

Book

Digital competencies - urgently needed! : recommendations on career and training prospects for the scientific labour market

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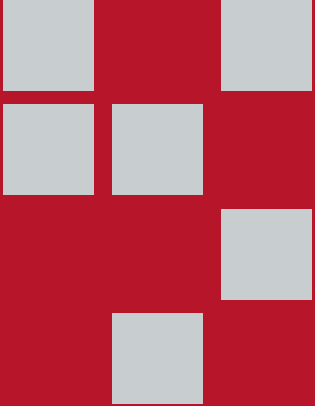
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6

DIGITAL COMPETENCIES – URGENTLY NEEDED!

Recommendations on career and training prospects for
the scientific labour market

Digital competencies – urgently needed!

Recommendations on career and training prospects for the scientific labour market

IMPRINT

This is a courtesy translation of recommendations the RfII adopted in April 2019.

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LIST OF ABBREVIATIONS

CC	Computer Centres
DFN	German National Research and Education Network (<i>Deutsches Forschungsnetz</i>)
GWK	Joint Science Conference (<i>Gemeinsame Wissenschaftskonferenz</i>)
HEI	Higher Education Institutions
HRK	German Rectors' Conference (<i>Hochschulrektorenkonferenz</i>)
NFDI	National Research Data Infrastructure (<i>Nationale Forschungsdateninfrastruktur</i>)
RfII	German Council for Scientific Information Infrastructures (<i>Rat für Informationsinfrastrukturen</i>)
UStG	Value-Added Tax Act (<i>Umsatzsteuergesetz</i>)
WR	German Council of Science and Humanities (<i>Wissenschaftsrat</i>)

1 PROBLEM STATEMENT

The shortage of skilled IT professionals in Germany is well known. Such diagnoses are usually heard in combination with complaints about the lack of digital competencies in other professions.¹ For science, seen as a labour market, these problems also arise in an urgent manner, albeit under even more difficult conditions and in competition with strong demand from the business sector. Digitality is reshaping entire disciplines and fields of research. The demand for specialised knowledge in the handling of digital methods and artefacts is growing rapidly, with the digital transformation in science² meeting relatively static institutional constraints. The requirements for the organisational structures of research institutions are also changing.

High demand for IT professionals in business and science

Many of the associated tasks and required competencies are new. For example, the management and quality assurance of research data as well as the linking of analogue and digital research materials open up new fields of occupation.³ New job profiles related to working with digital data are beginning to emerge in science: Data scientists, data curators/librarians, and research software engineers are needed. Keywords like digital literacy, data literacy, (or, more generally: information literacy) are also frequently mentioned in this context.

In the following, the German Council for Scientific Information Infrastructures (RfII) deals with fields of activity in science which are being transformed as a response to digitality. The educational mandate for society as a whole is of high significance for scientific institutions in Germany, especially for the universities. Nevertheless only the specific labour market and qualification needs of science itself are to be considered here. The focus is primarily on the strategic management of the staffing situation in publicly funded research. The question is how scientific research institutions, their funders and supporters, as well as currently employed staff can counteract the shortage of personnel resulting from the digital transformation. Another question is how publicly funded science in Germany will react in the medium term to changing needs in terms of skills, collaborative structures, and the division of labour,

In focus: scientific labour market

¹ Figures are available from the Bitkom association, among others, cf. Berg (2017) – Der Arbeitsmarkt für IT-Fachkräfte (German only), as well as from the Stifterverband. Estimates of the number of IT professionals needed in Germany in the next five years range from 95,000 data specialists for the business sector (Stifterverband (2017) – Hochschul-Bildungs-Report 2020, p. 71 (German only)) to 700,000 people with special technical skills (Stifterverband (2019) – Carta 2020, p. 52 (German only)). In addition, several million more people will need to expand upon their basic digital skills.

² The term “science” is used here in the sense of German “die Wissenschaft”, i.e. encompassing all disciplines.

³ The German Council for Scientific Information Infrastructures (RfII) defines research data as “all data generated in the course of scientific activity” (cf. RfII Key Terms “research data, research data management” (V2), <http://www.rfii.de/en/topics/#Forschungsdaten> (accessed: 25-07-2019) and RfII (2016) – Enhancing Research Data Management, p. 80.

and how it can respond to the new situation in the labour market and shape it to suit their own needs.

1.1 WORKING CONDITIONS IN PUBLICLY FUNDED SCIENCE

Scientific labour market: special conditions

The scientific labour market is subject to conditions that differ from those for research and development in the digital economy or in industry. Some of these conditions are helpful to promote change and innovative responses to the digital transformation while others tend to hinder them.

One of these underlying conditions is the freedom of science which is guaranteed by the German Constitution and the concomitant right to scientific autonomy. Academics enjoy a high degree of individual freedom in terms of how they organise their work. At the same time, publicly funded research institutions are bound to the formalised career and salary structures of the public administration in the German Federal Government and the *Länder*.⁴ Research is financed to a large extent through funding from third parties, especially at universities, and is thus subject to competitive mechanisms and, for the most part, short time horizons. In addition, research activities are tightly linked to teaching activities and the qualification of young scientists. The educational mandate of universities also includes the orientation towards the needs of business and society – which applies in a similar manner to the research mandate of non-university research institutions (especially the Fraunhofer, Helmholtz, and Leibniz institutes).

These general conditions lead to:

- Loosely coupled organisational structures, some of which are subject to collaborative self-organisation processes and increasing competition, while the others are based on a classic hierarchy;
- A binary and formalistic division of employees into the categories “scientific personnel” and “non-scientific staff”, with different levels of autonomy also reflected in their employment contracts;
- Wages and salaries oriented strictly towards formal professional degrees in conjunction with rigid staff employment schemes and – in terms of contracts – relatively inflexible practices in human resources management;
- A high percentage of temporary employees in a qualification phase (student and scientific assistants, doctoral candidates, postdocs, and even trainees in laboratories and other infrastructure sectors);

⁴ Rfll uses the German term *Länder* for the 16 federal states in the Federal Republic of Germany.

- A high percentage of project personnel and other people with temporary contracts;⁵
- For the employees with permanent contracts, relatively low mobility and fluctuation.⁶

The non-scientific employees are usually sorted into administration, library, and technical staff.⁷ The latter two will be referred to as “infrastructure” personnel in the following. Career paths include, for example, the classic administration or library career, but also include a series of skilled occupations in laboratories and technical service units. Since the 1990’s, science management has emerged as a new profession whose representatives are active in acquiring third-party funding, the coordination of large collaborative research projects, in departments of international affairs, or in dean’s offices, etc. These employees differ, in some cases significantly, from the rest of the non-scientific staff in terms of their proximity to science, their qualifications, and their pay groups. They may even be considered scientific personnel depending on which organisation or unit they work for.⁸

Orientation along career paths among the non-scientific personnel

For the scientific personnel, disciplinary socialisation is typical and also desired. This implies that it is not simply “data”, “big data”, “data analytics” or similar terms which characterise the competency profiles (those of applicants and those in demand) in the scientific labour market. Instead, it is the methods and research questions typical for specific disciplines that essentially characterise the work environments, and therefore the job profiles. Furthermore, working arrangements in science are characterised by a reputation-based, intrinsically motivated work ethic that comes in combination with collegiality and team orientation in many disciplinary cultures (but which does not exclude competition between researchers and/or research groups). In general, their formal hierarchies are also flat, even though such hierarchies often also perpetuate dependencies, for example because of student/supervisor relationships.

Disciplinary socialisation of the scientific personnel

Cooperative relationships between research, teaching, and administration are being intensively discussed, and they have already resulted in new divisions of labour, for example through the professionalisation of management tasks. In the area of information supply and data processing, there is traditionally

Organisational and “cultural” barriers between research and administration

⁵ Such as scholarship recipients, fellows.

⁶ Exceptions include career-oriented management positions and poaching talent from the business sector.

⁷ The methods used by German universities and non-university research institutions to collect these data differ in essential respects. For the purposes of this paper, the most appropriate staff categories possible are used.

⁸ This group is also referred to in the literature as the “third space”, whereby the German Council of Science and Humanities has clearly spoken out in favour of situating such management positions in the administration, cf. Banscherus et al. (2017) – Wandel der Arbeit, p. 19 (German only) and WR (2018) – Empfehlungen zur Hochschulgovernance, p. 85 f. (German only).

an organizational separation between research and such services, which are provided by the staff in central facilities such as libraries, computer centres, or data centres.⁹ Forms of close cooperation have been established in select cases – usually in technology-intensive or data-intensive areas where qualified technical personnel have very close ties to research. Traditional barriers exist between research and administration or the infrastructure, but behavioural and structural barriers also exist, for example in terms of human resources development. Innovations in research and research methodology therefore do not automatically lead to new qualification requirements and qualification efforts for the staff working in administrative or technical support units.

Overall, the conditions for qualification are good in the German scientific system

In terms of human resources development, though, it can be said that the German scientific system offers employees numerous opportunities for obtaining qualifications and developing competencies. Science is slightly ahead of the economy in this regard: at universities as well as non-university research institutions, the conditions for creating “teaching and learning” opportunities are good. Not only students, but everyone working in academia can gain research-related competencies and skills in knowledge transfer. The strong orientation of the German public salary system towards formal degrees is not unproblematic in this context,¹⁰ but it does reflect the high priority placed on qualifications. It also leads to substantial competitive disadvantages in comparison to businesses and scientific institutions in foreign countries; in times when the economy is doing particularly well, businesses are able to offer better contract conditions (permanent positions) and higher salaries.

Unsystematic acquisition of digital competencies thus far

In the framework of third-party funded research in particular, academic competencies are being expanded more or less unsystematically – especially where they relate to the digital transformation in science. Project work often allows one to gain specialised knowledge in advanced fields, and the introduction of structured doctoral programs and numerous preparatory courses for postdocs offer additional opportunities to obtain qualifications.¹¹ However, employers are making few structured investments in the digital competency profiles that will be needed in the medium term.

⁹ For the purpose of this paper, the term “data centres” includes various types of data archives and research data centres that primarily provide research data. In contrast, “computer centres” are understood to be facilities or departments that support the use of computers in general and provide computing power in particular.

¹⁰ WR (2019) – Empfehlungen zu hochschulischer Weiterbildung (German only).

¹¹ An overview of the current transdisciplinary competencies offered can be found in Konsortium BuWiN (2017) – Bundesbericht Wissenschaftlicher Nachwuchs, pp. 198-200 (German only), for an English summary see: Consortium for the National Report on Junior Scholars (2017) – National Report on Junior Scholars. If the teaching of and the need for “management competence”, “transdisciplinary research competence”, and “IT competence” described in the report also include the acquisition of data competence or data management competence is not clear.

In addition, internationalisation must also be taken into account as an important boundary condition for the expansion and maintenance of digital competencies in German scientific research institutions.¹² With the growing international competition for young academic talent, the mobility of students and young scientists offers opportunities to the academic labour market in Germany, but it also harbours risks. IT degree programmes at German universities have been able to attract international students. In IT-related disciplines, though, the German scientific system is also losing graduates to the international market.

Risks and opportunities of international mobility

1.2 ON THE APPROACH

To get an idea of the effect of the digital transformation on the scientific labour market, the RfII will initially analyse new and changing *tasks* for which the scientific system will require qualified staff. Based on these tasks, we will discuss *job profiles*, followed by a discussion of the required *competencies*. Measures for implementation in curricula are not the subject of this analysis.¹³

Tasks as a starting point for analysis

The RfII would like to take up on a recommendation already made in our position paper PERFORMANCE THROUGH DIVERSITY (2016), namely recommendation 4.5. “New occupations, degree programmes, training programmes”. In terms of research data management, we emphasised that: “data services, data management, and the design of information infrastructure services are scientifically complex problems of a new kind”,¹⁴ which require differentiated responses from education providers. The RfII also pointed out a “trend towards flowery professional titles”.¹⁵ It reiterated the importance of expanding the definition of the term “information competence” and called for fulltime degree programmes as well as non-academic vocational training to cover the needs of information and data centres. Finally, the RfII emphasised how imperative it is to keep qualified staff in publicly funded research.

Problems of a new kind

¹² Stifterverband (2017) – Hochschul-Bildungs-Report 2020, p. 54 ff. (German only).

¹³ There are already numerous surveys on this subject, for example the findings of the “Curriculum Design & Quality Development” group of the German Forum for Higher Education in the Digital Age (Hochschulforum Digitalisierung (2016) – Hochschulbildung im digitalen Zeitalter (German only), for an English summary see: Hochschulforum Digitalisierung (2016) – Pathways for Higher Education) the widely propagated model of the EU project EDISON (Demchenko et al. (2017) – Data Science Model Curriculum), or the recommendations of the German Informatics Society (GI/ITG (2018) – Curriculum Technische Informatik (German only)).

¹⁴ RfII (2016) – Enhancing Research Data Management, p. 44.

¹⁵ Cf. Hanraths (2015) – Hacker und Missionare (German only), Scholze/Mönnich (2014) – Data scientist the sexiest job in 21st century.

Specific changes in the labour market are difficult to assess – a focus on research data management

When the Rfll now discusses the problem of human resources in more detail, the diagnosis – starting with the “tasks” – delves into complex changes whose relevance is difficult to grasp for Germany (and in general). Based on the self-evaluations of individual stakeholders (e.g. libraries), various studies on the situation in parts of the higher education sector, and our own observations, it is possible to draw some conclusions regarding daily work routines characterised by digitality.¹⁶ These conclusions are rather claims, though, mainly due to a lack of data.¹⁷ The Rfll chooses research data management as it is one of the main fields where a specific demand for qualified staff, and therefore a need to act arises. In a modern scientific work environment, the so called “data competencies” cannot be viewed independently from the broader concept of digital competencies in general.

¹⁶ Among others: DBV (2018) – Positionspapier Wissenschaftliche Bibliotheken 2025 (German only); Arbeitsgruppe Forschungsdaten (2018) – Research Data Vision 2025 (German only); Gesellschaft für Informatik (2018) – Digitale Kompetenzen in der Hochschulausbildung (German only); as well as the empirical studies conducted by Banscherus et al. (2017) – Wandel der Arbeit and Gilch et al. (2019) – Digitalisierung der Hochschulen (German only).

¹⁷ Only the employment conditions and opportunities for young scientists are surveyed regularly (cf. Konsortium BuWiN (2017) – Bundesbericht Wissenschaftlicher Nachwuchs, p. 29 ff. (German only), for an English summary see: Consortium for the National Report on Junior Scholars (2017) – National Report on Junior Scholars). Comparable monitoring studies of other employees in academic and non-university research and comparisons within industry research are only available in a few cases or are lacking completely. The German official statistics cover the scientific support staff only very generally. The statistical surveys conducted by the employment agency also do not provide reliable information enabling differentiation, as the labour market statistics, which are classified by industrial sectors, do not include science as a sector.

2 THE DIGITAL TRANSFORMATION: TASKS AND THE DIVISION OF LABOUR

2.1 CHANGED PROCESSES, NEW TASKS

Changing processes always lead to new tasks. Characteristics of digital research include, among others, altered data collection methods, very large amounts of highly heterogeneous data, complex application programs, new analysis methods and visualisation techniques (simulation, virtual/augmented reality), an increasing need to purchase software-driven devices (including the related test and training phases), digital surveys and publishing, as well as group work with remote partners on digital artefacts instead of paper-bound procedures alone or in sequence. This applies to basic research and application-oriented research.

Transformation
of the research
process through
digitality

In the following, the transformation of tasks will be described roughly based on examples. The tasks are divided into three areas:

[A] Tasks arising wherever work is done that *support* scientific processes in that it fulfils technical or administrative prerequisites; a large portion of the employees working in these fields are qualified staff without academic degrees.¹⁸

[B] Tasks that require field-related as well as research-related knowledge and that *facilitate research collaboratively* or contribute otherwise (i.e. in the form of information infrastructure services) to the research process; people with scientific training often work in this area.¹⁹

[C] Typical tasks done in independently conducted research (and possibly teaching); PhD holders and candidates as well as people employed as senior scientists work in this area.

Tasks in the area of administrative and technical support [A] are simplified in some instances by digital work environments, but most become more demanding.²⁰

¹⁸ In Germany, employees will usually have completed at least a vocational training (the so called dual training system in Germany comprises education and training both at a vocational school and on the job). Continuing Vocational Education in so called “Fachschulen” and “Fachakademien” can be equal to the first level of higher education according to international standards but is not treated as an academic or scientific qualification in Germany.

¹⁹ With this rough division into three categories, we have deliberately refrained from using the binary categorisation into “scientific” and “non-scientific” staff – with a few possibly relevant exceptions.

²⁰ Over the last decades, a substantial number of non-scientific positions in laboratories and technical services have been eliminated. Due in part to digitisation (telemedia, miniaturisation, simulation), the percentage of classic lab employees, chief engineers, photographers, technical draughtsman, etc., at universities and research institutions has declined, cf. Banscherus et al. (2017) – Wandel der Arbeit, pp. 22–29 (German only).

Consolidation
and increasing
requirements for
supporting tasks

They are also condensed quantitatively because networking leads to more communication, higher information needs, and a higher work pace. Workplaces with rapidly changing equipment, the testing and installation of new hardware, the maintenance and repair of devices that are almost all equipped with software components require special knowledge or training in computer science. The growing number of different end devices, access locations (home office), and partners in joint projects (rights management) also increases the complexity of the requirements placed on the technical environment. Standard solutions for IT security, for example,²¹ can turn out to be unsuitable. The capacities for additional support or workplace services for research can be limited, e.g. in University computer centres, which is why “decentralised” or local IT support services (meaning within the departments or professorships) frequently need to be improvised: Costly external service providers are contracted or informal, unwritten areas of responsibility are formed. In many cases such tasks are assigned to the people fulfilling the role of an “administrator”. The job profile and professional training of these people often do not match the actual range of tasks.

“Scientification” of
research-related
tasks

Tasks that require field-related as well as research-related knowledge [B] are changing especially dramatically. This is because the research processes themselves are changing, but also because the digital transformation has changed the function of libraries and of computer and data centres. Employees act as “brokers”, connecting users and user groups for the digital processing of knowledge, and for the use of data services. Key tasks in research data management such as data curation including a needs analysis and the selection of software and long-term archiving methods require greater proximity to the researchers and to the research process itself. Especially in the infrastructure (library and technical services), jobs are also becoming more scientific in the sense that employees can and must work closely together with researchers – not only in specific cases, but for entire projects. This means it is almost always necessary to get highly qualified infrastructure experts involved, some of whom are from related disciplines, wherever researchers (need to) make path decisions in the overall research data life cycle (cf. also section 2.2). The growing legal challenges (implementation of directives, license agreements, copyright and licensing issues) as well as a notable increase in the scientists’ need for professional consulting services will change the range of tasks in information infrastructures. The same applies to the administrative part of science management, which has taken on new tasks due to database-driven reporting systems, contract management in joint projects, and digital scholarly communication.

²¹ This is a serious problem that has been completely ignored, presumably due to a lack of staff resources.

For researchers [C] the access to existing knowledge, the research methods, the presentation of research findings, and the publication cultures in the disciplines have been transformed. Automation, the use of databases, simulations, a variety of data analysis methods, linking and visualisation capabilities are altering specific steps in research procedures. Multifunctional repositories and platforms as communication hubs for researchers “digitise” scientific communication as well as the transfer of knowledge to the economy and society. Researchers are not only required to expand their – method-based – user competencies, but also gain the knowledge required to make targeted investment decisions. The area of digital reporting systems tailored to meet a variety of needs is growing rapidly, and researchers are becoming more involved in the development of such systems: One of the special features of the handling of digital data is that the documentation requirements (i.e. “metadata”) as well as the time and effort required to explicate the work steps involved in quality assurance are increasing dramatically. Researchers are also required to discuss criteria for assessing the transparency, plausibility, and reproducibility of their methods to a much greater extent. The overall quality of “digital” research – research planning and execution – not only depends on increased technical (or at least: user) knowledge, but also on knowledge of the corresponding legal and ethical foundations. Over the last two decades, the communication tasks of the individual stakeholders have also changed and intensified across all three areas.

Researchers also perform infra-structural tasks

The following can be stated:

- In some fields, tasks have been completely eliminated or reduced because the execution of these tasks has been digitised.
- The scope of other tasks increases, and completely new tasks will also arise. Work intensification and increased substantive requirements can be found in all three task areas [A], [B], and [C].
- The need for coordination and cooperation increases at the transitions between task areas [A], [B], and [C]; new kinds of division of labour will develop, especially at the transition from [B] to [C].

The digitisation of work processes will not free up personnel capacities in the scientific system. Instead, a task critique is required. Competencies and experience are often lacking or tasks are not anchored in the organisation (yet) because the stakeholders need to come together again (see the table in Appendix 1). Digital work methods therefore increase the complexity that comes in conjunction with networked and expanded environments and milieus. Furthermore, research in the digital age has increased its rate of output as well as its transparency (indicators, monitoring). The scope of services offered by organisational units and the requirements have increased consistently. The financial resources for public research and the boundary conditions of the scientific labour market stated above have essentially remained the same during this time. Locally, they also become worse in some cases, for instance in terms of the staff capacity for permanent tasks.

Higher performance and fewer personnel through digital work processes

2.2 DIGITAL RESEARCH PROCESS AND DIGITAL INFRASTRUCTURES

Traditional division of labour between research and infrastructure is on trial

There is a grown division of labour between research and infrastructure²² in the provision of information and organisation of data processing. The digital transformation puts this division in question. Through the increased use of digital research processes, tasks related to research and teaching have become closer to tasks classically associated with central infrastructure facilities. Researchers take on technically oriented tasks themselves such as collecting information or the technical configuration of their workplace. Tasks relating to the provision of advanced technical procedures are expanding rapidly in specific research projects. These tasks could be centralised, but could also be organised locally, e.g. in research units. This presents challenges to a division of labour based solely on qualifications: What can technical staff be charged with? Which tasks require a rather technical or an information science qualification, which require an organisation- and management-oriented qualification, and which even require disciplinary scientific training?

Professionalisation in the area of new infrastructure tasks

The tendency to reduce administrative/technical staff in the “decentralised” area (e.g. research units) stands in contrast to the unorganised growth in the area of infrastructure tasks mentioned above. The expanding field of research data management is a perfect example of this. Specialised expertise is being established in this field where staff supports and at the same time conducts research and also publishes papers. This can be seen for example wherever data corpora are being built, the quality of digital data is evaluated, and data sources as well as special tools for specific disciplines are selected or even modified, if necessary. Other such fields include the execution of data and error analyses or the programming of data queries and data transformations. Professionalisation is also required in terms of tasks like the indexing and modelling of metadata, the creation and implementation of data management plans, or in ensuring data integrity. Even monitoring innovations in the area of (specialised) digital tools and new data and methodology standards is an “infrastructural” task whose scientific importance is growing dramatically. The transformation described can be easily seen in the growing importance of research data management or data centres in research institutions.

²² Cf. the differentiation introduced in section 1.1 between the non-scientific area in administration and in infrastructure (library, technical services).

In the present institutional environment, it is hard to organise staff for collaborative infrastructure tasks on the interface to research. Employees with tasks of type [B] and [C] operate for various reasons, not least due to status and departmental thinking, often independent of each other. Promotion of interdisciplinary and transdisciplinary communication skills as a key competence can also be lacking on all sides. When scientifically trained staff switches to the area of scientific support services (area [B]), they are often assigned to another status group and lose academic privileges. The conventional binary structure of staff categories (scientific/non-scientific) has proven to be unsuitable for filling staff positions adequately (cf. section 1.1). In terms of the funding of research data management, surveys among researchers [i.e. area C] have stated repeatedly that the main obstacles are the lack of recognition for achievements other than the ability to raise third-party funds and publish research papers. Attempts to integrate a wider range of achievements into the scientific reputation system have not been successful in practice thus far.²³

Organisational
structure impedes
task-based
cooperation

The scientific system has reacted inadequately to the fundamental changes that the RfII would like to refer to here as the “scientification” of infrastructure tasks. Many of the skills needed are presently only being taught occasionally, for example through peer consulting and informal exchanges of experience in professional networks. Also, workshops and summer schools are organised by various stakeholders. Formal qualification paths, especially for people wanting to make a lateral career move, are rather rare in the current system. The necessary qualifications are therefore often obtained through learning by doing. Degree programmes or certified courses leading to formal qualifications are just as necessary as the systematisation of low-threshold learning paths since informal learning fits in well with many digital tasks. New areas of specialisation are being offered because of this, e.g. in data curation or through multidisciplinary information scientists and the evolution of disciplines looking for new methods (“Digital/Computational X”). More than 30 such degree programmes (e.g. Data Analysis, Data Science, or Information and Data Management) have arisen in Germany over the last years, and even established fields (like statistics) now offer programmes in digital data analysis.²⁴ However, the growing number

Lack of qualification
paths

²³ The EU project ACUMEN 2014 formulated a proposal (including a template) on how scientific achievements could be documented and evaluated on a wider basis. The “Researcher Portfolio” template includes expertise in methods, technologies, teaching, management, and knowledge transfers. The following are categorised as scientific output: datasets, software, tools, web and social media academic communication; and the “Influence” portfolio also includes online discussions, the number of followers and downloads; cf. ACUMEN Consortium (2014) – Guidelines and Portfolio.

²⁴ The monitoring of new degree programmes explicitly and primarily addressing digitality was attempted by the HIS and the German Forum for Higher Education in the Digital Age, and the Alliance Priority Initiative “Digital Information” also dealt with this topic; cf. Lübcke/Wannemacher (2018) – Vermittlung von Datenkompetenzen (German only); Heidrich/Bauer/Krupka (2018) – Ansätze zur Vermittlung von Data Literacy (German only).

of such degree programmes (and in the number of graduates with these degrees) will not be able to cover the current and medium-term demands of the scientific labour market, especially the demand from information infrastructure facilities.²⁵

Further education
and training
campaigns are
necessary

Further education and training campaigns for existing staff in scientific institutions are therefore urgently needed. The number of such offers is not very large at the present time and is not integrated systematically into the relevant academic programmes offered “on the market” on data science topics (primarily intended for non-scientific target groups).²⁶ Structural changes to lower the barriers are needed just as much as well.

2.3 EXTERNAL OR INTERNAL SCIENTIFIC RESOURCES

Own development
vs. purchasing
proprietary
IT solutions

Wherever tasks change drastically, it is also necessary for publicly financed research to use resources flexibly. In general, the conditions for the development of “own” solutions are met, especially at universities. Project formats such as teaching and doctoral projects in information or computer science have already supported local digitisation processes. In the early years of the digital transformation in particular, this led to the impression that scientific institutions have advanced IT competence (and even the necessary IT facilities) already „in-house“.

Meanwhile, science is also confronted with complex and highly specialised, internationally established standard technologies in many fields. In general, the alternatives are to develop a complex solution in-house or purchase expensive products and/or enlist the services of commercial providers (for example developers of special software).

“External” solutions lead both to a loss of control over the technology,²⁷ and to financial risks due to potentially costly dependencies. In the globally

²⁵ On the issue of specialisation cf. Stiller (2018) – Data Science aus Sicht der Mathematik, p. 45 ff. (German only). Businesses are not only demanding the development of new degree programmes, but also the expansion of existing curricula in all subjects. (Meyer-Guckel et al. (2019) – Future Skills Diskussionspapier 3, p. 5 (German only)).

²⁶ For example through the “Further Education GmbHs” of the universities (in part together with external education providers) or at the Fraunhofer Academy. For further education programmes at universities, the German Council of Science and Humanities urgently recommended more activity, the hiring of more staff, and the creation of a consistent financing system, cf. WR (2019) – Empfehlungen zu hochschulischer Weiterbildung (German only). Universities in particular are primarily perceived as providers of continuing academic education, but the needs of science itself are rarely addressed (e.g. Meyer-Guckel et al. (2019) – Future Skills Diskussionspapier 3 (German only)).

²⁷ When proprietary software is used, without the ability to control details relevant to the scientific process, a black box effect takes hold that impacts the quality of research results, for example with respect to its reproducibility.

networked publishing industry, in the use of large-scale clinical equipment, in the simulation of molecules, or in the area of research software, public research is faced with the question of how far it wants and can work with commercial products and/or partners.

On the other hand, the choice between developing in-house solutions and purchasing proprietary solutions (i.e. outsourcing) is a staff decision to a certain extent. Especially when dealing with sophisticated, possibly even complex medium-term development tasks or providing digital support to team-based research projects outside of their “own” field of research, research institutions are poorly positioned in the labour market in terms of the ability to meet their needs. A classic computer centre or even a library already managing information from multiple disciplines is seldom able to perform specialized, research-related programming tasks. Where this is possible, it is due to third-party funding. Young scientists with temporary employment contracts have their own qualification interests in mind and often leave temporarily funded research infrastructure initiatives after a few years. “Information infrastructure” tasks or other tasks that advance science through digital know-how are not really attractive to university graduates or administrative/technical professionals (IT specialists) because of the lack of – reputation-based or financial – incentives.

Research institutions
often without
an alternative to
outsourcing

Through the establishment of IT competence centres, science has been able to counteract this in part (especially in the area of high-performance computing). Also the National Research Data Infrastructure (NFDI), which is currently being established in Germany, can be expected to have qualification effects at the interface between research and advanced infrastructure tasks. However, it is impossible for research organisations as employers and competitors to be well positioned in the labour market, neither in terms of job profiles and salary structures, nor in terms of a potential – and possibly common – strategy to balance out the ratio of internal to external IT resources. The result is that the “excess” of digital tasks is paradoxically met not only by a “lack” of active management of the digital transformation, but also a lack of suitable financial resources. Even in areas where science has enough funds or wants to invest, it is often impossible to find suitable staff, not least because there are no internal applicants or no employee could be qualified and held. Where capacities or competencies for the management of software development are lacking, project leaders are more likely to decide on commercial software solutions (that may cost more, and at the expense of independence) than to take on innovative programming tasks themselves. For the scientific employees, a job in the IT industry or launching their own start-up to program such software and then offer it at market prices is often more attractive than three more years working on a research project especially acquired for them.

Too many tasks
– not enough
management

Challenges posed by academic spin-offs

The increasing outsourcing of tasks to business partners is also an effect of spin-offs from the world of science. Prototypes developed in a research setting can then be developed to the point where they are ready for the market (and possibly offered in turn to researchers as commercial products). To develop the competencies needed for publicly accessible and controlled services, promoting academic spin-offs can be a sensible way to counteract developments in the free market that are unfavourable for the public sector (e.g. monopolisation and higher prices for successful products resulting from publicly funded science). In terms of science policy however, the potential gains and benefits that such spin-offs can have for society as a whole should be balanced against the medium-term opportunities of solutions developed by science's own efforts. Getting involved in spinoff activities opens the opportunity to integrate companies that provide scientific services more tightly over the medium term.

2.4 COMPETENCY PROFILES AND PROFESSIONS

Expectations on competencies

Certain expectations are placed on the tasks and objectives of science in terms of competencies, and correspondingly on job profiles as well. In addition to scientists (professors and scientific staff), the recognised and "plannable" professions defined by competence profiles include:

- Information specialists (documentalists with dual training, specialised staff for media and Information services, as well as those with academic degrees: web editors, scientific documentalists, archivists, and librarians);
- IT professions (dually trained IT specialists and those with academic degrees: information scientists, including information scientists like bioinformaticians who have studied an additional discipline);
- Technical lab staff (lab assistants with dual training and lab managers with academic degrees and/or scientific training);
- Administrative professions (staff with administrative training and higher-level administration positions filled by people with academic degrees such as lawyers and science managers).

In actual employment situations, employees are categorised either as scientific staff or non-scientific staff. The digital transformation, though, has begun to change job profiles.²⁸ The rapidly developing, simultaneously increasing number of highly specialised, field-related and research-related tasks [B] has also compelled individual researchers and scientific institutions to call for new job profiles. Data curators/librarians or data scientists are new (potential) professional titles in this context. The Federal Employment Agency in Germany has already recognised data scientist as an official profession.²⁹

New, expanded,
and transformed
job profiles

The extent to which this or comparable multidisciplinary competency profiles actually are practical solutions for the needs of science is not clear at present. The amount of domain knowledge needed (meaning an understanding of the scientific work done in specific disciplines or their methodological “cultures”) leading to a requirement for a specialised academic degree cannot be stated in general. Generally, various options are available – especially in the area of discipline-related infrastructure tasks: completely new job profiles can be developed, existing ones could be expanded based on disciplinary competency profiles (specialisation to meet the specific requirements of the discipline), or job profiles can be completely transformed and in turn change the respective competency profiles by closely interlinking digitality and the disciplinary skills in the training and education phase (in the highly qualified area, e.g. through degree programme patterns like “Digital/Computational X”). Additionally, the acquisition of specific additional competencies on the basis of further (academic) education and professional training programmes is a relevant option.

The changes to job profiles and organisational roles outlined should also be reflected in the future personnel categories used by universities and non-university research institutions. Dividing non-scientific personnel into categories like administration, library, and technical services is not sufficiently complex. Functions or organizational roles – like those already established for staff in the scientific personnel categories – would be more convincing. In 2013, the German Council of Science and Humanities has recommended additional personnel categories for the scientific staff, recognizing key activities in the areas of research, teaching, knowledge transfer, and infrastructure services. Policy makers have not followed this recommendation thus far.³⁰

Existing personnel
categories are not
sufficient (any more)

²⁸ An example of this is the ongoing reform process for job profiles in archives and libraries, which also includes public service traineeships at the level of the *Länder*.

²⁹ Recognised as a profession by the Federal Employment Agency, Profession ID: 129987, systematic number: 43104-132, <https://berufenet.arbeitsagentur.de> (accessed: 25-07-2019).

³⁰ WR (2013) – Perspektiven des deutschen Wissenschaftssystems, p. 45 (German only).

3 INTERIM SUMMARY: TAKING BROAD, TASK-BASED ACTION

The “scientification” of infrastructure tasks requires reactions tailored to science

The digital transformation has changed scientific work due to new, and in many cases also more complex, tasks – and it will continue to have a large impact in the future. This applies not only to competencies, but also to organisational models and even to institutional innovations. Human resources departments and the “configuration” of the scientific system must take into account the increasing amount of networking, collaboration, and “interdisciplinary” communication pressure as well as the “scientification” of research-related infrastructure tasks. It is also necessary to strengthen the infrastructure-related competencies of researchers in light of the rapidly growing digitality of research. The strategic question of job profiles – not solely considered from the perspective of the general labour market, but in terms of the needs of science itself – also has to be addressed. In other words: A structural transformation is taking place, and the challenge for science is now to react specifically as a united system – beyond simply meeting qualification needs.

Competition for the “best minds” within the general labour market as well as the effects of the lack of qualifications in public administration pose additional challenges beyond those illustrated. The urgently needed human resources are lacking for both reasons – the digitality-based transformation with rapidly growing or new tasks and the (special) problems encountered when recruiting and qualifying staff inside the scientific system. For these reasons, the focus should not only be directed towards new educational content, but also on the structural level in order to find scientifically appropriate and sustainable solutions that contribute to the progress of digitality. Whether or not digitisation will increase the total number of employees in scientific institutions is a matter independent from this conclusion.

Coordinated action is necessary

For this reason, the Rfll recommends decisiveness, but also obtaining an expanded picture of the situation and implementing a large number of coordinated activities at various levels. Overall, the creation of new job profiles inadequately reflects the actual needs. The following is also obvious: In research and teaching, it is not only competency training in terms of “data” that is lacking. Instead, science is characterised by disciplinary objects and methods that themselves are changed by digitality.³¹ It is by no means clear if new university degree programmes with a very open focus on “data”, which are currently in high demand, are suitable for covering the specific needs of the scientific labour market in the future.

³¹ For information on the transformation of the scientific system through data-intensive research, cf. the upcoming recommendations of the German Council of Science and Humanities.

3.1 ASSIGNING TASKS

If changed tasks are the key criteria for determining personnel needs (instead of new job profiles) the increasing importance of digital processes and associated work expectations become obvious. In certain task areas, the digital transformation is creating typical quantitative shortages (there is no “place” in institutional staffing plans or there is simply a lack of funds, see Table 1 in the Appendix) as well as qualitative problems (personnel is not sufficiently competent and/or qualified or competent/qualified personnel cannot be acquired). The latter is exacerbated especially in institutions that already need to improvise due to quantitative shortages.

Quantitative shortages and qualitative problems

3.2 STAKEHOLDERS, RESPONSIBILITIES, LEVELS OF ACTION

The digital transformation is changing the requirements of the scientific labour market for structural reasons and permanently. It is therefore necessary to raise awareness that this requires “qualitative” changes at the management level of the scientific system. The term “digitisation” and the demand for more highly and very highly qualified specialists and the simultaneous demographic transformation are quite common. However, the stakeholders involved are not fully aware that in consequence the restructuring of the scientific labour market has to be organised.

Initiating the restructuring of the scientific labour market

To cover the current and medium-term need for labour in the German scientific system, and thus ensure its performance internationally, at least two actions must be taken. Firstly, the structural changes require the support of scientific policy makers and public funding bodies. Secondly, solutions are required that can only be provided by the scientific system itself. Science has significant resources in this regard – namely the ability to qualify personnel according to its own needs – that are already available in principle. These resources need to be used on behalf of science though: The institutions must recognize themselves as training facilities and personnel developers covering their own needs. Linking with ongoing initiatives and best practice examples are a good option, and existing policy recommendations for the digital transformation, e.g. from the Council of Science and Humanities, can be followed. A question to be clarified is the extent to which stakeholders (and with which resources) can and should initiate action, as well as how responsibility for the tasks at hand can possibly be shared. Likewise, the tension between the need for sustainable, controllable and quality-oriented transformation and the need to speed up (in view of possibly unmanageable developments) is a controversial issue for the scientific labour market.

Covering labour needs – a common task

Länder and federal
policy design is
needed

The boundary and framework conditions for the competitiveness of employment in publicly funded science are subject to economic policy and of an overall societal interest. However, they can only be developed in context and through *Länder* and/or federal policies. This is well known. Yet the RfII would like to recall emphatically precisely this fact: Germany does not have a separate labour market policy for publicly funded science. It is needed, though, because the future of Germany as a scientific and business powerhouse depends decisively on the attractiveness of the scientific labour market, especially in view of the digital transformation. Therefore the RfII also recommends reconsidering the boundary and framework conditions of the scientific labour market described above, and thus political areas of action. This concerns especially the provision of more leeway in terms of legal and collective bargaining agreements, which consider the specific nature of scientific employment relations, as well as the competitive situation with employment options outside of the scientific system.

3.3 PROPOSALS FOR ENABLING POLICY TO SHAPE THE SCIENTIFIC LABOUR MARKET

Coordinated and
proactive utilisation
of the freedoms
that are available

In the situation outlined above, with its complex challenges, there are no simple possibilities for action in terms of governance, either politically or in the scientific system locally. However, universities and research institutions must actively utilise the freedoms they do have by taking proactive and coordinated action. The RfII also considers expanding space for strategic action wherever possible as a task of science policy and of public funding bodies. In terms of the ability of policy to shape the scientific labour market, the recommendations below are based on the following assertions:

1. The digital transformation as a whole will not free up any personnel capacities in publicly funded science. Instead, the tasks and scope of services offered by organisational areas will expand and the level of complexity of these activities will rise. Ultimately, every decision regarding staffing also determines if and how research will be able to fulfil promises of quality associated with digital processes in science.
2. The general conditions of the scientific labour market are inherently suitable to meet challenges such as the “scientification” of infrastructure tasks and even the rising need for competency training. There are substantial capacity shortages, though. This means it is necessary to organise qualification programs and provide them with a legal framework that allows it to react to digital and organizational transformation processes.

3. The traditional division of labour between research and research-related or supporting units will be dissolved in part by the digital transformation and replaced by new forms of cooperation and new kinds of tasks. In terms of personnel and staff planning, relatively few options have been available so far to assign research-related tasks that do not require scientific training. Similarly, there is not enough freedom to design positions in publicly funded science to be sufficiently competitive. This means strategies are needed to counteract the present pillarisation of tasks and professions and to provide for an evolutionary process towards closer connection of scientific tasks and related infrastructural or support tasks as well as professions.
4. Solving staffing problems is generally a management problem, but the problems at hand can in total not be solved locally. Publicly funded research can be regarded as a network of employers with a common interest in the development of human resources that can and should find collaborative solutions. Yet the German Federal Government as well as the German *Länder* are also called upon to take the following recommendations as a cause for promoting cooperation in favour of solutions that are as consistent as possible.

4 RECOMMENDATIONS

Universities
and research
institutions share
the responsibility

The following recommendations are primarily directed towards higher education institutions (HEI) and non-university research institutions. They are challenged to define their role as training facilities and personnel developers for the scientific labour market more actively and strategically than to date. In this sense, they should analyse the challenges posed by digitality in terms of their corresponding task portfolio and decisively address the current lack of personnel and competence in the scientific system.

Designing
employment in
publicly funded
science to be
competitive

Furthermore, science and politics are also called upon to share responsibility. Where transformed tasks affect job level requirements, competency profiles, and professions, it is necessary to react in the same way as it is necessary to ensure sufficiently high attractiveness of employment in science and to attract internationally recognized staff. To accomplish this, public service employment conditions in the scientific sector must be made more competitive than is currently the case. Some issues in this regard (for example those relating to labour laws) extend beyond the joint science policy of the federal government and the *Länder*.

Strategic
human resources
development:
establishing digital
job profiles

In the field of scientific infrastructure, there are several options available for strategic staff recruitment and staff development (see also section 2.4.):

- *Establishment of new job profiles* in the area of “data” and digital methods;
- *Expansion of existing job profiles* on the basis of special disciplinary competency profiles;
- *Transformation of job profiles* through digital method components;
- *Acquisition of additional competencies* on the basis of further education and training so staff can take on new or changed tasks in everyday working life.

In terms of the needs resulting from digitality and the special labour market situation in publicly funded science, the Rfll recommends considering all four options and pursuing each of these options with equal effort. The area of further education and training last mentioned is also particularly important in this respect (see also section 4.1 in the following). It is expected that the requirements in the framework of new digital professions will transform very rapidly in the future.

4.1 TRAINING CAMPAIGN: QUALIFYING STAFF QUICKLY AND IN RESPONSE TO DEMAND

Since digital processes are already deeply embedded in science and also continue to develop, the continuous, specialised qualification of researchers and research-related/supporting staff is not only fundamental, but is a key to the future: Even new employees with the best possible training will require continuous training on new digital innovations (“lifelong learning”).³² “Continuing academic education” offered on the market such as degree programmes for professionals, which can be studied part-time, certification courses, and “contact studies”, some of which are offered by scientific institutions, are intended for target groups outside of academia and are often tailored to the needs of business. The institutions internal staff programmes only rarely include courses with comparable academic or scientific standards. Courses organised by “practitioners” in the field such as data science workshops and summer schools are seldom formalised, much less institutionalised.

Continuous qualification (upskilling) – now and in future

In order to professionalise internal staff, the RfII proposes a training campaign for professionals within the German scientific system. The goal should be to qualify employees in science according to need, across disciplines, and with assured quality so that they can contribute to advancing science by continuously taking on new tasks subject to the conditions of digitality.

Training campaign for professionals within the scientific system

The RfII specifically proposes the following actions in this regard:

4.1.1 Universities and research institutions should offer existing staff members broadly accessible, and possibly in-service training to acquire expertise in defined modules such as data, information, and digital methodology more systematically than before. Required expertise should also address the development and use of information infrastructures. To increase the level of efficiency and acceptance of the qualification programmes, training courses should be modular in design and consider self-acquired competencies.

Modular courses for existing staff

4.1.2 To prevent redundancies and overlaps in the training portfolio as well as in terms of best practice learning, the RfII welcomes efforts to develop education and training offers for the acquisition of digital competencies cooperatively and with reference to internationally successful programmes (cf. Recommendation 4.4). Existing competence networks and their programmes could also play an important role.

Applying best practices and using competence networks

³² The RfII will not discuss secondary education in detail in this paper but does support teaching digital competencies in school, as already suggested by various parties (cf. KMK (2016) – Bildung in der digitalen Welt (German only), for an English summary see: KMK (2016) – Education in the Digital World; from the perspective of researchers and innovation policy EFI (2018) – Report 2018).

Linking informal
and regular
training formats

4.1.3 Informal training formats like “internal internships”, temporary staff exchanges, and working abroad, for example for library and computer centre staff, are expressly welcomed wherever they are already in practice; smaller facilities should also explore such options and qualify their personnel in the framework of collaborative structures. Regular education and training programmes on digital research processes would also be desirable for professors and science management staff (up to the level of department heads, managing directors, chancellors, and university administrators) and should be promoted much more strongly than today.³³

4.2 STRUCTURING CURRICULA FOR DEGREE PROGRAMMES

Specifying scientific
requirements on
“data science”

The term “data science” currently in circulation is an effective term, but also open to interpretation. However, when dealing with the corresponding qualifications for the scientific labour market in the context of advanced research, the relation to the scientific discipline is and remains – beyond any knowledge of “data science” methods – of primary importance. Regarding the own needs for data analysis expertise, the RfI considers specification of the scientific requirements and clarification of the exact type of needs within the system necessary.

The RfI recommends the following in this context:

Considering
disciplinary demand
in new degree
programmes

4.2.1 Dedicated involvement of the scientific communities (or professional associations, provided they play a norm-setting role for teaching in their scientific communities) in matters of course development for digital science in their particular discipline or domain. The extent to which the scientific labour market actually needs new basic and interdisciplinary data science or method-based degree programmes (such as simulation science or data analytics) or where alternatives such as extension of existing scientific degree programmes (“Digital/ Computational X”, such as Computational Engineering or Digital Humanities) are the better choice must be decided based on the specific needs of the particular disciplines. At universities, new degree programmes should consequently be developed in a participatory process with the scientific communities and/or professional associations representing a community.

Designing adaptable
curricula

4.2.2 In new degree programmes, the curricula should be designed as flexibly as possible to allow them to be adapted continuously to current requirements and technical innovations. Self-regulation and quality assurance opened

³³ For information on the special requirements for these management decisions, cf. for example HRK (2015) – Options for Action for Research Data Management.

through system accreditation can be used for this purpose. Elements of undergraduate data science or scientific degree programmes should become part of modular programmes for further education and training. Universities and scientific communities are encouraged to consider a basic module on “digitality in academic and non-academic professions” for all students at German universities during their undergraduate studies which can be adapted to the requirements of the particular discipline.

4.2.3 Whether or not the job profiles like data curator³⁴ currently being demanded can cover the needs of science and whether or not general job profiles (“scientific data administrator”) or more specific job profiles (data administrators specialised on specific disciplines) are needed could be tested based on model degree programmes subject to subsequent evaluation. A suitable stakeholder (e.g. the German Rectors’ Conference in the framework of the “Higher Education Compass” database) should monitor new degree programmes relating to data science. In addition to the scientific discourse, it is also essential to ensure the public availability of information on these degree programmes and the results of the evaluations.

Evaluating the professional applicability of data- and infra-structure-related degree programmes

4.3 TECHNICAL STAFF: EDUCATING THE NEXT GENERATION

The need for specialized support for applications and devices as well as for research documentation has grown dramatically in recent years. However, sustainable staff solutions are lacking: The tasks are performed by assistants, doctoral candidates, or scientific employees, working beyond their „official“ job descriptions (cf. section 2.1 and the table in Appendix 1). Examination of where these tasks could be sensibly located as well as professionalisation of the staff performing these tasks is urgently necessary in the opinion of the Rfll.

Assigning (new) technical tasks

The Rfll proposes the following in this context:

4.3.1 Universities and other research institutions should make greater use of the possibility of employing professionally trained personnel without a university³⁵ degree for research supporting tasks and develop suitable staff categories for their roles and positions. Typical tasks would be working on software for projects funded by third parties, research data administration, long-term archiving, or research data management consulting and the clarification of legal issues. These tasks should then be adequately reflected in staffing schemes.

Gaining non-scientific personnel to support researchers

³⁴ Deutscher Bundestag (2012) – Enquete-Kommission Internet und Digitale Gesellschaft, p. 28 (German only).

³⁵ This refers to the German vocational or “dual” training system, for more information see footnote 18.

4.3.2 Scientific institutions should analyse the “landscape” of infrastructure facilities that they operate internally and/or externally - such as computer centres and specialised competence centres - and develop their human resources sustainably.

Strategies for
co-financing
permanent staff

The facilities should allocate project funds to cofinance (permanently employed) support staff (from programme allowances and overhead funding of public research, among other sources).³⁶ Organisational strategies for defined, standardised services as well as open and transparently organised access to all services of the infrastructure facilities and competence centres at the research facility should be the aim.

Consider possible
future dependencies when
outsourcing

In cases of outsourcing of digital services, universities and research institutions are encouraged to develop a strategy that addresses the issue of dependency on commercial providers and promotes the development of own competencies, if necessary by collaborating with others in the scientific system.³⁷

Educational
content directed
towards the needs
of the scientific
labour market

4.3.3 The stakeholders responsible for vocational professions are not only recommended to enhance the respective occupational profiles, and correspondingly the educational content, soon, but also to explicitly include requirements of the scientific labour market. Universities of Applied Sciences, too, should focus more than before on the needs of the scientific labour market in their course portfolios.

Financing
participation
in professional
training
programmes

4.3.4 To be able to effectively qualify technical personnel in the infrastructure sector for higher-level tasks, it is necessary to arrange financing (of fees and possibly including a leave of absence) for career-oriented training programmes. The funding opportunity created by the German legislature, referred to as “Upgrading Training Assistance”, could also be used and, if necessary, adapted for the development of human resources in the scientific system.³⁸ Opportunities for studying as a part-time student should also be expanded. In combination with suitable public promotion, this route could be a possibility to reduce the staffing problems of scientific institutions.

³⁶ Several years ago, the German Rectors’ Conference spoke in favour of a general financing share to finance the overhead incurred for research data management, see HRK (2014) – Management of Research Data.

³⁷ Self-organisation through the German National Research and Education Network (DFN) can serve as an early and positive model for this purpose.

³⁸ “Upgrading Training Assistance” (previously: “Advanced Further Training Assistance”) on the basis of the Upgrading Training Assistance Act (AFBG) promotes participation in measures to receive professional upgrading training. A group of experts from acatech spoke out in favour of a competition of ideas for a “training assistance” programme among the providers of student grants (“Studienförderwerke”, cf. Guggemos et al. (2018) – Digitale Transformation und Lebenslanges Lernen, p. 11 (German only)).

4.4 QUALIFICATION ALLIANCES

The high need for qualifications, and especially the recommended training campaign (cf. Recommendation 4.1), cannot be resolved in a satisfactory manner locally. There is competition within science for the rare personnel, especially in highly specialised fields like artificial intelligence or for jobs that are in particularly high demand.³⁹ Existing initiatives for entry-level qualification and for continuous training are heterogeneous within the scientific system. They lack in part in transparency, coordination, accessibility, and quality assurance (cf. Recommendation 4.10). Local, regional, or even inter-organisational collaboration (for example in the Alliance of Science Organisations in Germany) can contribute to boosting a broad, effective push in qualifications for the benefit of everyone involved. The following recommendations for possible qualification alliances are of a fundamental nature and are based on an analysis of existing models that could be adapted or expanded.

Creating alliances that transcend geography and organisations

4.4.1 The lack of qualified personnel in the areas of computer and information science as well as in technical services and laboratories can be alleviated by *Fachhochschulen*⁴⁰ and universities through suitable cooperations: Graduates could (parallel to post-graduate employment) be offered opportunities for post-graduate courses.

Facilitating post-graduate studies at *Fachhochschulen* and universities

4.4.2 Following on from established forms of cooperation and existing model and pilot projects between universities and non-university research, the RfII proposes to combine training efforts for digitally qualified personnel in scientific systematically. The RfII sees a series of suitable activities, although they are only presented as examples here and not described in full detail:

Combining professional training efforts throughout the sciences

- Students can benefit from programmes that allow them to transfer between universities, *Fachhochschulen*, and non-university research institutions early on during their undergraduate studies. Especially non-university research institutions are good candidates for extracurricular practical semesters, as they operate important research and information infrastructures. In turn, they would benefit greatly from graduates that have already trained in the context of their infrastructures. Similar win-win situations can also be expected over the medium term from exchanges between universities and *Fachhochschulen*.

Enabling transparency

³⁹ For example in the area of research data management.

⁴⁰ Note that in Germany, there is an ongoing debate regarding the relations between Universities (which provide scientific training and have the right to award doctoral degrees) and the Universities for Applied Sciences (*Fachhochschulen/Hochschulen für angewandte Wissenschaften HAW*) whose programmes are usually targeted towards employability in the general labour market (cf. WR- Wissenschaftsrat (2010) – Empfehlungen zur Rolle der Fachhochschulen, p. 18 ff. (German only)). Several recommendations address these relations, and in these cases we use the German term “*Fachhochschulen*” to mark the distinction between the two types of HEI.

Establishing priority programmes for graduates

- Graduates can be recruited specifically for the field by offering additional-doctoral positions with topics like data science, data analytics, or “Digital/Computational X”. These positions can either be created in existing graduate-schools or consideration can be given to starting new schools which focus on these topics. Again, the inclusion of *Fachhochschulen* and non-university research institutions in such activities should be ensured.

Expanding expertise in methods for new roles

- Compact courses on methodological competences developed for graduates from all disciplines can serve as a career starting point for new roles such as data curator, data manager, or data analyst. Ideally, scientific organisations would establish graduate schools with digital profiles as shared interdisciplinary centres of excellence to educate young, digitally qualified scientists. In turn, such schools could be linked to additional joint education and training activities.

Forming dual training collaborations

- In parallel to such scientifically oriented centres of excellence, dual training collaborations could be formed, for example in the area of the scientific documentation, to enable smaller sites to provide dual training opportunities as well. Particularly the *Fachhochschulen*, in collaboration with companies, seem well suited to becoming potential nodes of such collaborations.

Promoting joint ventures

- Joint ventures are also conceivable in the area of further education and training.⁴¹ However, the obstacles for the mutual provision of services arising from Section 2 of the Value-Added Tax Act (UStG) await a solution also in the area of education programmes. Scientific organisations and politicians are aware of the need for action and should urgently solve this problem. Research funders as well as the providers of information infrastructures should be enabled to contribute to the development of services by financing corresponding programmes.

Strengthening cooperation with societal initiatives

4.4.3 Interesting scientific and science-related activities, which have an impact on the public, often take place outside of the publicly financed infrastructure and established scientific institutions. Examples include initiatives like “Datenschule.de”, the Open Knowledge Foundation, and Wikimedia (“Coding da Vinci”), but also initiatives that introduce young people to computer science and the natural sciences such as “Jugend forscht” or the MINT initiatives funded by the German Federal Government and the *Länder*. Young people, and especially the target group of girls and young women, could be subsequently introduced to data-based digital research in the framework of alliances with and between these stakeholders and inspire them find work in the scientific labour market.

⁴¹ Cf. also the recommendations of the German Council of Science and Humanities: WR (2019) – Empfehlungen zu hochschulischer Weiterbildung, p. 13 (German only).

Scientific institutions and infrastructural facilities as well as individual employees are already active in this area in one form or another. In the opinion of the RfII this involvement should be strengthened and supported wherever possible. Relevant offers (such as jointly organised *hackathons*, scientifically supervised research papers and competition entries) should be expanded beyond the boundaries of school subjects and disciplines wherever possible and also include promising extracurricular learning centres and successful approaches from citizen science.

4.5 CLOSER INTERACTION OF INFRASTRUCTURE AND RESEARCH STAFF

The separation of administrative/technical and scientific staff counteracts – especially at universities – the necessary and desired integration of the tasks and services that are offered and operated by infrastructure facilities into the actual digital research. One effect of this division is that there are hardly any incentives to work in research-oriented jobs in the infrastructure sector. Interdisciplinary centres of excellence, research data centres with their own research mandate, and “data laboratories”⁴² are different approaches to resolving this. The scientific system overall as well as the individual research institutions should pursue options of this kind on their own initiative. The RfII recommends that scientific institutions and responsible stakeholders at the level of the federal government and *Länder* change the boundary conditions in a way that enables stronger links between these two areas (cf. also section 3.2):

4.5.1 (Central) infrastructure units are encouraged to employ more scientifically trained staff wherever this will further increase the quality of the services offered. To facilitate the connection to relevant research, they should be provided with a moderate number of qualification positions (such as PhD positions). To achieve the desired embedding of research and infrastructure, it would be helpful to investigate cooperative models, for example when filling positions in libraries with scientifically trained personnel. Ideally, this would be done where a position at an interface between libraries and faculties or departments needs to be filled and the staff would also be involved in research tasks. For libraries, computer centres, and data centres, it would have to be examined whether the appointment of an adequate professorship would help the infrastructure institution to achieve its goals.

More scientifically
qualified staff in
central infrastructure
units

⁴² This also means initiatives going by various names (Data Science Lab, Data Innovation Lab, Simulation Lab) in which students and researchers can test methods and procedures of data-based research together with employees from information infrastructure facilities.

Creating sustainable joint projects

4.5.2 Joint projects between research, libraries, computer centres, and data centres, for example information infrastructure subprojects (INF projects) in DFG-funded Collaborative Research Centres or in “data laboratories”, should generally be conceived and sustainably developed in the sense of a cooperation of equals. Training programmes for scientific staff as well as for the infrastructure staff should also cover flexible, interdisciplinary communication skills. They should become part of, or possibly even be a high-profile feature of internal qualification efforts within the German scientific system (cf. Recommendations 4.1 and 4.9) as well as of undergraduate degree programmes offered in Germany (cf. Recommendation 4.2).

Merging consulting services

4.5.3 Joint help desks of the different infrastructure facilities and other service units dealing with data services or relevant consulting services⁴³ should be the general goal. Appropriately tailored regional or transregional collaborations are also conceivable to create more capacity for specialisation, for example regarding legal issues.

Bringing infrastructure services to the attention of public

4.5.4 Data management discourses and possibly discussions on digital methods should be promoted by research institutions as communication projects or as social infrastructures. The professionalisation of public relation activities (e.g. by writing articles for journals or the press) should be pursued with equal vigour in science support units. Expertise in information science informatics or methodology is relevant for media communication and should be marketed accordingly. Scientific infrastructure services must therefore become an integral topic in the scientific public relations and in human resources development of the institutions.

4.6 CHANGES IN LABOUR LAW

Creating appropriate wage rules for science

The combination of salary structures in the German public service and fixed-term employments is hindering the ability of scientific institutions to recruit the staff urgently sought on the scientific labour market, particularly digital experts at all levels of qualification that are suited for such work. Many contracts are temporary, and compared to a job in the private sector or to similar positions in foreign countries, the salary is noticeably lower. The enhanced reputation gained by working in science usually does not compensate for these disadvantages. Positions with scientific infrastructure tasks can even involve the de facto loss of the “scientist” status in terms of pay group or job valuation as well as a loss of esteem from other

⁴³ Here as well, research data management (the creation of data management plans, etc.) is an obvious example.

researchers (reputation). For this reason, the RfII also speaks in favour of calls for nationwide wage rules specifically for science – even when the political feasibility of such a goal is relatively low. More flexible work and wage regulations must be pursued, and the research-related service personnel must be categorised more specifically into the existing status groups.

4.6.1 For numerous scientific and science-related tasks regarding the establishment and rollout of information infrastructures (and sometimes their discontinuation or transfer to another organisational responsibility) scientifically qualified personnel is not needed over the long term, but for a limited period of time. For infrastructure tasks with a medium range horizon – from the establishment of a data warehouse at a university and comparable IT change management to the rollout and operation of a data infrastructure for research topics whose long-term financing cannot be foreseen – the necessary employment conditions are difficult to realise under the current legal conditions. The RfII sees a need for greater flexibility here to be able to hire qualified staff for complex, research-related information infrastructure tasks and to reinforce staff at scientific institutions in critical areas. The required flexibilisation should locally be used with foresight in the framework of strategic human resources development. Well qualified staff could be offered permanent position options early on – if necessary in permanently funded infrastructure areas.⁴⁴

Judging the potential
for flexibilisation

4.6.2 Flexibilisation of salaries as an added incentive should be facilitated for IT professionals as well as for academic teaching and research staff who are engaged in the establishment of information infrastructures in digital projects, centres of excellence, and other such organisations (in addition to their jobs in research and teaching). The ability to place graduates with *Fachhochschul*-degrees into pay groups of the higher public service⁴⁵ must be made easier in general by law and at the organisational level, and such opportunities must also be made public.

Enforcing salary
supplements for
engagement in infra-
structure services

4.6.3 Part-time degree offers (cf. Recommendation 4.1) should be designed so that graduates qualify for higher pay groups. The option of obtaining a doctorate parallel to employment (with the corresponding leaves of absence) should also be opened up for employees in areas that support research and in non-scientific staff groups.

Creating career
opportunities

⁴⁴ The German Rectors' Conference (HRK) has already adopted corresponding guidelines in 2012 for universities HRK (2012) – Hochschule im digitalen Zeitalter (German only); HRK (2012) – Higher education institutions. However, they recommended in 2015 to establish unlimited term positions for permanent tasks, see HRK (2015) – Core Theses.

⁴⁵ For pay groups in the higher public service, candidates must usually have a university degree (scientific training).

Breaking up rigid
job categories

4.6.4 The requirement to categorise jobs in central facilities as “non-scientific” fixes the organisational status of employees in the research-related infrastructure area in a manner that is not desirable. Measures should be identified and used to make these outdated requirements more flexible – for example by allowing them to be in two status groups. It is also desirable that staff categories better reflect functions and organisational roles in the infrastructure sector in a more differentiated way (cf. section 2.4). This would be one more step towards greater visibility and reputation and would allow structural developments in this area to be tracked, for example in the framework of *Kerndatensatz Forschung*.⁴⁶

Acquiring inter-
national staff

4.6.5 The options available for employing international staff, which have been expanded recently in public law, should be fully utilised by universities and other research institutions.

4.7 GREATER VISIBILITY FOR EXCELLENT PERFORMANCE IN DATA-RELATED ACTIVITIES

Creating visibility
for infrastructure
excellence

Significant scientific achievements in the digital and data-related area (such as the establishment of high-profile data collections) are often not reflected in the traditional understanding of research excellence. Instead they are assigned to the field of mere infrastructure development. Commitment here does not have the reputation effect needed to make working in this field of activity a more attractive career option for scientists. In the first position papers recently published by emerging NFDI consortia, various disciplines have already explicitly addressed the development and introduction of new criteria for evaluating performance and scientific reputation as a task of the NFDI (and a result of the development spurred by the NFDI).⁴⁷ Politicians cannot and should not interfere with the reputation mechanisms of science. However, they can contribute to the further diversification of the system of scientific evaluation methods and performance evaluations in favour of infrastructure services.

To increase the visibility of excellence in the area of scientific data infrastructures, the RfII proposes the following:

Awards for innovative
data services and
collections

4.7.1 Research funders, foundations, and other bodies funding publicly financed science should hold special competitions and issue awards for innovative data services and digital collections. Such programs could also be initiated in the context of the NFDI.

⁴⁶ The *Kerndatensatz Forschung* (core research dataset) is a specification developed in 2016 by the German Council for Science and Humanities as a step towards harmonisation of research reporting in Germany, see <https://www.kerndatensatz-forschung.de/> (German only, accessed: 25-07-2019).

⁴⁷ For example Schmitt et al. (Mai 2018) – Positionspapier NFDI4ING (German only) or Koepler et al. (Aug 2018) – Thesenpapier NFDI4Chem (German only).

4.7.2 The universities and their departments and faculties are encouraged to open up and use new doctoral study paths which provide for the creation of digital editions or data corpora based on scientific methods as a reviewable scholarly achievement worthy of a dissertation (e.g. according to the model of historical-critical editions).

Establishing data corpora as service worthy of a doctorate

4.7.3 Infrastructure services should be considered in indicator-based performance assessments or as evaluation criteria. In particular, taking on longterm responsibilities in the framework of research data infrastructure services should be a standard “performance parameter” at universities and non-university institutions, and it should be possible to evaluate this parameter accordingly (e.g. in target agreements with funders). A personal commitment to the transfer of knowledge and competence in the digital age, e.g. high-profile “roles” in scientific networks or platforms, should also be taken into account as a special achievement, both in performance assessments and pay scale increases or for classification as a “scientific” activity in staff valuation schemes. Taking on such additional tasks should also be recognised in a manner that has an impact on academic reputation instead of or in addition to promoting the common reduction in teaching loads.

Expanding the system of performance indicators

4.7.4 Data-related tasks should be more visible in the mass media because they form the basis for numerous scientific breakthroughs – especially in the area of interdisciplinary cross-cutting topics underlying the major societal challenges (demographic change, climate change, common diseases, etc.). Scientific facilities, as well as individual researchers, should acknowledge the infrastructural and data dimension of their research as a relevant and necessary driver of scientific progress in their own scientific communication and scientific reports, when assessing and recruiting staff, and when teaching.

Communicating the importance of the infrastructure and data dimension

4.8 TEACHING DIGITALITY NOT ONLY AS A TECHNICAL SUBJECT, BUT COMPREHENSIVELY

The digital transformation is perceived as a “technical” phenomenon because of the impact and rapid development of innovative technologies. The digital transformation indeed takes place in technology as its medium. However, the possibilities and consequences it unleashes have an impact at the level of the knowledge system as a whole and on societal orientations. In the opinion of the RfII, the digital transformation is not only about application of modern technical processes, but at least to the same degree about basic questions regarding a future (scientific) data culture in the “knowledge society”.⁴⁸

Digitality promotes cultural transformation

⁴⁸ Regarding the creation of a new “data culture” compare RfII (2016) – Enhancing Research Data Management, p. 46 ff.

The RfII therefore recommends the following for educational content for qualification programmes:

Teaching basic technical, ethical, and legal knowledge

4.8.1 To achieve a basic understanding of the digital transformation in the sciences, the RfII believes that basic digital training should not only include a technical understanding of the tools and processes used to generate, assess, and use data, but also include other non-technical knowledge. Such knowledge could include, for example, basic knowledge of ethics that extends beyond simply preventing misconduct, basic knowledge of legal systems (European as well as international comparative law), basic knowledge in the history and philosophy of science, as well as social science theories on the functions, structures, and consequences of technological transformation.

Supporting the discussions of methods in the disciplines

4.8.2 Researchers as well as the staff directly supporting them in the research process should be able to recognise the relationship between the current transformation and the existing methodological discourses of the disciplines. The qualification programmes recommended above for various target groups and objectives (cf. Recommendations 4.1, 4.3, and 4.9) should thus choose an approach that puts the digitally-driven transformation of knowledge production in a holistic perspective.

Embedding digital competencies in and across disciplines

4.8.3 The definitions of the terms “digital literacy” and “data literacy” should be expanded beyond their initial narrower meaning and replaced by a more scientifically-oriented, and if necessary discipline-related definition of competencies that include an understanding of the implications of digitised processes on science itself. This also includes the ability to communicate across disciplines.

4.9 SCIENTIFIC QUALITY ASSURANCE FOR TRAINING PROGRAMMES

Creating a uniform further education and training system

The requirements for education content for tasks performed in digital science – regardless of whether the tasks are supportive, facilitative, or part of independent research/teaching – go beyond those for what is generally defined as “continuing academic education”.⁴⁹ The suitability of presumably relevant offers for work-related qualification in science can therefore be difficult to assess. The RfII proposes therefore to not only to make existing programmes more transparent,

⁴⁹ “Wissenschaftliche Weiterbildung” is a technical term in Germany that differentiates professional training courses at the “technical and didactic level of a university” from other continuing education programmes, cf. KMK (2001) – Sachstandsbericht wissenschaftliche Weiterbildung, p. 2 (German only).

for example by providing information on potential fields of work for which participants will be qualified, but also to create a sufficiently simple, yet compelling and uniform system of professional qualifications (certificates) “by science for science”. This would be helpful as a serious point of reference in the expansive and complex education market.

The Rfll provides the following recommendations in this regard:

4.9.1 The training campaign recommended in 4.1 should lead to pragmatically designed certificates that can specifically be obtained within the scientific community.⁵⁰ Such certificates could serve as proof of learning achievements when hiring staff or even when appointing professors and would thus certify a professional qualification.

Nationwide
introduction of
professional
certificates

4.9.2 In addition to the requirements described in 4.8, the certificates awarded within the scientific community should be based on a more precise determination of the “soft” digital and data skills required for the scientific labour market; and they should also encompass interdisciplinary and transdisciplinary work skills as a key scientific qualification. It could also be important for the scientific labour market to develop training programmes for specific disciplinary contexts that account for the special methods or data-related particularities of a task or scientific field. The courses completed should be eligible for recognition if a degree programme at a university is commenced.

Taking soft skills into
account in training
programmes

4.9.3 The stakeholders involved should combine their efforts and compile documentation on all education and training programmes offered nationwide that meet the scientific requirements described here. In the medium term, the basic idea of a scientific seal of approval should serve as a guideline. The development and recognition of certificates by all organisations involved could require new forms of division of labour and the cooperation of stakeholders in the scientific system. The NFDI and the NFDI consortia could play an active role in this regard.

Seal of approval
for education and
training programmes
in the scientific system

4.9.4 The effects of the recommended efforts in the education and training sector (4.1) and in certification on the German scientific landscape should be monitored scientifically in order to determine criteria for measuring success or failure on an empirical basis. In this way, qualification initiatives can be promptly corrected or adapted as required.

Evaluating and
adapting qualification
initiatives through
accompanying research

⁵⁰ Certificate here means the completion of a training programme after taking a test or applying some other assessment of learning progress (for example in the sense of a “university certificate”), in contrast to a simple certificate of participation. Cf. also <https://weiterbildungsguide.test.de/infotehk/abschluesse/abschluesse-allgemein> (German only, accessed: 25-07-2019).

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A.1 TASKS IN DIGITALLY BASED RESEARCH AND THEIR ASSIGNMENT

The transformation in digitally based research described in Chapter 2 is shown below in a corresponding table. The table illustrates the discrepancy between the current practice and the actual need (column 3). The last column describes the type of human resources development problem to be solved. In the current practice, there are numerous examples of new tasks that are performed by existing staff members in addition to their normal tasks or that have not been assigned to anyone in the organisation. The problems to be solved are typically related to “staff recruitment” (there are no such positions, appropriate compensation options, or attractive career perspectives), training or qualifications, or the corresponding specialisations or competency profiles are lacking.

The examples are provided in no particular order and are grouped according to the categories stated in section 2.1 (Changed processes, new tasks):

[A] Supporting tasks in areas in which technical or administrative prerequisites for research arise (generally staff without an academic degree);

[B] Tasks that require field-related as well as research-related knowledge and that facilitate the research process in a collaborative way or contribute in the form of information infrastructure services, a scientific training is often a prerequisite;

[C] Tasks in independently conducted research and possibly in teaching (staff with a university degree or doctorate).

The list does not claim to be complete, and is instead intended to stimulate all stakeholders to add to the list and make the list more precise. Quotes are placed around job profiles that have not been formally established yet (in Germany).

Table: Tasks in digitally based research: a collection of examples

Type of task	Examples of new and existing tasks whose scope and complexity are increasing	Current status and situation	Need – possibly including the job profile	Type of problem
A. Tasks supporting science	Workstation administration, system administration	Own Computer Centres (CC), external service provider, or performed “on the side” by employees in local units without formal qualifications	Job profile: IT specialists/ information scientists, system administrators	Staff recruitment, high and heterogeneous discipline- and project-specific requirements
	Digital documentation of (digital) research processes	Status and situation/ assignment unclear	Lab technicians/assistants, documentation assistants, specialized data administrators	Lack of routines and description standards (ontologies); high need for further development and training
	Conversion routines in the long-term archiving of research data	Almost completely lacking	IT specialists/ information scientists, data administrators, data archivists	Transformation of a job profile, specialisations and training programmes currently in development
	Monitoring of license and embargo periods for scientific publications (incl. data)	Done in the library	Repository managers/ publication managers	High need for training
	Monitoring new software products, exchanging/ comparing experiences	Few established	IT specialists	Staff recruitment, high and heterogeneous requirements
	IT security	Own CC or external service provider (IT security officers)	Trained IT security experts	Staff recruitment, complex problems that require a high level of coordination, including with researchers
	Testing new hardware	Own CC	IT specialists	Staff recruitment, experience
	User support (first level)	Assigned heterogeneously	Librarians, data consultants, application specialists	Rapidly increasing requirements, staff recruitment
	Access to services: authentication and authorisation	Computer centres	IT specialists	Staff recruitment, experience with rights management in joint projects spanning several locations

Type of task	Examples of new and existing tasks whose scope and complexity are increasing	Current status and situation	Need – possibly including the job profile	Type of problem
B. In a research setting	Maintenance of data corpora, maintenance planning, data integrity, and data quality	Done by trained scientific employees	Data librarians, data curators	Staff recruitment, hardly any formally qualified personnel
	Decisions to migrate data	Almost completely lacking	Information scientists, data curators	Staff recruitment, hardly any formally qualified personnel (lack of standards)
	Provision of (digital) information services	Done in the library	Librarians (subject specialists), data librarians	Lack of specialisation
	Monitoring innovations in the area of (specialised) digital tools	Is unsystematic, often done “as an aside”	Data scientists, information scientists, “Digital/Computational X”	Lack of an established review process for data and software (and of reviewers)
	Adaptation and development of specialised tools (development of research software)	Information scientists and other scientists (learning by doing)	Information scientists (developers), “Digital/Computational X”	Lack of developers with domain knowledge (“Digital/Computational X”)
	Decisions to purchase large software packages, testing of new software	Improvised committees, purchasing departments in central administration	Participative process situated at the management level	Unclear assignment of the task, competency profile unclear, special expertise in the purchasing of IT is necessary
	Creation of data management plans	Scientists in cooperation with information scientists or “research data specialists”	Data managers, IT specialists	Qualitative problem: Shared task, often without appropriate support or knowledge
	User support (second level)	Done by CC and libraries	Specialists trained in data science	Lack of knowledge and experience with the methods used in the discipline
	Methodological support	Scientific staff, information scientists, libraries – is done “as an aside” and unsystematically	“Digital/Computational X”, scientific staff	Acquisition of qualified personnel, knowledge of the discipline and generic knowledge is necessary
	Compliance management	Lacking (except for guidelines)	Research managers, management, legal experts, if necessary	New kind of specialisation
	Legal framework relating to the use of data	Own legal advisors, external consultants	Research data specialists, lawyers	Special knowledge necessary, high need for training
	Support for variable target groups	Libraries, CC, is “done as an aside”, often only first level	Research data specialists, information scientists	Knowledge of the discipline and generic knowledge is necessary
	Following scientific innovations in the subject studied	Barely possible	Conferences and training courses, integration in research teams	Knowledge of the current state of their own technical discipline is lacking
	Development and maintenance of a generic service portfolio	CC, IT competence centres	Information scientists, “Digital/Computational X”	Staff recruitment, complex problems that require a high level of coordination, including with researchers
	Development of an education and training programme	Libraries, CC, competence centres of all kinds	Specialists trained in data science, “Digital/Computational X”	Discipline-specific, data-related knowledge and experience
	Public relations for infrastructure services	Is “done on the side” or is not done at all	Professionalised infrastructure personnel	Lack of a mandate, lack of routine

Type of task	Examples of new and existing tasks whose scope and complexity are increasing	Current status and situation	Need – possibly including the job profile	Type of problem
C. Tasks in research	Building up data corpora, path decisions, documentation	Scientific staff	Scientific staff with further training in infrastructure issues	Lack of standardisation, very time-consuming task, at the same time no gain in reputation
	Data analyses	Self-organised interdisciplinary teams, multidisciplinary information scientists, external service providers	Scientists, “Digital/Computational X”, scientific staff, data scientists	Rapidly advancing fields: complex algorithms, big data research strategies
	Programming own queries/ data analyses	Semi-skilled staff	Information scientists, “Digital/Computational X”	Programming skills
	Creating visualisations	Scientists with various backgrounds, learning by doing	Information scientists, “Digital/Computational X”	Rare combination of qualifications, hardly any appropriate degree programmes
	Methodological discourse and critique	Scientists	Scientists, scientist conducting research on methods	Responsibilities are not differentiated
	Establishment of community-specific standards	Scientists	Data management experts, scientists	Task not assigned to anyone, lack of expertise in methods
	Identification of suitable digital methods for research projects in the particular discipline	Scientific staff	“Digital/Computational X”, scientific staff	Lack of overview and review platforms, digital “manuals”
	Planning of own data science projects	Scientists	Scientists, “Digital/Computational X”, data scientists	Lack of expertise in methods
	Decisions on archiving and discarding data	Scientists (independently)	Scientists and data archivists	Lack of guidelines, standards, expertise, and legal solutions
	Application for third-party funding of large-scale IT facilities and purchasing equipment for these facilities	Scientists	Hardware specialists in the computer centre, legal specialists	Scientific and technical expertise is needed
	Knowledge transfer through academic teaching	Scientists and e-learning centres	Data specialists, methodologists, scientists	Qualitative problem: curricula, resources

A.2 COUNCIL, MEMBERS, AND GUESTS

The German Council for Scientific Information Infrastructures has 24 members and is composed as follows to ensure equal participation:

- 8 representatives of scientific users from a broad spectrum of scientific disciplines
- 8 representatives of information facilities who cover the entire range of the German scientific system
- 4 Representatives of the German federal government and the *Länder*
- 4 Representatives of the public

The first 16 representatives are appointed in a procedure similar to that for members of the German Council of Science and Humanities. The other 8 representatives are nominated by the federal government and the governments of the *Länder* in the Joint Science Conference (GWK). All members are appointed by the chair of the Joint Science Conference for a term of four years. Guests can be invited to council meetings or parts thereof when there is a corresponding need.

“The composition of the Council reflects our conception that the future of scientific information infrastructures is a joint task of the providing institutions, the scientific users, the funders, and related national and international stakeholders.”

– Joint Science Conference, November 2014 –

Representatives of scientific users

Prof. Dr. Marion Albers

Faculty of Law, University of Hamburg

Prof. Dr. Lars Bernard

Faculty of Environmental Sciences, Technical University of Dresden

Prof. Dr. Stefan Decker

FIT – Fraunhofer Institute for Applied Information Technology and RWTH Aachen

Prof. Dr. Petra Gehring (Chair)

Department of History and Social Sciences, Technical University of Darmstadt

Prof. Dr. Kurt Kremer

MPI – Max Planck Institute for Polymer Research, Mainz

Prof. Dr. Wolfgang Marquardt

Forschungszentrum Jülich GmbH

Prof. Dr. Joachim Wambsganß

Centre for Astronomy of Heidelberg University (ZAH)

Prof. Dr. Doris Wedlich

KIT – Karlsruhe Institute of Technology – Division I: Biology, Chemistry, and Process Engineering

Representatives of the federal government and the Länder

Rüdiger Eichel

Ministry of Science and Culture of Lower Saxony

Dr. Hans-Josef Linkens

Federal Ministry of Education and Research

Dr. Dietrich Nelle

Federal Ministry of Education and Research

Annette Storsberg

Ministry of Culture and Science of North Rhine-Westphalia

Representatives of information facilities

Sabine Brünger-Weilandt

FIZ Karlsruhe- Leibniz Institute for Information Infrastructure GmbH

Prof. Dr. Dr. h.c. Friederike Fless

DAI – German Archaeological Institute and Free University, Berlin

Prof. Dr. Michael Jäckel

Trier University

Prof. Dr. Stefan Liebig (Deputy Chair)

DIW – German Institute for Economic Research, Berlin

Prof. Dr. Sandra Richter

German Literature Archive

Katrin Stump

University Library of Braunschweig

Prof. Dr. Klaus Tochtermann

ZBW – Leibniz Information Centre for Economics and Kiel University

Prof. Dr. Ramin Yahyapour

GWDG – IT in science and University of Göttingen

Representatives of the public

Dr. Anke Beck

IntechOpen publishing

Marit Hansen

Data Protection Commissioner of Schleswig-Holstein

Dr. Nicola Jentzsch

SNV – Stiftung Neue Verantwortung (Foundation for New Responsibility, until 03/2019)

Dr. Harald Schöning

Software AG

Guests (before 11/2018)

Peter Büttgen

BFDI- Federal Commissioner for Data Protection and Freedom of Information

Dr. Till Manning

Ministry of Science and Culture of Lower Saxony

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