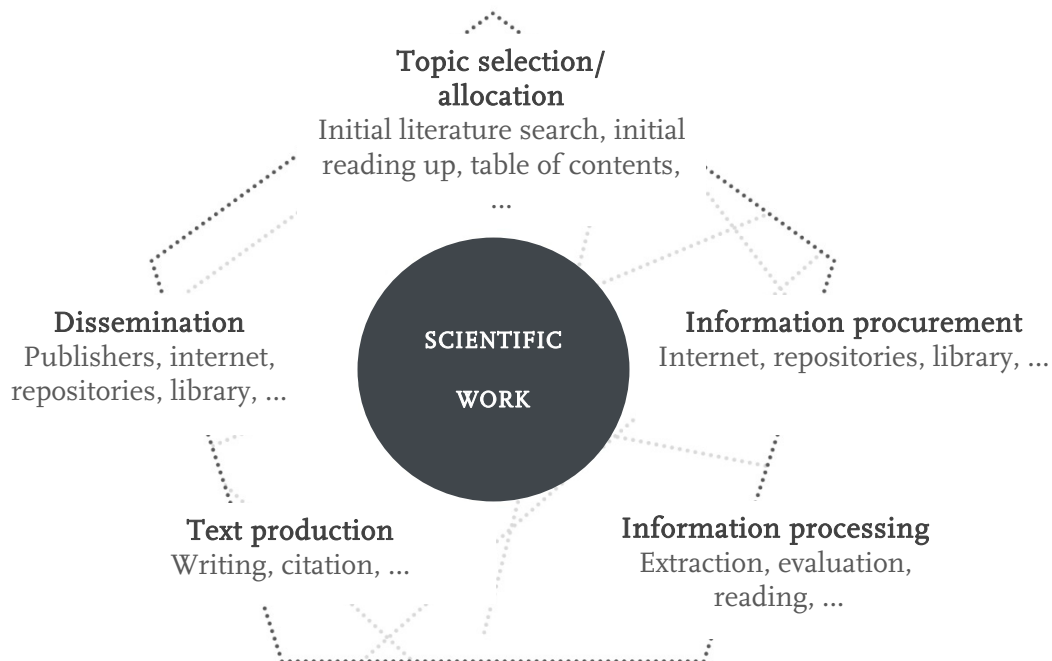


**THE INFORMATION PROCUREMENT AND PUBLISHING BEHAVIOUR  
OF RESEARCHERS  
IN THE NATURAL SCIENCES AND ENGINEERING**



– Evaluation of a survey focusing on non-textual material –

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### *Published by:*

Technische Informationsbibliothek (TIB) – German National Library of Science  
and Technology  
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### *Funding agency*

SPONSORED BY THE



Federal Ministry  
of Education  
and Research

engage – Key Technology Ventures AG, Karlsruhe, was commissioned by the Technische Informationsbibliothek (TIB) – German National Library of Science and Technology to conduct this survey, which was financed within the “Professionalisation and continuation of the concept for exploitation of research results at the German National Library of Science and Technology, Hannover (TIB)” project (funding ID: 03101441) funded by the Federal Ministry of Education and Research (BMBF). Within this project, TIB’s knowledge and technology transfer concept is further developed, adapted to new structures, and extended to include new topic areas. TIB seeks to increase the number and quality of utilisation projects, to better market its offerings, and to implement new, innovative services.

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## DATA SET

The questionnaire used in the survey and an anonymised selection of the raw data are available at <https://doi.org/10.22000/54>.

## FOREWORD

Dear Reader,

For centuries, libraries had a virtual monopoly on the provision of information. In the age of digitalisation and the internet, however, the opportunities to share knowledge are multiplying and the marginal costs of information exchange are falling dramatically. Libraries in general, and the Technische Informationsbibliothek (TIB) – German National Library of Science and Technology in particular, must reposition themselves in the increasingly digitised world of information exchange. The scientific community is also facing changes and new challenges, such as the growing importance of research data, Open Access, new collaborative forms of cooperation, multimodal forms of publishing, and changing copyright laws.

As the Information Centre for Science and Technology, our ambition is to support researchers at all stages of their work by providing both ‘analogue’ and digital services. Owing to the heterogeneity of our user groups, representing various fields of research and organisations, it is particularly important to find out more about use scenarios and requirements. This is a pivotal aspect because TIB offers researchers an increasing range of digital services in addition to classic information provision to support them in the production of scientific work. Examples of such services include the AV-Portal for audiovisual content, the interdisciplinary data repository RADAR for the digital preservation of research data, SlideWiki for the collaborative creation of OpenCourseWare, DataCite for the referencing of research data, and services offered by international consortia such as ORCID and arXiv, in which TIB is closely involved.

Encompassing responses from more than 1,400 researchers, this study contributes to the better understanding of our user groups’ needs and requirements and to ensuring that future developments target their needs even more effectively. The results of the study confirm a number of assumptions: research data has now become a central element of scientific output; Open Access can help generate greater visibility, but requires that publication media have a similarly high reputation; in addition to traditional publications, other modalities such as software, knowledge graphs, 3D models, videos and data are gaining in importance. We hope that other information centres and technology libraries will benefit from the results of the study.

Regards,



Professor Dr. Sören Auer – Director of the Technische Informationsbibliothek (TIB) – German National Library of Science and Technology

## INTRODUCTION

The challenges arising from changing research and publishing behaviour, from the upheaval in the publishing market and from the emergence of very different forms of distribution and use have changed and continue to change the tasks involved in the provision of information. The ever-increasing digitalisation of work procedures and processes has a significant effect on the demands customers and users place on modern information services. These continuing dynamic developments in the area of information provision and knowledge discovery are influencing and changing the entire range of library services.

Nowadays, scientific libraries act as modern information infrastructure facilities that seek to support researchers throughout the scientific process with innovative services. To meet this challenge, libraries must continuously analyse the changing needs of scientific communities, monitor trends, implement technical innovations and develop services tailored to target groups so as to ultimately review, again and again, whether their users' expectations have indeed been met. It was with this goal in mind that TIB set out to conduct this study.

Commissioned by the Technische Informationsbibliothek (TIB) – German National Library of Science and Technology, Leibniz Information Centre for Science and Technology, engage AG conducted a quantitative online survey on the topic of information procurement and publishing behaviour among researchers in the natural sciences and engineering between the end of 2016 and the beginning of 2017. More than 1,400 researchers from German higher education institutions (HEIs) and non-university research institutions provided insight into their research activities and expressed their opinions.

The aim of the study was to gain a more accurate and varied picture of potential library users and their information procurement and publishing behaviour. The survey focused on the use, production and handling of non-textual material such as audiovisual media, 3D objects and research data, which have so far been little studied in the library context.

The questionnaire used in the survey contained closed questions, addressing issues relating to the use of search tools and to modes of access in information procurement as well as to the production and publication of various scientific contributions and material. A number of questions were aimed at determining the need for advice on matters such as Open Access publications, the use of repositories and the allocation of Digital Object Identifiers (DOI) for non-textual material. As such, the study sheds light on the user behaviour of researchers as well as their potential need for new services and user-centred advisory services.

## SURVEY RESPONDENTS

A total of 1,464 questionnaires were taken into account in the statistical analysis (questionnaires that were not evaluated were highly incomplete, for example). 36%

of the respondents were from a non-university research institution (most of which from the Leibniz Association and the Max Planck Society), 35% were from a technical university and 22% from a university. Respondents from universities of applied sciences and other institutions made up around 3% each. With regard to the respondents' fields of research, there was a slight predominance of mathematicians and natural scientists over engineers (54% compared to 42%). Most researchers represented the subjects of Physics and Astronomy (23%), Mechanical Engineering and Process Engineering (17%) and Chemistry (14%). Concerning academic status, doctoral students and other academic staff members such as project staff predominated the survey (each group accounting for around 30%), followed by post-doctoral researchers (18%) and professors (15%). Less than 5% of the participants were library employees. 26 to 35-year-olds made up the largest age group, accounting for 34% of the respondents.

## RESULTS

Selected results from the survey are explained below in relation to the thematic key areas. The questionnaire used in the survey and an anonymised selection of the raw data are available at <https://doi.org/10.22000/54>.

### INFORMATION PROCUREMENT

The first block of questions addressed the use of search tools and modes of access to specialist information.

When it came to finding out about the latest developments and trends in their discipline, the surveyed researchers stated that they used traditional methods such as scientific publications most frequently (90% used them frequently to very frequently) as well as personal contact with other experts (70%) and visits to specialist events (40%). The latter were selected by professors much more frequently than the other groups of respondents. By contrast, academic networking platforms such as ResearchGate or current research information systems such as Elsevier Pure and Thomson Reuters were never, rarely or only occasionally used by nearly 80% of the scholars. Twitter, blogs, web forums, webinars, alerts and RSS feeds played virtually no part as alternative modes of information procurement in science and research for the vast majority of the respondents.

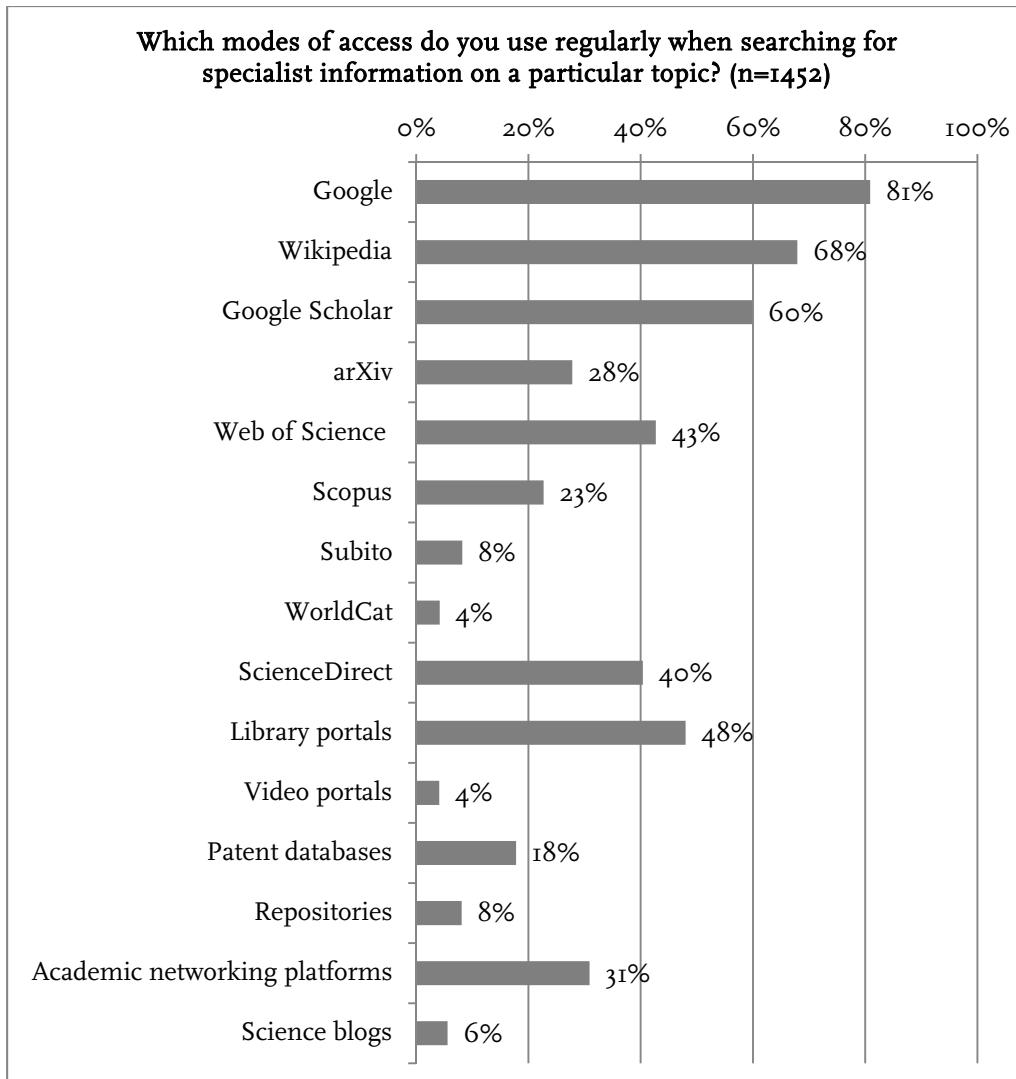


DIAGRAM 1 – MODES OF ACCESS TO SPECIALIST INFORMATION USED REGULARLY

According to the survey, researchers regularly used a wide range of tools in the search for specialist information on a particular topic (see Diagram 1; multiple responses were permitted). Google and Wikipedia took first and second places as modes of access, which were used regularly by around three-quarters of the respondents across all groups. Google Scholar, in third place, was particularly popular among the computer scientists (74% used it); in contrast, the lowest response frequency was seen among the architects and civil engineers (44%). According to the survey, doctoral students were the largest group that used Google Scholar (78%). Almost half of the researchers used library portals (in other words, a library’s own catalogue or a union catalogue). Around 40% of the respondents confirmed that they used other science-specific portals such as Web of Science or ScienceDirect, although the figures differed greatly depending on the area of research concerned.

With regard to the particular advantages and strengths of the modes of access used, in the case of Google and Wikipedia, the most frequent response (88% and 87%, respectively) was easy access to the search function – not only under the advantages of Google and Wikipedia themselves, but also when compared to the other modes of access. 74% and 72% of the respondents, respectively, also considered this to be an advantage of scientific video portals and Google Scholar. The criterion of having a “user-friendly user interface” was also assessed positively in the case of Google, Google Scholar, Wikipedia and scientific video portals, with almost half of the respondents considering these search tools to be particularly advantageous. This was mentioned as an advantage most frequently in the case of Google Scholar (58%). On the other hand, most of the respondents considered the relevance of the hits (76%) and the extensive data corpus (71%) to be the particular strengths of science-specific tools such as Web of Science. Library portals were in the mid range. Among all of the modes of access mentioned, arXiv and library portals were considered by 66% and 55% of the users to be particularly advantageous on account of their direct access to data and documents (multiple responses were permitted).

Concerning the question about the forms of publication and proportion of specialist information used, it came as no surprise that different types of specialist articles, including articles in Open Access journals, were used by the highest percentage of scholars in their search for information. 60% of the respondents stated that images and graphics accounted for at least a moderate proportion of the specialist information and research data used (for example, measured data, material samples, structural formulae, simulation data); around half of the respondents mentioned non-commercial publications (so-called grey literature such as conference proceedings) (see Diagram 2).



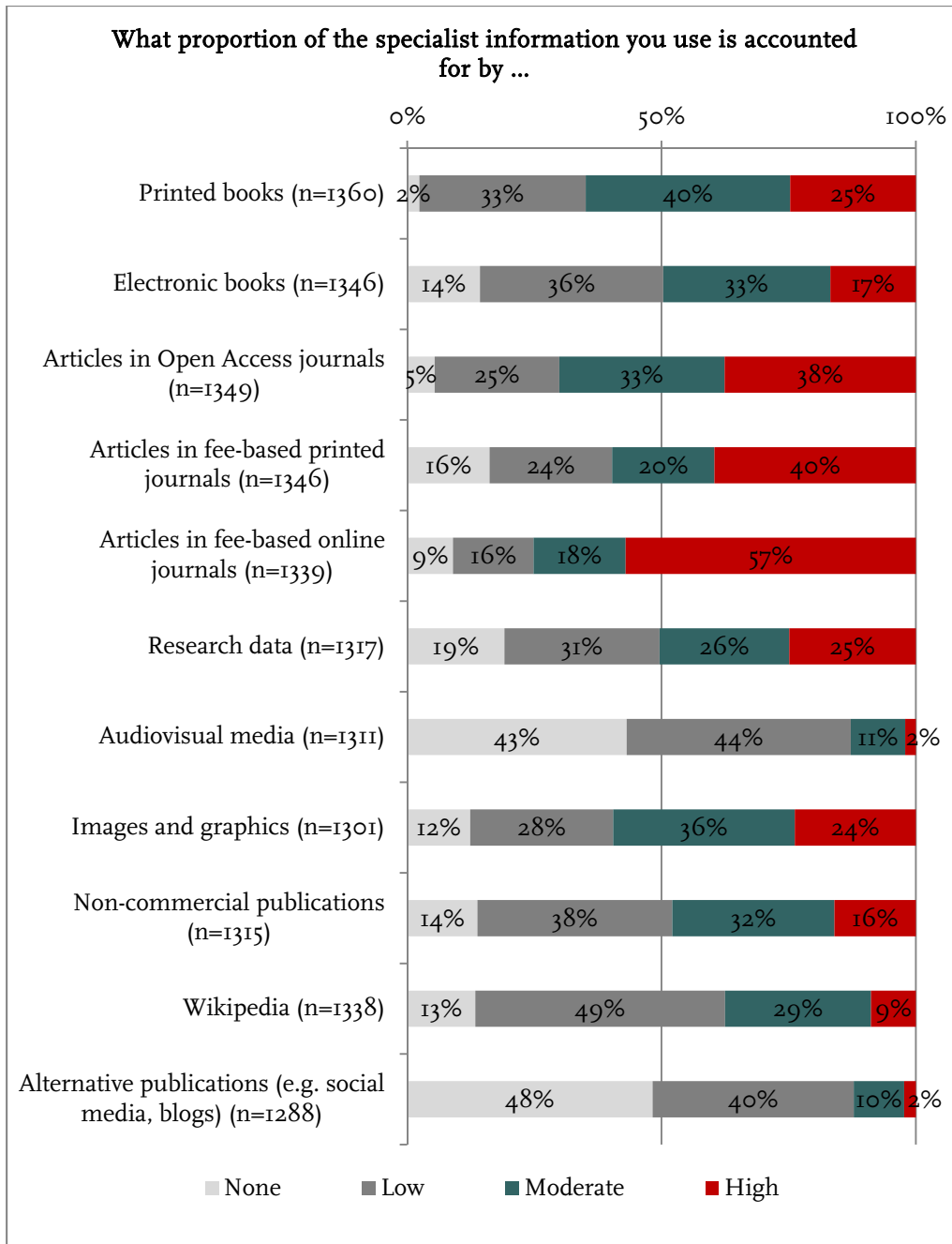


DIAGRAM 2 – PROPORTION OF SPECIALIST INFORMATION USED

The respondents' assessments differed depending on their academic status. For example, post-doctoral researchers (and in some cases also doctoral students) used a high proportion of Open Access journals, fee-based online journals, electronic books and research data much more frequently than professors. In contrast, professors used a high proportion of articles in fee-based printed journals and printed books more frequently than the other status groups.

## PRODUCTION OF SCIENTIFIC CONTRIBUTIONS AND MATERIAL

In addition to traditional publications, data such as spreadsheets, electronic text documents, photos, graphics, films and databases is also produced in all scientific disciplines. In the block of questions concerning publishing activities and services, a differentiation was initially made between the “production” and “publication” of various scientific contributions and material in the questions asked.

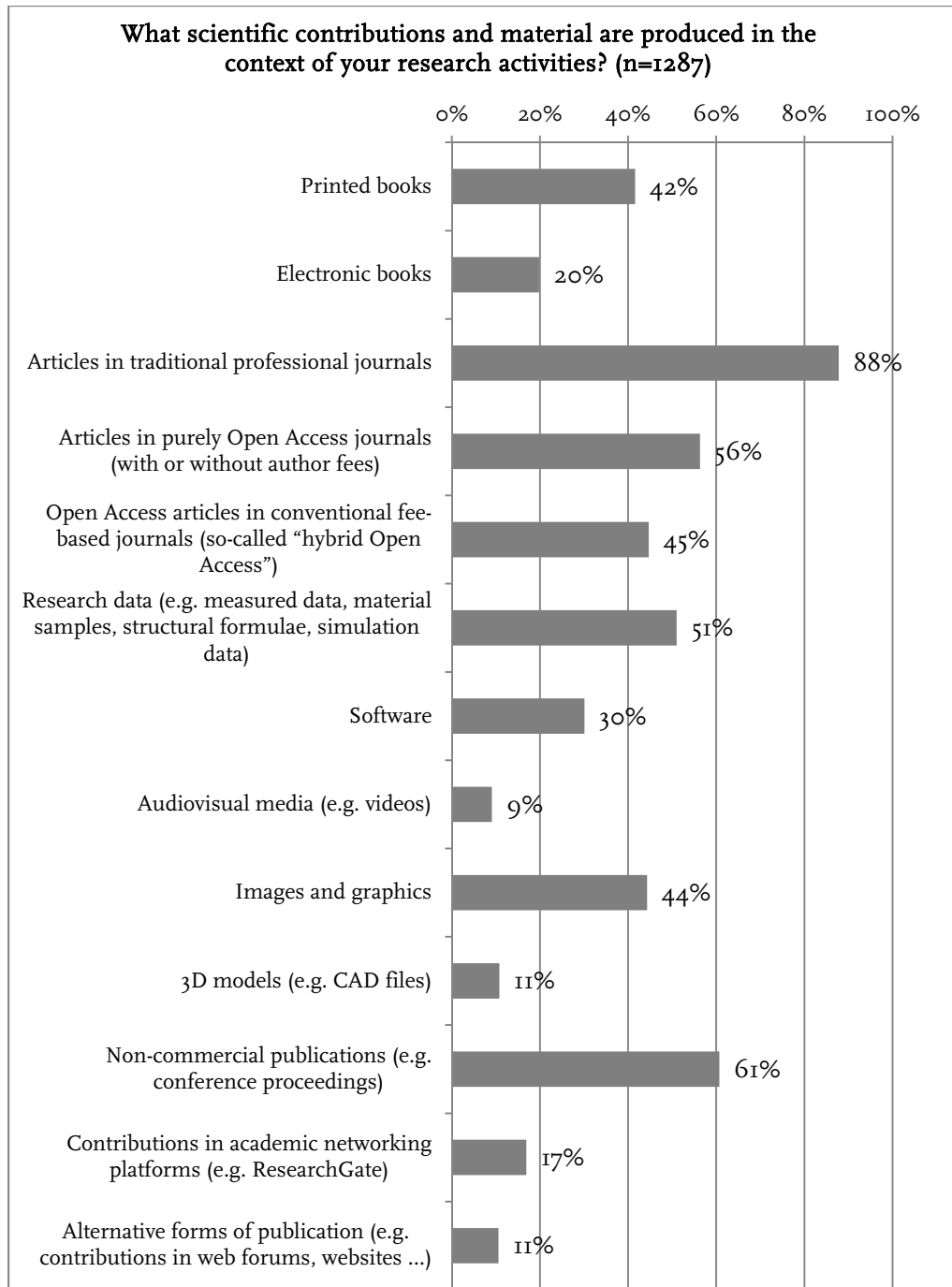


DIAGRAM 3 – PRODUCTION OF SCIENTIFIC CONTRIBUTIONS AND MATERIAL

Among the scientific contributions and material produced in the context of research activities (see Diagram 3; multiple responses were permitted), the

respondents mentioned articles most frequently on average, including articles in traditional professional journals, in purely Open Access journals and as Open Access articles in conventional fee-based journals (so-called hybrid Open Access). The biologists, physicists, astronomers and geoscientists came top in the case of Open Access publications.

Over 60% of the respondents also specified non-commercial publications (such as conference proceedings) in this context. These appeared to be particularly relevant in the areas of Mechanical Engineering and Process Engineering, Electrical Engineering and Information Technology, Architecture and Civil Engineering, and Materials Science and Materials Engineering (specified by 69-77%).

Printed books were stated at an above-average rate (60%) by the architects and civil engineers (the average was 42%). It also became apparent that considerably more printed books were produced by the older age groups (by 32% in the group of 26 to 35-year-olds compared to 58% in the 56 to 65 age group).

In addition to textual material, non-textual material was also increasingly produced in the research process: for example, around 44% of the respondents stated that they produced images and graphics in the course of their research activities. Images and graphics were especially produced in the more design-intensive disciplines such as Architecture and Civil Engineering as well as Mechanical Engineering and Process Engineering, with more than 50% of these researchers specifying such material. The same applied to respondents from the fields of Physics and Astronomy. 3D models such as CAD files were also stated most frequently by the architects and civil engineers (25%) and the mechanical engineers and process engineers (22%). In addition, almost 10% of the respondents produced audiovisual material in the context of their research. Examples included simulations and recordings of experiments.

Research data (such as measured data, material samples, structural formulae, simulation data) was produced by over 50% of the researchers surveyed; such data was produced most frequently by the chemical scientists, geoscientists, mechanical engineers and process engineers, electrical engineers and IT specialists (around 60%) and least frequently by the mathematicians (20%).

The production of scientific software was specified by an average of 30% of the researchers, whereby the distribution understandably varied very considerably from subject to subject: it was specified by 74% of the computer scientists, 46% of the electrical engineers and IT specialists, and, in contrast, by a maximum of 10% of the chemical scientists, materials scientists and materials engineers, and biologists.

### **PUBLICATION IN OPEN ACCESS JOURNALS**

Open Access is the term used to describe free access to scientific and scholarly publications. Articles published in Open Access journals can be read by all users free of charge and may be used under certain licence terms. With regard to

publication in Open Access journals, 67% of the respondents involved in publishing activities also published in Open Access journals, as opposed to 33% who had not yet done so.

The most frequently stated reasons for publishing in Open Access journals were free accessibility, greater visibility and citation probability (see Diagram 4; multiple responses were permitted). It appears to be particularly important to post-doctoral researchers that readers are able to freely access their work (78% compared to the average of 66%).

The majority of the respondents who published Open Access were unable to estimate the annual costs incurred for Open Access publications (69%). Among those who provided information about the costs of Open Access, 54% specified between 1,001 and 5,000 euros, only 14% selected a higher amount. Project funds (60%) and institutional publishing funds (46%) were mentioned most frequently as a source of funding for Open Access publications (multiple responses were permitted). Among members of non-university research institutions, financing from an institutional publishing fund was specified considerably more frequently (58%) than by members of technical universities (37%) and universities (42%).

Around 30% of the respondents who did not publish Open Access stated too high costs, inadequate reputation and impact, and a low level of quality as their grounds for deciding against publishing their work in Open Access journals (see Diagram 5; multiple responses were permitted). Professors selected the last two reasons at an above-average rate. In turn, a large number of engineers (34%) stated that they did not know of any Open Access journals in their field of research.

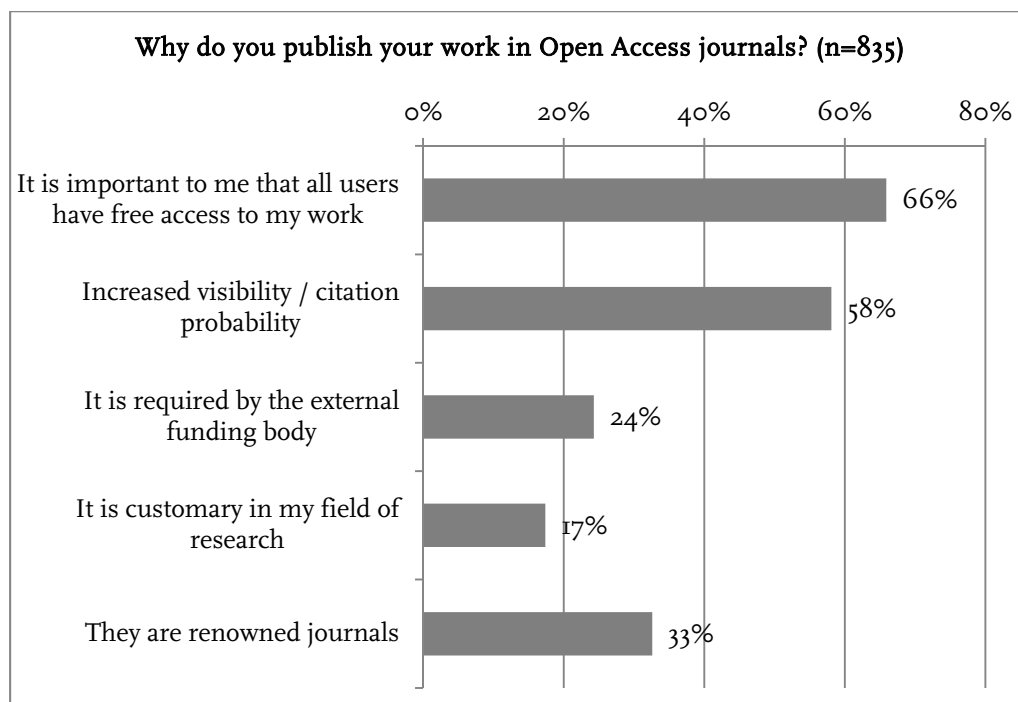


DIAGRAM 4 – REASONS FOR PUBLISHING IN OPEN ACCESS JOURNALS

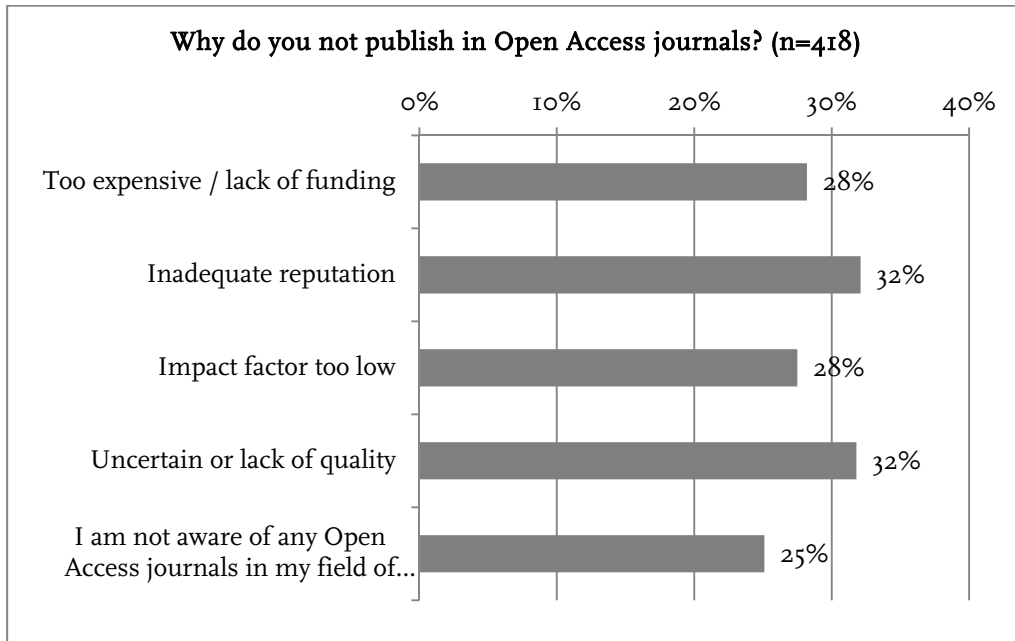


DIAGRAM 5 – REASONS FOR NOT PUBLISHING IN OPEN ACCESS JOURNALS

When asked about their need for advice on Open Access publications, almost 70% of the respondents stated that they had no such need. In contrast, almost one quarter signalled a need for advice on copyright and almost one fifth on requirements by external funding bodies (multiple responses were permitted). Doctoral students in particular expressed an above-average need for advice.

**THE USE OF TEXT REPOSITORIES**

In addition to primary publications, such as in Open Access journals, texts can also be made accessible as secondary publications via repositories such as arXiv and Econstor or institutional repositories.

The use of text repositories for the secondary publication of specialist articles was investigated in the study. Among the 1,150 researchers who responded to this question, 65% did not use repositories, 22% confirmed their use and 13.5% had plans to do so in the future. The use of text repositories was especially widespread among professors (28%), and least common among doctoral students (15%) (see Diagram 6). Taking into account the different fields of research, it was noted that the members of mathematics and natural sciences departments used text repositories considerably more frequently (29%) than the members of engineering faculties (15%).

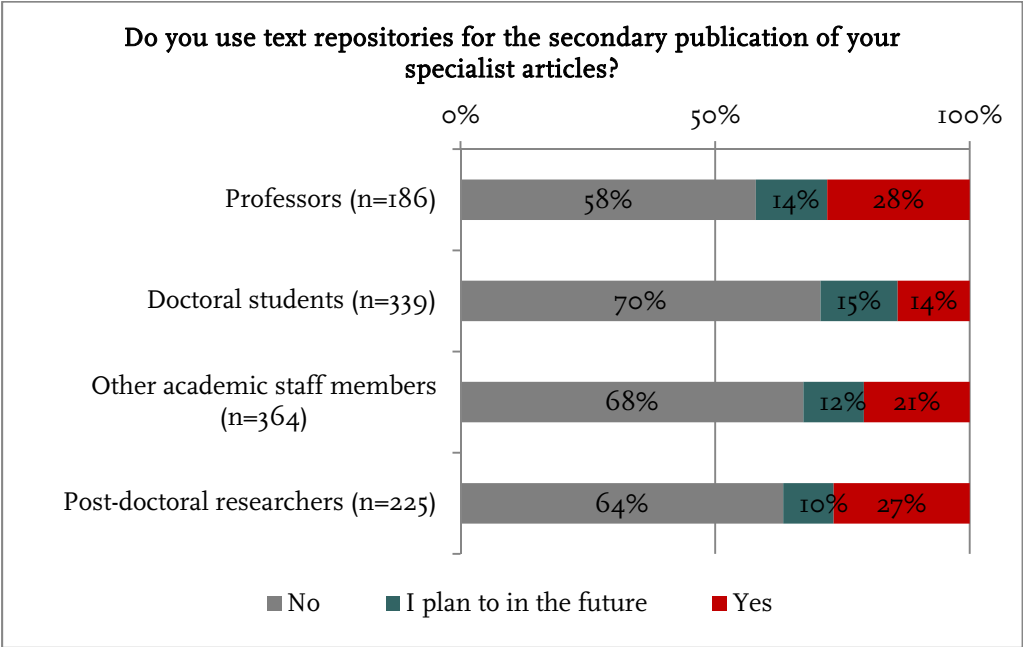


DIAGRAM 6 – THE USE OF TEXT REPOSITORIES FOR SECONDARY PUBLICATION

The main reasons for using text repositories stated by the respondents were primarily to disseminate and increase the visibility of their publications and to ensure quick publication (see Diagram 7; multiple responses were permitted).

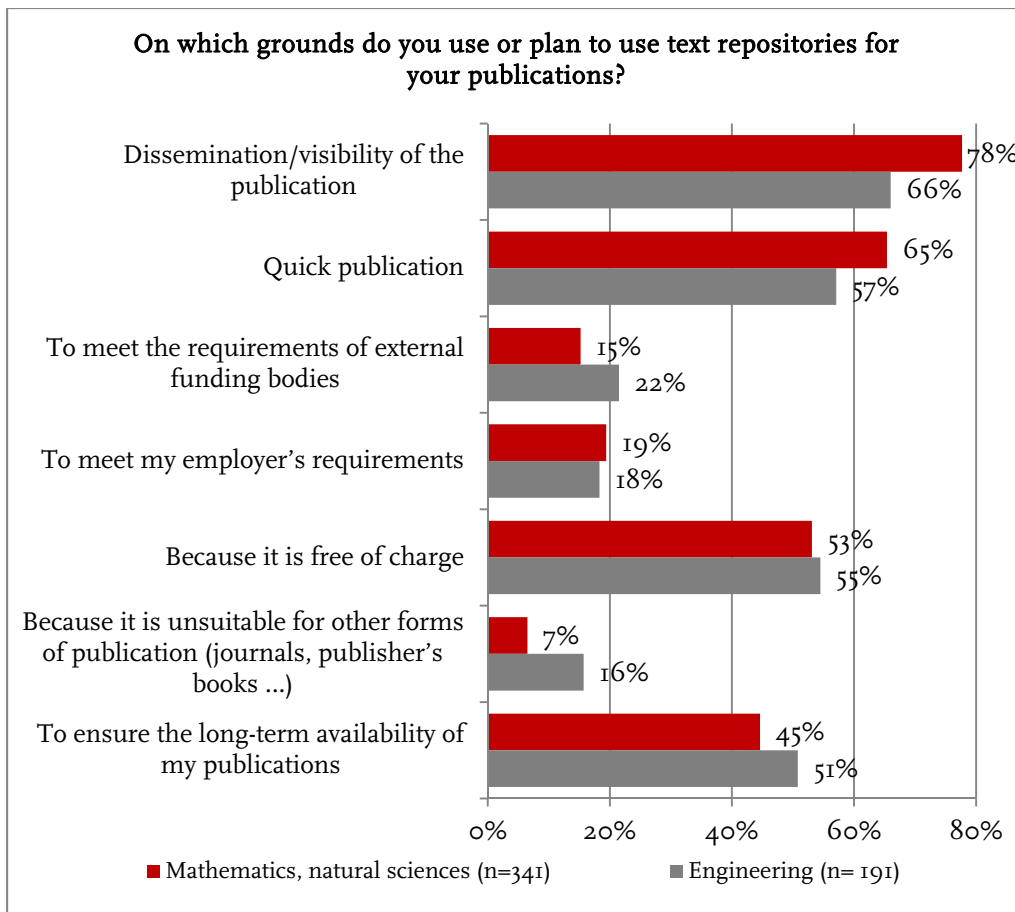


DIAGRAM 7 – REASONS FOR USING TEXT REPOSITORIES

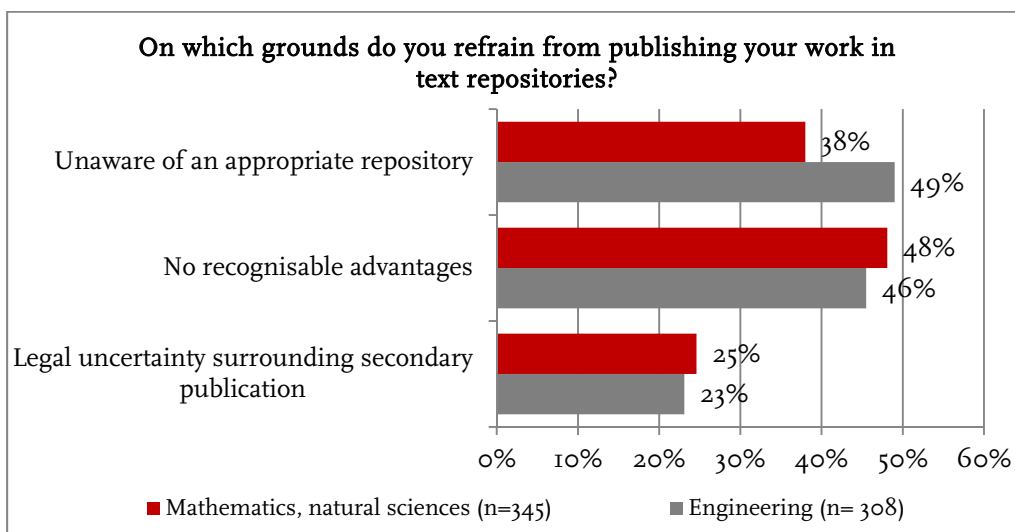


DIAGRAM 8 – REASONS FOR NOT USING TEXT REPOSITORIES

The counterarguments of “No recognisable advantages” and “Unaware of an appropriate repository” dominated the answers given by the respondents who did not use text repositories (see Diagram 8; multiple responses were permitted). The former reason was specified particularly frequently by professors and post-doctoral

researchers. In contrast, doctoral students and other academic staff members stated most frequently that they were unaware of an appropriate repository (49% and 45%, respectively). The most striking difference when comparing fields of research in this regard was that the engineers also stated the reason “Unaware of an appropriate repository” slightly more frequently than the mathematicians and natural scientists (50% compared to 40%).

### PUBLICATION OF NON-TEXTUAL MATERIAL

The evaluation of responses concerning the handling of non-textual material produced during research activities revealed large discrepancies between the production and the frequency of their publication (see Diagrams 3 and 9).

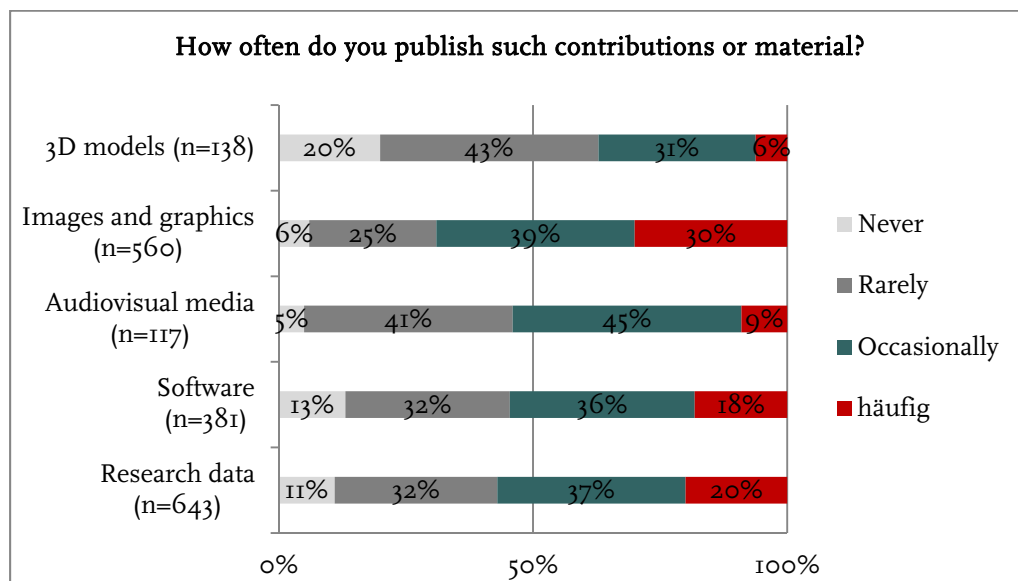


DIAGRAM 9 – PUBLICATION OF NON-TEXTUAL MATERIAL

The majority of researchers produced research data, for example, but only 20% published such data regularly; in contrast, around 40% publish such data rarely or never. 30% of the physicists and astronomers stated that they frequently published the research data they produced, the most active areas of research in this respect. 29% of the post-doctoral researchers stated that they frequently published such research data, putting them in top position among the status groups in this respect. In contrast, doctoral students (14%) were slightly below average.

Scientific software was published frequently by 18% of those who produced software in the course of their research activities; in contrast, 45% published such software rarely or never. The proportion of respondents who published software occasionally to frequently was highest among the professors (66%). Doctoral students, on the other hand, represented the highest proportion of researchers who never published software (21%).



According to the respondents, the audiovisual material and 3D material produced in the research process was published at least occasionally by almost 54% and 37%, respectively. The non-textual material most frequently published was images and graphics, which was published at least occasionally by just under 70% of the respondents.

When asked about their need for assistance with regard to non-textual material, just under 40% of all respondents stated that they had no such need. In contrast, 40% of those who responded to the question stated that they needed search support, followed by just under 30% who stated a need for assistance with regard to citability and one quarter each concerning licensing issues and publication (see Diagram 10; multiple responses were permitted). The greatest need was signalled by biologists (77%) and architects and civil engineers (72%). The higher age groups tended to have less need for support (70% of the 26 to 35-year-olds expressed a need compared to just under 50% in the 56 to 65 age group). However, this group also tended to use and produce less non-textual material. In general, the respondents who produced research data or other non-textual material had a greater need for assistance in the areas mentioned.

Further analysis in subsequent studies should clarify the reasons for the discrepancy between material produced and material published, particularly when viewed together with the information about the need for assistance in the publication of non-textual material, for instance. In addition, it is important to take a closer look at the type of publication, for example, as an independent publication or in the context of other, mainly textual forms of publication. Another aspect for subsequent investigation is the question of overlapping in the categories covered, since non-textual material from the areas of 3D, audiovisual and images/graphics can be research data as well as results from research, for example.

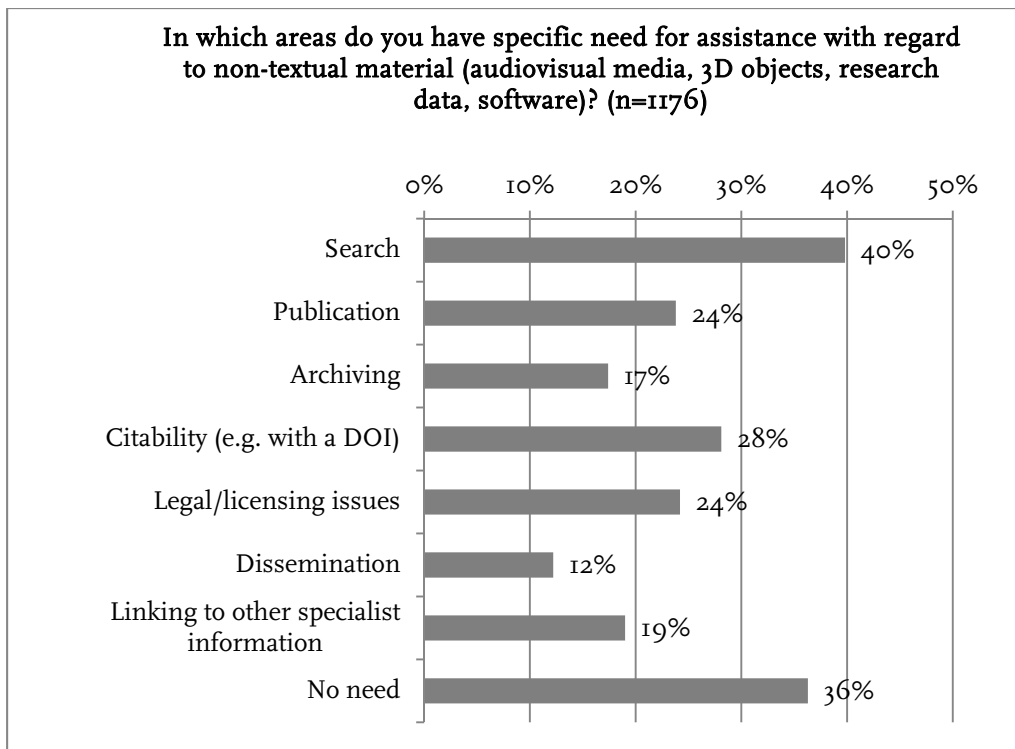


DIAGRAM 10 – NEED FOR ASSISTANCE IN THE AREA OF NON-TEXTUAL MATERIAL

### THE USE OF DATA REPOSITORIES

Depending on the type of data and their specialist discipline, researchers have the possibility to permanently store their research data in repositories, where it can also be published on request. Responding to the question regarding the use of data repositories for archiving or publishing research data, around 45% of those who produced research data stated that they used or were planning to use repositories. Just under four-fifths of the repository users used them to archive their research data and almost half (also) to publish such data (see Diagram 11).

The use of data repositories to publish or archive research data was highest among the professors (27% and 37%, respectively), and lowest among the doctoral students – 20% used repositories for archiving purposes only and just 5% for publishing. The mathematicians and natural scientists were slightly more willing to use repositories (just under 50%) than the engineers (just under 40%). When doing so, the vast majority used a data repository at their own research institution.

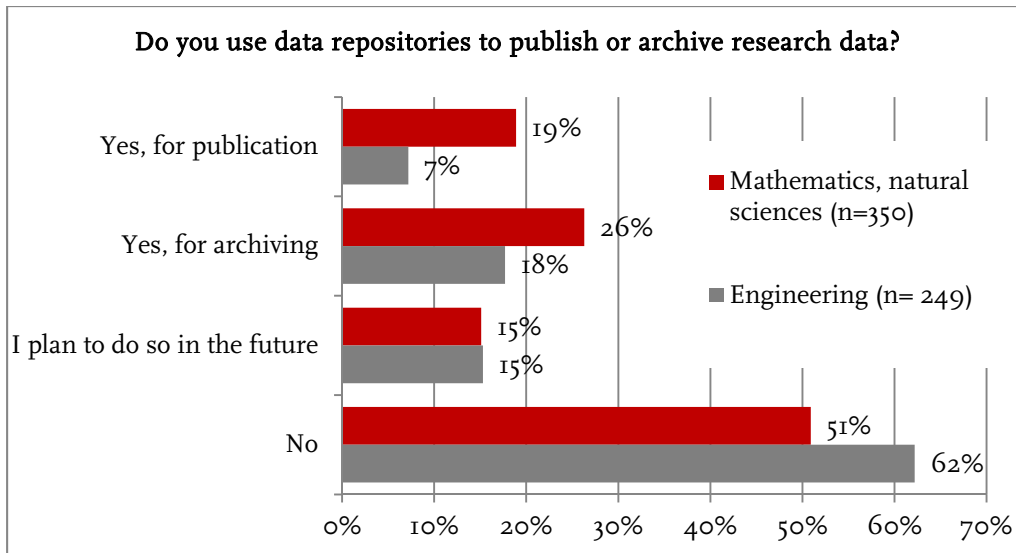


DIAGRAM 11 – THE USE OF DATA REPOSITORIES

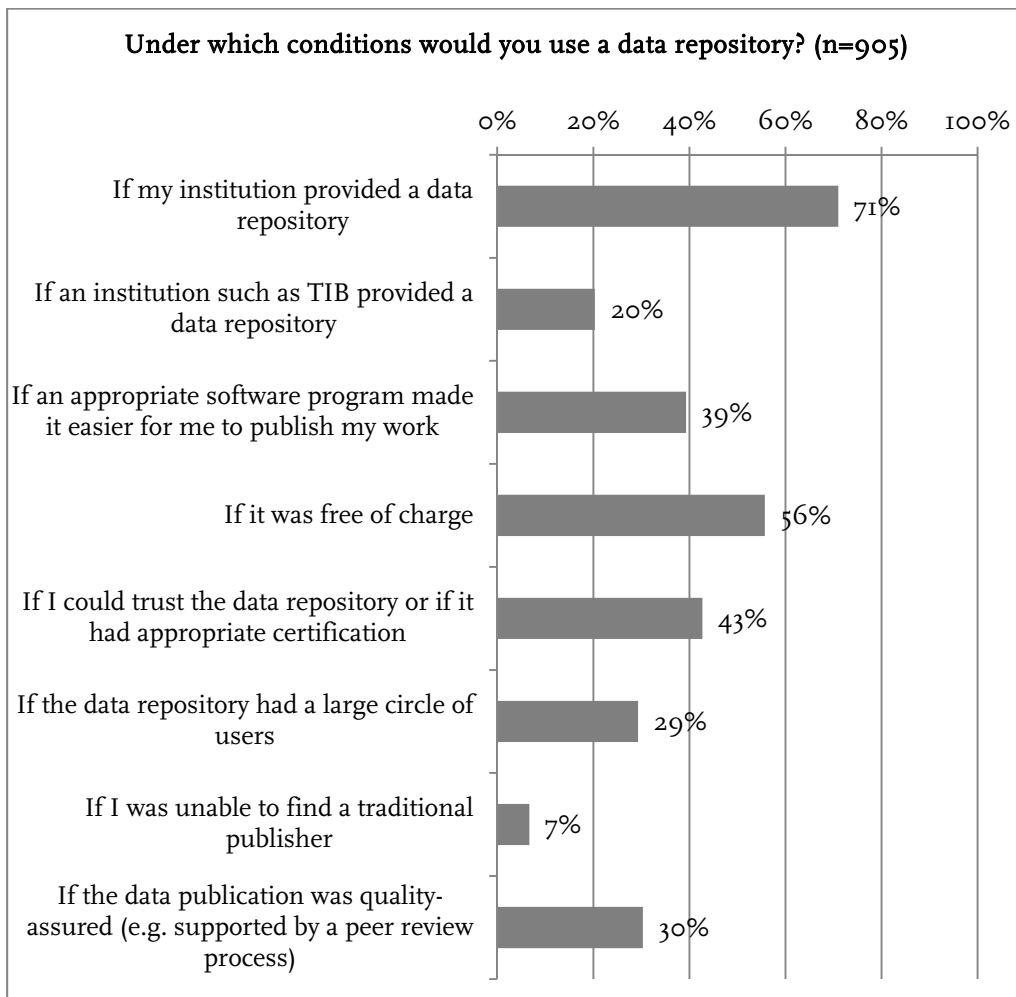


DIAGRAM 12 – CONDITIONS FOR THE USE OF DATA REPOSITORIES

For around 70% of those who did not yet use data repositories, the response “If my institution provided a data repository” was stated most frequently as the condition for the hypothetical use of data repositories. The free use of such repositories was likewise crucial to the majority of this group of respondents. The certification of repositories would also increase the trust the researchers have in them, and hence their willingness to use data repositories (see Diagram 12; multiple responses were permitted).

Just under half of the respondents were unable to assess whether their institution provided sufficient services in the area of research data management (for example, advice, data publication assistance). Around half of the remaining respondents stated that their institutions offered adequate services, the other half negated this question.

### **PUBLICATIONS WITH DIGITAL OBJECT IDENTIFIERS (DOIs)**

A Digital Object Identifier (DOI) is used for the citation and linking of digital publications on the internet. A DOI ensures persistent and unique access to scientific results. DOIs can be allocated for articles in Open Access journals and for grey literature as well as for research data and other non-textual material such as videos, images and 3D models. Whereas DOIs for scientific articles are usually allocated by publishers, DOIs for other digital objects are mainly allocated by the relevant infrastructure operators (for example, institutional and generic repositories). Consequently, an author’s choice of repository indirectly affects whether or not a research data publication, for instance, has a DOI.

73% of the respondents confirmed that they published their work with DOIs, 18% were unaware of DOIs, and 9% knew about DOIs, but had not yet produced any publications with DOIs. In this connection, the mathematicians and natural scientists specified publications with DOIs much more frequently than the engineers (85% compared to 60%).

Most of the publications with DOIs were scientific articles. Non-commercial publications (such as conference proceedings) were mentioned by 20% of the respondents, followed by research data (11%). The other publications were specified by only 0.4 to 2% of the respondents (see Diagram 13; multiple responses were permitted).

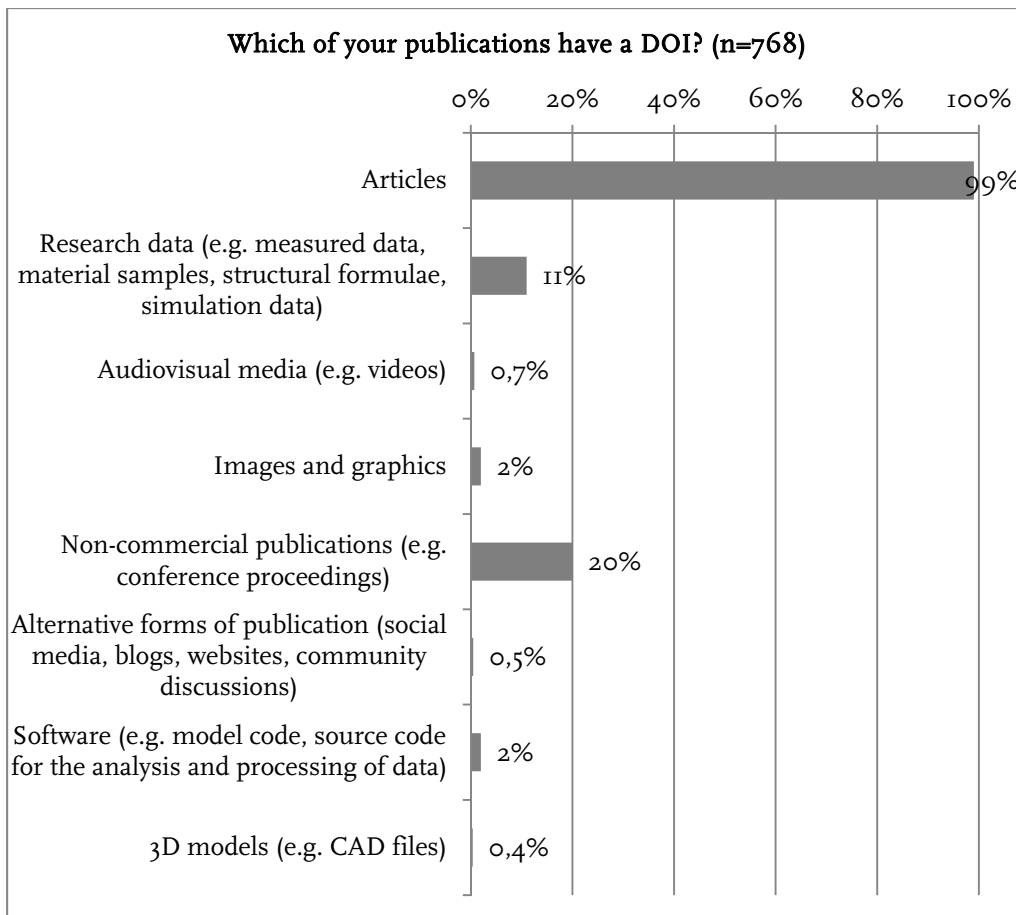


DIAGRAM 13 – PUBLICATIONS WITH DOIS

When broken down into scientific disciplines, the analysis revealed major differences. For example, the publication of research data with DOIs was considerably more widespread among the mathematicians and natural scientists (12% compared to 7% in the other disciplines). In turn, an above-average proportion of engineers produced non-commercial publications with DOIs (30% compared to 15% in the other disciplines). The computer scientists and geoscientists were particularly striking in this respect: the non-commercial publications produced by nearly 40% of the computer scientists had a DOI; around 40% of the geoscientists published their research data with DOIs.

It can be concluded from the responses that the majority of the researchers no doubt resorted to DOI allocation services offered by publishers. Apart from that, i.e. with regard to other contributions and material besides articles, publications with DOIs were not very widespread. In the next question, concerning the main reason for this, the majority of the researchers who responded to this question directly stated that they were unfamiliar with this possibility (56% on average). When comparing the different status groups, this reason was stated particularly frequently by post-doctoral researchers. It seems that many had a lack of adequate information about the registration of DOIs. In addition, professors were

comparatively frequently unable to recognise any advantages (see Diagram 14; multiple responses were permitted).

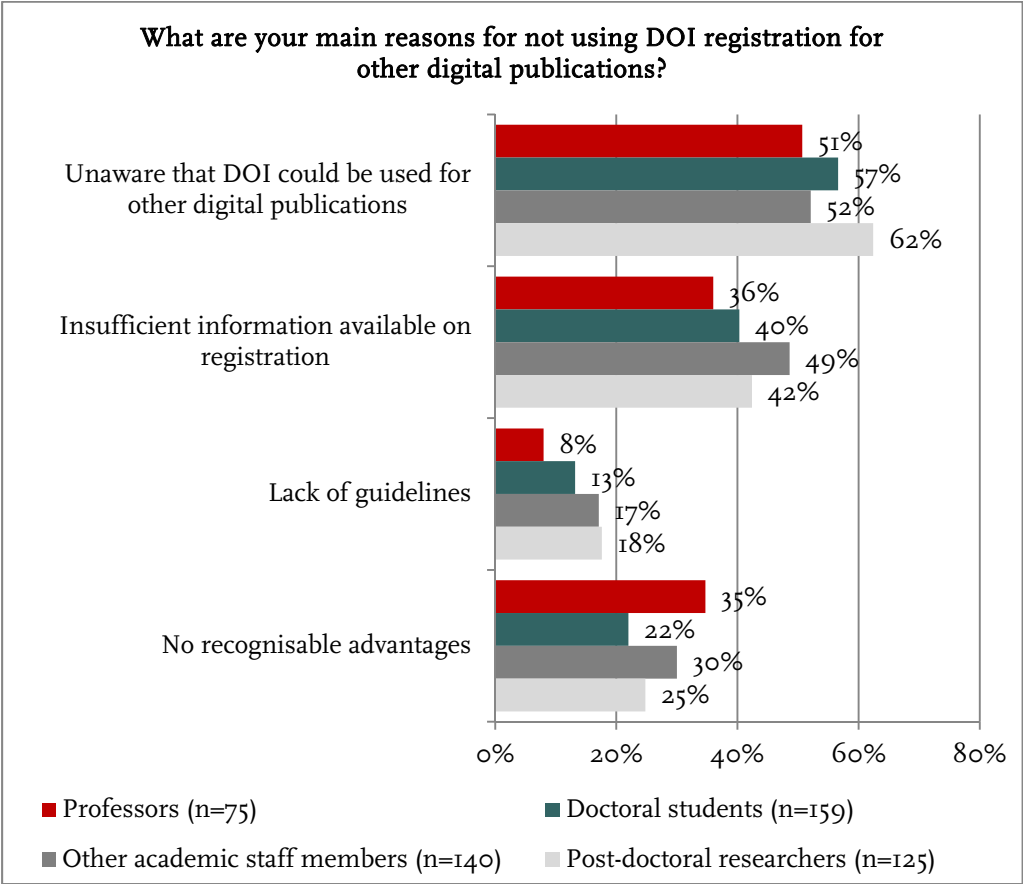


DIAGRAM 14 – REASONS FOR NOT USING DOI FOR OTHER DIGITAL PUBLICATIONS APART FROM ARTICLES

With regard to advice on DOI, 57% stated that they had no need for such information. However, each of the advisory services suggested as responses (advice on publishing and citing research data as well as on technical issues and legal matters) were selected by around one quarter of the respondents (multiple responses were permitted). In this respect, advice on publishing and citing research data, for example, was selected particularly frequently by doctoral students (just under 40%). Taken as a whole, this group had the greatest need for information with regard to DOIs, and professors had the least need.

## CONCLUSION

The survey conducted primarily provided an indication of the existing need for advice on the handling of various material and contributions arising in the context of scholars' research activities. This refers not only to search and publication, but also the reuse of research results.

With regard to the publication of specialist articles in Open Access journals, almost one in three respondents signalled a need for advice, such as on copyright or the requirements of external funding bodies. Among those who did not publish in Open Access journals, lack of knowledge about relevant journals in their respective area of research was often selected as a response. More information about the advantages of Open Access and on possibilities for funding could increase researchers' willingness to publish Open Access. Similar findings were revealed by the responses on the use of text repositories: many scholars were unaware of suitable repositories or the advantages of using them were not apparent.

The respondents appeared to have little awareness of the significance of disclosing research data and other non-textual scientific material for the transparency and reproducibility of research. For example, the survey revealed that only a relatively small proportion of the research data, audiovisual media or scientific software produced was published. The effort associated with processing the data in relation to the advantages of publication, which were not clearly recognised, was stated as a reason for this in several comments. The need for assistance expressed with regard to publication opportunities, the allocation of Digital Object Identifiers, citability or licensing issues relating to the handling of such material may be interpreted as a further obstacle. Many of the respondents would also be willing to use data repositories for the publication and long-term archiving of their research data if a free repository was provided in their institution or if another trustworthy repository was available. In addition, many respondents were unable to provide information on support services in the area of research data management at their institution or considered them to be inadequate.

A number of respondents explicitly pointed out that the decisions on whether their work was to be published in Open Access journals or in text or data repositories were often made at the management level and were not at the discretion of individual researchers.

Different academic statuses (whereby a high status often correlates positively to a higher age) often signified different media behaviour among the researchers. It can generally be stated that doctoral students exhibited the greatest frequency in the production of non-textual material and had the greatest the need for advice; both declined as academic status increased. These needs also varied considerably depending on the academic discipline concerned. For example, it appears that the use of Open Access, research data and repositories was more widespread among

mathematicians and natural scientists and was associated with fewer uncertainties than among many engineers.

No definitive conclusions can be drawn on whether the identified need for advice resulted from the fact that researchers were unaware of the services available in their institutions and in external organisations – such as scientific libraries – and that marketing and distribution activities would have to be optimised accordingly, or whether existing services would need to be adapted better to the different needs that target groups seemed to have, depending on users' academic status and discipline, or whether new services would need to be developed.

On the basis of the user needs identified, services should ideally be developed or optimised and subsequently communicated to the relevant user groups using targeted measures.

This points to untapped potential, particularly for scientific libraries, to cooperate more closely with scientific institutions and communities in the conceptual design, combination and marketing of formats and services targeting specific groups.

## **ACKNOWLEDGEMENTS**

We are grateful to all TIB colleagues who contributed their specialist knowledge in the formulation and selection of questions prior to the survey. We would also like to thank the many researchers who took the time to complete the questionnaire, providing us with valuable information.