ESCALATE

Erasmus+

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Higher education institutions/Universities Responses to Digitalization (IO1)

Germany Country Report

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List of Abbreviations

AI	Artificial Intelligence
BMAS	Bundesministerium für Arbeit und Soziales
BMBF	Bundesministerium für Bildung und Forschung
BMWi	Bundesministerium für Wirtschaft und Energie
BPM	German Association for Human Resource Managers
BReg	Bundesregierung
CHE	Center for Higher Education Development
CIO	Chief Information Officer
ESCALATE	Coordinated Higher Institutions Responses to Digitalisation, Erasmus+ KA2 - Cooperation for innovation and the exchange of good practices, KA203 - Strategic Partnerships for higher education
DFKI	Deutsches Forschungszentrum für Künstliche Intelligenz
DESI	Digital Economy and Society Index
EU	European Union
HEI	Higher Education Institution
HFD	Hochschulforum Digitalisierung
HFD	Hochschulrektorenkonferenz
ICILS	International Computer and Information Literacy Study
ICT	Information and Communication Technology
IMD	International Institute for Management Development
IT	Information Technology
KfW	Kreditanstalt für Wiederaufbau
KMK	Kultusministerkonferenz
KOFA	Kompetenzzentrum für Fachkräftesicherung
MKW	Ministerium für Kultur und Wissenschaft in Nordrhein Westfalen
MINT	Mathematik, Informatik, Naturwissenschaften, Technik
OECD	Organisation for Economic Co-operation and Development
PC	Partner country
PIACC	Programme for the International Assessment of Adult Competencies
R&D	Research and Development
SME	Small and medium enterprise
SOTA	State-of-the-Art
VCI	Verband der Chemischen Industrie
VDI	Verein Deutscher Ingenieure
WP	Work Package
KA	Key Action
ZEW	Leibnitz Zentrum für Europäische Wirtschaftsforschung

1 Introduction

For years, the economy and society in Germany have been undergoing a dynamic transformation process through digititalisation and networking whereby the far-reaching change processes involve both opportunities and risks. This is symbolically reflected in the discussion on the change to Industry 4.0 - the increasing integration of production with information and communication technology and the connected socio-economic and political implications. The *D21 Digital Index 2019 /2020*[1] an annual situation picture provides interesting insights in terms of digital literacy of the German society. It stated that digital competence in Germany is slowly increasing. But it also highlights the widening gap between those parts of society that are participating in some form in the increasing digitization and those that are digitally offside (Initiative D21, 2020). In 2014, the International Computer and Information Literacy Study (ICILS) revealed that nearly 30% of German schoolchildren do not have basic computer skills and hence are lagging behind in international comparison. This has triggered a large debate in Germany about the quality and future viability of the digital education.

For a country like Germany with a high level of technological and industrial orientation, digitalisation is of eminent importance for its future competitiveness. A survey of the European Center for Digital Competitiveness with around 500 top executives from business and politics, estimated that 79 percent of respondents consider the strength in the field of digitalisation to be central to Germany's competitiveness. However, the overwhelming majority (89 percent) is also convinced that this competitiveness has not yet been achieved and that Germany is lagging behind in many areas with regard to digitisation (ESCP, 2020). An international comparative study by Vodafone Institute for Society and Communication (2018) shows that only 47% of Germans see their country as digitally advanced country compared with Sweden with 80%. IMD ranks Germany 18th in its *2020 World Digital Competitiveness Ranking*[2]. This means that Germany will lose ground in digital competitiveness compared to 2016. The weak points are mainly in the technological infrastructure and digital education (IMD, 2020). In an international comparison, Germany only occupies a midfield position in terms of current digitalisation in *European Commission's Index for the Digital Economy and* Society, Germany ranks 12th among the 28 EU countries (DESI 2020).

According to DESI only 5% of Germans have never used the Internet. Germany has made progress on most connectivity indicators and ranks 8th in connectivity, but must promote the provision with ultra-fast broadband connections for example to reduce the digital divide between urban and rural areas. Overall, internet usage in Germany is above the EU average (rank 9). However, there are weaknesses in the use of professional social networks and participation in online courses, which is below the EU average. When it comes to the integration of digital technology by businesses, Germany ranks 13th among the EU countries

[1] The *Digital Index* consolidates the four sub-indices access, usage behaviour, competence and openness into a single indicator. The sub-index is currently rising by three index points compared to 2018/2019. On a scale of 0 to 100 points, the German society thus achieved an average index value of 58 points.

[2] IMD World Digital Competitiveness Ranking measures the capacity and readiness of 63 economies to adopt and explore digital technologies as a key driver for economic transformation in business, government and wider society

and is thus slightly above the EU average. German companies are increasingly taking advantage of the opportunities offered by Big Data: 15% in 2018 (above the EU average). But only 12% of German companies use cloud services (compared to the EU average of 18%). Germany lags far behind in digital public services (especially E-Government and E-Health), ranking 26th among the EU countries and thus far below the EU average. In the area of human capital, Germany ranks 10th among the EU countries and is thus well above the EU average. At least basic digital skills and basic software skills are well above the EU average. Germany ranks fifth for both indicators.

The high proportion of students of technical and natural science subjects in Germany should be emphasised. 38% of first-year students today choose a MINT[3] subject (Bildungsbericht 2020, 191). This is a very high proportion by international comparison, which is primarily due to the above-average importance of engineering sciences in Germany (OECD 2019a, 240). The share of ICT specialists in the labour force is in line with the EU average (3.9%). A major challenge for Germany in shaping the digital change is the increasing demand for ICT specialists. The share of ICT specialists in the total employment of women is 1.4%, which is also in line with the EU average. The share of ICT graduates in the total number in Germany is 4.7%, well above the EU average of 3.6% (DESI 2020).

Nevertheless, it is clear that in international comparison there is still a need for action in Germany, especially by the availability of fibre optic connections, the use of digital technologies and applications, the development of digitalisation strategies and the competence development.

2 Methodology

This report was based on literature review with the main focus on online research. We searched the online literature for articles, web-pages and data which describe the impact of digitalisation on the labour market, future of work, and the issue of digitalisation in higher education. The country report assumes that the transformation process of increasing digitalisation is changing Germany at various levels. As a result, knowledge and competence requirements are changing, which in the economic context leads to demands for specific skills and competencies and shows existing gaps and needs for action. Furthermore, current national data were used to describe political initiatives that aim to address the digital skills gap. Added to this were findings from studies and reports by economic and public initiatives such as the Stifterverband[4] and the Hochschulforum Digitalisierung (HFD)[5], which focus in particular on developments at universities in a socio-economic context. In addition, innovative practical examples were sought that could serve as possible future models and best practice to promote digital skill development.

[3] MINT subjects is a summary term for teaching and study subjects or professions in the fields of mathematics, information technology, natural sciences and technology.

[4] Donors' association for the promotion of humanities and sciences in Germany. Stifterverband, is a non-profit registered association with the fields of education, science and innovation. The Stifterverband analyses, advises, promotes and networks a large number of actors of science and industry.

[5] HFD is a publicly funded think tank dealing with higher education in the digital age. It is a project of the Stifterverband, the Centre for Higher Education Development (CHE) and the German Rectors' Conference (HRK). The HFD is funded by the Federal Ministry of Education and Research (BMBF).

3 The potential impact of digitalization

Digital transformation is generating a fierce debate among education providers, policy-makers, economists and industry leaders about its societal impact. As digitalization disrupts society ever more profoundly, concern is growing about how it is affecting issues such as jobs, wages, inequality, health, resource efficiency and security. Current estimates of global job losses due to digitalization range as high as 2 billion by 2030 (World Economic Forum). There is currently great uncertainty, with concerns also about its impact on wages and working conditions.

3.1 Labour market related requirements and Skills shortage

The future world of work will be increasingly shaped by digital information and processes. In this context, there will be an increasing integration of digital technologies and internet-based applications in workflows. This of course influences labour markets, with new and changed occupational profiles and requirement profiles. Competent handling of digital technologies and collaboration techniques will become a central prerequisite - not only for economic success, but also for social participation (Kirchher et al., 2018). Hammermann and Stettes (2015) show that in the course of digitisation not only higher demands are placed on IT skills, but also on social and personal skills. The socio-economic discourse is increasingly being shaped by the question of what skills will be needed in the working and living environments of the future and what is the economic and social impact of a lack of digital skills and competences. Creating a clear picture is made more difficult by the fact that there is no common understanding of the different skills, abilities and competences associated with the concept of digital literacy or "digital skills". With *DigComp 2.1- The Digital Competence Framework for Citizens*, the European Commission has provided a reference framework as part of the Europe-2020-Strategy since 2017 (Carretero et al., 2017). Other approaches to measuring digital competences include *PIAAC*[6], *LEO*[7], *ICT Literacy Test*.

With the increasing digital penetration of the world of work, the demand for appropriately qualified IT personnel with both academic and non-academic backgrounds is growing (Wolter et al., 2016; Zika et al., 2019). It is estimated by the OECD that in the next ten to twenty years, 14% of jobs in the OECD area are highly likely to be automated and a further 32% are likely to undergo significant changes. At the same time, however, 40% of the new jobs created in the last ten years have been in highly digital-intensive industries (OECD 2019b). These trends more or less also apply to Germany. The *Global Human Capital Trend Study 2019* by Deloitte shows for Germany that almost every third respondent states that artificial intelligence, robotic process automation and robotics for individual areas and functions are already used in companies today. Over 56 percent of all study participants report that automation is used as a supporting measure to increase productivity, and 49 percent report that it is used to eliminate repetitive tasks or transactional work (Deloitte 2019). It is therefore reasonable to assume that digitalisation does

[6] *Programme for the International Assessment of Adult Competencies*
[7] Assessment of Reading and writing skills (Literacy)

not generally make existing occupations completely superfluous; there are more likely to be shifts in job and occupational profiles that are supplemented by new tasks or activities (Ertl et al., 2019; Kuhlmann & Voskamp, 2019).

One of the central challenges with regard to the digital change in Germany is the oft-stated reminder of an increasing lack of skilled workers and experts and the associated threat to the competitiveness of Germany as a business location. The penetration of computer science into almost all areas of work and life has been accompanied by an above-average increase in the number of jobs for computer specialists in recent years. For the period from 2010 to 2017, the ICT sector is even showing the highest growth rate in the industry with 250,000 new jobs (+27 percent) (BMWi, 2018). In 2019, 5.8% of German companies were using AI in products, services or internal processes (BMWi, 2020), which indicates a growing demand for skilled workers with the appropriate know-how.

There is a considerable shortage of skilled workers in some IT sectors in Germany. For years, there have been problems in Germany in filling vacancies for software developers with specialists who have completed at least 4 years of computer science studies. The Federal Agency of Employment stated in 2019 that the demand for IT specialists is at a peak level, measured by the number of jobs registered in 2018. With 20,000 job offers, the number of vacancies exceeded that of the previous year by 16 percent (BA, 2019). The *Ingenieurmonitor* of VDI[8] came to the conclusion, that with an average of 43,590 vacancies per month in 2018, the computer science professions form the largest category of job offers in the engineering professions (VDI, 2018). BITKOM the Federal Association for Information Technology, Telecommunications and New Media identifies 124,000 vacancies for IT specialists (Bitkom, 2019a).

The shaping of digitisation and thus the increasing demand for skilled workers with digital skills is becoming a challenge for the competitiveness of the 3.8 million small and medium-sized enterprises (SMEs) in particular. After all, SMEs provide the majority of jobs and generate the largest part of value added in Germany. The 2019 company survey carried out by KfW Research (2020) shows clearly that the digital change has reached the breadth of the SMEs in Germany. But 38% of SMEs surveyed see a lack of IT skills among existing employees or a lack of IT specialists on the labour market as a stumbling block. Two years earlier the figure was 29 %. Most SMEs are trying to build digital literacy through further training. It is also interesting to note that apparently the employment of university graduates favours digitization. Thus, digitisation projects have increased, especially in companies with university graduates. This share is three quarters higher than in companies without university graduates and almost twice as high in companies with their own R&D (KfW Research, 2020).

A Special survey by KfW Research (2018) is dedicated to "digital literacy": Which skills are important from the point of view of the companies, which ones are lacking? To this end, a differentiation was made between basic skills and advanced skills:

- Digital basic skills: skills such as the operation of standard software (e.g. office packages) and devices (e.g. smartphones and tablets). More than three quarters of SMEs (78%) attach great

[8] The Association of German Engineers

importance to these skills, while only 8% attach no importance at all. Online skills are also important for the majority of SMEs (51%) - e.g. Internet research, handling social media or online marketing. The operation of special software or digital production machines is important for 45% of SMEs.

- Advanced digital skills: Programming skills are important for only 18%, while more than half (54%) have no need at all. The situation is very similar with complex statistical data analysis. They are of great importance for 16% of SMEs. In summary, 24% of SMEs have a strong need for advanced digital literacy.

The knowledge-intensive sectors of the economy have the greatest need of all digital skills. This applies both to the research and development intensive manufacturing industry and to the knowledge intensive service providers. The sectors IT and financial service providers as well as mechanical engineering and health care stand out in particular. The need for more complex digital literacy is strongly concentrated in R&D-intensive industries: 54% of SMEs in this sector need programming skills and 38% need statistical data analysis. Overall, the demand for digital skills in R&D-intensive manufacturing is below average. In fact, one third of the SMEs do not believe that their needs are covered: 34% of SMEs lack one or more digital skills; 14% even face significant bottlenecks, i.e. the need for at least one digital skill is not even partially covered. Knowledge of complex statistical data analysis appears to be particularly scarce. Only 55% of SMEs that need this digital literacy see their needs covered. When it comes to acquiring digital skills, clearly more SMEs rely on training than on recruitment or outsourcing. In 70% of the SMEs with a need for digital skills, in-company training plays a role, and in 31% a large one. Significantly fewer SMEs rely on recruitment. Companies tend to focus on short training courses. Intensive retraining or courses of study play a major role for only half as many SMEs (13%) as shorter continuing training courses (26%) (KfW Research, 2018).

A study by IW Consult on behalf of the German Association of HR Managers (BPM) examines what continuing education and digital education will look like for the labour market of the future and how the need for qualifications and competences will change in the process. About 700 HR managers from German companies took part in the survey. 8 out of 10 of the HR managers surveyed assume that new job profiles will probably emerge in their companies in the course of digitisation over the next five years. This is more common in large companies (89.7%) than in SMEs (66.7%). 84.1% expect that IT user skills will increase in the next 5 years and 71.2% for IT expertise and software programming. The need for skills in IT expertise and software programming is clearly formulated. Only 57,9% of those surveyed have this need covered. The main results can be summarised as expert knowledge, IT knowledge and social and personal skills form the new educational canon for the digital working world. The lack of flexibility threatens to become a shortage of skilled workers in the digital age, the potential of digital learning offers for education and training is not fully exploited, and the low-skilled in particular will come under increasing pressure on the labour market in the future (BPM, 2018).

A survey by the Stifterverband makes a further contribution to the need for competence in Germany. Over 600 companies were included. In addition, 20 guideline-based expert interviews were conducted with

personnel managers from companies. The study is part of the *Future Skills* program an initiative of the Stifterverband. It is based on the observation that although a number of competence categorizations have already been developed for future skills the current competence needs of German companies have hardly been addressed there so far. The interest in knowledge is to learn what skills will be needed in the working and living environments of the future? And how great is the need of German companies for such "future skills"? These qualifications are transversal competences that allow for flexibility in dealing with new and unknown situations. This means that current competence requirements of German companies can be mapped to which the universities can respond with appropriate training programs (Kirchher et al. 2018).

Future skills are defined in this study as “skills that will become significantly more important for professional life and/or social participation over the next five years - across all sectors and industries” (Kirchher et al. 2018, 4). This is based on a twofold challenge. On the one hand, the challenge at the top, which is that specialists are needed to handle transformative technologies in all industries. On the other hand, the challenge at the broad end, in terms of new key qualifications for all employees.

Based on the statements of HR managers and taking into account existing concepts, a framework with 18 so called future skills was developed that distinguishes between three categories:

Technological skills (Skills necessary for the design of transformative technologies)

- Complex data analysis
- Smart hardware/robotics development
- Web development
- User-centered design (UX)
- Design and administration of networked IT systems
- Blockchain technology development
- Tech Translation

Basic digital skills (Skills that enable people to navigate and participate actively in a digitalised environment)

- Digital literacy
- Digital interaction
- Collaboration
- Agile working
- Digital learning
- Digital ethics

Classical skills (Competences and characteristics whose importance in working life will increase in the coming years from the perspective of companies)

- Problem solving ability
- Creativity
- Entrepreneurial action & self-initiative
- Adaptability
- Persistence

For the area of technological skills, the survey results have been used to derive a demand of around 700,000 people with the relevant skills in the economy alone by 2023. In addition, over 2.4 million workers each need to be trained in key skills such as agile working, digital learning or collaboration techniques. The needs of public employers are not yet included. Complex data analysis is the tech skill with by far the largest gap in demand (455,000 people). This high value indicates that in the future, companies will collect and process large amounts of data to an even greater extent than before and that artificial intelligence based on complex data analysis will become increasingly important. The field of complex data analysis is also considered to be of the greatest importance for professional profiles outside IT departments. If the area of public employers is also taken into account, an average of 220,000 people a year would have to acquire advanced technological skills over the next five years. The HR managers surveyed all agree that by far the greatest need for further training in the coming years will lie in digital and non-digital key qualifications such as agile working, digital learning and collaboration techniques. Percentage of employees who should master the Future Skill in five years:

- Collaboration (86%)
- Persistence (76%)
- Digital Literacy (76%)
- Entrepreneurial action and personal initiative (74%)
- Digital Learning (72%)
- Agile Working (66%)

3.2 Industry 4.0

With over 6.4 million employees in more than 46,000 companies and an annual turnover of 1,948 billion euro, the manufacturing industry accounts for almost a quarter of the gross value added in Germany. The German economic structure is strongly influenced by the industrial sector. This means that Germany has the highest industrial share compared with the large advanced countries (USA 11,6%, France 10,9%, UK 10,0%) (VCI, 2019).

Industry 4.0 is a future project and is originally based on the research union of the German Federal Government and a project of the same name in the *High-Tech Strategy* of the Federal Government. Internationally Industry 4.0 today stands for the digitization of the industry and for an economic paradigm shift. Basically, the term Industry 4.0 describes the "… technical integration of CPS[9] in production and logistics and the application of the Internet of Things and Services in industrial processes - including the resulting consequences for value creation, business models and downstream services and work organisation" (Forschungsunion & acatech, 2013). It is characterized by a strong individualization of the products under the conditions of a highly flexible (large series) production. Customers and business partners are directly involved in business and value creation processes. The production is combined with high quality services. With more intelligent monitoring and decision-making processes, it should be

[9] Cyber-Physical Systems - refers to the fusion of the physical and virtual worlds. This means that a network is created between man, machine, product, object and ICT system.

possible to control and optimize companies and entire value-added networks in almost real time. In the study "Industry 4.0 - now with AI" by the association Bitkom (2019b), 53 percent of the 555 companies surveyed stated that they already use special applications for Industry 4.0.

The digitisation of industry will lead to considerable job shifts between individual sectors and occupational fields. At the same time the use of Industry 4.0 technologies opens up a spectrum of possibilities for the design of work. In the social discourse the development towards Industry 4.0 is associated with opportunities and risks. A basis for the implementation of Industry 4.0 is the extensive automation of production. By contrast, Germany is facing high risk of job automation, with a total of 54.2% of jobs at risk of automation (OECD, 2019c). Bonin et al. transfer the study of Frey and Osborne[10] to Germany. They point out that in the course of digitisation, individual activities are usually automated and, more rarely, entire professions. On the basis of automation probabilities based on activity structures in the workplace, the authors conclude that 12% of jobs in Germany have activity profiles with a relatively high probability of automation (ZEW, 2015). According to the OECD employment outlook, 18.4 percent of all jobs in Germany are threatened by automation (OECD, 2019d). Dengler and Matthes (2015) follow an activity-based approach, which infer the substitutability of an occupation from the activities. In order to identify potential substitutability, it was estimated how many activities characterising a profession could already be performed by computers or computer-controlled machines. Occupations with a substitutability potential of more than 70 % are more likely to be replaced or changed by computers or computer-controlled machines than occupations with a lower substitution potential. A second study (Dengler/Matthes, 2018) for 2016 gives a comparative value of 25 percent with a high potential for substitutability in Germany. The authors differentiate, among other things, according to requirement levels, which, in the order of increasing formal educational qualifications, are referred to as "helpers", "professionals", "specialists" and "experts". It is shown that helpers have the highest substitutability potential and that the substitutability potential decreases with increasing educational attainment. Other authors also expect a decline in employment in codifiable routine activities in the middle qualification segment on the one hand and a increase in manual and complex cognitive non-routine activities on the other hand. Also affected are in particular people with low income (Arntz et al. 2016, Frey/Berger 2015).

An outlook on the competence and qualification needs up to 2030 provided by a study of the Federal Ministry of Labour and Social Affairs (BMAS) sees a need for competence in the digital production world in having an understanding of systems and the ability to compress, analyse and interpret data. Data mining experts are additionally required for this. Overall, it is not expected that "analogous" activities, such as the maintenance and repair of machines, will be of no further significance in the future. Rather, employees will be required to have a more comprehensive competence profile, in which traditional skills are supplemented by new, expanded skills (Patscha et al. 2017).

[10] Frey and Osborne (2013) examine the automatability of occupations in the USA using expert assessments and occupational activity structures. Frey, C. & Osborne, M. A. (2013). The Future of Employment: How Susceptible are Jobs to Computerization?, University of Oxford.

However there is general agreement that the requirements to the workforce will increase and competence development and further training are regarded as the central levers for successfully managing digital change in social and economic terms. The German Academy of Science and Engineering acatech outlines in its *Competence development study industry 4.0* that a key objective of skills development for Industry 4.0 is to avoid a double digital divide: between large companies with a high level of digitalization and SMEs on the one hand, and between high- and low-skilled workers on the other. The study was based on a number of competencies that are crucial for companies to implement Industry 4.0, as well as employee skills that are relevant to the new digital working environment (acatech, 2016).

The overall result shows that the companies as a whole see the greatest need in the areas of data evaluation and analysis at 60.6 percent and process management as cross-divisional networking at 53.7 percent. In terms of required employee skills, topics such as interdisciplinary thinking and acting (61.1 percent) and increasing process know-how - i.e. the cross-divisional understanding of the interrelationships in production and the value chain - are named as central qualification requirements by 56.2 percent. The study also showed that in many areas SMEs indicate higher skill needs for their operations than large firms, especially for process and customer-oriented competencies such as customer relationship management (48.8 percent) and for infrastructure and organization-related competencies such as handling specific IT systems (48.4 percent). On the other hand, large companies indicate a partly significantly higher demand especially for technology and data-oriented corporate competencies - such as cloud architectures (49.4 percent or artificial intelligence/algorithms 47.1 percent (acatech, 2016).

General, it can be seen that the areas of data evaluation and analysis, process management and increasing process know-how as well as interdisciplinary thinking and acting are named by the companies as central elements of competence development and personnel qualification for Industry 4.0. However, it is considered important to differentiate in terms of needs and future priorities between large companies, which focus more strongly on technology and data-oriented topics, and small and medium-sized enterprises, which place greater emphasis on process and customer-oriented as well as infrastructure and organization-related areas of competence.

The Research Advisory Board of the Platform Industry 4.0 identifies the following development needs:

- New forms of practice-oriented and individual learning as well as working environments conducive to learning for the further development of action skills and competences
- Digital-based and intelligent solutions for different qualification and competence levels with special consideration of low qualified employees
- Concepts of a (methodological) change from educational and qualification processes to forms of scalable use of digital methods (Plattform Industrie 4.0, 2019).

3.3 Social divides

The availability and development of digital literacy becomes more and more a key requirement for professional and social participation. The phenomenon of the digital divide is primarily evident in the use and acceptance of digital media and therefore has an impact on issues related to the development of

digital literacy. For Germany, too, there are differences in digitisation with regard to region, age, educational background and daily computer use. The *D21 Digital Index 2019 /2020* shows that the German society takes a step forward, but digital divide remains. However, 14% of the German population are still offline, whereby it must be stated here that abstinence mainly affects older (average age 71), female persons (67%) with a rather low level of schooling (71%). The Index identifies different user groups and types with specific characteristics in the population. Compared to previous years, a clear shift towards the most digital of the three groups can be observed. The group of "digitally on the sidelines" shrinks by three percentage points to 18 per cent and thus still comprises around 11.5 million people. The "digital keepers", is shrinking from 42 to 38 percent. The group of "digital pioneers" is now the largest at 44 percent (+7 percentage points). Around 28 million people are thus dealing openly and confidently with the demands and achievements of digitisation. Germany differs greatly from other countries in the acceptance and perception of digitisation and its impact on the individual and society (Initiative D21, 2020). The Vodafone study (2018) compares 9 countries (6 from Europe, the fast developing markets India and China and the USA). To evaluate the importance of technology in life, participants are categorised into two groups: Early and late adopters[11]. Germany and Sweden have the lowest number of early adopters (30%) in contrast to Bulgaria and China (44%). In the study participants were asked how enthusiastic they are about digitisation and the use of new technologies compared to the society they live in. Even here Germany is at the bottom of the table. Only 34% say they are (very) enthusiastic compared to their society. Germans (48%) and Britons (47%) have the least positive attitudes about digitisation and the use of new technologies in different areas of life (India 89%, China 83% and Bulgaria 74%). Germans are also rather critical with regard to increasing the chances of participation in social life for older people through digitisation. Only 31% recognise a positive influence (China 69%, India 62%, USA 46%). The *D21 Digital Index* notes however, that three-fourths of the population believe that in five years' time it will be virtually impossible to get by without the Internet. They also consider basic knowledge of digitization to be a necessary prerequisite for opportunities on the labor market. On a personal level, half of the population is interested in expanding their knowledge of digitization.

The same report does not yet describe systematic and comprehensive forms of competence enhancement when it takes a look at how knowledge is acquired in the society around digitisation issues. Learning by doing" continues to be the most common form of knowledge acquisition. A quarter of the total population has experience with systematic further education on digitisation in the form of free or financed training courses. Within the scope of their professional activities, 19 percent of those surveyed are expanding their digital competence. Every fourth employee is paid for training in this context, and of those with an office job every third. Furthermore, it can be seen that the younger generations are more digital affine (14- to 29-year-olds with the highest level of competence). In general, working people, especially those with a desk job, have a higher index value than people without a job (46 to 73). Higher educated people, with an

[11] Early adopters: very enthusiastic about digital technology; try new technologies first; follow actively news on the latest technological developments and innovations. Late adopters: they don't think that new technologies have improved their lives; They only use new technical products after most of their friends, colleagues, etc. have started to use them; Computers confuse them; they'll never get used to them (Vodafone, 2018).

index value of 71, have a significantly higher degree of digitisation than people with lower formal education (40). The study clearly shows that the status of being online of low educated people differs significantly from the rest of the population. Over 90 percent of people with high and medium education are online, and only 64 percent with low education. The *Digital Literacy Monitor* comes to similar conclusions: People with less formal education and those not in employment are significantly less likely to learn digitally (32 and 28 percent respectively) than employed and academic people (59 percent). In the professional context, the respondents are divided: just under 40 percent of those in employment see new job opportunities on the one hand, and almost as many feels increasingly under pressure. 43 percent state that digitization has already noticeably changed their work processes. For people with an office job, the figure is as high as 58 percent. Nevertheless, almost three-quarters of those in employment feel that they can cope with the current digital requirements. People with above-average knowledge of digitization recognize a greater need to further expand their knowledge. 78 percent of those in employment see lifelong learning as a central factor for professional success. 27 percent of them feel this is a burden, and for people with a low level of education it is even two out of five. In summary the report clarifies that the more digital people are today, the greater the impact they expect from digitisation and the more positive their attitude to it (Schmidt et al., 2017).

A special evaluation of the *D21 Digital Index 2018/2019* recognizes a Digital Gender Gap, because women achieve a lower degree of digitisation than men across all socio-demographic characteristics. A typology based on the D21 digital index locates women more often than average in the group of "digitally offside", a group of persons with a low index value between 0 and 40. Accordingly, the group the "digital pioneer", a group of people with a high index value between 70 and 100, predominantly occupied by men. The evaluation of selected results of the *D21 Digital Index 2018/2019* from a gender perspective shows that there are still differences between women and men in terms of digital skills, openness to technological trends, digital working and knowledge acquisition on digital topics. The extended analysis by characteristics such as age, education or professional activity points to significant differences within the group of women and also within the group of men (Initiative D21, 2020).

The KOFA study examined the extent to which equal opportunities for women and men have been achieved in the course of digital change. It was found that at the working level, digitization arrived almost everywhere and women and men are equally represented in digital industries. But within the top 5 digital industries women and men work in different professions. Men mainly in IT professions and women more likely in office and secretarial occupations and in commercial training occupations. In the IT occupations, there are clear signs of gender differences. Only 16.5 percent of all IT specialists are women. Gender differences can also be found in the use of occupation-specific software and the development and maintenance of software and IT systems. It was also found that companies involve women less often than men in the selection of new technologies. Women are therefore less likely to be creators of digitization (Seyda, Flake, 2019, 4).

3.4 Artificial Intelligence (AI)

Artificial intelligence (AI) is today considered one of the decisive key technologies and will have a lasting impact on the economy and society in the coming years. With the sometimes leap-frogging improvement of AI procedures and the simultaneously increasing availability of data, the application possibilities of AI are expanding. In just a few years, many of the products that make up the position of the German economy in the world will be equipped with intelligence (Bauer et al. 2017). The industry association Bitkom expects the global market volume for cognitive computing to increase fivefold by 2020 (Bitkom, 2017). McKinsey (2017) estimates that in Germany, GDP could be 4 percent or EUR 160 billion higher than without AI by 2030, and the market for AI is growing by 25 percent annually. PwC (2018) expected by the year 2030 an increase of the German GDP by 11.3 per cent solely as a result of AI-based innovations. Due to the strong production sector, effects of AI, such as productivity increases, are considered higher for Germany than for other European countries. The same study supports the assumption that the main share of labour productivity growth in practice relates to skilled jobs (PWC, 2018, 13).

BMWi (2020) provides a statistically representative overview of the current status of the use of artificial intelligence (AI) in companies in Germany in 2019. Overall, it can be stated that in 2019 around 17,500 companies have used AI in products, services or internal processes. This corresponds to about 5.8% of all companies surveyed. In 2019, companies of the German economy achieved a total turnover of almost € 60 billion with products and services with direct AI use. An analysis of the distribution of AI in the individual industries reveals that the ICT sector is the leader with 17.8%, followed by financial services (12.2%), business-related services (11.2%) and electrical and mechanical engineering (6.8%). The main reason for the high proportion of AI in the ICT sector is that AI is used here for its own processes and products, while AI solutions are also developed for other sectors. In 2019, about 0.3% of all employees in the companies were mainly involved in the development, introduction and maintenance of AI procedures. That is about 50,000 persons. The ICT sector has the highest share (1.51%), followed by business-related services (0.88%) and the electrical engineering/mechanical engineering sector (0.35%). In terms of AI employees per enterprise using AI, an enterprise using AI in the automotive sector employs on average 32 persons mainly or to a lesser extent in the AI sector. In other manufacturing industries, on the other hand, it employs only just over 4 persons. The average of all enterprises using AI in Germany in 2019 was 8 persons working mainly or partly in this sector.

In 2019, 30 % of the companies in the German economy that used AI in their business had vacancies in the AI sector. The highest proportion of AI-using enterprises with job vacancies in 2019 is in the ICT sector (60%). In electrical and mechanical engineering, every second AI using enterprise had open AI jobs. 43 % of the vacancies could not be filled at all.

In terms of the skills that companies require to fill open AI positions, software programming is by far the most important. 70% of the companies with open AI jobs said that this knowledge was very important, another 26% said it was important and only 1% said it was not important. Programming skills are therefore a basic requirement for AI positions. Other requirements like database management is mentioned as very

important by 43% of the companies with open AI positions. Knowledge of mathematics, although only 31% of the enterprises with open AI jobs are considered very important, 45% consider it important, so that this formal skill can be considered the second most important qualification requirement. 59% of enterprises with open AI vacancies cite industry-specific knowledge as an important or very important skill requirement.

3.5 The impact of digititalisation on continuing education

Especially as information and internet technology is in constant development, the permanent education and training of digital skills is of central importance (Aktionsrat Bildung, 2018, 61). The continuing education and learning of adults is becoming increasingly important, especially due to demographic change and accelerated technological development. It can be shown empirically that technical progress has led to a changed need for (further) education (Hammermann, Stettes, 2015; 2016). The continuing education system in Germany is seen as an independent fourth pillar of the education system. Since 1998 scientific continuing education has been a statutory task of German universities. It is therefore the central task of the universities to expand their continuing education programs both in continuing education Master's programs and in individual subject-specific modules. Especially considering the size of the gap in technological future skills, the number of future school leavers taking up studies in this field will be far from sufficient to meet the demand. In the field of continuing education and lifelong learning, four basic tendencies of content and formal merging processes can be identified:

- The merging of academic and professional content and target groups,
- a merging of the content production of companies and educational institutions,
- a coupling of digital and physical training environments
- an interlocking of informal and formal learning (Stifterverband, 2019)

In principle, there is an insufficient statistical data basis for continuing academic education in Germany, which is also due to the fact that HEIs account for only three percent of all lecturer hours and represent only a small share of the continuing education market (Stifterverband, 2019; Kamm, Schmitt, Banscherus & Wolter, 2016). The market for continuing education and learning in Germany is changing due to the new requirements of digitalisation in terms of new content and teaching and learning formats. However, digital continuing education still takes place primarily informally and online at home (Schmid, Goertz, Behrens, & Bertelsmann Foundation, 2018). More and more, HEIs in Germany are devoting themselves to continuing academic education, i.e. they offer continuing education programs for companies and other institutions based on their qualification profiles or study programs that are didactically and methodologically prepared at university level.

Digitisation represents new content requirements in the form of IT competencies, but also higher demands on cooperation and communication skills as well as independence and planning competence, as working methods and cooperation also change (Seyda et al. 2018). At the same time, it raises the question of how a permanent adaptation to the requirements of the digital transformation can be achieved through lifelong learning processes. The discourse on the digital transformation processes can also be conducted

to determine whether a paradigm shift of the continuing education system is required with a new teaching and learning culture and changed institutional framework conditions. Results of a study of the University of Applied Sciences Neubrandenburg show that digitisation is changing continuing education in the following areas:

- Digitisation of analogue knowledge and information,
- The use of new, digital media, new forms of learning and appropriate didactics,
- New competence requirements and competence development as content and goal of continuing education and training (Fischer et al., 2018, 6).

In recent years, a large number of continuing academic education programs have been developed at German HEIs, from online seminars to part-time study programs. In response to the needs of those interested in continuing education and against the background of the digitisation of higher education, digital learning and teaching has gained in relevance for continuing academic education. Continuing Academic Education 4.0, understood as continuing education at universities with digital components. The so-called *Continuing Education 4.0* can understand as "continuing education at HEIs with digital components, such as digital forms of learning and teaching and digital processes and subject-related topics in the context of the digitisation of HEIs" (Mah et al. 2019, 8).

A survey by Stifterverband and McKinsey (2019) to the situation of higher education in Germany states that the field of quaternary education (supply and demand for continuing education at higher education institutions, part-time study and flexible study opportunities) has hardly changed between 2015 and 2017. The range of part-time Master's programs has developed positively. The study estimates that in 2017, state universities will have offered a total of 44 continuing education programs for technological future skills - almost two thirds of them for complex data analysis or user-centred design. According to the companies surveyed, HEIs are becoming increasingly important for companies in teaching future-oriented skills: one in four companies works with universities to cover their skills needs. HEIs are currently of particular relevance in the professional training and continuing education of technical experts. With an estimated 2,000 participants annually in continuing education Master's programs for technological skills at state universities, there is still great potential for universities here (Stifterverband, 2019).

The following key findings from the university survey can be summarised in thesis form:

1. Presence formats dominate academic continuing education - but blended learning is on the rise.
2. Mobile learning and adaptive online learning are seen as having great future potential.
3. There is a range of potential for improvement in the cooperation between universities and companies.
4. Cooperations in continuing education do not come about or fail due to lack of resources and lack of interest on the part of companies.
5. The highest growth rates in continuing education are expected by the universities for problems arising in the area of digitization (Stifterverband 2019).

HEIs have to orient themselves more strongly to the changed professional biographies and the demand from companies and other parties interested in continuing training. Therefore, HEIs have to broaden the

range and format of courses and offer flexible academic continuing education opportunities and the possibility of studying while working should be further strongly expanded. Alliances between universities, between educational institutions and companies and between public and private platform providers can be helpful, to build flexible customised programs through which competences can be acquired. A fundamental condition is to further promote the permeability of the higher education system in order to open up educational opportunities to new target groups.

4 Current policy and educational/universities responses

Digitalization is transforming the skills needed by Europe's working population to successfully engage in the world of work in a globalized modern economy. In this context, higher education institutions play a key role in providing the digital skills required by the labour market in the globalized modern economy. Consequently, national education systems must swiftly and appropriately respond to the challenges digitalization poses.

4.1 German Digital Policy

In Germany the federal and the federal state (the ´Länder´) governments are jointly responsible for digital education. In Germany, the development of digital literacy is seen as an interdepartmental task and therefore plays an important role in all relevant strategies. It can also be noted that a wide variety of strategies, programs and funding measures exist at state and federal level to support the digitisation of universities.

Key initiatives in the last two years: In November 2018 the Implementation strategy of the Federal Government for shaping digital change entitled "*Shaping Digitisation*" was adopted. In this implementation strategy, there is a concentration on priority projects that the ministries have identified (BReg, 2020). The *AI Strategy Germany* of the Federal Government, also adopted in November 2018 (BReg, 2018), also the Ministry of Education and Research's (BMBF) Digital Strategy adopted in April 2019 entitled "*Digital Future: Learning. Research. Knowledge*" (BMBF, 2019a) and in the MINT-Action Plan of February 2019 (BMBF, 2019b). In March 2018 a new Minister of State for Digitisation was appointed, reporting directly to the Federal Chancellery.

4.1.1 Digital Agenda

In 2014 Germany adopted its *Digital Agenda* (Bundesregierung, 2017). The Federal Government's Digital Agenda sets out the guidelines for digital policy and bundles measures in central fields of action in order to accompany and help shape digital change and is a starting point for the future digital policy of the Federal Government. The Federal Ministry of Economics and Energy, the Federal Ministry of the Interior and the Federal Ministry of Transport and Digital Infrastructure are jointly responsible for its implementation. The strategy consists of five fields of action. 1. Digital literacy, 2. Infrastructure and equipment, 3. Innovation and digital transformation, 4. Society in digital change and 5. Modern state. Each field of action is preceded by common guiding principles.

The field of action *Digital literacy* focuses on the main points *School education*, *Education, training and further education* and *Competent society*. The intended objective is, that "all people become able to take advantage of the opportunities offered by digitization. They should be able to shape digital change in a self-determined way and deal responsibly with the risks."

Focus: School education

In order to strengthen digital literacy at the approximately 43.000 schools in Germany, the *DigitalPakt Schule* (Digital Pact for Schools)[12] was launched by the Federal Government in cooperation with the federal states and the municipalities. The initiative wants to accompany the central future task of "learning in the digital world" with a nationwide infrastructure project. The aim is to provide strong support for the digital (learning) infrastructure of schools, taking into account a needs-based qualification of teaching staff, through federal funds and accompanying measures at the level of the federal states. This should enable schools to implement digital education on the basis of a technical-pedagogical deployment concept. For the five-year term (2019-2023), the financial volume on the federal side amounts to five billion Euro.

Focus: Education, training and further education

Digital literacy must also be an essential component of continuing education. Therefore, there is a desire to support universities, companies and training institutions to teach digital literacy. Especially in vocational training digital policy wants to push the opportunities offered by digital media and applications. Digitization and Industry 4.0 will have an impact on the content of job descriptions. Selected initiatives:

Since 2016, the umbrella initiative "*Vocational Education and Training 4.0*" has been pooling the activities of the BMBF to gear the structure and content of dual vocational training to the requirements of an increasingly digitized and networked economy. The overall objective is to increase the proportion of people with basic digital skills from the 68 percent calculated by Eurostat to 75 percent by 2025. The activities aim to analyze the impact of digitization on tomorrow's qualification requirements, to promote the use of digital media in vocational education and training, to support small and medium-sized enterprises (SMEs) in the transformation process to economy 4.0. It also includes the digital equipment of inter-company vocational training facilities (ÜBS) and their competence centres, the further development of technology-oriented methods for measuring vocational action competences and the qualification of trainers in companies and training facilities, teachers at vocational schools and examiners.

One part of the initiative is the program *Digital Media in Vocational Education* to support the development, testing and use of new educational offers with digital media in vocational education and training. The program *JOBSTARTER plus* (2017-2020) is concerned with the development of regional support structures for SMEs, with the human resource requirements through automation and digitization. The *ASCOT+* transfer initiative *"Measuring competence in vocational education and training"* (2017-2021)

[12] https://www.digitalpaktschule.de/

complements the core initiatives of Vocational Education and Training 4.0 with a competence-oriented perspective.

The activities in this focus will support through the *National Continuing Education Strategy* (2018-2021) with which the Federal Government, the Länder, industry, trade unions and the Federal Employment Agency are jointly laying the foundations for a new culture of continuing education and lifelong learning in Germany. Digitisation and digital skills are of great importance in this context. The strategy combines measures to enable even more people to participate in digital change. One objective is to further develop training qualifications and training courses in consultation with the economic and social partners in order to take account of additional competence requirements, e.g. in the course of digitization. Groups of people with below-average participation in continuing training should receive special support, as should SMEs which do not have large personnel departments to develop continuing training concepts. A nationally binding anchoring of the assessment and certification of informally acquired skills should be promoted, especially for the promotion of digital skills (BMBF, 2019c).

Focus: Competent society

Digital competences are key competences of the digital society. This is to be supported by projects, which, among other things, help children and young people to grow up well with digital media, including age-appropriate media environments. Furthermore, the digital competence of older people is to increase in a targeted manner and also support them in keeping up with digital developments.

The field of action *Innovation and digital* has among other things the focus on Transformation in higher education and research. The research area "Digital Higher Education" focuses on innovative digital teaching-learning formats and their structural design and success conditions. And is intended to support universities in the digitization process and to generate scientifically sound knowledge for policy and practice. Within the framework of a first call for funding published in 2016, 20 projects are dealing with the three main topics "Adaptive Learning and Examination Environments", "Interactivity and Multimedia of Digital Learning Environments" and "Research on Theory and Practice in Digital Learning Environments". Within the framework of a second funding line from 2017, 9 projects of interdisciplinary research consortia are investigating didactic, technological and organisational design aspects of digital education formats, which have a high potential to answer university and education policy questions. The current third funding line focuses on digital teaching and learning concepts within individual disciplines and subjects, so-called digital subject concepts.

4.1.2 High-Tech Strategy 2025

The *Hightech-Strategy 2025* forms the strategic umbrella of the Federal Government's research and innovation policy. The strategy focuses on the topics "Health and Care", "Sustainability, Climate Protection and Energy", "Mobility", "City and Country", "Security" and "Economy and Work 4.0". Digitization is being promoted as a central cross-cutting issue in all the fields mentioned (BMBF, 2018).

The promotion of AI plays an important role within the Hightech-Strategy. The Artificial Intelligence Strategy was created for this purpose. The "*Artificial Intelligence Strategy of the Federal Government*" (AI

Strategy) was adopted by the Federal Cabinet in November 2018. Up to and including 2025, the federal government plans to invest a total of about 3 billion € for the implementation of the strategy. The following objectives are pursued:

1. Making Germany and Europe a leading AI location and thus contribute to securing Germany's future competitiveness.
2. A responsible and common good oriented development and use of AI.
3. Embeding AI ethically, legally, culturally and institutionally in society as part of a broad social dialogue and active political shaping (BReg, 2018).

The central measures of the AI strategy include the further development of competence centres for AI research in addition to the German Research Center for Artificial Intelligence (DFKI) the world's largest AI research institute. This includes the establishment of regional competence centres of labour research in order to link labour research in the age of AI more closely with work design in operational practice. In the final stage a network of at least twelve centres and application hubs is to be created and should promote the emergence of an AI ecosystem. In addition, a program for the promotion of young scientists and teaching in the field of AI is to be set up. At least 100 additional new professorships are to be created to ensure that AI is firmly anchored at universities. By setting up and supporting the operation of a "teaching-learning platform AI", a contribution will be made to securing and developing the skilled labour base in the field of AI, which is important for technological performance. The platform is to include target group-oriented content with corresponding didactic-tutorial support. Learners will thus have access to quality-assured online courses.

The AI strategy of the Federal Government not only provides for increased financial support for existing institutions and projects, but also promotes new projects that are started in the field of artificial intelligence. A future project worth mentioning is the opening of the German AI Observatory. The AI observatory is a project of the Federal Ministry of Labour and Social Affairs (BMAS). Starting in March 2020, it will analyse the effects of the application of artificial intelligence on work and society. In a next step, recommendations for action will be developed and European and international structures on the topic of AI in work and society will be established.

A further focus is on the promotion and support of SMEs in the application of AI and the implementation of digital business models. There are 26 competence centres *Mittelstand 4.0*[13] as regional contact points throughout Germany that impart knowledge on the application of digital technologies and offer special demonstration and testing opportunities. An additional "Competence Centre Digital Crafts" supports skilled and management personnel in the crafts sector by providing practical information and training on digitization. The centres are intended to support companies in order to strengthen their innovative strength in the long term by systematically enabling them to develop and use market-ready and SME-relevant AI applications for themselves. Special AI training courses, workshops and AI trainers can be used.

[13] https://www.mittelstand-digital.de/MD/Navigation/DE/Home/home.html

The applications Intelligent Assistance Systems, Industrial Analysis (Smart Data Analysis) and Intelligent Products and Services (AI as a Service) are particularly relevant for German SMEs.

In December 2019 a national agency for leap innovations was founded (SprinD GmbH)[14] The agency is intended to be a flexible and rapid government instrument to support and accelerate the breakthrough of highly innovative ideas into the market. The primary goal of the agency is the discovery and further development of research ideas that have the potential for leap innovation. Within the framework of a National Strategy for Continuing Education, the Federal Government will develop a broadly effective set of instruments to promote the skills of the working population.

4.2 HEIs response to digitisation

4.2.1 Status of digitisation

According to the German Rectors' Conference, "Universities are the 'engines' of economic and social innovation in Germany and a key sector on the road to 'Industry 4.0" (HRK, 2018, 2). The current digitization activities of HEIs, however, are still largely limited to basic infrastructure and further education offers as well as selective initiatives, which are usually not yet integrated into complete study programs. Only a few universities have so far made the transition from selected pilot projects to the general introduction of digital teaching and learning tools and learning formats in complete courses of studies of the universities succeeded.

In the winter semester 2018/19, there were a total of 426 private and public universities in Germany. As socio-economic actors, universities are also involved in processes of digitisation and the corresponding effects. Universities are setting up more and more chairs focusing on digitization, with three out of ten new professors appointed in 2018 explicitly dealing with digitisation issues, according to the university managers surveyed (Stifterverband, 2018).

Just as structures and processes in the economy and society are subject to far-reaching changes, so too science and universities, which are increasingly opening up to the potential of digitisation. Examples are increased activities in the field of study and teaching. In recent years, more and more topic- and state-related networks, university associations and state initiatives have been founded. Examples of university networks on digitization of federal states in Germany:

- *Higher Education Network Digitisation of Teaching* (HND BW) (Baden-Wuerttemberg)
- *Virtual University of Bavaria* (vhb) (Bavaria)
- *E-Learning Network Brandenburg* [eBB] (Brandenburg)
- *Hamburg Open Online University* (HOOU)
- *Digital University NRW* (DH.NRW) (North Rhine-Westphalia)
- *Network digital university teaching in the context of heterogeneity as a quality challenge for studies and teaching* [HET LSA] (Saxony Anhalt)
- *eteach network for qualification in the field of digital university didactics* (Thuringia)

[14] https://www.sprind.org/de/

The focus study "*Digitisation of the universities*" of the HIS Institute for Higher Education Development (Gilch et al., 2019) aims to analyse the process of digitisation at universities across Germany, taking into account the dimensions of research, teaching, administration and infrastructure. For this purpose, 395 heads of universities were surveyed (realized sample n= 119). One of the central results with regard to the significance and status of digitisation is that the significance of digitisation at universities in Germany is generally considered to be high. With regard to their own university as an institution as a whole, 82.6% of the universities assess the importance of digitisation as high or very high. The digitisation of teaching and learning (75.7%) and the digitisation of administration (71.9%) are attributed the greatest importance.

It should be noted that, only 54.5% of the universities have a written strategy or a concept for the digitisation of the university as a whole. Area-specific (digitisation) strategies exist primarily for teaching and learning and administration. According to their own estimates, 34.3% of the universities have achieved a high or very high level of digitisation in the field of research, 29.3% in the area of teaching and learning and 23% in the area of administration. Overall, it can be concluded that only 20.4% of the universities can be classified as having a high or rather high level of digitisation.

For the area of teaching and learning, the qualitative interviews refer to “lighthouses” and projects that exist at many universities in a wide variety of forms, but have so far by no means led to widespread penetration. The use of digital teaching tools is highly dependent on the actors and the subject cultures. Instruments and tools of digital teaching:

1. mobile learning: 24.7%
2. lecture recording (i.e. live digitized lecture): 19.4%
3. social media: 19.2%
4. open educational resources: 18.9%
5. online peer and collaborative learning: 16.0%
6. e-portfolio: 13.8%
7. inverted classroom: 13.2%
8. simulation-supported learning: 11.6%
9. adaptive learning: 7.4%
10. augmented or virtual reality: 7.3%
11. game-based learning: 6.2%

The study emphasizes that the status, strategic and organizational anchoring in the university as well as the structural and political framework conditions differ for the individual universities. It becomes clear that, with regard to the framework conditions of digitisation, there are many external, i.e. political, legal and social influences. These include, above all, competitive pressure, development trends such as Industry 4.0 and also cooperation to shape digitisation.

4.2.2 New courses in digital topics

The German higher education landscape is extremely diverse. For example, 20,029 study programs can be completed at 395 universities and universities of applied sciences in which almost 2.8 million students were enrolled in the winter semester 2019/20 (HRK, 2019). In recent years, a wide range of courses has

been developed and offered at German universities in response to digital change. Some universities are focusing on taking new technological developments into account in their courses of study and enabling students to specialize in these future technologies. To this end, new courses of study are being developed that aim to acquire specific technological future skills. For example, since 2014, the universities have made increased efforts to continuously expand the range of courses offered in the field of data science.

In the field of complex data analysis, there are currently more than 50 study programs, through which an estimated 75,000 graduates will be released onto the labour market in the next five years, which corresponds to about 14 percent of all graduates from MINT programs (Stifterverband, 2019, 24ff.):

- Complex data analysis (52)
  Master in Data Science, LMU Munich; Master in Big Data Analystics, University Ulm; Bachelor in Data Science, University of Applied Science Ostwestfalen-Lippe
- Smart hardware/Robotics development (40)
  Master in Automation & Robotics, TU Dortmund; Master in Mechatronic & Robotics, University Hannover
- User-centered design (UX)
  Bachelor in User Experience Design, Technische Hochschule Ingolstadt; Bachelor in User Experience, Aalen University
- Web development (4)
  Master in Global Software Development, Fulda University of Applied Sciences; Bachelor in Softwaredevelopment & Mediainformatics University of Applied Sciences Stralsund
- Blockchain technology development (1)
  Master in Blockchain & Distributed Ledger Technologies, Mittweida University of Applied Sciences

In recent years, the Industry 4.0 topic area has found its way into study programs, the establishment of research-intensive competence centres and numerous industry and university cooperations in a variety of ways. So currently 13 universities and universities of applied science offer distance learning for the topic Industry 4.0. These offers are particularly suitable for part-time/on-the-job qualification.

- *Zentrum Industrie 4.0 (Centre Industry 4.0) - Cyber-Physical Learning Factory,* University of Applied Sciences Aalen
- *Centre for Digital Transformation (ZDT),* Baden-Wuerttemberg Cooperative State University (DHBW) Stuttgart
- *Master Smart Factory*, University of Applied Sciences Esslingen

Artificial intelligence is a technological megatrend. In the coming years, it will change both the economy and people's everyday lives worldwide. Currently, there is a lack of experts in the fields of AI, machine learning and data science in Germany. Since decades AI is already established as a branch of computer science at German universities. Today, however, AI is primarily understood as a cross-sectional technology. As an interdisciplinary course of study, the study of AI is based on a correspondingly broad range of content from both technical and scientific disciplines as well as from the field of human sciences. In recent years, a large number of new institutes and research associations have been established at German universities, or classical computer science institutes have expanded their offerings to include AI elements. Currently there are about 75 Bachelor's and Master's programs with a focus on Artificial

Intelligence. According to a survey by Bitkom, Germany has approximately 164 AI university professorships (Huber et al., 2020). Selection of university initiatives:

- Funding line "*Artificial intelligence / Machine learning*": The Ministry of Culture and Science of North Rhine-Westphalia funds the promotion of young researchers in the field of artificial intelligence. The aim is to support doctoral students and young researchers at the beginning of their careers with a cross-location Research Training Group and the "AI starter" format. The cross-location research training group aims to train doctoral students and network the participating universities in the field of basic AI research (MKW, 2020).
- *AI-Campus* at Osnabrück University: It links the research-strong and application-oriented subjects of computer science, cognitive science, business informatics and mathematics research groups In addition to research, the focus is on academic training and the promotion of young scientists. The Research Training Groups "Situated Cognition" and "Computational Cognition" funded by the German Research Foundation (DFG) offer special academic qualification opportunities (Universität Osnabrück, 2020).
- *Munich School of Robotics and Machine Intelligence*[15] at Technical University Munich
- *Cyber Valley*[16] (Region Stuttgart-Tübingen): The Max Planck Institute for Intelligent Systems, the Universities of Stuttgart and Tübingen and large companies such as Daimler, Bosch, Amazon and Facebook are among those involved in the Cyber Valley research network. This makes Cyber Valley one of the largest research cooperations in Europe between science and industry in the field of artificial intelligence. Top international teams research primarily into machine learning and autonomous robotics. In future, 100 doctoral students are to be trained at the Graduate School for Intelligent Systems.

4.2.3 Curriculum 4.0 - Approaches to anchoring digital literacy in the curriculum

As early as November 2012, the German Rectors' Conference (HRK) adopted the resolution "Higher education in the digital age: Understanding information literacy anew - Managing processes differently" (HRK, 2012). The resolution forces a mapping of the digital transformation at curricular level. Thus, each module should contain a standardised as well as a subject-specific component of information literacy. In 2019, the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany also adopted "Recommendations on Digitisation in University Teaching", which calls on the federal states, to press ahead with the targeted inclusion of digital content in curricula. This should ensure, that media literacy and subject-specific digital competences are adequately anchored in the curricula of study programs (Michel et al., 2018).

The term Curriculum 4.0 is associated with an approach to digital transformation. Ultimately, it is a matter of examining degree programs from the perspective of comprehensive digital change, whether and how they address the new/changed competence requirements associated with change and how they may

[15] https://www.msrm.tum.de/startseite/
[16] https://cyber-valley.de/

need to be further developed (Michel et al., 2018). As part of a study for the Higher Education Forum on Digitisation, Grünewald (2020) is looking into the question of how far advanced the curriculum-oriented discourse in the individual disciplines already is and where there is a need for support. The term Curriculum 4.0 is referred here to 3 levels: digital teaching concepts and methods, digital teaching content, curricular changes due to digital competence requirements. It is stated that numerous digitisation discourses are held from the level of the higher education actors down to the subject level, but the subject areas are very different. Nevertheless, the lack of a holistic view of the digitisation activities of the universities is noted above all. Current approaches to the curricular anchoring of digital competences in different disciplines (Grünewald, 2020):

- *Humanities and Social Sciences*: The Association Digital Humanities in the German speaking countries e.V. (DHd) promotes the combination of humanities and information technology methods to the Digital Humanities. It is recommended to integrate Digital Humanities into the individual disciplines of the humanities in order to sensitise students to digitization.
- *Computer Science*: In 2018 the Society for Computer Science (GI) published a strategy paper, which addresses the fundamental topic of data literacy. It points out ways in which sustainable progress should be made at various levels such as politics, specialist disciplines, universities, but also curricular. In particular, the early integration of data literacy into curricula, the creation of part-time courses of study for further education and uniform standards for competence profiles and the development of interdisciplinary curricula of Data Science education.
- *Engineering Sciences:* The main industry associations like Association of German Engineers e.V. (VDI), The Mechanical Engineering Industry Association (VDMA), Association for Electrical Engineering, Electronics, Information Technology (VDE) provide regular impulses on the status quo of engineering science curricula and the competence needs of the industry and give concrete recommendations for their revision according to the strategic goal of digital transformation. 4ING the umbrella organization of the Faculty Days of Engineering and Computer Science at universities represent around 2,500 professors, 15,000 employees and 135,000 students at universities in Germany. Since 2018, a central focus has been on the topic of digitisation and its consequences for engineering courses of study. Accordingly, activities are to be stepped up in order to establish subject-specific frames of reference to achieve more uniform standards of competence transfer.

With the funding line *Curriculum 4.0.nrw*[17], the state government of North Rhine-Westphalia, in cooperation with the Stifterverband, supports the universities in North Rhine-Westphalia in the digitisation of university teaching. So far 22 digitisation concepts have been selected by universities. The aim of the selected digitisation concepts is to further develop individual study program modules or to advance the curricular development and/or redesign of entire study programs.

[17] https://www.stifterverband.org/curriculum_4_0_nrw

DigiKiZ, Technical University Braunschweig: The "Quality plus[18]" program of the State Lower Saxony funds the "DigiKiZ" project, which focuses on promoting the teaching of digital competence in higher education. For this purpose, the current modules of business informatics will be expanded at suitable locations to include the teaching of 21st Century Skills and new courses in the area of key qualifications will be designed. As soon as the students have attended several suitable courses, they can obtain the "DigiKiZ" certificate as proof of their digital competence (TU Braunschweig, 2020).

5 Critical points and Gaps in Policy Response

Within the European Union, the European Commission's Digital Economy Society Index for 2018 shows that EU countries face deep digital development gap and therefore „it should invest more in digital and also complete the Digital Single Market as soon as possible to boost Europe's digital performance". Even more, the same disparity is seen on digital skills, „while Nordic countries and the U.K. have populations with notably advanced digital skills, almost half of all Europeans still lack basic technical competences", according to the index

5.1 Improving digital literacy in School Education

The promotion and development of digital skills and competences must, of course, be encouraged as early as the school education stage. There is a great need in Germany to catch up, especially in the area of digital promotion in schools. The backlog of schools in Germany in terms of their ability to help shape the digital transformation is clearly addressed in the D21 report. Only a minority of respondents find that schools sufficiently provide the necessary digitization skills, especially in the view of international competitiveness (Initiative D21, 34).

It becomes clear that there is a need for a holistic approach with the appropriate framework conditions. The over 40,000 schools in Germany are faced with the challenge of mapping digitisation in learning concepts in terms of content on the one hand and, on the other, of creating the framework conditions for the use of digital media and modern IT equipment and a well-conceived school philosophy. To successfully and meaningfully integrate digital media into daily practice requires an ongoing strategic development process within the school. In particular, equipping schools in Germany with new information and communication technologies is still underdeveloped. Visible efforts have been made in this respect for years. With its strategy *'Education in the Digital World'*, the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder (KMK) presents a concept of action for shaping the requirements for education in the digital world. The *DigitalPact School* is a program to improve the digital infrastructure and equipment of schools especially broadband expansion, provision of digital workplaces for teachers and hardware and software for digitally supported teaching. This must now be implemented

[18] With Qualität plus - Program for the Development of Tomorrow's Studies (Q+) - the Lower Saxony Ministry of Science and Culture (MWK) promotes innovative teaching at Lower Saxony's universities. The use of digital media is at the centre of the funding.

promptly for elementary schools to the secondary schools even for vocational schools. It would be helpful to define minimum technical standards for schools throughout Germany.

Extensive empirical findings show that Germany has in some cases a considerable backlog in international comparison. However, results of the *Monitor Digital Education* by the Bertelsmann Stiftung on the situation of digital learning clearly show that schools fail to recognise the educational potential of digitization (Schmidt et al., 2017b). Only 8 % of school principals attach strategic importance to it and see digital change as part of their systematic school and teaching development. The international comparative study ICILS 2018 (Fraillon et al., 2019) provides interesting insights into the state of digital education in Germany and points out gaps and development needs. The aim of the study was to determine how well students are prepared for university studies, the professional world and life in a digital world. The results clearly show that the conditions for learning with digital media have changed very little since the study began in 2013. The study provides information on three areas: First, as in 2013, the information and computer-related skills of 14-year-olds (eighth grade students) were tested. In the second part, the framework conditions and the use of digital media by teachers and the equipment of the schools were examined more closely. In a third part, competencies in the field of "Computational Thinking" were recorded among the students for the first time. Core findings:

- *Dominance of classical frontal teaching*: Almost a quarter of teachers use digital media in class every day. In the other countries the rate is twice as high or higher. Only 4 % of students use digital media independently in class (91 % in Denmark). The potential of digital media for learning is also estimated to be much lower in Germany than in other countries. Only 35 % of teachers agree with the statement that the use of digital media can support students' learning processes (penultimate place). Digital media are mainly used to support frontal teaching. Hardly any possibilities of internet-based cooperation are used. Germany ranks last in the joint development of digitally based lessons with other teachers.
- *Poor framework conditions for digital teaching*: The digital equipment of schools in Germany is considered to be in great need of improvement. There are on average 10 students per classroom for every computer provided; about 41 students on a tablet and about 68 students on a laptop. Only 15 % of the students use their own devices in class.
- *Low level of digital literacy*: Only one third of students have only very rudimentary computer and information-related skills and thus belong to the lower two competence level groups. 2 % of students reaches the highest level of competence. Clearly visible are differences in social background. Only 57 percent of students from disadvantaged families reach the third level of competence, compared to 81 percent of their classmates from privileged families. There is also a disparity between boys and girls. Girls achieve better results than boys in all areas of computer and information-related skills. The newly investigated competence area "Computational Thinking" is hardly included in the German curricula. "Computational Thinking" means: *"Totality of thought processes that are used to model problems and methods for their solutions in such a*

way that algorithmic processing becomes possible". German students are also below average in this area of competence (Fraillon et al.,2019).

In addition, a curriculum would have to be developed that sets transparent and binding standards for learning content. This implies that methodological concepts have to be developed on how information and communication technologies can be used profitably and purposefully in teaching. It would be beneficial if there were a platform accessible throughout Germany that pools digital learning material and other open access education resources. A major weakness of German school-system is above all the lack of teachers who in addition to their pedagogical teaching skills, also have the digital literacy skills to teach them. One demand may therefore be to improve teachers' digital literacy and to make it a mandatory part of teacher training. However, this must be accompanied by an expansion of teacher training and teacher education in the field of "digital literacy", which is bindingly established (Aktionsrat Bildung, 2018, 20). By appointing "digital mentors", responsibilities can be created to accompany the design, updating and implementation of a digital school framework.

5.2 Building a framework for Data Literacy

In its key point paper on data strategy German federal government defined increasing data literacy as one of four key areas of action and of establishing a data culture. Data literacy is increasingly developing into a basic competence and to be able to exist and participate in the digital world in science, work and society. The HFD defines Data literacy as "…the ability to deal with data in a planned manner and to be able to use and question it consciously in the respective context. This includes the skills to collect, explore, manage, curate, analyse, visualise, interpret, contextualise, assess and apply data (Stifterverband, 2017).

Ridsdale et al. (2015) assume that an early development of data-literacy skills is an important basis for the development of interdisciplinary and domain-specific skills. Data-related skills have become increasingly important in scientific education at universities in recent years, such as a growing number of specific data science programs (Lübcke & Wannemacher, 2018). According to the Stifterverband and McKinsey, up to 95,000 people with advanced data knowledge are currently required in Germany (Stifterverband, 2017, 71). Surveyed experts of study of Lübcke & Wannemacher, 2018) assume an even higher demand for skilled workers, if the digital transformation in companies arrives on a broad scale and then people with data analysis skills are needed on every specialist level.

The Deloitte study "Datenland Deutschland" (2015) also draws attention to a lack of suitable study programs for data science at universities. In the core disciplines of computer science and mathematics, however, a large number of new data science courses have been established, especially since 2014. The institutional communication of data literacy has not yet reached the breadth of universities and study programs. HEIs should also pay more attention to the strategy to teach data-literacy skills across disciplinary boundaries through the curricular anchoring of competence modules. The transfer of data literacy concepts to other disciplines can thus promote the development of the content of the disciplines. At the same time, basic data science skills needed on the labour market can be taught to more groups of students (Lübcke & Wannemacher, 2018, 56). An innovative example is the DATAx concept of Leuphana University. Within the framework of an interdisciplinary introductory semester, students can initially build

up central basic knowledge in the fields of mathematics, statistics and programming in online self-study. This methodological training specifically integrates contents of data literacy education and is open to all Bachelor students of all disciplines. Afterwards, real data from practice and cooperation partners is made available in an Open Data Hacking Space and can use this as a basis for practical projects in the field of data analysis and visualization (Stifterverband, 2019).

5.3 Building a framework for lifelong learning

"*We need a culture of further education in Germany that makes you want to learn for life*" (Anja Karliczek, Federal Minister of Education) (BFB, 2018). Because knowledge is becoming obsolete at an ever-faster rate, initial training/education is less and less sufficient to meet the demands of an entire working life (Kruppe et al., 2019, 37). At the same time, demographic developments pose particular challenges for regional education and labour markets.

The digitization of the world of work is calling into question a structure of working life that has been established over decades. Lifelong learning is one of the most important keys to the transformation process in order to sustainably secure individual work and employability - even beyond company boundaries. In all sectors, there will also be activities and professions that will be eliminated as a result of the digital structural change and cannot be retained through adaptation qualifications. In particular, the opportunities and structures for continuing education, higher qualification and retraining must be expanded (Kruppe/Leber/Matthes 2017).

In future, HEI`s have to play a central role in meeting the demand for lifelong learning. To achieve this, universities must increasingly open up the continuing education market. However, it should be noted that, compared to other countries, higher education in Germany is traditionally not a business model. The role of state universities in continuing education is still small - their current market share is well below 10 percent. Private providers dominate the market with flexible, demand-oriented study programs. With new in-service continuing education and training programs, HEI`s can tap into additional target groups, such as working people and returners. In response to the needs of those interested in continuing education and against the background of the digitisation of higher education, digital learning and teaching has gained in relevance for continuing scientific education. The KMK defines academic continuing education as "*the continuation or resumption of organised learning after completion of an initial phase of education and, as a rule, after taking up gainful employment or family activities, whereby the continuing education offered corresponds to the technical and didactic level of the university. ...] Continuing academic education usually ties in with professional experience, but does not necessarily require a university degree*" (KMK, 2001). There is therefore an urgent need to develop concepts to position universities as actors for lifelong learning against the background of the digital transformation. Various initiatives and programs have developed and promoted the first innovative approaches:

As an example, the program "*Advancement through Education: Open Universities*" funded by the Federal Government and the Federal States promote the establishment and expansion of continuing education programs at universities in the context of lifelong scientific learning. In particular, it should take into

account the fact that there is a coexistence of higher education and vocational education and training. This is intended to improve the permeability between vocational and academic education and training and to create conditions under which new knowledge can be integrated into practice more quickly. Since 2011 376 continuing academic education programs, ranging from preparatory and bridge courses to certificate programs and part-time Bachelor's and Master's programs, have so far been transferred into regular operation at the 101 HEIs funded nationwide (BMBF, 2020b). Three-quarters of the target group consists of working people. By 2018, a total of 295 continuing scientific education courses had been transferred to regular operation as part of the competition. These are demand-oriented courses of study in a wide variety of formats, primarily in the form of entire study programs, certificate programs and individual modules. The specialist spectrum is also broadly diversified. The diverse range of courses increasingly uses new forms of teaching and learning such as MOOCs, interactive elements and blended learning.

Thanks to their academic competence, HEIs are predestined to act as regional partners to ensure the employability of people. For SME`s, especially in rural areas, the digital transformation poses a particular challenge, especially with regard to a shortage of skilled workers and digital performance. Companies are therefore dependent on developing the skills of their employees and maintaining their employability in the course of digital change. Education clusters can play an important role here in future. These are alliances of regional partners to strengthen and better link education provision and labour market needs. An example of a regional cooperative interaction is the model project: "*Q 4.0 - Digital competence in continuing education"*[19]. Four universities and five administrative districts, the Federal Employment Agency and other cooperation partners have joined forces in an initiative to successfully implement the model project and to strengthen further training opportunities for companies in the rural area of South-East Lower Saxony. By spring 2022, an further training concept for companies will be developed which is geared to regional needs and which will then be prepared by regional further training providers, the Employment Agency and the Job Centre.

The joint funding program *Smart Qualified* of the Stifterverband and the Daimler Fund is part of the initiative *Future Skills* and therefore supports universities in the strategic (further) development of academic continuing education as an educational mission in the digital age. In this way, universities are to push ahead with their cooperation with companies in the development of continuing education programs for the world of work 4.0. In this way, HEIs are to push ahead with their cooperation with companies in the development of continuing education programs for the world of work 4.0 or develop new formats of qualification for the target group of working people. Sample projects:

- *"Development and testing of a New Business Development certificate course to become an "Innovation Specialist" in the form of a blended mobility further training course"*, Aalen University
- "*Digitisation in medicine - Curriculum for continuing medical education*", Martin Luther University of Halle-Wittenberg

[19] https://www.dikom-projekt.de/

- "*Change 4.0 structure - dialogue-oriented prototyping for smart further training*", TH Köln - University of Applied Sciences

5.4 Impacts and Lessons Learned of Covid-19

The corona pandemic has led to a surge in digitisation at universities in Germany. In order to avoid infection risks, universities were forced to move established processes, such as, for example, the complete teaching program into digital space. Within a short period of time, courses, examinations, campus events and the services offered to students had to be largely digitised. The extensive conversion to online study poses great challenges for many universities but they have acted quickly. In the 2020 summer semester, in which teaching could be carried out almost exclusively digitally due to the corona pandemic, 90% of the 148 university administrators surveyed by the Stifterverband at the beginning of the 2020 summer semester consider their universities to be well prepared. A recent special survey by the Stifterverband published in October 2020 has shown that in the 2020 summer semester 91 percent of the courses conducted were already in a digital format, compared to just 12 percent before the Corona crisis. Around 60 percent of the students and teachers surveyed said they were satisfied with the changeover to digital teaching formats. Nevertheless, the university management believes that the digital infrastructure needs to be further expanded (Winde et al., 2020).

Nevertheless, the new circumstances have also revealed the existing weaknesses with regard to the digitisation of universities. Before the Corona Pandemic, the general conditions were as follows:

- only 14% of universities have a digitisation strategy
- 17% of universities have sufficient staff for technical support
- Average number of key project sites for digital teaching and learning: 4.3
- 85% of all universities have a learning management system (Friedrich, 2020).

With a small proportion of only 3.5 percent, apart from specialised institutions such as the FernUniversität[20] in Hagen, only a few universities have had experience with pure distance and online study courses. In a study from 2016, the websites of a total of 402 private and public universities in Germany were examined. The study identified 190 universities that have digitally supported, supplemented or even completely replaced their continuing education programs and offerings virtually. After all, only every 14th higher education institution offered completely virtual, (fully digitalised) teaching and study programs, such as online bachelor's or master's programs or even certificate programs (Schmid; Thom, Görtz, 2016).

Prior to the digital summer semester 2020, German universities used digitisation primarily to enrich presence formats, with around a third of them also using so-called blended learning approaches, i.e. the combination of online and presence formats, while pure online teaching was previously offered for special target groups, such as students who are studying while working. Usual concepts of digital teaching from the teacher's perspective were selective pure online teaching (17% of the universities), 73% of universities

[20] A public research university that is primarily focused on distance teaching.

enrich their teaching with digital media and 36% of the universities pursue a blended learning approach (Wannemacher, 2016).

In summary, the past digital semester was a tour de force for many universities, lecturers and students. The changed framework conditions caused by the Covid-19 pandemic have revealed weaknesses, which above all point to the need to anchor digital education formats in universities in a sustainable manner. Nevertheless, it is clear on the one hand that these effects of the corona pandemic are not an exceptional situation, but will rather be a new normality for universities. From the results of the survey, the Stifterverband deduced tendencies in which direction the transformation processes should aim in the coming months and years. A systematic framework is proposed, which is divided into the five areas of strategy and culture, didactics, organisation, skills and infrastructure. On this basis, the authors derive proposals for improving HEIs teaching in the medium term:

- HEI`s should drive forward comprehensive organisational development: higher education teaching, must be prepared for a digitised science, economy and society and use the potentials of digitisation for the further development of research and teaching.
- HEI`s should develop strategies for cultural change: Determining the right mix of digital and analogue teaching formats for individual academic disciplines.
- Expansion of didactic formats: develop methods that integrate digital and analogue teaching and enable more flexible examination formats
- Renewal of organisational structures: for example, establishement of a Chief Digital Officer for the central coordination of digitisation measures; building alliances to jointly promote digital teaching formats.
- Strengthening teaching alliances and -clusters: Universities, companies and research institutes should be involved in regional and national teaching alliances. This allows didactic formats, knowledge bases and resources to be developed and shared. The modalities for crediting achievements achieved at other universities are to be simplified accordingly.

6 Good practice identified locally and nationally

6.1 National Initiatives

6.1.1 Quality Pact for Teaching

Since 2011, the BMBF has been supporting the improvement of study conditions and teaching quality at German universities with the program *"Quality Pact for Teaching"* (QPL) in cooperation with the Federal States. The universities are supported in qualifying their staff for teaching, supervision and counselling. Further goals are to ensure and develop high-quality university teaching. A central field of action is the digitalization of teaching and the associated integration of electronic learning modules into the regular curriculum. In the period from 2011 to 2020, projects, measures and structures totalling 2 billion euro have been financed at the universities. From 2021 onwards the follow-up program "*Innovation in higher education teaching*" aims to create structures for permanent support for the further development of university teaching. The aim is to promote the exchange and networking of relevant actors as well as the transfer of knowledge for successful teaching and new results and findings. In order to provide continuous incentives to design teaching innovations, the development of innovative study and teaching formats is to be supported by appropriate funding (BMBF, 2020b).

6.1.2 KI-Campus - The learning platform for artificial intelligence

In October 2019, the research and development project "*KI Campus - The Learning Platform for Artificial Intelligence*"[21] funded by the BMBF was launched. Mid 2020 the platform was released as beta version. The focus is on the prototypical development of a digital learning platform specialized on the topic of AI. Students, professionals and other lifelong learners will find openly licensed, free learning opportunities on the AI Campus. Over the coming months, a total of more than 20 "AI Campus Originals" will be produced on various AI topics. These free learning opportunities, from podcasts, videos and courses to the "Micro-Degree", are being developed by scientists from numerous universities in Germany and Luxembourg as well as by leading experts from the German Research Center for Artificial Intelligence (DFKI). In addition, the learning platform KI-Campus curates and recommends German and English language learning offerings from other platforms, based on academic quality standards.

6.1.3 HPI Schul-Cloud

Supported by the BMBF, the Hasso Plattner Institute (HPI) has been developing the *HPI Schul-Cloud*[22] (School Cloud) since September 2016. It is intended to create the technical basis for teachers and students to use modern digital teaching and learning content in every subject via any device without any special technical knowledge. With the HPI Schul-Cloud digital learning platform, learning material can be made centrally available to all students, individual tasks can be entered and collected, feedback can be given to students directly in the platform or lessons can be taught via video conferencing. In response to the

[21] https://ki-campus.org/
[22] https://hpi-schul-cloud.de/

Corona pandemic in 2020, it was opened to all schools throughout Germany. Professional partners in the development of the cloud are teachers and students of the MINT-EC network of excellence with more than 300 schools. Other project partners include Wikimedia Deutschland e. V., a society for the promotion of free knowledge, and edu-sharing.net e. V., a network for sharing digital media and content in education.

6.1.4 Future Skills Program

As a major joint action program of business and civil society, the Stifterverband (Donors' Association) initiative "*Future Skills*"[23]aims to improve the conditions for acquiring digital and other future-relevant skills. The initiative started in 2018 promotes and networks students, teachers, companies and educational institutions. The initiative comprises various support programs that deal with different aspects of future skills. The Stifterverband provides an impetus to prepare the education, science and innovation system for the demands of the future. It is intended to contribute to giving people the skills they need for the digital change in business, science and society. University Forum on Digitisation (HFD)[24] is a joint initiative of the Stifterverband the CHE Centre for Higher Education Development and the German Rectors' Conference (HRK). With the HFD, a national, independent platform is being created which bundles and moderates the dialogue on the digitisation potential of German universities. Current funding programs:

Data Literacy Education: With the support program "*Data Literacy Education*", the Heinz Nixdorf Foundation and the Stifterverband would like to make a contribution to establishing the acquisition of data literacy for students of all subjects at German universities. In addition, teachers are to be supported in adapting their teaching content and methods to the challenges of a fully digitized world. A major focus here is above all on collaboration between teachers and university stakeholders and the development of teaching-learning concepts. In order to strengthen inter-university and extra-university cooperation, the network "Data Literacy Education" was founded to enable a lively and regular peer-to-peer exchange. The aim is for the network universities to mutually benefit from each other's experience through professional exchange, peer-to-peer formats and collegial advice and thus support each other in implementing their data-literacy programs.

Innovation Hubs@Campus: With this program, the Stifterverband and Dieter Schwarz Foundation promote innovation hubs in the context of universities and strengthen their strategic integration into university development. The aim is to strengthen the role of universities in regional innovation ecosystems and help universities to position themselves more strategically as actors in the innovation system - as innovation-affine and networked in research, teaching and knowledge transfer

Digital Skills - Learning in regional networks: With this competition, the Koerber Foundation and Stifterverband support the development of innovative regional concepts for teaching digital skills. The call for proposals was explicitly aimed at regional networks for MINT education, so-called MINT regions, which

[23] https://www.future-skills.net/initiative
[24] https://hochschulforumdigitalisierung.de/

already have appropriate partner structures and wanted to expand their commitment to informatics education and digital skills in a targeted manner.

6.1.5 Fraunhofer Alliance Big Data and Artificial Intelligence

The Fraunhofer Society, based in Germany, is the biggest organization for applied research and development services in Europe (74 institutes, 28.000 employees). Some basic funding for the Fraunhofer Society is provided by the state through the federal government together with the federal states, but more than 70% of the funding is earned through contract work, either for government-sponsored projects or from industry (Fraunhofer, 2020). In the *Fraunhofer Alliance Big Data and Artificial Intelligence*, more than 30 institutes combine their cross-sector expertise. The alliance support companies in the implementation of big data strategies, develop software and data protection-compliant systems for big data and train specialists and managers as "data scientists".

The certification as data scientists takes diverse tasks (using predictive models, extract forecasts from data for decisions and measures at all business levels) into account through a modular competence profile. The modular training and certification program, consists of a three-step certification and training on specific methods and application areas. Three steps:

1. Data Scientist Basic Level
2. Specialist in Data Analytics, Data Management or Machine Learning
3. Senior Data Scientist

The training program is nationally and internationally networked: As a partner of the "*European Data Science Academy*", the aim is to integrate the training content into a European curriculum and develop it further in cooperation with renowned institutions according to their needs. As a partner of the Professional School of the European Institute of Innovation and Technology (EIT Digital), Fraunhofer build selected courses with online content, tasks and tests to "blended learning" formats. Fraunhofer Academy[25] is the further education institution of the Fraunhofer Society. It was founded in 2006 to promote the transfer of research knowledge from the research of the Fraunhofer Institutes to commercial enterprises. Offers for companies (selection):

- Fit4Digitalization: Management program for medium-sized companies
- Future Digital Skills: Qualification in digital skills for industry on three levels.
  1. Fundamental skills: Basic Digital Skills, Self-Management, Methods
  2. Application of transformative technologies: f.e. Machine Learning, Blockchain, Cloud Computing
  3. Deep Dive for Technology Experts: Human-Machine Interaction, Digital Sovereignty, Data Analytics, AI, Smart Hardware and Robotics
- Industry 4.0 for expert teams
- Vocational training and Industry 4.0: Qualification of vocational school teachers and trainers in Industry 4.0 Applications

[25] https://www.academy.fraunhofer.de/

The training concept combines online learning with face-to-face units and special transfer formats to create an effective learning design for competence development in companies. The content can be personalized and combined to create flexible learning paths for job families, role or task profiles. Particularly noteworthy is the use of e-learning tools as a central component of the blended learning concept:

- iAcademy - mobile Learning via App
- Learning assistance system PickNick (Fast training in a 3D working environment for logistics)
- Common Learning Middleware ((CLM) makes it possible to combine different teaching/learning technologies into a common infrastructure)
- Digital Game-Based Learning (DGBL)

Other non-university AI research institutes in Germany which are offering AI trainings and qualifications:

- German Center for Artificial Intelligence (DFKI)
- Max Planck Society for the Advancement of Science: e.g. the Max Planck Institute for Intelligent Systems
- Munich School of Robotics and Machine Intelligence (MSRM)
- Cyber Valley" research network: Consisting of the Max Planck Institute for Intelligent Systems, the Universities of Stuttgart and Tuebingen, and companies such as Daimler, Bosch, Amazon and Facebook

6.1.6 Chambers of Commerce and Industry (IHK)

The 79 IHKs in Germany and their training centres are service providers for the commercial economy and fulfil state tasks, particularly in the context of dual vocational training. They also offer a broad portfolio of further education and qualification for digitization and the development and acquisition of digital skills, especially outside an academic qualification and prerequisite. For example, the Live-Online Course for further education: "*Additional qualification: Digital competence"* for apprentices and skilled workers or "*E-Commerce Manager (IHK)"*. According to the German Qualifications Framework (DQR), special IHK degrees (Fachwirt or Betriebswirt) are equivalent to a university degree (such as Bachelor or Master). A relative new training occupation (since 2018) is the Federal Certificate of Proficiency in E-Commerce or the Technical Specialist (IHK).

An answer to the increasing demand for skilled workers for the area of Industry 4.0 was given with the further qualification as "*Specialist for Industry 4.0 (IHK)".* The target group here are skilled workers in the production and production environment who are involved in the concrete implementation of Industry 4.0 projects and technical specialists who have to plan and design Industry 4.0 projects.

6.1.7 University networks on digitisation

Network digital university teaching (HET LSA)

The 7 HEI`s of the federal state of Saxony-Anhalt have joined forces to further develop existing competencies in the field of teaching quality[26]. The digital university teaching network is aimed at teachers, students and staff of central institutions (computer centres, e-learning and university didactics centres, libraries etc.) of the universities in the HET LSA network. One of the main tasks of the network is to provide information on digitisation in teaching and learning. The network supports the universities in Saxony-Anhalt by creating and providing framework conditions for the digitisation of studies and teaching. For example, by networking different learning platforms and campus management systems.

Furthermore, the development of inter-university offers to support teachers in the use of multimedia elements as well as the qualification of students. A wide range of training and qualification offers are provided: "*Certificate Multimedia teaching",* Webinar Series: *"Online Teaching Basics",* Online course*: "Designing university teaching with digital elements".*

Digital University NRW (DH.NRW)

The Digital University NRW[27] is a nationwide unique association of 42 universities, universities of applied sciences as well as art and music colleges in North Rhine-Westphalia. As part of the state-wide digitization offensive, the Ministry of Culture and Science in cooperation with the Digital University NRW supports the universities in consistently using the opportunities offered by digitization in cross-university cooperation.

One joint initiative is "*hm4mint.nrw*". Within the framework of the Digital University NRW, a new cross-university online course offering in this form, "hm4mint.nrw", was launched for the 2019/2020 summer semester. The offer was developed by the RWTH Aachen University and the FH Aachen. By the end of the year, a total of 17 universities in North Rhine-Westphalia will officially offer the online course in higher mathematics for their engineering courses. Digital formats allow teaching to be more independent of location and time and also more individual. hm4mint.nrw is the first cross-university online course to be used at universities in North Rhine-Westphalia, which is also integrated into the curricula of the participating universities. Other funding lines and projects: "*Curriculum 4.0.nrw"* - Digitisation concepts for the further development of individual study program modules; "*Digital Tools in University Teaching*"; "*HD@DH.nrw: University didactics in the digital age"*.

DIGKOM, Nuremberg Institute of Technology Georg Simon Ohm

DIGKOM[28] is a university certificate for Digital Competences and is a networked and structured qualification program for students. The focus is on communicating current topics and trends from the fields of digital competence, the promotion of self-learning competences and the reflection and self-

[26] https://www.vielfalt-in-studium-und-lehre.de/
[27] https://www.dh.nrw/
[28] http://www.th-nuernberg.de/digkom

assessment of students' competence levels. The program has an interdisciplinary structure, is open to all fields of study and is integrated into the curricula of the degree programs. Using a modular construction kit concept, students attend courses and workshops according to their interests and individual needs.

6.1.8 German Research Center for Artificial Intelligence (DFKI)

The DFKI is Germany's leading business-oriented research institution in the field of innovative software technologies based on artificial intelligence methods. It is a public-private partnership with large and medium-sized companies, the states of Bremen, Lower Saxony, Rhineland-Palatinate and Saarland as shareholders and the BMBF as project sponsor. It has about 1000 scientists, of which about 460 are student employees.

Research at DFKI focuses on Data Management & Analysis, Image Recognition & Understanding, IT Security, Learning Systems, Human Machine Interaction, Robotics, Sensors & Communication, Speech and Text Comprehension, Autonomous Systems and Virtual & Augmented Reality. As an institute of application-oriented research, DFKI has close contact to target groups from the university education sector and a large network in industry. It also has a high level of expertise in the field of machine learning and a wealth of experience in graduate and post-graduate training as well as in knowledge transfer to industrial users. In addition, various qualification options are offered in the fields of AI and data science.

UPLINX: a cross-location qualification program for machine learning with direct practical and application-related relevance; *MOOCs (Massive Open Online Courses)* for higher education and adult education; qualification as *AI manager* together with the Bitkom Academy (DFKI, 2020).

6.1.9 Q 4.0 - Qualification Initiative Digital Change

Vocational training in Germany is characterised by the dual system with the two learning locations company and school. Digital technologies are changing work and business processes - with massive consequences also for vocational training. This requires new approaches and concepts for in-company training. For training staff, this means adapting training processes to digital changes. And this with sometimes large regional and sector-specific differences. In collaboration with the Federal Institute for Vocational Education and Training (BIBB) and practice partners from the chambers, the BMBF is funding the development and testing of continuing training modules to strengthen the basic media and IT skills of vocational training personnel. In so-called *"MIKA seminars"* (Media and IT competence for training personnel), the participants learn and try out in the context of their own everyday training how they can use digital media in a fitting and profitable way in company teaching and learning processes. In MIKA seminars, participants develop digital skills in six different areas relevant to education and training:

- Protect data & act securely
- Communicate & Cooperate
- Search & process content
- Create & share content
- Problem solving & reflection

- Understanding the digital world: Analyse and evaluate digital media for in-company training (BMBF, 2020)

At the end of the project phase, a tried and tested seminar concept will be available for use throughout Germany. In addition, the BMBF is funding a nationwide *Q 4.0 network* focusing on qualifications to adapt training to digital change. It is a joint project of the German Economic Institute (IW) and the Bildungswerke der Wirtschaft (Industry`s education organizations). In order to advance the qualification process, the NETWORK Q 4.0 is developing novel further education modules for the adaptation of training processes to digital change. In doing so, regional and sector-specific differences are taken into account in particular.

6.1.10 Bitkom Academy

Bitkom is the industry association of the German information and telecommunications industry. Founded 1999 it represent more than 2.700 companies of the digital economy. The membership spans more than 1.000 SMEs, over 500 startups and nearly all German global players. Since 2005, the *Bitkom Academy*[29] offer qualification programs for the digital economy and digitalized world of work. Bitkom Academy offers around 400 further training courses every year, with about 13.000 participants in 2019. The trainings aimed at decision-makers, managers, business developers, IT specialists, project and data managers as well as employees with team responsibility outside of IT. Besides a variety of seminars on topics such as Digital transformation, Project management, IT security or Digital marketing different Part-time Certificate courses are also offered. These are modularized and strongly practice-oriented. Some examples:

- Training as Data Scientist
- Training as AI Manager - Certificate Course in Artificial Intelligence in cooperation with DFKI - German Research Center for Artificial Intelligence
- Training as Robotic Process Automation (RPA) Manager
- Training as Augmented Reality (AR) Manager

Worthy of special mention is the so far unique certificate course "Training for AI Manager" - the first training in the field of artificial intelligence with a certificate. The course consists of five modules in which participants learn the basics of artificial intelligence and hybrid value creation through heuristics, knowledge-based systems and machine learning.

[29] https://www.bitkom-akademie.de/

7 Recommendations

Digital competence and digital excellence are essential for Germany's future viability. “The particular challenge of the 21st century is to ensure that all sections of society benefit from the increasing integration of digitization into society” (Orr et al., 2019, 26). In international comparison, Germany lags behind in many areas of digital education. With the Corona Pandemic 2020, the digital challenges facing institutions in all areas of education become particularly clear. However, digital concepts, instruments and methods have increasingly found their way into personal life and educational institutions, but the potential is far from being fully exploited. This also applies to the current situation and performance of HEIs.

With the *Digital Agenda* the Federal Government presented digital policy guidelines for Germany and defined measures in central fields of action to accompany and help shape digital change. At the same time, a wide range of initiatives and programs at the federal and state level have been launched with the aim of promoting the development of digital skills in the population. In essence, this will be a matter of further specifying of what skills do people need for their professional-, but also for their social life in the coming years? Which skills and competences will become necessary in the course of the digitisation of society and economy? And how must develop the education system in order to make its contribution to the teaching of these skills? The central role of school education, vocational education and training and higher education in Germany is particularly evident here in mapping the promotion of digital skills in corresponding concepts.

A summary looks at the current status of the development of digital competences in Germany does not allow a complete picture for any comprehensive statements. However, the selection of studies and reports are used, as well as the political and public initiatives identified, make it possible to identify tendencies, which requirements are becoming more important in the course of digitisation, which gaps currently exist and which fields of action need to be strengthened in the future. The discourse on the development of digital competences is based on the assumption that digitisation will have far-reaching effects on future personnel and qualification requirements as well as on the labour and training market. Overall, it is clear that the issue of digitisation is increasingly to be shaped at the social level and cannot be seen exclusively from the technical perspective. So, it can be understood as a social innovation (Buhr, 2015).

As a cross-cutting issue, digitisation therefore requires a broad-based digital basic education in order to avoid a digital divide - in the professional world - in the education system as well as in the private sector. The digital transformation of society and the world of work changes the requirements for people especially on the labour market. Some skills, competences and characteristics are becoming more important for participation in society, while others are losing their importance. An example of this is the Stifterverband's description of so-called *future skills* which increasingly being attributed decisive importance (Kirchherr et al., 2018).

The acquisition of digital competence must be an integral part of educational objectives in the context of lifelong learning and anchored in all organisations. The focus here is on the promotion of digital skills in the education system, which implies that the acquisition of digital literacy must be ensured through the cross-curricular embedding of digital educational content and digital technologies. The creation of framework conditions to meet the new challenges of digitisation and Industry 4.0 for the workforce should be emphasised.

Higher Education Institutions

"It is crucial that the education, higher education and vocational education and training systems also orient themselves more strongly towards the skills needed in the future and develop appropriate educational provision" (Kirchherr et al. 2018, 11). HEIs in Germany will, even more so than before, be an essential key to managing and shaping digital change and face the challenge of preparing all their students, and increasingly also other target groups, for the digitalised world of work. The Hochschulforum Digitalisierung (HFD) concludes that the question can no longer be whether digital or analogue higher education is better or worse, but how it can be designed in the future. It is not a question of digitisation per se, but of how digital media affect the learning process, how digital media can make the study process more individual and flexible and how added value can be offered from the perspective of teachers and learners.

- 1. Digitisation is not technisation or technologisation, but didactic, curricular and organisational innovation.
- 2. Collaboration is the key to the successful digitisation of higher education teaching.
- 3. Digitisation not only creates virtual learning spaces, but also changes existing physical learning spaces (HFD, 2016).

With activities such as the promotion of research on digital higher education and programs such as the *Quality Pact for Teaching* or *Advancement through education: Open universities* the Federal Government is involved in many different ways in areas that are related to the digitization of HEIs in the broadest sense. Nevertheless, these can only be support impulses from the state, which must be implemented by HEIs in their own concepts. From the preceding observations and general developments, recommendations for promoting digital skills can be derived for HEIs and politics, covering various fields of action.

Recommendations for policy:

- *Monitoring the demand for skilled labour*: The state of knowledge about which competences will be important for skilled workers in the future depends on appropriate assessment tools, which look at the developments on the German labour market. There are already various monitoring instruments that examine the demand for skilled workers in various forms (e.g. MINTMeter, the bottleneck analysis of the Federal Employment Agency). However, there is no comprehensive regular monitoring of the future demand for skilled labour, the continuous demographic regional, sectoral and skills developments in a regularly adjusted forecast (Patscha et al., 2017). On the basis of such continuous monitoring, companies and private continuing education providers could

develop new offerings and adapt existing content and formats. In general, further ways and instruments must be developed to support companies and professionals in identifying skills gaps.

- The public sector should systematically promote the sustainable renewal of teaching and learning formats and create a corresponding framework of legal certainty. This includes, among other things, financial support for the development of the corresponding infrastructure, for personnel and digital teaching. The Stifterverband (2019) calls for targeted financial support for teaching innovations and also enable HEIs to become active in the continuing education market.
- *Digital Platforms*: At present, many different digital platforms exist at HEIs or are under development, which often tend to function as isolated solutions. The Stifterverband (2019) recommends promoting platform ecosystems in order to network fragmented digital educational offers. National concepts such as the MILLA concept (Modular Interactive Lifelong Learning for All, a concept for the development of a national continuing education platform) should be dovetailed with corresponding European initiatives.
- *Ensure digital literacy of teaching and training staff*: Digital competences must be an integral part of teacher education (teachers at schools, universities and further education institutions) - in teacher training and study seminars. This includes for example the targeted promotion of teaching innovations and the strengthening of continuing education opportunities for teachers throughout Germany. Models for teachers' competences have to be developed and empirically validated (Aktionsrat Bildung, 2018, 22).
- *Promotion of Lifelong Learning & On-the-Job Training*: The development of the digital strategy should also take more account of the education policy component, which can be achieved by adapting educational content and digital training to prepare employees well for the economy 4.0 and supporting long-term labour market success. Companies must establish strategies for a continuous education process to support the development of digital skills of the workforce. At the same time, in order to maintain the employability and employment prospects of today's employees, more flexible and individualized paths of digital training must be created (new practice-oriented Blended Learning Concepts for On-the-job-Training). For the acquisition and development of digital skills, relevant support programs must include tax incentives for both companies as well as for employed persons. Especially SMEs need more financial support for further education and training advice.
- *Vocational training* has a special role to play in Germany and must be continuously developed and made more dynamic in view of ever new occupational requirements. In vocational education and training in particular, training regulations as well as learning field concepts and curricula must be adapted to the requirements of digitisation. To this end, an intensive exchange with the needs and practical requirements of businesses and industry must be ensured. The existing principle of dual vocational training already offers very good conditions for this. The dual system therefore needs to be strengthened by the state and must remain as an attractive career and qualification path. This can be promoted by more permeability and the link between vocational and academic education.

Recommendations for HEIs:

- *Strategy*: A central necessity is that digitization must be located as a strategic topic. Rohner (2017) considers it necessary for all universities to draw up a tailor-made digitisation strategy in order to strengthen their competitiveness and do justice to the heterogeneity of students. HEIs need strategic goals and an organisational framework for this process that integrates all decision-making levels from faculty to faculty and university management. The digitization strategy must rather manifest itself in fundamental cultural and social changes. The conception and implementation of this strategy may therefore not simply be delegated to e-learning representatives, to heads of computer centres and CIOs. The university management must push ahead with the development and implementation of an adequate and stringent strategy and ensure it in cooperation with all university members. Digitisation can contribute to modernisation, for example to meet existing challenges such as those of an increasingly heterogeneous student body. Beyond this, however, universities can also use digitisation to raise their profile (Draeger et al. 2017). The individual fields of action at university level must therefore be considered more closely interlinked and not in the form of isolated solutions.
- HEIs will have to change their educational strategies, open up new fields of action and fill gaps in order to anchor the topic of digital competences and skills more firmly in the future and to meet the needs of the market. HEIs are called upon to broaden their course offerings and formats, to open up more to the demand from companies and other parties interested in continuing education. Digital skills should be taught in a more interdisciplinary and increasingly individualized study concepts.
- *Curricula development:* In addition to new courses of study, the existing curricula must continue to be geared towards promoting digital skills, not only in technical and scientific subjects. Curricula must become more flexible and adaptable. For this reason, an approach should be taken not only to further digitise existing curricula and modules in terms of content and methodology, but also to examine how digitisation can be holistically anchored in the curriculum and thus provide a basic orientation for the subject to digital literacy. One option would be to redesign the study entry phase and imparts transdisciplinary digital and cross-sectional competences that are obligatory for all subject areas. In this way, methods of computer science and modules for "Complex data analysis" can also be increasingly applied in humanities and social science subjects. An example of this is the "*Digital Humanities*" program offered at the University of Leipzig, the University of Wuerzburg and LMU Munich.
- *Positioning on the further education market:* HEIs, as places of expert knowledge and know-how should also be involved more strongly in the increasingly important field of quaternary education. This field should be developed more strongly as a third pillar alongside academic training and research. Digital transformation is changing the market for higher education. One of the core demands placed on the Higher Education Institutions is first and foremost the realization of necessary new academic education offers and formats that meet the requirements of the concept of lifelong learning. Overall, Higher Education Institutions in Germany must increasingly develop

the continuing education market, especially in the field of transformative technologies. In particular, the growing demand for skilled workers with technological and IT skills is opening up opportunities for universities to develop appropriate courses. This can be achieved through various job-related continuing education and training formats, from online seminar up to the part-time course of study.

- *Regional cooperation and networks*: A great potential lies in the interlinking of physical and virtual further education offers. This should be achieved through cooperations, such as alliances of universities, between educational institutions and companies and between public and private platform providers. As a result, cooperation between universities and companies must be further intensified. With regard to the societal role of promoting digital skills and competences, the relationship between universities and their regional environment needs to be examined in more detail in the future. Especially universities of applied sciences and small and medium-sized universities in particular should act as regional innovation drivers and partners for the qualification of future and demand-oriented competences. For example, regional network centres could be set up for the topic of data literacy, bringing together SMEs with HEIs. In order to multiply approaches to digital literacy and exchange best practice examples, cooperation opportunities between educational institutions be expanded, developed and used. The range of dual courses offered at universities and companies should be increased to match the rising demand for highly qualified experts, and the cooperation between higher education institutions and business companies should be encouraged (BMWi, 2017, 4).
- *New study formats*: In future, it will therefore be more important to achieve openness in the structure of study formats. On the one hand, this will enable the heterogeneity of individual educational biographies to be better addressed. On the other hand, a simpler mutual recognition of academic achievements between different institutions makes it possible to link up repeatedly with previous academic achievements in order to enable flexible study options (Hochberg et al., 2019). In terms of content, HEIs should therefore distinguish themselves with new courses and study programs. At present, the core disciplines of computer science and mathematics in particular are key drivers in the establishment of new data science courses. Thus, in addition to an increase in the number of computer science degree programs, it can be observed that new degree programs are being implemented, focusing on specific competences and skills, such as Data Science, Digital Transformation, Business Analytics or Cyber Security. Further possibilities exist in the conception of Master's programs, for example in computer science, which are also open to other disciplines. This takes account of the fact that data-driven work is required in many specialist disciplines. However, it is foreseeable that not only advanced Data science experts are needed.
- *New forms of Certifications*: The changing demands on competence profiles in the digital age also require new forms and ways of certification, as continuing education and training in the field of digital competences is increasingly informal and non-formal. Need, for development and promotion of codified additional qualifications for the acquisition of digital skills and crediting of

digital teaching formats. Examples like HFDcert[30] include peer-to-peer certifications. With HFDcert, it is possible to have all activities and competences in the field of digital teaching and learning recognised by the community and documented in an online portfolio.

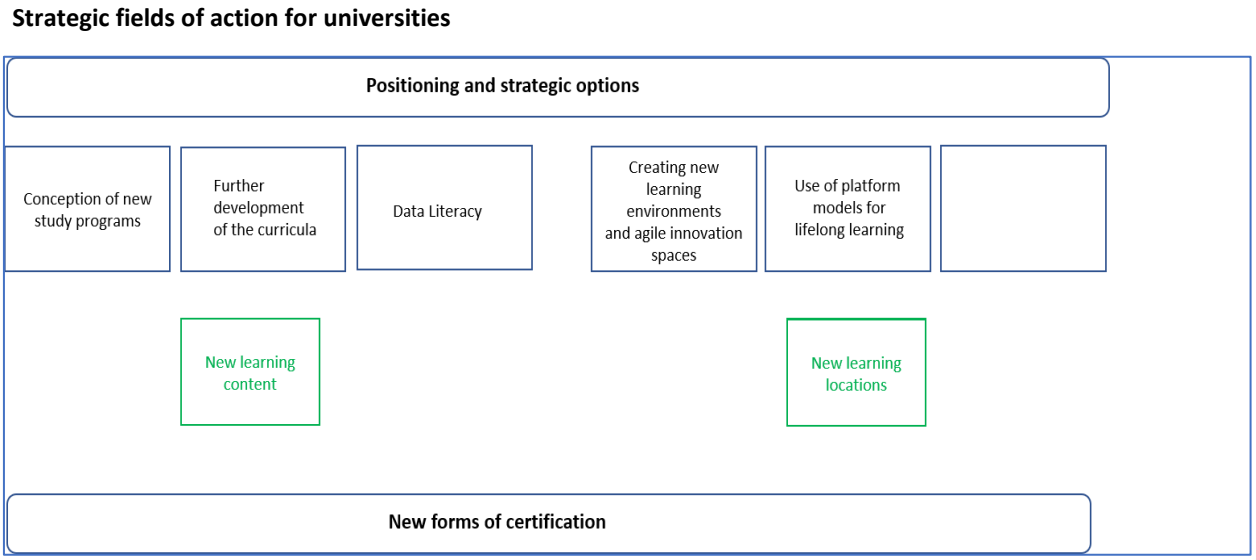

Figure 1. Strategic fields of action for universities, Source: Own representation based on Stifterverband/McKinsey 2019, 24

[30] https://hfdcert.de/

Annex 1

Future-Skills-Framework

The Future Skills Framework, which represents the current skills needs of business and society, was developed in summer 2018 by the Stifterverband and McKinsey together with companies.

Category	Capability	Description
Technological skills	Complex data analysis	Examine large amounts of data efficiently with analytical methods
	Smart hardware/robotics development	Develop physical components for "intelligent" hardware-software systems
	Web development	master programming languages for back- and frontend development for web applications
	User Centric Design (UX)	Products for optimised functionality with intuitive usability
	Design and administration of networked IT systems	Set up a complex IT infrastructure with interfaces to other IT systems and continuously manage and develop it
	Blockchain technology development	Set up decentralised databases
	Tech-Translation	Moderate between technology experts and involved non-experts
Basic digital skills	Digital Literacy	Master basic digital skills
	Digital Interaction	When interacting through online channels, understand others and behave appropriately towards them
	Collaboration	Working together effectively and efficiently regardless of geographical proximity and across different disciplines and cultures
	Agile Work	Working iteratively ("rapid prototyping") in a team responsible for an end product
	Digital Learning	build valid knowledge from digital information

	Digital Ethics	critically examine digital information and the effects of their own digital actions and make appropriate ethical decisions
Classical skills	Problem solving ability Creativity Entrepreneurial action & self-initiative Adaptability	

Source: Kirchherr et al (2018). Future skills: Which skills are lacking in Germany?

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