view and treatment of Open Science is emphasised and provides approaches for further problem fields that require closer examination.
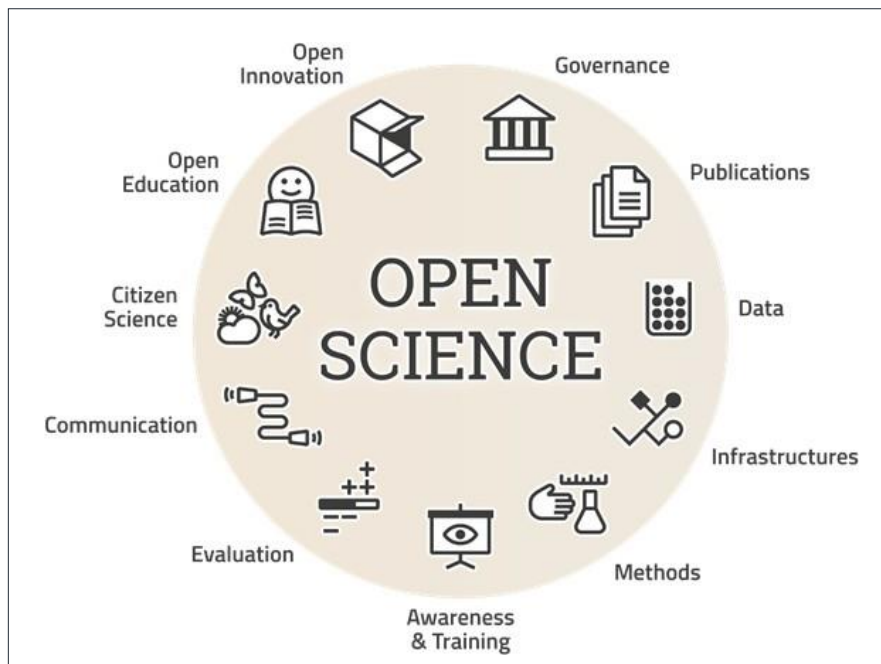
2. Open Science

Since the digital transformation rapidly changes the way researchers practise science, transparency, (interdisciplinary) cooperation and a new understanding of research integrity become increasingly important. This affects the research system itself and furthermore the relationship between science and society which is mainly based on trustworthiness, knowledge and technology transfer and participation. Open Science has the potential to increase both trust in science and the impact of science on society as well as to foster co-creation, knowledge transfer and innovation. As a consequence, researchers and research institutions are faced with an increasing amount of challenges, requirements and obstacles, but also with great values and benefits, if the framework conditions are implemented in a sufficient and effective way.

To foster the Open Science transformation, the Arqus Alliance commits to guiding principles and joint implementation activities in an Openness Position Paper (OPP) in early 2022. This document follows international and especially European positions on Open Science, above all the UNESCO Recommendations on Open Science. In the OPP, Open Science is defined as "a set of good practices, principles and goals that aims to reduce barriers in all aspects of the research process for the benefit of research and society. It encompasses transparency, accessibility, reproducibility, comprehensibility, trustworthiness, participation and inclusiveness in all parts of the research process."

In that sense, Open Science is described as an integral part of research integrity and ethics, joint research and innovation activities and a driver of societal changes. It has a positive impact on research quality and aims to share knowledge, enhance trustworthiness and increase cooperation between scientific disciplines as well as with citizens, industry and public authorities. This development is based on the

comprehension of research as a common good and on the insight that research data and results should be findable, accessible, interoperable and reusable (FAIR). Both - researchers and research institutions - are invited to take their responsibility in this transformation seriously.

In the OPP the partner universities acknowledged openness as a fundamental value which implies the advancement of institutional transition towards Open Science from a strategic, practical, cultural and financial perspective. This includes activities in all Open Science sections:

Graphic 1: Elements of Open Science
Source: Kaier, C., Walter, H. (2022): Arqus Openness Position Paper, p. 8

Open Science as a cross-cutting topic is also included in joint research activities and as a guiding principle in the joint mission statement of the Arqus Alliance. To reach these goals Arqus universities aim to raise synergies, share knowledge and experiences as well as support and infrastructures, like consulting, training and IT-infrastructures for a joint Open Science approach.

Excursus: Where is SwafS (Science with and for Society)?

Open Science strives, among others, to share knowledge, increase societal engagement in research, enhance trustworthiness and raise interdisciplinary cooperation with citizens, industry and public authorities. The goal of strengthening the interactions between science and society in research, was first expressed by the European Commission in their working paper "Science, Society and the Citizen in Europe" in 2000. Since then, the goals and orientation have been adapted accordingly to the knowledge and experience gained in new programmes, and with them also the terms have changed.

In the Horizon 2020 programme, SwafS was integrated as a separate and essential call with its main goals to foster "effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility." The follow-up program, Horizon Europe, no longer includes SwafS in an explicit way but as part of the idea of "Strengthening the European Research Area" - "Reforming and Enhancing the European RI System." The goals contain "accelerating the transition towards Open Science, engaging and involving citizens and civil society organisations in co-designing and co-creating responsible research and innovation agenda and content, facilitating

participation by citizens and civil society organisations in its activities and promoting gender equality and strengthening the gender dimension."

By considering this evolution of SwafS as an integral part of all Research and Innovation projects, WP5 decides to follow the EU commission`s realignment and integrate SwafS in the following way:

- Considering society as a stakeholder and target group of Open Science activities
- Engaging researchers by regarding research as a common good and consequently communicating research results in a proper way to the public
- Fostering Citizen Science and knowledge transfer activities as an integral part of Open Science
- Indicating researchers on the meaning of research results for society by considering important Open Science activities for society in the survey
- Thematically focusing on Green Deal/Climate Change and Artificial Intelligence in Arqus RI as a reaction on societal needs

3. Work Package 5: Open Science Agenda

WP5 is one of the six operational Work Packages of Arqus R.I. and aims to enable and facilitate the transition of Arqus universities to Open Science to intensify joint research and foster excellence, openness, transparency and effective engagement with and for society. In supporting this long-term process, the work of WP5 is primarily aimed at researchers and research institutions. The goal is to increase Open Science awareness among them and support researchers in acquiring knowledge and skills to open up their work and research in a responsible way. For this, the needs and obstacles in the practice of Open Science have to be explored and addressed and information and training materials tailored to researchers have to be developed. In addition, a pool of experts will be installed that can serve as a source of best practice and support, especially with a thematic focus on AI/digitization and climate change/Green Deal.

Thus, WP5 together with WP6 takes up the challenge "to open up to society" and focuses on the cultural change regarding opening up research processes. Furthermore, Open Science is a cross-cutting topic and runs through practically all Work Packages of Arqus RI. Sharing experiences regarding Open Science among all Arqus partners will also significantly enhance the second funding period of the Arqus Alliance.

3.1 Goals and deliverables

WP5 includes four goals:

Goal 1: Coordinating Open Science in Arqus as a cross-cutting topic with other WPs for a joint approach concerning values, criteria and open source infrastructure.

Goal 2: Analysing Open Science skills implications for alternative assessment approaches (in coordination with WP3).

Goal 3: Identifying experts and establishing a joint expert network of Open Science practitioners within the Arqus Alliance (e.g. for the topic areas "Green Deal/Climate Change" and "AI/Digital Transformation") and maintaining them as a joint "Open Science Ambassador Network".

Goal 4: Developing shared materials for open science training to foster open innovation targeting the topic areas "Climate Change" and "AI/digitization".

To achieve these goals, three deliverables were formulated, whereby this report represents the work and results of the first deliverable:

D 5.1 *Recommendations to enhance SwafS and Open Science across Arqus WPs and for innovative research impact assessment*

D 5.2 Network of Open Science Ambassadors relating to "Green Deal/Climate Change" and "AI/Digital Transformation"

D 5.3 Provision of Open Science training materials with emphasis on "Green Deal/Climate Change" and "AI/Digital Transformation"

3.2 Work approach and description of process

The work approach of WP5 is based on the insights of the Arqus OPP, which aims to realise a commitment on fostering Open Science within the Arqus Alliance and show possibilities on how to support and implement Open Science infrastructures at universities. Since the recommendations in the OPP are related to all Open Science elements and show numerous possible activities that promote Open Science implementation, this report aims to specify those proposals with a particular focus on the needs of researchers and potential synergies of Arqus partners.

During the work progress, on average, two staff members per university of the Arqus Alliance (until June 2022 including Bergen, but without the new partners Wroclaw and Minho, that joined by the end of 2022), were involved in the elaboration. In order to develop useful and targeted recommendations for the further development of Open Science in the Arqus Alliance, three work processes were undertaken to form the basis of the recommendations:

1. a review of existing policy situation, facilities and support at Arqus universities on Open Science,
2. an analysis of existing literature on the topic, starting with the Arqus OPP,
3. an Alliance-wide survey among researchers on their experience, needs and opinions on obstacles related to Open Science.

3.2.1 Open Science Status Quo at Arqus Universities

In order to get a detailed overview of the current situation at the individual partner universities regarding Open Science policy situation, facilities and support, the status quo was captured by updating a chart that was first filled in by the project partners as part of the Arqus project in 2019/20. A complete list of the raised questions are added in the appendix. The individual member universities were asked to gather information on selected topics such as:

- Existence of a national or institutional Open Science policy
- Open Science as an element of Good Scientific Practice at the respective university
- Recognition of Open Science practices in research assessment
- Availability of Open Science training for researchers
- Support for Science Communication, Citizen Science and Stakeholder Engagement initiatives

The answers indicate that Open Science support and recognition has been implemented in different ways at all of the Arqus universities, but mainly for particular sections. On the policy level all partners provide guidelines for good scientific practice, research data and publication policies. Guidelines or policies that cover all Open Science sections are not completely common in all Arqus member states, even if national Open Science strategies have been adopted in Austria, France, Italy and Spain with different granularities and commitments.

Most universities indicate that they have established dedicated Open Science support for their researchers (Open Science offices, training opportunities, etc). Counselling and training in Open Data and Open Publications are the best-established support offers. Most universities also provide publication and data repositories. Open Education is partly covered too, by training, counselling and infrastructural offers, mostly on platforms like Moodle. What is still missing is a well-developed support for Citizen Science activities at Arqus universities. Thus, Science Communication is at some universities not supported by institutional or generic counselling or training, but by discipline-specific and individual ones.

In most cases, Open Science activities are currently not rewarded nor considered as a part of institutional research assessment, despite Open Access publications being displayed and monitored at most universities. Only in Spain, France and Austria Open Science activities are partly considered as job, promotion or tenure criteria as integral part of the national Open Science strategy. Institutional Funding is only provided for Open Access publication fees, but not for Open Data or other dissemination activities.

To summarise: Open Science is considered and discussed in all Arqus universities but has so far been implemented only gradually, with different emphases on Open Science sections and levels of support. Most universities rate Open Science as a strategic topic for research and innovation transition. Counselling, training and IT-infrastructure and partly funding for Open Access publications were offered by almost all Arqus universities. Nevertheless, the amount of Open Access publications and data could be easily measured quantitatively and made available for use within the respective research assessment system. All other Open Science sections are only supported to a minor extent or not at all Arqus universities on an institutional level. It is notable that the Arqus partner universities in Granada and Lyon, being subject to respective national strategies, provide the most comprehensive support and guidance for most Open Science sections.

3.2.2 Open Science Literature

To get in touch with the most familiar recommendations and obstacles to enhance and practise Open Science from a broader perspective, WP5 members chose and analysed respective publications, mainly (position) papers from the European Commission and publications from Open Science related projects. In this report, the results of this literature review will be combined with the researcher's perspective in the survey results to support the recommendations with insights from discipline-specific and international perspectives. Furthermore, it was essential to read all Arqus strategy papers and publications that are related to Open Science to integrate and sort their results into the current report and the other way round. Thematically, the literature review focused mainly on values of Open Science, difficulties in implementing support and infrastructures and behavioural change regarding the transformation of research. In addition to the Arqus OPP, the following publications were central:

- UNESCO (2021): Recommendations on Open Science. November 2021.
- European Commission (2021): European Research Area Policy Agenda – Overview of actions for the period 2022-24.

To make a further selection from the already large supply of literature on the topic, those publications were dealt with that are (with one exception) not older than five years, because these reflect current developments and incorporate former ideas and reflections on Open Science. Furthermore the literature selection treat the following questions:

- Which recommendations could be given to implement Open Science within the research system (research institutions, science system/researchers, science and society)?
- Which obstacles could hamper practising Open Science (science to science and science to society)?
- Which Open Science-activities are researchers doing/could researchers do?
- Which skills do researchers need to practise Open Science and how could research institutions support them to do so? How will these skills promote alternative research assessment?

A comprehensive list of the literature discussed, implemented in the current report and for further reading can be found at the end of this report (chapter 6: Bibliography).

3.2.3 Survey among Researchers

During the initial work in WP5, an essential gap in the development of Open Science at universities became obvious: the involvement of scientists and researchers as well as their needs and obstacles in the process. Therefore, a questionnaire was developed with the aim of asking researchers about their current experiences with Open Science activities, their assessment of possible obstacles as well as needs and suggestions to make it easier to practise Open Science. Central to this was the initial question of what Open Science activities researchers are actually practising. A collection of activities was made through internal questioning and by consulting literature.

The questionnaire, which was created with *LimeSurvey*, was consciously kept short in order to encourage as many researchers as possible to participate. The 15 questions are divided into the following topics: Open Science Activities, Open Science Enhancement and Open Science Support, plus personal data. A detailed list of the questions can be found at the end of the report as an appendix. Answers were provided both as multiple choice and free text options. The evaluation of the quantitative results was done by using R and SPSS, the qualitative results were evaluated by using Python and implementing Latent Dirichlet Allocation (LDA) Topic modelling. Detailed reading and analysing the narratives was also essential to get a better picture on researchers' attitudes concerning Open Science practices and their societal impact.

The members of WP5 spread the questionnaire within their respective universities. Depending on the individual procedure, it was sent via email distribution lists, newsletters and research networks. Participation was possible within eight weeks between June 20, 2022 and August 15, 2022. 865 researchers took part in the survey, with 547 fully completing the questionnaire.

3.2.3.1 Main Results
General information:

Most participants in the survey were researchers from the Natural Sciences (32%), followed by the Social Sciences (23%) and Engineering and Technology (18%). With nearly 50%, the largest group of participants was professors, followed by PhD-students (11%). Further groups of participants, like PostDocs and senior scientists, are represented in a similar quantity (around 9%). The number of participants differs much from university to university. The most important contributors by numbers of participants are the Universities of Padua and Granada.
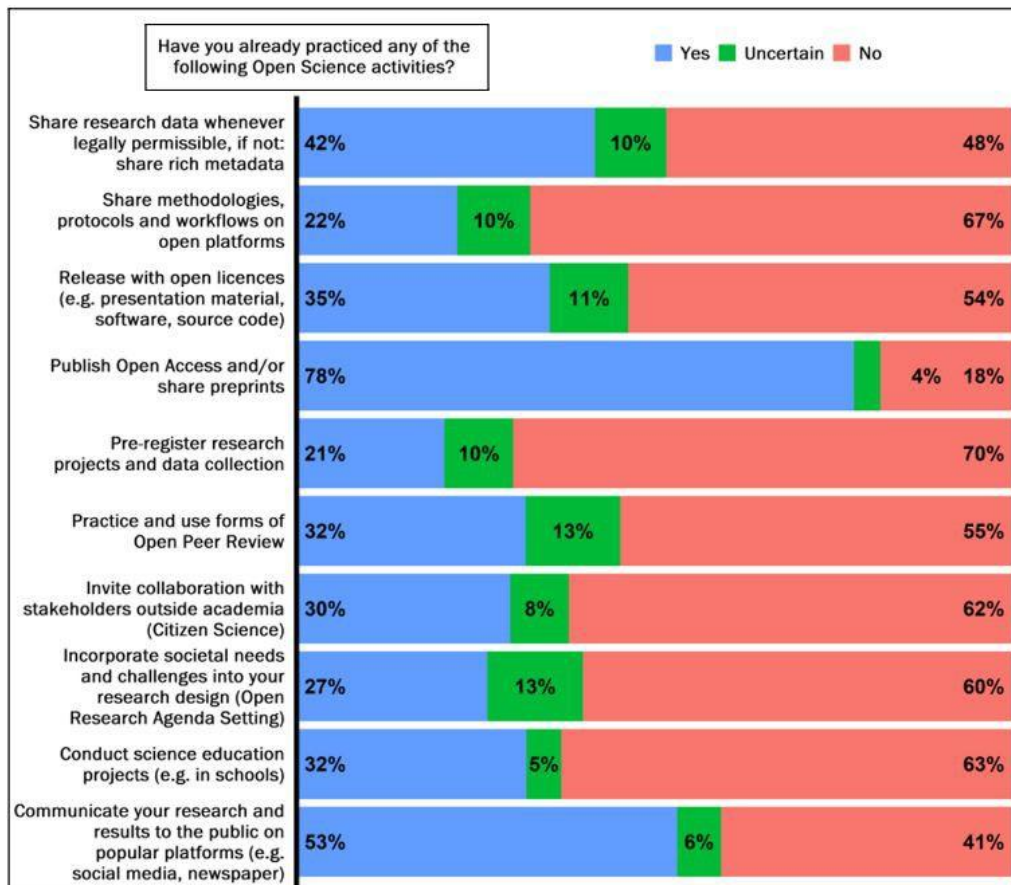
Open Science Activities:

Almost two-thirds of the respondents stated that they already practised Open Science. Around 40% practise Open Science regularly or whenever they can. 24% practise Open Science frequently, while almost 17% never or just once did so. 5.5% abstained from answering.

From the researchers' perspective, the most important Open Science activities for their scientific career are (see graphic 2 below): *Publish Open Access and/or share preprints* (73%), followed by *Communicate your research and results to the public on popular platforms (e.g. social media, newspaper)* with 31% and with 29% *Share research data whenever legally permissible, if not: share rich metadata*, as well as with 25%: *Release with open licences (e.g. presentation material, software, source code)* [triple answer possible].
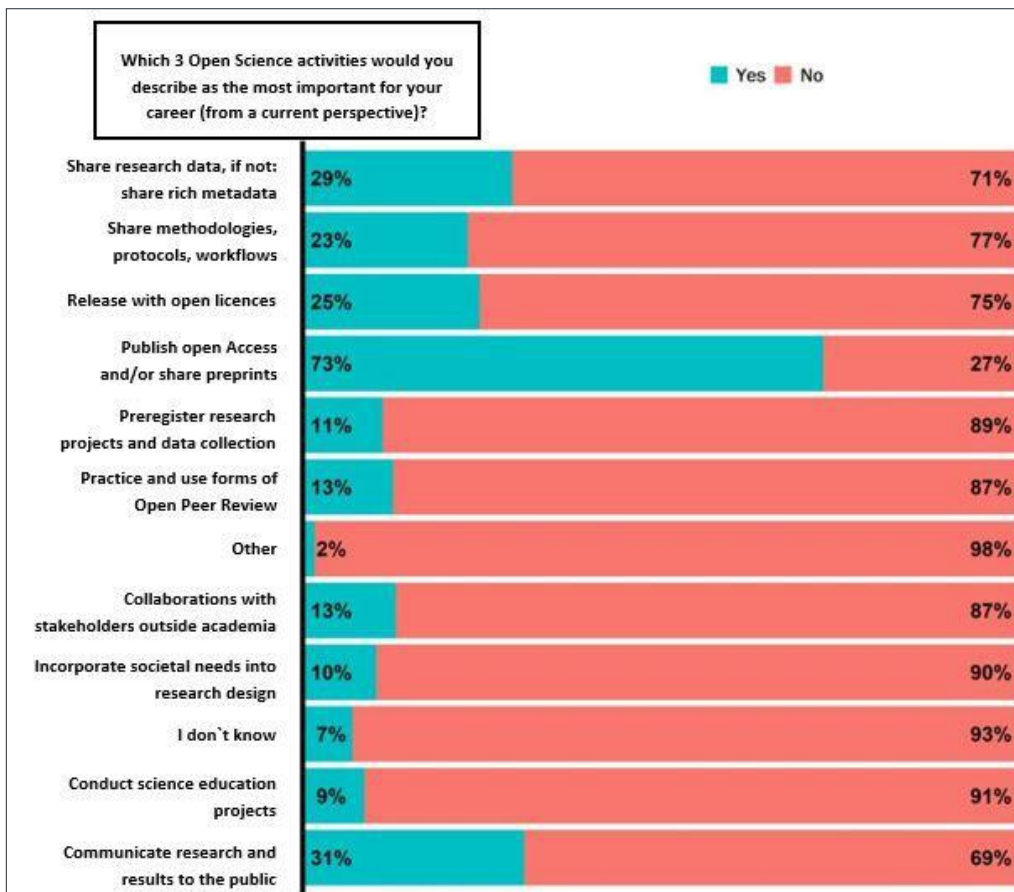
Graphic 2: Survey Question Which 3 Open Science activities would you describe as the most important foryour career? [up to three tickle possible]; Source: own generation

These statements are also reflected in the results of the question about the activities practised (see graphic 3). Accordingly, the three most practised Open Science activities, that are most important for the current career of researchers, are: *Publish Open Access and/or Share preprints* (78%), *Communicate your research and results to the public on popular platforms (e.g. social media, newspaper)* (53%) and *Share research data whenever legally permissible, if not: share rich metadata* (42%) [triple answer possible]. Since these three activities were either rewarded in research assessment (funding and publication requirements, policies, good scientific practice) or are related to a minimum of financial effort (social media are usually free of charge) and generate attention, it can be concluded that the willingness on practising Open Science is strongly related to rewards and incentives.

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Have you already practiced any of the following Open Science activities?	Yes	Uncertain	No
Share research data whenever legally permissible, if not: share rich metadata	42%	10%	48%
Share methodologies, protocols and workflows on open platforms	22%	10%	67%
Release with open licences (e.g. presentation material, software, source code)	35%	11%	54%
Publish Open Access and/or share preprints	78%	4%	18%
Pre-register research projects and data collection	21%	10%	70%
Practice and use forms of Open Peer Review	32%	13%	55%
Invite collaboration with stakeholders outside academia (Citizen Science)	30%	8%	62%
Incorporate societal needs and challenges into your research design (Open Research Agenda Setting)	27%	13%	60%
Conduct science education projects (e.g. in schools)	32%	5%	63%
Communicate your research and results to the public on popular platforms (e.g. social media, newspaper)	53%	6%	41%

Graphic 3: Survey Question Have you already practised any of the following Open Science Activities?
Source: own generation

Publish Open Access and/or share preprints are also ticked by 47% of the participants, making them the second most important Open Science activity for society (see graphic 4). According to researchers, the only activity that is slightly more important is *Communicate your research and results to the public on popular platforms (e.g. social media, newspaper)* (48%). In third and fourth place are *Communicate your research and results to the public on popular platforms (e.g. social media, newspaper)* (43%) and *Invite collaboration with stakeholders outside academia (Citizen Science)* (34%) [triple answer possible; note: in this question, the answer option *Incorporate societal needs and challenges into your research design (Open Research Agenda Setting)* has been removed].
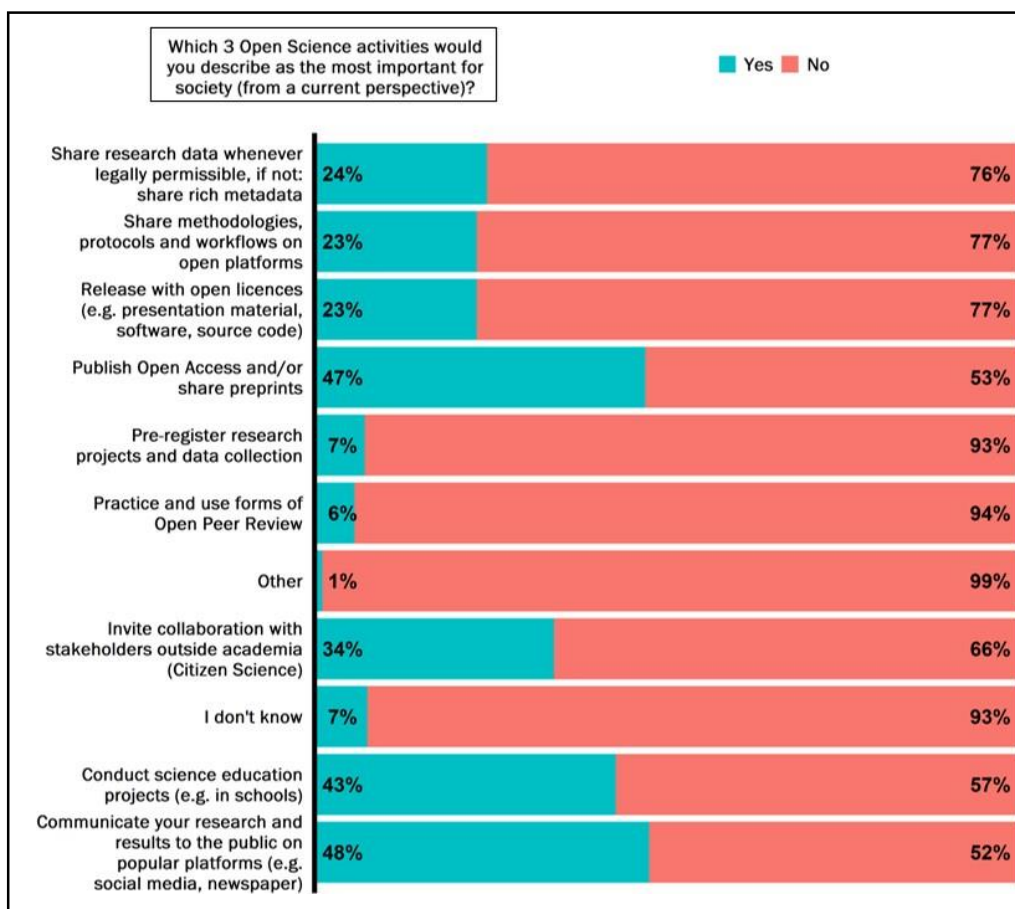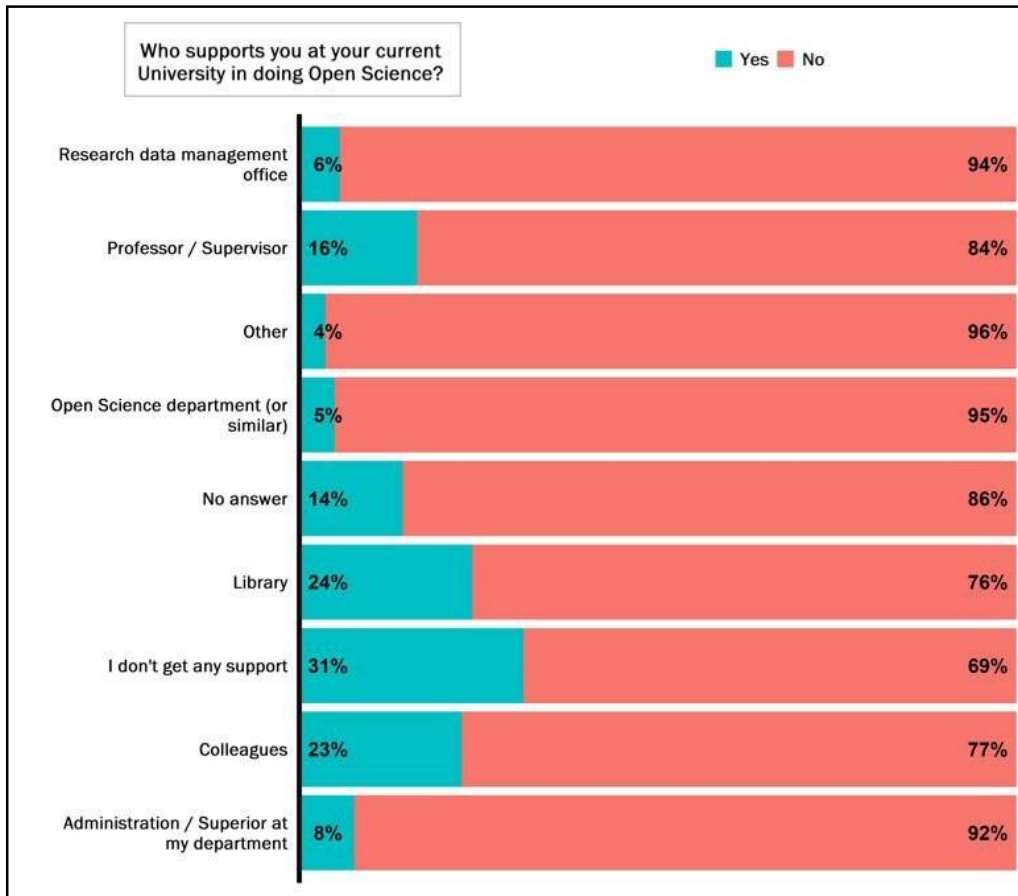
Graphic 4: Survey Question Which 3 Open Science activities would you describe as the most important for your society? [up to three tickle possible]; Source: own generation
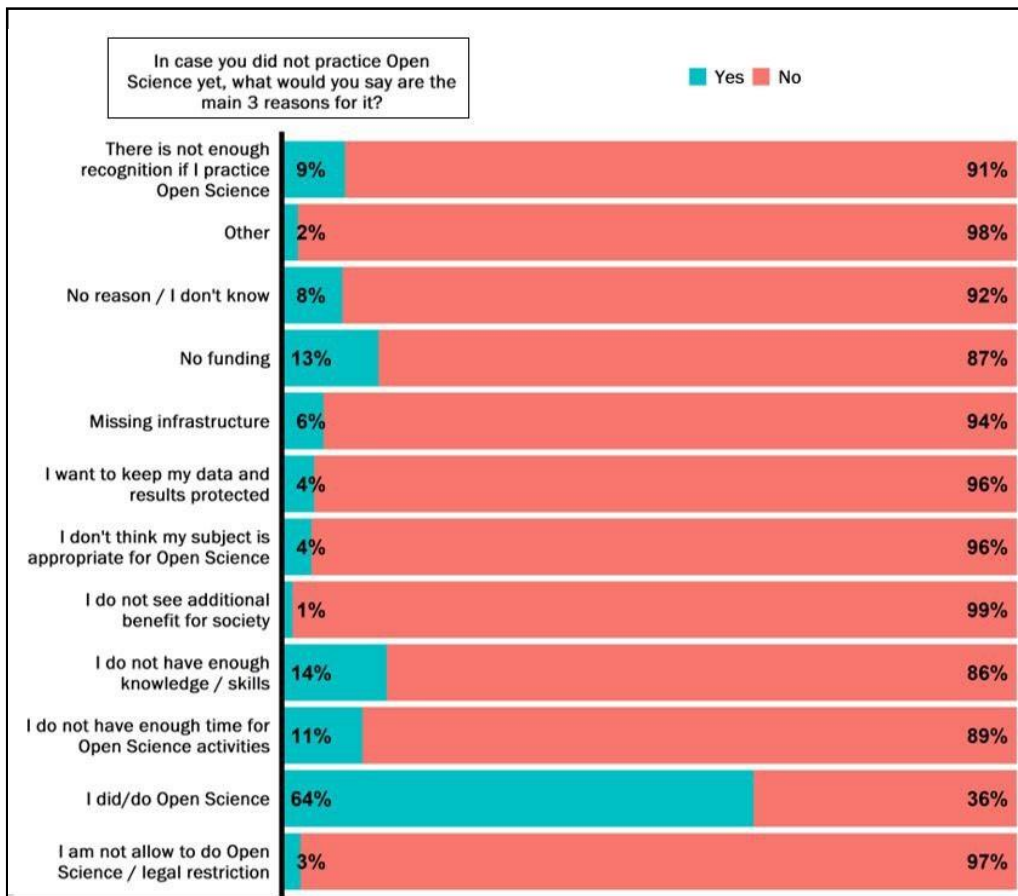
Open Science Support:

Quite surprising, but also revealing was the statement of 31% of the respondents that they would not receive any support at all in practising Open Science at their current university (see graphic 5). Researchers indicate that they receive the most support from *libraries* (24%), *colleagues* (23%) and *professors/supervisors* (17%). Only barely 5% stated that they were supported by some kind of *Open Science department or service*. Therefore, it can be concluded that there are only to a small extent dedicated institutions at the universities as a contact point for Open Science as a whole or that their existence is very little known [triple answer possible].

Graphic 5: Survey question Who supports you at your current University in doing Open Science?
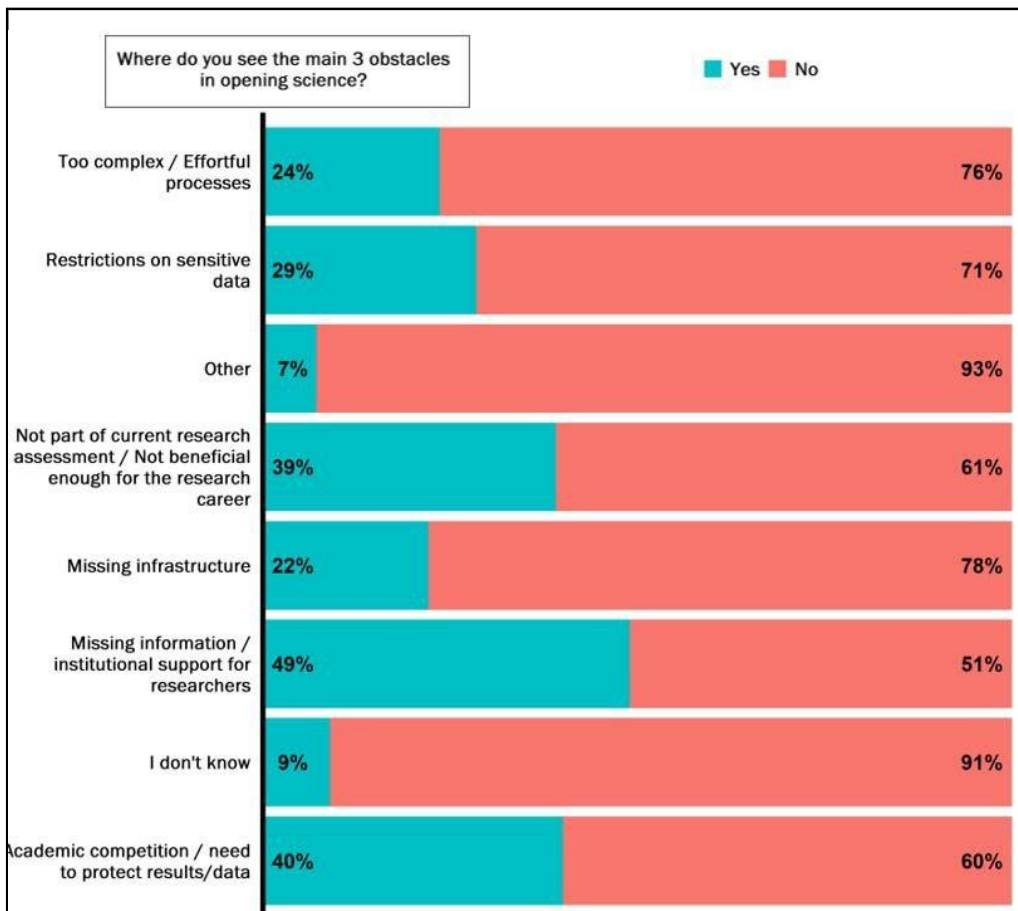*[multiple tickle possible]; Source: own generation*

Open Science Enhancement:

Beside the statement that many researchers already practise Open Science (64%), various reasons were given for not practising Open Science (see graphic 6): *too little knowledge / skills* (14%), *no funding* (13%) and *I do not have enough time for Open Science activities* (11%). Another 8.6% said: *there is not enough recognition if I practise Open Science* and 5.7%: *Missing infrastructure*. 4.4% want to protect their data and results, and 4% think their subject is not suitable for Open Science [triple answer possible].

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Graphic 6: Survey question In case you did not practise Open Science yet, what would you say are the main 3 reasons for it? [up to three tickle possible]; Source: own generation

The lack of support services is also reflected in the results of the question on the biggest obstacles to Open Science (see graphic 7). According to researchers, the most important obstacle is *Missing information / institutional support* (49%), followed by *Academic competition / need to protect results/data* (40%) and close behind: *Not part of current research assessment / Not beneficial enough for the research career* (39%) [triple answer possible].

Where do you see the main 3 obstacles in opening science? — Yes / No

Obstacle	Yes	No
Too complex / Effortful processes	24%	76%
Restrictions on sensitive data	29%	71%
Other	7%	93%
Not part of current research assessment / Not beneficial enough for the research career	39%	61%
Missing infrastructure	22%	78%
Missing information / institutional support for researchers	49%	51%
I don't know	9%	91%
Academic competition / need to protect results/data	40%	60%

Graphic 7: Survey question Where do you see the main 3 obstacles in opening science?
[up to three tickle possible]; Source: own generation

These results also reflect the outcomes of the open text questions on how Universities could support researchers (more) in doing Open Science. The answers show that researchers expect among others funding, information, rewards and training *("Open science and communication activities take a lot of time. But they do not lead to scientific publications and presentations, so they are invisible e.g. for grant reporting or even workload management. Doing a communication project takes hours off our daily work. Yet currently it's considered an extra activity and this can be stressful and lead to burnout with no recognition. For many people the choice between one more paper or a communication event is decided by necessity").* Researchers state that Open Science is very expensive, especially in the form of Article Payment Charges for publishing in (Gold) Open Access *("My university could provide funding for publishing open science papers because it is unaffordable to pay from my own salary." - "Open access journal PUBLISHED BY THE MONEY!!! NOT BY THE SCIENCE CONTRIBUTION [sic]").* This in turn causes a great imbalance of contributors and (re)users of Open Knowledge of different academic status groups like early career and senior researchers and of more and less funded researchers. These imbalances thus increase suspicion and denial at worst *("All this OS discussion is pushed by greed of publishers and should not be carried out giving them money").* Other important factors for not practising Open Science (more often) are a lack of time *("Open Science involves many tasks in addition to just publishing a paper open access, and all of these take time (such as preparing and sharing data sets, analysis scripts, materials, etc. which all need explanations so that they are useful to others). And this additional work is currently not considered when it comes to promotions. It's labour on top of an academic's already full workload [sic]")* and proper infrastructures *("More information about resources that are available, that can be used to favour open science" - "I would like somebody to help me, to explain to me").*

4. Recommendations to enhance Open Science

The survey results as well as the status quo of Open Science indicate which needs of researchers are most relevant for Arqus institutions in the attempt of fostering Open Science. Generally, the survey results on the needs of researchers are in line with the more than 60 recommendations given in the Arqus OPP. This report strives to be even more specific focusing on three general recommendations including concrete measures to be taken in each case.

As observed in the survey evaluation as well as in the status quo questionnaire, the recommendations focus on the following needs:

- Missing skills, information/awareness and support
- Missing rewards and benefits
- Missing resources (staff, time), infrastructures and funding

4.1 Recommendation 1

> **Develop and share policies, guidance and training offers among Arqus researchers, provide consulting and increase visibility of Open Science support services.**

4.1.1 Status Quo

From the researchers' point of view, institutional support for Open Science is not sufficient. Both the training and information services offered by the universities as well as the most widely conducted Open Science activities are aimed primarily at Open Access publishing, sharing research data and communicating research findings on popular platforms. Time constraints and financially limited resources to contribute to Open Science activities, uncertainties in openly sharing results and competitive pressure lead to less engagement with diverse Open Science activities, or such activities are not prioritised in research activity.

Furthermore, there are only a few universities within Arqus that provide dedicated Open Science policies and/or guidelines, just for selected sections as mentioned above - Open Publication and Open Research Data. It is not clear whether the universities do not offer enough guidance and support, or whether this is simply not perceived and made use of. Also, there are differences of configuration between the universities within the Alliance.

It should be noted that in recent years there is an increasing overload in the workload of researchers: In addition to the regular activities of research, publication and teaching, researchers are more and more expected to take part in additional training, e.g. on data protection, gender equality, etc. Without denying the legitimacy of these trainings, this abundance of demands on researchers must be taken into account. Institutions should weigh up between necessary and desirable skills and activities and design their training offerings accordingly in a targeted, efficient and manageable manner. On the other hand, researchers demand more training opportunities to extend their skills in Open Science practising.

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4.1.2 Observed Risk

Since researchers need proper skills for practising Open Science in a sufficient way, universities and other research institutions need to guide and support them, otherwise it will be even more difficult to overcome the described obstacles, especially the lack of resources, time and an increasing effort for researchers. Missing policies, guidance and skills evoke insecurities and displeasures as well as ignorance of the guidelines of good scientific practice at worst. Institutional requirements on practising Open Science will remain vague. The mind shift to more transparency, cooperation and data-driven research will be suspended. Besides that, also legal insecurities could occur, e.g. by sharing person related research data or not following copyright regulations. Missing training and consulting causes researchers to not benefit sufficiently of Open Science.

4.1.3 Concrete Measures

- Develop specific training offers on various Open Science activities based on researchers' requirements, ensure the visibility of these offers and provide (individual) consulting for researchers respecting their needs concerning research assessment.

- Monitor and evaluate on a regular basis the needs of researchers regarding skill building and Open Science training, and highlight also the benefits and possibilities to overcome obstacles for researchers in doing Open Science.

- Create an Arqus-wide pool of online training materials and open online workshops, include discipline-specific offers, and make training and materials accessible within the Alliance for all members and beyond, e.g. by sharing training materials at European OpenPlato platform.

- Map local support units, make Open Science institutions and contact points for support visible, and increase Alliance-wide collaboration and network of support units.

- Promote skill building of research support officers / research managers according to local, national and European-wide Open Science funding requirements and opportunities, values, principles and policies.

- Build networks and spread competencies for joint training offers to foster skill building, e.g. by establishing a community of practice of (discipline-specific) training multipliers within Arqus Alliance.

- Provide Open Science policies and standards according to research assessment criteria, and merge already existing guidelines and/or policies on various Open Science sections.

> **Introduce rewards and incentives for Open Science practices in research(er) assessment respecting discipline and career stage specifications.**

4.2.1 Status Quo

Arqus universities consider Open Science practises few in research evaluation, promotion and tenure criteria as shown in the Status Quo questionnaire. Regardless of this, most universities of the Arqus Alliance committed to actively participate in the Coalition of Advancing Research Assessment (COARA) and strive to recognise Open Science as criteria in research assessment. However, there is currently no activity from the Arqus Alliance yet to participate in those initiatives as an Alliance. The survey results highlight the need for researchers to recognise and reward Open Science activities: For 39% of the respondents, it is one of the main obstacles that Open Science is *Not part of current research assessment / Not beneficial enough for the research career* (see graphic 7)*.* This is also shown in the free text answers in the survey. Researchers expect to get a positive impact on their career and academic advancement by rewarding Open Science activities.

However, no detailed conclusions on researchers' view of research assessment can be drawn based on the survey results. Researchers answered the question on their expectations on Open Science rewards not related to research assessment criteria but to support and funding offers. The narrative analysis shows similar data concerning institutional support and needs of rewarding Open Science. However, the survey results show that it is necessary to reward Open Science activities and to provide incentives for researchers to change their research practices. Therefore, insights from WP3 *Alternative Assessment Approaches* were integrated in the current report to underline the great importance of rewards and incentives for putting Open Science into practice.

4.2.2 Observed risk / obstacle

In the current research process, Open Science activities are dependent on the individual initiative and intrinsic motivation of researchers. Mostly, these motivated researchers see the added value of good scientific practice and sharing research results openly, even without receiving sufficient reward from institutions. But the current research process is still characterised by high publication pressure and work overload by additional work besides research. In order to progress in their scientific careers, researchers - especially early stage researchers - have to prioritise publishing over further Open Science activities (despite Open Access publishing). Knowledge transfer to the public and increasing transparency will not be achieved by just publishing Open Access without proper communication of research results.

Furthermore, Open Science is not yet sufficiently recognised as an essential part of good scientific practice by researchers and research institutions. It is essential to shift that mindset dedicated to Open Science as an inherent part of research practice and increase transparency, trustworthiness and cooperation. Open Science activities have to be part of research assessment and evaluation in accordance with discipline and career stage specific developments and needs. While many Arqus researchers have indicated that they publish Open Access, share their research data or communicate their results to the public on popular platforms, this does not automatically mean that the change in values has taken place within the whole research process, including research institutions.

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4.2.3 Concrete measures

In order to give more and sustainable weight to Open Science, it must be more strongly integrated into research evaluation as well as part of job advertisements:

- Commit to considering Open Science in research evaluation respecting the needs of researchers, considering discipline-specific differences and evaluation routines and treating Open Science activities as criteria for hiring academic staff as well as including these in job advertisements.

- Explicitly recognize Open Science and transparency as inherent part of research integrity and good scientific practice.

- Acknowledge Open Science practices as scientific contributions whether they relate to research outputs or processes with respect to discipline and career stage specifications.

- Monitor Open Science activities on the individual institutional level and enhance visibility in order to support researchers, e.g. in local research information systems (CRIS).

- Start pilots and discursive formats (e.g. panels, working groups) including researchers as well as academic support staff for the development of quality based criteria and for the recognition of open science activities in research assessment respecting discipline-specific cultures.

- Respect and involve researchers from different academic status groups, disciplines and gender in the transformation of research assessment and by developing qualitative based criteria.

- Participate actively in the Coalition for Advancing Research Assessment (COARA) or similar initiatives and share COARA implementation plans between Arqus members.

4.3 Recommendation 3

> **Provide resources, infrastructures and funding to enable Open Science activities regarding the discipline-specific needs.**

4.3.1 Status Quo

Researchers state that they need more time and additional infrastructures for practising Open Science. Tools could help to save time and effort. They should be preferably Open Source and low-threshold. Publishing research results and data are essential for practising Open Science. Each Arqus university already provides Open Access repositories, but not all provide repositories for publishing research data yet, which is primarily important for small research communities without discipline-specific offers. Further tools and platforms have to be evaluated and shared subsequently by Arqus members as strived by the Joint Research Action Plan (JRAP), which was developed as a strategic document for the further collaboration in the Research and Innovation dimension in Arqus.

Most important to researchers is additional funding. Since (Gold) Open Access publications are expensive for authors and their institutions and publishers still favour business models that require Article Processing Charges, especially early stage researchers find it difficult to publish Open Access in high quality journals without proper funding. Most Arqus universities provide Open Access funding, but researchers still state that this is not sufficient. Furthermore, researchers suppose exploitation of their research findings by costly contributors fee. They are not up for participating in further commercialisation of

science. Also, analysing and preparing research data for publication is an additional task that needs skilled staff, proper infrastructure and finance, which is currently not available at most Arqus universities.

4.3.2 Observed risk / obstacle

If researchers are not able to practise Open Science in a proper way because of missing infrastructures, especially technical offers, and a lack of institutional funding, the requirements of research funding organisations will not be fulfilled. Early stage researchers are mostly dependent on institutional financial support. If institutional funding is not sufficiently provided, they are losing in the academic competition and will be less visible. Inclusivity and equality will not be realised, if not all academic status groups got the same working conditions regarding their discipline-specific needs. This is also valid for access to proper supportive infrastructures, like special tools for data analysis or research software. On the other hand, constantly increasing publication fees by publishers reduce the willingness, trust and the opportunities for researchers to publish their results openly.

4.3.3 Concrete measures

- Develop a mapping of existing infrastructures, staff competencies and capacities as well as individual services at each Arqus institution to be able to coordinate Open Science efforts in a more strategic way along all member institutions.

- Provide long-term financial support for quality-assured, preferably community-owned and open source infrastructures and tools, based on transparent criteria for development and implementation.

- Provide proper funding for Open Access publications and data sharing via publication funds, especially for early career researchers and discipline-specific needs (e.g. publishing Open Access monographs).

- Provide staff resources that support researchers in practising Open Science by providing consulting and training and coordinate related activities.

- Establish and sustain open platforms for sharing research software and tools and infrastructures within the Arqus alliance, such as open access journals, repositories or discipline-specific, national or international infrastructures that meet established quality standards.

- Provide researchers with shared access to trustworthy Open Science infrastructures within the Arqus Alliance and support each other by further developments of research infrastructures in accordance with the JRAP.

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5. Concluding reflections

The current report tries to provide insight into the needs and obstacles of researchers regarding Open Science and to formulate concrete measures and actions, universities and the Arqus Alliance should strive to foster Open Science.

To reach the goal of enhancing openness, transparency and cooperation it is necessary to strengthen Open Science as an essential part of good scientific practice and research integrity. This is strongly related to transforming research assessment and scientific quality control mechanisms as well as developing qualitative criteria as a basis for a modified research culture. For the success of Open Science implementation, it is crucial to enhance the motivation for and trust of researchers. This could be achieved by adjusting research evaluation, research assessment criteria and requirements for researchers. So far, this is reflected especially in the development of Open Access publications. Nevertheless, the current report emphasises also the negative effects of these developments and stresses the responsibility of researchers and research institutions to handle the implementation of Open Science practises seriously, carefully, equally and inclusive.

Universities have to protect the freedom of research, consider the needs of researchers concerning practising Open Science and career stage specifications. Additionally, discipline-specific cultures should be considered too, especially by developing qualitative based metrics for research evaluation and assessment. Universities are responsible to provide adequate working conditions and low-threshold service offers, especially training, guidance and IT-infrastructure. Therefore, universities have to define their expectations and aims regarding the strategic implementation of Open Science practises and support. They should focus on quality aspects, awareness and reducing barriers. Besides that, universities should prioritise which Open Science practises are most relevant taking into account discipline and career stage specific requirements and which elements of Open Science could be covered in joint action (for Arqus JRAP). Therefore, existing infrastructures, resources and policies should be combined and made openly accessible for researchers. It is essential to plan in a long-term perspective since Open Science aims to transform research cultures in a substantial way and is still an ongoing process, which needs constant evaluation and transformation.

All academic status groups have to be included in the transformation process, notably early career researchers, since they are affected by stronger regularities and dependencies regarding Open Science practises like sharing research data or publishing Open Access. Guidance and policies support Open Science practices and communicate expectations and duties to all stakeholders. Standards help to avoid insecurities, especially legal ones, like data protection rules or copyright issues for data publishing.

Equally important are rewards and incentives to enhance Open Science practising. These should consider: providing support according to the needs of academic status groups and disciplines, promoting easy to adopt Open Science activities, like preregistration, open/community peer review, preprints and open access publication, publicly sharing open and usable data and code, and conducting replication studies, as well as considering negative results in academic discourse (academic error culture; confirmation bias). Besides that, appropriate funding is essential to foster Open Science. Without financial safety and rewards, researchers are not willing to take the additional efforts of practising Open Science. Nevertheless, researchers should be active and bring in their perspective to policy making, developing guidance and training offers as well as transforming scientific quality control mechanisms.

Open Science is not an aim in itself and values do not occur by just promoting Open Science. Transparency alone does not necessarily generate quality, equality and trustworthiness. Therefore, universities should ask themselves before starting implementation processes:

- To what extent do universities strive for more openness and transparency?
- What do universities expect from fostering Open Science and what are their expectations from researchers?
- Which Open Science areas/aspects should be prioritised by universities in a strategic and in a practical way (policy/guidance, funding, support, infrastructures, human and financial resources, synergies, outsourcing and cooperation, external requirements)?

Despite that, there are various challenges and obstacles that could occur due to misconceptions:

- Declining acceptance of Open Science by disrespecting discipline-specific research cultures, researchers needs and solely top-down processes
- Waste of data and publications and a loss of quality by missing standards for practising Open Science
- Sole responsibility for practising and/or implementing Open Science on researchers or research institutions
- Research assessment does not correspond to Open Science requirements, competitive pressure in most disciplines
- Double structures and parallel developments by not considering synergies for implementation of support infrastructures
- Deepening the imbalance between academic status groups when different duties and rights for practicing Open Science were not considered

Therefore, the aim of the current recommendations should be to raise awareness on careful and effective implementation of Open Science infrastructures, to build a proper environment for all researchers at all academic status groups and to foster the mind shift to more openness and transparency, considering research as a common good, raise the intrinsic motivation of researchers to share knowledge openly and in the end enhance the values of Open Science for all - researchers and society.

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7. List of figures

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Appendix:

A) Status Quo Open Science at Universities

A. Open Science Context

A.1 Is there a national Open Science Policy in your country?

A.2 Are there national guidelines on research assessment in your country?

A.3 Are there national guidelines on good scientific practice in your country?

A.4 Are there national infrastructures/repositories for publications and/or data in your Country?

A.5 Are there relevant regional or national initiatives promoting Open Science in your Country?

A.6 Did your institution issue an institutional publication strategy or recommendations for its scientists that mention Open Science issues?

A.7 Does your institution reward/consider further activities in- and outside academia in promotion or tenure criteria, like volunteering, membership in scientific associations, political engagement?

A.8 Does your institution provide counselling/support on Open Educational Resources?

A.9 Does your institution provide infrastructure for Open Educational Resources?

B. Open Science

B.1 Does your institution state that it recognizes Open Science activities of researchers in research evaluation and/or promotion and tenure criteria, e.g. by displaying Open Science activities separately?

B.2 Has your institution introduced an institutional Open Science programme?

B.3 Has your institution developed a series of Open Science training for university members but also for any related actors (companies…)?

B.4 Is there an Open Science Steering Group at your institution to develop official policies around Open Science?

B.5 Is there an Open Science Office that offers info materials and counselling to researchers?

B.6 Is Open Science considered to be Good Scientific Practice in national or institutional guidelines?

B.7 Are researchers at your institution subject to guidelines on reproducibility of research output?

B.8 Are there bottom-up initiatives such as Open Science communities at your institutions?

C. Open Access

C.1 Did your institution issue an Open Access Policy?

C.2 Does your institution monitor the share of OA publications?

C.3 Does your institution display the share of OA publications in its CRIS?

C.4 Does your institution display OA publications as such in their CRIS?

C.5 Does your institution consider OA publications of researchers in promotion and tenure criteria?

C.6 Does your institution aim to adhere to Plan S (or similar) criteria for Open Access to scholarly articles?

C.7 Does your institution provide an institutional repository for Open Access publications?

C.8 Is there a mandate for deposit of publications in a repository at your institution?

C.9 Does your institution host OA journals as part of its OA strategy?

C.10 Does your institution have an OA university press?

C.11 Does your institution offer an open access publication fund to support researchers for open access publications?

C.12 Does your institution offer financial support for open access monographs?

D. (Open) Research Data

D.1 Has your institution issued a Research Data Management Policy?

D.2 Is there a policy on long-term availability (preservation) of research data in your institution?

D.3 Does your institution provide an institutional Research Data Repository?

D.4 Does your institution provide Research Data Support?

D.5 Does your institution declare that it supports the FAIR Data Principles?

D.6 Is there a strategy for participation in the European Open Science Cloud in your institution? If so, (how) do you wish to cooperate on this with ARQUS partners?

D.7 Are there people dedicated to RDM support in your institution?

D.8 Is your institution involved in national research data management initiatives?

D.9 Does your institution monitor and display Open Data?

D.10 Does your institution consider Open Data in promotion or tenure criteria?

D.11 Is your institution a member of international Open Science/data Management networks such as RDA?

E. Citizen Science

E.1 Does your institution have an institutional strategy on Citizen Science?

E.2 Does your institution provide support/counselling on Citizen Science?

E.3 Does your institution provide training and/or training materials on Citizen Science?

E.4 Does your institution provide funding for Citizen Science activities?

E.5 Does your institution monitor and display Citizen Science activities?

E.6 Does your institution consider Citizen Science activities in promotion and tenure criteria?

F. Science Communication

F.1 Does your institution provide support/counselling on Science Communication?

F.2 Does your institution provide training and/or training materials on Science Communication?

F.3 Does your institution monitor and display Science Communication activities?

F.4 Does your institution afford and foster the opportunity to communicate research results to the public (e.g. via newsletter, website, newspaper)?

F.5 Does your institution consider Science Communication activities in promotion and tenure criteria?

B) Survey Questions

1. How would you rate your knowledge on Open Science in general so far?

[1...never heard about it; 5...profound knowledge on different aspects]

2. Have you already practised any of the following Open Science activities?

[Yes; No; Don't know]

[Pre-register research projects and data collection; Publish Open Access and/or share preprints; Release with open licences (e.g. presentation material, software, source code); Share research data whenever legally permissible, if not: share rich metadata; Practice and use forms of Open Peer Review; Share methodologies, protocols and workflows on open platforms; Communicate your research and results to the public on popular platforms (e.g. social media, newspaper); Conduct science education projects (e.g. in schools); Invite collaboration with stakeholders outside academia (Citizen Science); Incorporate societal needs and challenges into your research design (Open Research Agenda Setting)]

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3. Now that you may have received additional information about Open Science, how often would you say you have done / you do Open Science?

[Never; One single time; A couple of times; Frequently; Whenever I can; No answer]

4. Which 3 Open Science activities would you describe as the most important for your career (from a current perspective)?

[Pre-register research projects and data collection; Publish Open Access and/or share preprints; Release with open licences (e.g. presentation material, software, source code); Share research data whenever legally permissible, if not: share rich metadata; Practice and use forms of Open Peer Review; Share methodologies, protocols and workflows on open platforms; Communicate your research and results to the public on popular platforms (e.g. social media, newspaper); Conduct science education projects (e.g. in schools); Invite collaboration with stakeholders outside academia (Citizen Science); Incorporate societal needs and challenges into your research design (Open Research Agenda Setting)]

5. Which 3 Open Science activities would you describe as the most important for society (from a current perspective)?

[Pre-register research projects and data collection; Publish Open Access and/or share preprints; Release with open licences (e.g. presentation material, software, source code); Share research data whenever legally permissible, if not: share rich metadata; Practice and use forms of Open Peer Review; Share methodologies, protocols and workflows on open platforms; Communicate your research and results to the public on popular platforms (e.g. social media, newspaper); Conduct science education projects (e.g. in schools); Invite collaboration with stakeholders outside academia (Citizen Science)]

6. In case you did not practise Open Science yet, what would you say are the main 3 reasons for it?

[I did/do Open Science; I do not see additional benefit for society; I do not have enough time for Open Science activities; I do not have enough knowledge / skills; Missing infrastructure; I don't think my subject is appropriate for Open Science; No funding; I am not allow to do Open Science / legal restriction; I want to keep my data and results protected; There is not enough recognition if I practise Open Science; No reason / I don't know; Other:...]

7. Where do you see the main 3 obstacles in opening science?

[Missing information / institutional support for researchers; Missing infrastructure; Not part of current research assessment / Not beneficial enough for the research career; Restrictions on sensitive data; Too complex / Effortful processes; Academic competition / need to protect results/data; I don't know; Other:...]

8. Who supports you at your current University in doing Open Science?

[Professor / Supervisor; Colleagues; Open Science department (or similar); Library; Research data management office; Administration / Superior at my department; I don't get any support; No answer; Other:...]

9. In case you want to do (more) Open Science, how could your University support you? (max. 500 characters, approx. 3 lines) [Open Question]

10. Do you have ideas how the University could reward practising Open Science (more)? (max. 500 characters, approx. 3 lines) [Open Question]

11. Do you have additional thoughts you want to share regarding the topic? (E.g. personal experience and success stories on how Open Science helped you in your career) (max. 500 characters, approx. 3 lines) [Open Question]

12. Please state your kind of position:

[Non permanent: PhD student; Non permanent: senior scientist, (junior)professor; Permanent: postdoc, academic assistant, lecturer, senior scientist; Permanent: professor; Other:...; No answer]

13. What is your research field?

[Natural Sciences (incl. Mathematics; Computer / Information / Earth / Biological / Physical / Chemical sciences); Engineering and Technology (incl. Civil / Electronical (Information / Mechanical / Aerospace / Chemical /Materials / Bio / Biomedical / Environmental Engineering, Environmental / Industrial biotechnology, Nano-technology); Medical and Health Sciences (incl. Basic / Clinical medicine; Health sciences, Medical biotechnology, sports sciences); Agricultural Sciences (incl. Agriculture, forestry, fisheries; Animal and dairy sciences; Veterinary sciences; Agricultural biotechnology); Social Sciences (incl. Psychology; Economics, finance, business; Educational sciences; Sociology; Law; Political sciences; Social and economic geography; Media and communications); Humanities (incl. History and Archaeology; Languages and literature; Philosophy, ethics and religion; Arts); Other:...; No answer]

14. Please select your current University:

[Bergen; Granada; Graz; Leipzig; Lyon/Saint-Etienne; Padua; Vilnius; No answer]

15. Age:

[below 30; 31-40; 41-50; 51-60; 61 and older; No answer]