
VOCATIONAL EDUCATION
AND TRAINING FOR THE
FUTURE OF WORK

GERMANY



Vocational education and training for the future of work: Germany

Policy strategies and initiatives to prepare vocational education and training (VET) systems for digitalisation and future of work technologies

Please cite this publication as:

Huismann, A. (2020). *Vocational education and training for the future of work: Germany*. Cedefop ReferNet thematic perspectives series.

http://libserver.cedefop.europa.eu/vetelib/2020/vocational_education_training_future_work_Germany_Cedefop_ReferNet.pdf

Author: Adrienne Huismann

Contributors: Ute Hippach-Schneider and Martina Krause

Reviewed by Cedefop

© Copyright: BIBB (Cedefop ReferNet Germany), 2020

Reproduction is authorised, provided the source is acknowledged.

The thematic perspectives series complements the general information on vocational education and training (VET) systems provided in '[VET in Europe database](#)'. The themes presented in the series feature high on the European agenda.

Thematic perspectives provide national overviews of specific themes in a common format and offer comparative dimension across the EU Member States, Iceland, Norway and the United Kingdom. They are available at:

<http://www.cedefop.europa.eu/en/events-and-projects/networks/refernet/thematic-perspectives>

This thematic perspective was prepared based on data/information from 2018 and 2019.

The opinions expressed here do not necessarily reflect those of Cedefop.

Thematic perspectives are co-financed by the European Union and ReferNet national partners.

ReferNet is a network of institutions across Europe representing the 27 Member States, plus Iceland, Norway and the United Kingdom. The network provides Cedefop with information and analysis on national vocational education and training (VET). ReferNet also disseminates information on European VET and Cedefop's work to stakeholders in the EU Member States, Iceland, Norway and the United Kingdom.

<http://www.cedefop.europa.eu/en/events-and-projects/networks/refernet>

Table of contents

Chapter 1.	Introduction: Policy debate on VET 4.0.....	4
Chapter 2.	Digital strategies and initiatives.....	5
2.1.	Context of VET 4.0.....	5
2.2.	VET 4.0 initiative	7
2.3.	Polarisation 4.0	9
Chapter 3.	Occupational screening and update of training regulations.....	10
3.1.	Preliminary investigations on IT occupations.....	10
3.2.	Operational maintenance tasks in automobile industry.....	10
3.3.	Selected occupational screening.....	11
3.4.	Updated and new training occupations.....	12
Chapter 4.	Intelligence 4.0 for VET	14
4.1.	Anticipation of future skills needs	14
4.2.	"Economy 4.0" or digitalisation scenario.....	16
4.3.	Job advertisement analyses	17
4.4.	ASCOT+ initiative of skills assessment in VET	18
Chapter 5.	VET 4.0 learning practices.....	20
5.1.	Digital transformation in training centres	20
5.2.	Supporting SMEs to provide training 4.0	21
5.3.	Digital media in vocational training.....	22
5.4.	Digital qualification for trainers and teachers	23
5.4.1.	Qualification of in-company trainers.....	23
5.4.2.	Qualification of vocational school teachers	25
Chapter 6.	Adapting to AI and automation.....	27
6.1.	German AI strategy	27
6.2.	Initiatives on implications of AI in VET and work	28
6.3.	Initiatives and programmes for staff affected by automation.....	32
Chapter 7.	Conclusion: Challenges in the digital age	34
	Abbreviations and acronyms	35
	Bibliography	36
	Weblinks	39

CHAPTER 1.

Introduction: Policy debate on VET 4.0

Digital innovation affects manufacturing processes, work organisation and qualification profiles. When looking at a recent bibliography on 'Industry 4.0 – Economy 4.0 – VET 4.0' ⁽¹⁾, it is apparent that the current policy debate on VET 4.0 in Germany was launched about a decade ago, together with Industrie 4.0 ⁽²⁾. Indeed, the first TASKS (technology, assets, skills, knowledge, specialisation) conference ⁽³⁾ already took place in 2010. The debate has been stirred up in 2013 by the polarisation thesis of Frey and Osborne and the question of its transferability to Germany. Since then, there have been many quantitative studies on work automation and risk potential for the German labour market, using different approaches and assumptions. According to the fifth wave (2018) of the BIBB-IAB qualification and occupational projections (QuBe), which forecasts the development of labour supply and demand until 2035, there are indications that the overall effect of digitalisation on employment will be relatively slight. In fact, the main expectation is that the *nature of work* will fundamentally change, with more demanding tasks ⁽⁴⁾. Initial and continuing vocational education and training should be able to prepare employees to such changes.

With the umbrella initiative VET 4.0, the Federal Ministry of Education and Research (BMBF) and the Federal Institute for Vocational Education and Training (BIBB) have been addressing since 2015 issues in research, development and practice, related to the digital transformation of the world of work and vocational education and training. Projects on occupational screening, on skills forecasting, and on developing digital media competence of apprentices and trainers have been carried out. In parallel, training centres and SMEs have received support for the digitalisation process. Training regulations have been updated and new regulations developed. The BIBB congress 2018 ⁽⁵⁾ was dedicated to 'Learning for the future: tomorrow's VET - experiencing innovations' and the most recent TASKS conference focussed on 'Robotics, artificial intelligence and the future of work' ⁽⁶⁾. The debate goes on!

(1) Langenkamp, K.; Linten, M. (2019)

(2) internet of things / smart production

(3) <http://www.iab.de/de/veranstaltungen/konferenzen-und-workshops-2010/tasks.aspx>

(4) See Sections 2.3 and 4.2

BMAS (2017). See Annex 1, p 48 for overview on studies on work automation
https://www.bmas.de/SharedDocs/Downloads/EN/PDF-Publikationen/skill-and-vocational-development-needs.pdf?__blob=publicationFile&v=3

<http://www.oecd.org/germany/Employment-Outlook-Germany-EN.pdf>

(5) <https://kongress2018.bibb.de/kongress/online-dokumentation/index.html>

(6) <https://www.bibb.de/en/81599.php>

CHAPTER 2.

Digital strategies and initiatives

Germany ranks 12th out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019. The country performs well in most DESI dimensions, especially in digital skills, connectivity and use of internet services. The score in the “Integration of digital technologies by enterprises” has increased. The country’s greatest digital challenge is to improve online interaction between public authorities and members of the public (i.e. low use of e-government and e-health services) ⁽⁷⁾. To be able to meet the challenges of digitalisation, the German government has started to address this new issue about a decade ago with the Industrie 4.0 strategy, followed by the Digital Agenda and the Digital Strategy. This chapter sets the background of VET 4.0 (Section 2.1) before describing the national VET 4.0 initiative (Section 2.2). In parallel, the research study “Polarisation 4.0” has been analysing the implications of digitalisation on employment, job profiles and qualification requirements in the economic and working world of tomorrow from the start (Section 2.3).

2.1. Context of VET 4.0

Nowadays, the term 4.0 is used everywhere: Society 4.0, Economy 4.0, Technology 4.0, Work 4.0, School 4.0, Qualification 4.0, Agriculture 4.0, VET 4.0... Germany 4.0. For example, Kollmann and Schmidt (2016), expressed the widespread need to adapt to digital transformation. The German federal government published the ‘Digital Agenda 2014-17’ in 2014 ⁽⁸⁾. The Digital Agenda comprised implementation measures in seven fields of action: infrastructures; economy and work; public administration; society; education, research, science, culture and media; security, protection and trust for society and the economy; European and international dimension. The Federal government (all federal ministries) also involved the German Bundestag ⁽⁹⁾, the federal states and local authorities, civil society, business and science, as well as the social partners, data protection experts and representatives of the network community for the implementation and further development of the Digital Agenda. The annual national digital summits ⁽¹⁰⁾ bring all

⁽⁷⁾ <https://ec.europa.eu/digital-single-market/en/desi>

⁽⁸⁾ https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/it-digitalpolitik/digitale-agenda.pdf;jsessionid=15E031BD7C007EC213E4E34DF5504ECF.2_cid373?__blob=publicationFile&v=4

⁽⁹⁾ <https://www.bundestag.de/ada>

⁽¹⁰⁾ <https://www.de.digital/DIGITAL/Navigation/DE/Service/Digital-Gipfel/Digital-Gipfel.html>

stakeholders together. Following the Digital Agenda, the Federal government developed a Digital Strategy ⁽¹¹⁾ in 2016, consisting of five fields of action: digital competence; infrastructure and equipment; innovation and digital transformation; society in digital change and modern State. Twice a year, the government publishes an implementation report, documenting the measures and progress made in each field ⁽¹²⁾. However, it had all started in 2011 with 'Industry 4.0' (internet of things / smart production).

Industrie 4.0 is a national strategy implemented by the BMBF ⁽¹³⁾ and the Federal Ministry for Economic Affairs and Energy BMWi ⁽¹⁴⁾. It aims to drive digital manufacturing forward, by increasing digitisation and the interconnection of products, value chains and business models. It also aims to support research and its implementation in mainstream practice, the networking of industry partners and sectors, as well as standardisation. Industrie 4.0 is part of the German government's High Tech 2020 strategy (BMBF, 2011) ⁽¹⁵⁾. At the Hanover fair 2013, it was institutionalised with the 'Platform Industrie 4.0' ⁽¹⁶⁾, bringing together various industry associations: BITKOM (IT, telecommunications and new media), VDMA (mechanical engineering) and ZVEI (electronics), who account for more than 6 000 member companies. In April 2015, the Platform Industrie 4.0 was expanded - more actors from companies, associations, trade unions, research and politics were added. It has become a large network, which serves as a central point of contact for policy-makers. BMBF and BMWi have jointly allocated 200 million euros in funding ⁽¹⁷⁾.

(11) <https://www.bundesregierung.de/breg-de/themen/digital-made-in-de/die-digitalstrategie-der-bundesregierung-1549554>

(12) <https://www.bundesregierung.de/breg-de/themen/digital-made-in-de>
<https://www.bundesregierung.de/resource/blob/992814/1605036/61c3db982d81ec0b4698548fd19e52f1/digitalisierung-gestalten-download-bpa-data.pdf?download=1>

(13) <https://www.bmbf.de/de/zukunftsprojekt-industrie-4-0-848.html>
https://www.bmbf.de/pub/Industrie_4.0.pdf

(14) <https://www.bmwi.de/Redaktion/EN/Dossier/industrie-40.html>

(15) Updated until 2025: <https://www.bmbf.de/de/die-neue-hightech-strategie-86.html>
<https://www.hightech-strategie.de/de/hightech-strategie-2025-1726.html>

(16) <https://www.plattform-i40.de/I40/Navigation/EN/Home/home.html>
<https://www.bmwi.de/Redaktion/EN/Publikationen/plattform-industrie-4-0-digital-transformation.html>

(17) https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf

The fourth industrial revolution also implies changes in the world of work ⁽¹⁸⁾ (Work 4.0) ⁽¹⁹⁾ and has a direct impact on education in general and vocational education in particular. The Science Year 2018, an initiative of the BMBF, focused on 'Working life of the future' ⁽²⁰⁾ as well. Following Industrie 4.0, Artificial Intelligence (AI) has come to the fore (*Künstliche Intelligenz, KI*). The Science Year 2019 ⁽²¹⁾ was dedicated to AI. The German government has formulated a strategy on artificial intelligence ⁽²²⁾ in November 2018 ⁽²³⁾ – See Chapter 6.

2.2. VET 4.0 initiative

Since digital innovation affects manufacturing processes and work organisation, it will also affect qualification profiles. In a joint initiative 'VET 4.0', which started in 2016 ⁽²⁴⁾, BMBF and BIBB addressed issues in research and development, related to the digital transformation of the world of work and vocational education and training. VET 4.0 contributes to the implementation of the digital agenda through exchange of information on an ongoing basis between academia, policy-making and practice.

The initiative brought together a wide range of projects. These included projects already under way such as the preliminary examination for the potential modernisation of IT occupations (see Section 3.1) and the joint VW-BIBB project on operational maintenance 4.0 (see Section 3.2). The umbrella initiative VET 4.0 has three main pillars:

- (a) Pillar 1: occupation and sector screening. The focus is on the analysis of selected training occupations, advanced training regulations, and sectors that are already partially or fully affected by digital transformation. The goal is to

⁽¹⁸⁾ Recommendations for Work 4.0 are formulated at an early stage by Industrie 4.0 stakeholders: <https://www.plattform-i40.de/I40/Redaktion/EN/Standardartikel/Working-Groups/working-group-05.html> and <https://www.acatech.de/Publikation/kompetenzen-fuer-industrie-4-0-qualifizierungsbedarfe-und-loesungsansaeetze/>

⁽¹⁹⁾ Work 4.0 (Arbeit 4.0) is the concept, which describes how the world of work may change until 2030 and beyond in response to the developments associated with Industry 4.0, including widespread digitalisation. The Federal Ministry of Labour and Social Affairs (BMAS) introduced the concept in 2015, when it launched a report entitled *Re-imagining work: green paper work 4.0*. Within a dialog process, the BMAS has developed a 'vision for quality jobs in the digital age' and presented the outcomes in the 'white paper work 4.0'. <http://www.arbeitenviernull.de/>; <https://www.bmas.de/EN/Services/Publications/a883-white-paper.html>

⁽²⁰⁾ <https://www.wissenschaftsjahr.de/2018/uebergreifende-informationen/about-the-science-year/>

⁽²¹⁾ <https://www.wissenschaftsjahr.de/2019/>

⁽²²⁾ <https://www.ki-strategie-deutschland.de/home.html>

⁽²³⁾ <https://www.bmbf.de/de/strategie-kuenstliche-intelligenz-offiziell-auf-digital-gipfel-vorgestellt-7488.html>

⁽²⁴⁾ <https://www.bibb.de/en/49603.php>; www.bmbf.de/de/berufsbildung-4-0-3246.html

- formulate recommendations for the restructuring of IVET and CVET, as well as adapting the systemic framework conditions (see Section 3.3).
- (b) Pillar 2: digital literacy/media competence. This project aims to define media competences, which should be considered as an entry requirement and as a key competence across occupations in VET (for apprentices, teachers and trainers). Funding programmes to better equip training centres and to support small and medium enterprises (SMEs) in view of digitalisation complement this approach of promoting media competence in VET (see Chapter 5).
 - (c) Pillar 3: demand for skilled staff. A third project aims to establish a monitoring and forecasting system across occupations and sectors. The existence of such data would allow determining which qualifications will be needed for VET 4.0. (see Chapter 4).

By combining the outcomes from the different VET 4.0 projects, overarching conclusions for the future design of VET may be derived and disseminated among policy-makers, research and practice. For example, under the motto 'learning for the future: tomorrow's VET - experiencing innovations', around 900 VET experts from 25 countries discussed the current challenges and perspectives of VET on 7 and 8 June 2018 in Berlin, at the BIBB congress 2018 ⁽²⁵⁾. Two of the six forums were dedicated to VET 4.0: IVET and CVET in the digital age (Forum I) ⁽²⁶⁾ and learning places with a future: cooperative and digital (Forum 2) ⁽²⁷⁾. Another example of dissemination: Each year, the association *Innovative Berufsbildung* ⁽²⁸⁾ awards the Hermann Schmidt Award for special achievements in selected areas of vocational training. In November 2017, under the umbrella of the VET 4.0 project, four projects having developed best practices in 'VET for the digitised working world' won the award ⁽²⁹⁾.

The topic 'VET 4.0' remains a priority among policy-makers. In June 2018, the German Bundestag established the Study Commission 'Vocational training in the digital work environment'. The Commission is analysing the developmental prospects for vocational training in the future world of work, examining the economic and social potential of modernisation, and deriving specific recommendations for action for policy-makers. The 38 members of the Commission will submit their final report by summer 2021. The Study Commission consists of 19 Members of the Bundestag and 19 experts from relevant practical fields, associations and research institutes.

⁽²⁵⁾ <https://kongress2018.bibb.de/kongress/online-dokumentation/index.html>

⁽²⁶⁾ <https://kongress2018.bibb.de/kongress/online-dokumentation/forum-i/index.html>

⁽²⁷⁾ <https://kongress2018.bibb.de/kongress/online-dokumentation/forum-ii/index.html>

⁽²⁸⁾ In 1996 W. Bertelsmann Verlag and the BIBB established the non-profit association *Innovative Berufsbildung e. V.* in order to initiate, promote and publicise innovative trends in vocational education and training. It launched a competition named after Prof. Dr. Hermann Schmidt who was the chairman of BIBB from 1977 to 1997.

⁽²⁹⁾ <https://www.bibb.de/de/72331.php#>

2.3. Polarisation 4.0

Technical progress brings about change - this will be particularly noticeable in the world of work. New requirements arise, work processes are redesigned and new skills are needed. New jobs will be created, others will disappear. In order to know, which competences will be required, the right course must be set now. This is where the 'Polarisation 4.0' project comes in, which was launched in November 2015 under the leadership of BIBB (2015-22) ⁽³⁰⁾. The project analyses, which jobs will continue to exist in the future and which skills will be relevant in the future from the point of view of the employed and the companies. In particular, it examines which specific activities are already being replaced or will potentially be replaced in the near future. The underlying consideration is that programmable activities or routine activities can be replaced by machines. Studies from the Anglo-Saxon area such as those by Frey and Osborne (2013) are not transferable to the work and training situation in Germany (Tiemann, 2016).

The BIBB research project analyses polarisation processes (1) from the point of view of gainfully employed persons; (2) according to the assessment of companies (Lukowski and Neuber-Pohl, 2018); (3) based on the analysis of job advertisements on future job requirement profiles for gainfully employed persons. These results will be incorporated into (4) a scenario for the future development of economy/work 4.0 up to 2035 (see also Section 4.2). The results of the study are intended to help determine the job profiles and qualification requirements in the economic and working world of tomorrow ⁽³¹⁾. Although ongoing digitalisation of the production and service sector is stoking fears of job losses, there are indications that the overall effect on employment in Germany will be relatively slight. In fact, the main expectation is that the *nature of work* will fundamentally change. As the use of digital technologies increases, employees will be able to carry out more demanding tasks. The second part of the project uses data from a current additional survey of the BIBB Establishment Panel on Qualification and Competence Development to investigate the impacts of the deployment of digital technologies from firms' point of view.

⁽³⁰⁾ <https://www.bibb.de/de/dapro.php?proj=7.8.146>; <https://www.bibb.de/de/76955.php>

⁽³¹⁾ https://kongress2018.bibb.de/wp-content/uploads/2018/06/forum_l_helmrich_tag_1_final_dok.pdf

CHAPTER 3.

Occupational screening and update of training regulations

In order to adapt vocational training to the new demands brought by digitalisation, it is first necessary to investigate changes in work processes, tasks and requirements profiles of skilled workers. This chapter presents preliminary examinations for the potential modernisation of IT occupations (Section 3.1) and the joint VW-BIBB project on operational maintenance 4.0 (Section 3.2). Section 3.3 introduces the study having examined systematically the influence of digitalisation on fourteen selected occupations. According to the results and recommendations of these occupational screenings, BIBB has worked with the federal ministries, the social partners and experts to revise training regulations taking into account the latest economic, technological and societal requirements (Section 3.4).

3.1. Preliminary investigations on IT occupations

Preliminary investigations on information technology (IT) occupations took place from February 2015 to April 2016. BIBB investigated whether the current dual training programmes for four IT occupations should be modernised. The target audience comprised company managers, human resources and training staff, skilled IT workers, apprentices, workers' councils, bodies representing young people and apprentices, and vocational school teachers. The results of the online survey were used to inform the final report published in December 2016 ⁽³²⁾. Based on this report and recommendations, stakeholders (particularly employer and employee organisations) were asked to check the need to modernise training regulations.

3.2. Operational maintenance tasks in automobile industry

The digitalisation of work in the high-tech areas of the automobile industry and of the automobile supplier sector is a good example of the change in task and requirements profiles for skilled workers in engineering and plant construction. Within the scope of a pilot project from February 2015 to April 2016, BIBB joined the Volkswagen Academy to undertake a sample investigation of work tasks and activity profiles in the areas of operation, maintenance and repair of production systems. The aim was to investigate existing training and 'matchability' of the corresponding occupations and regulatory instruments, in order to derive recommendations for

⁽³²⁾ www.bibb.de/voruntersuchung_itberufe

regulatory work and the structuring of training. Participatory observations of training and work processes were carried out at five automobile locations and interviews were conducted with training managers, production and maintenance managers as well as skilled workers ⁽³³⁾.

3.3. Selected occupational screening

BMBF and BIBB jointly supported the research initiative 'Skills, qualifications and competences for the digitised work of tomorrow' ⁽³⁴⁾. The study examined systematically the influence of digitalisation on fourteen selected occupations. The focus was on work processes, tasks and qualification needs. The spectrum of analysis included professions as diverse as agricultural services specialist, designer of digital and print media or plant mechanic for sanitary, heating and air conditioning systems. Through the study of these job profiles, the requirements for the qualification of skilled workers were to be recognised at an early stage. Based on these findings, recommendations for action were formulated for the development of training regulations or for the further training of trainers. The study also examined, which digital skills apprentices (and trainers) need, in order to successfully complete vocational training.

In November 2017, around 450 experts exchanged views and ideas at the conference 'VET 4.0 – the future opportunities of digitalisation' ⁽³⁵⁾, among them many people responsible for training in their companies, as well as teachers and trainers from training centres or vocational schools. Results and recommendations for action from the initiative were presented at an expert conference in November 2018 ⁽³⁶⁾.

Findings from the selected screening show that the process of 'digital penetration' in training occupations is occurring at different rates, dependent on the company and on the occupation. Digitalisation has reached all fourteen of the occupations investigated ⁽³⁷⁾. However, only one in three of the surveyed skilled

⁽³³⁾ Vocational training - digitisation of work in production-supporting areas of the automotive industry using Volkswagen as an example and possible consequences for affine training occupations, by Zinke et al., 2017.

⁽³⁴⁾ Period 2016-18, Funding by BMBF: 2.75 million Euros.

Results of overall comparative study in: Zinke (2019), WDP 213, BIBB, Bonn

⁽³⁵⁾ Documentation of this conference is available at www.bibb.de/en/65876.php

⁽³⁶⁾ <https://www.bibb.de/en/87878.php>

⁽³⁷⁾ Plant mechanic for sanitary, heating and air conditioning systems; farmer; agricultural services specialist; warehouse operator; warehouse logistics operator; industrial clerk; agricultural and construction machinery mechatronics engineer; machine and plant operator specialising in food engineering; machine and plant operator specialising in textile engineering and specializing in textile finishing; audio-visual media producer; designer of digital and print media; orthopaedic technician; road builder; sewage engineering technician; mechanic in plastics and rubber processing.

staff, trainers, supervisors and training managers already assess the degree of digitalisation in their workplace as high. Therefore, in many cases, slight changes to training regulations (for example, the provision of additional qualifications and mandatory optional modules) seem sufficient in a transition phase.

It is also apparent, that increasing digitalisation is accompanied by a further shift in expectations regarding the core competences of skilled workers. Occupational competence remains important; the use of information and communication technologies, digital work and IT security are increasingly integrated into work tasks; process and system understanding are demanded, as are independent and continuous learning, flexibility, as well as problem-solving and communication skills. This reflects the German concept of the 'coherent vocational action competence' (Hensen and Hippach-Schneider, 2016), which means that acquiring key competences does not take place by teaching isolated lessons or modules, but is integrated in the vocational learning process. These learning processes are based on professional activities identified in the real working world, in the companies.

3.4. Updated and new training occupations

Young people and young adults are currently able to choose from 327 recognised dual training occupations. In the last decade (since 2008), BIBB has worked with the federal ministries, the social partners and experts from the field of company practice to revise 138 training regulations in order to take into account the latest economic, technological and societal requirements. This illustrates the adaptability of dual vocational education and training in Germany and emphasises the system's ability to embrace change.

In 2017, 13 IVET and 19 CVET regulations⁽³⁸⁾, and in 2018, 24 IVET regulations⁽³⁹⁾ were modernised with significant involvement of the social partners, in order to ensure up-to-date qualifications that correspond to the current and foreseeable development of technical standards. Digitalisation of work, data protection and information security have all now become integral components of training in the industrial metal and electrical professions⁽⁴⁰⁾ as well as in the IT professions.

Further, new additional qualifications (Hippach-Schneider and Huisman, 2018) have been developed. For the metal working occupations, these are process integration, system integration, IT-based plant modifications and additive manufacturing procedures. Additional qualifications introduced for the occupation of mechatronics fitter are programming, IT security, digital networking and additive manufacturing procedures. The electrical occupations will include programming, IT

⁽³⁸⁾ https://www.bibb.de/en/pressemitteilung_64609.php

⁽³⁹⁾ https://www.bibb.de/en/pressemitteilung_82427.php

⁽⁴⁰⁾ https://www.bibb.de/en/pressemitteilung_81176.php

security and digital networking in future. The recommended time for the imparting of all additional qualifications is eight weeks. Testing takes place in the form of a task-based oral examination included in the final examination. These optional training contents are certified separately. They provide apprentices with an attractive way of expanding their skills sets to include new competences, which are demand. The additional qualifications also improve opportunities for skilled workers to pursue continuing training.

In some industries and for certain fields of activity, new job descriptions are emerging. An example is the job of 'management assistant in e-commerce' ⁽⁴¹⁾, a new cross-branch dual training occupation for the booming online trade sector, which was introduced in August 2018. BIBB worked with the social partners and experts from the field to draw up training regulations for the new three-year VET programme. Management assistants in e-commerce will work for companies, which sell goods or services online. These include manufacturers and service providers, as well as firms involved in the wholesale sector, foreign trade, retail or tourism. Further, the social partners intend to develop advanced training regulations with a view to creating further career pathways for management assistants in e-commerce.

⁽⁴¹⁾ Europass certificate supplement
https://www.bibb.de/tools/berufesuche/index.php/certificate_supplement/en/kaufmann_im_e-commerce_e.pdf

CHAPTER 4. Intelligence 4.0 for VET

Computer-based procedures, big data and AI analytics can be used for skills assessment and to understand how skill needs are changing, which allow making qualification and occupational fields projections. This chapter presents different approaches to anticipate future skills needs (Section 4.1), as the QuBe forecast study (qualification and occupational projections) with one scenario illustrating labour market developments in case of strong digitalisation (Section 4.2). Section 4.3 focuses on jobs advertisement analyses using big corpora and AI analytics, which are a useful source of information for qualification development research. The ASCOT+ initiative is using computer-based procedures to assess skills and competences in VET, as described in Section 4.4.

4.1. Anticipation of future skills needs

The research network FreQueNz⁽⁴²⁾ implements systematic recording and early identification of future skills needs (Hippach-Schneider and Huismann, 2018). The network includes several research institutions, an education organisation, BIBB, the Trade Union Confederation (DGB) and the Employers' Organisation for Vocational Training (KWB). BIBB monitors new skills requirements using different and complementary approaches:

- (a) Qualification and occupational fields projections (QuBe)⁽⁴³⁾: BIBB and the Institute for Employment Research (IAB) are working together to develop forecasting model calculations on labour market developments by 2035⁽⁴⁴⁾. This study breaks new methodological ground by tracing the routes between occupations learned and those actually adopted (occupational flexibility). Long-term developments in occupational fields and qualifications can now be displayed in a more differentiated manner. This makes it possible to take necessary action at an early stage to improve the match between supply and demand in the labour market⁽⁴⁵⁾. The projections show, for instance, areas where a considerable shortage of skilled workers may occur and which skills levels are at risk of being affected by unemployment⁽⁴⁶⁾.
- (b) Company surveys help build a comprehensive picture of technological and organisational developments and the associated skills requirements. Such

⁽⁴²⁾ <http://www.frequenz.net/>

⁽⁴³⁾ <https://www.bibb.de/en/11727.php>

⁽⁴⁴⁾ https://www.bibb.de/en/pressemitteilung_87651.php

⁽⁴⁵⁾ <https://kooperationen.zew.de/dfgflex/links/datensaetze-deutschland/bibbiab-erhebungen.html>

⁽⁴⁶⁾ https://www.bibb.de/en/qube_datportal.php

- surveys are conducted regularly among the companies represented on the BIBB panel. Known as the reference company system (*Referenz-Betriebs-System, RBS*), these are more than 2 000 training and non-training firms which vary in size, sector (e.g., industry, services, crafts), legal form, length of time in operation and main occupations of their employees. There are also surveys in selected sectors geared towards particular fields of work. These yield sufficiently differentiated and empirically verified information on the requirements in individual occupations ⁽⁴⁷⁾.
- (c) The VET 4.0 initiative ⁽⁴⁸⁾ was launched in 2016 by BMBF and BIBB. As already mentioned (Chapter 3), it includes various projects, such as the research initiative ‘Skills, qualifications and competences for the digitised work of tomorrow’, and the preliminary examination of the potential restructuring of IT occupations.
 - (d) Job advertisement analyses yield empirically verified information on the demand for skilled workers in the job market and the (ideal) qualification profiles desired by companies ⁽⁴⁹⁾.
 - (e) Advertiser surveys determine whether vacancies have been filled and, if not, why not ⁽⁵⁰⁾.
 - (f) Surveys of guidance staff generate expertise on in-company strategies for change and skills development ⁽⁵¹⁾.
 - (g) Representative surveys of people in employment ascertain their perceptions of expertise requirements, job profiles, working conditions and continuing education and training needs ⁽⁵²⁾.
 - (h) Regular surveys of continuing education providers gather data on the implementation, reception and modifications to courses, along with experience and assessments of trends in training establishments.
 - (i) Structural and longitudinal studies of CVET courses listed in the KURS database yield information on changes and trends in provision.
 - (j) The BIBB is part of a new research portal ‘demowanda.de’ with facts about demographic change in the world of work. In addition to quantitative assessment, the BIBB’s qualification development also identifies qualitative trends.

⁽⁴⁷⁾ <https://www.bibb.de/de/12471.php>

⁽⁴⁸⁾ <https://www.bibb.de/en/49603.php>

⁽⁴⁹⁾ <https://www.bibb.de/veroeffentlichungen/en/publication/show/8146>

⁽⁵⁰⁾ <https://www.bibb.de/arbeit-im-wandel>

⁽⁵¹⁾ <https://www.destatis.de/DE/Startseite.html>; <https://expertenmonitor.bibb.de/index.php>

⁽⁵²⁾ <https://www.destatis.de/DE/Startseite.html>; <https://www.bibb.de/arbeit-im-wandel>; <https://www.bibb.de/de/11148.php>; <https://de.statista.com/>

These BIBB research activities focus on changes in existing fields of work or the emergence of new fields, and the accompanying development in qualification requirements, including the factors, which influence these. The BMBF also supports the development of a 'labour market barometer' (*Arbeitsmarktbarometer*), a future-oriented labour market monitoring system⁽⁵³⁾. The federal states and several regions pursue individual early identification activities (e.g., regional monitoring of qualification developments, skill needs surveys). Social partners are also involved in early identification, mainly in the context of modernising initial and further training regulations. Investigations into skill needs and qualification development are also carried out by:

- (a) sector-specific associations, such as the Association of Engineers (VDI)⁽⁵⁴⁾ and the German association of information technology, telecommunications and new media (BitKom)⁽⁵⁵⁾;
- (b) the Institute for Employment Research⁽⁵⁶⁾;
- (c) several foundations, such as the Hans-Böckler Foundation⁽⁵⁷⁾, Friedrich-Ebert Foundation⁽⁵⁸⁾, Konrad-Adenauer Foundation⁽⁵⁹⁾ and the Bertelsmann Foundation⁽⁶⁰⁾;
- (d) other stakeholders.

All these activities help ensure that VET adapts to and meets qualification needs.

4.2. 'Economy 4.0' or digitalisation scenario

The fifth wave (2018) of the BIBB-IAB qualification and occupational projections (QuBe, mentioned above) forecasts the development of labour supply and demand until 2035, as well as the calculation of indicators that reflect the skilled personnel situation in the occupation. The QuBe baseline projection reflects labour market developments if existing trends and behaviour are maintained in the education system and in the economy. Scenarios are used to illustrate developments that deviate from the baseline projection. The "Economy 4.0" or digitalisation scenario, for example, makes it clear what a labour market development could look like if, in particular, sectors that have been little digitised demand new technologies more strongly than so far.

⁽⁵³⁾ <https://www.iab.de/de/daten/arbeitsmarktbarometer>

⁽⁵⁴⁾ <https://www.vdi.de/presse/publikationen/>

⁽⁵⁵⁾ https://www.bitkom.org/de/markt_statistik/806.aspx

⁽⁵⁶⁾ <https://www.iab.de/de/befragungen.aspx>

⁽⁵⁷⁾ <https://www.boeckler.de/index.htm>

⁽⁵⁸⁾ <https://www.fes.de/>

⁽⁵⁹⁾ <https://www.kas.de/>

⁽⁶⁰⁾ <https://www.bertelsmann-stiftung.de/cps/rde/xchg/bst>

In the Economy 4.0 scenario, 2,542,000 jobs would be lost on the one hand and 2,768,000 jobs would be created at the same time. This corresponds to a total change in the working landscape of 11.7 percent of jobs (5.2 million of 45.2 million jobs). Digitalisation will be accompanied above all by a shift in the occupational structure resulting from the creation and disappearance of jobs because of digitalisation. In terms of requirement levels of qualification, the demand for complex and highly complex activities will rise while it will decline for unskilled as well as simple skilled activities. This shows that the development towards Economy 4.0 will also affect the medium-skill range of the labour market, which is particularly strong in Germany. However, skilled workers with vocational training can also benefit from a rise in complex activities if they develop their own competences accordingly, through advanced or higher VET (for example, qualification as master craftsperson). Policy makers must adapt the provision of IVET and CVET to train people who have the potential to shape the implementation of such an Economy 4.0 ⁽⁶¹⁾.

Based on the QuBe project, the Federal Ministry of Labour and Social Affairs (BMAS) is developing a new analytical instrument for forecasting the supply and demand of skilled labour in Germany (*Fachkräftemonitoring*) ⁽⁶²⁾. The BMAS forecast "Digitalised world of work" ⁽⁶³⁾ is based on the "Fachkräftemonitoring" project. The forecast shows that the economic and occupational structural change will lead to the fact that in 2035 the working environment will differ from today's by more than 7 million jobs. There will be occupational shortages of skilled labour, although there is no evidence of nationwide shortage of labour. Shortages can be identified for occupational groups like "medical health professionals", "agriculture", "plumbing, sanitation, heating, air-conditioning", "police, criminal service, court and prison services" and "education, social work, curative care education". On the other hand, there is a high level of competition for jobseekers in jobs with broad access for persons without occupational or vocational qualifications. This is the case, for example, in "warehouse management", "cleaning" and "gastronomy".

4.3. Job advertisement analyses

Job advertisements are a useful source of information for BIBB's qualification development research. They describe, among other things, the requirements, tools

⁽⁶¹⁾ <https://www.bibb.de/de/85571.php>

Wolter et al. (2018) https://www.bibb.de/dokumente/pdf/qube_welle5_W4.0_final.pdf

Weber, E. (2017) <https://www.iab-forum.de/en/digitalising-the-economy-the-future-of-employment-and-qualification-in-germany/>

⁽⁶²⁾ <https://www.bmas.de/DE/Themen/Arbeitsmarkt/Fachkraeftesicherung/daten-und-fakten.html>

⁽⁶³⁾ Zika, G. et al. (2019)

and tasks of the advertised vacancies - albeit unstructured and unsystematic. In order to enable statistical analysis of the data, the BIBB is working with the University of Cologne to develop a methodology for extracting information from job advertisements. A method for classifying text sections has already been successfully used on a BIBB-internal database with several million job advertisements, thus creating the basis for further steps in extracting information from the full texts of job advertisements ⁽⁶⁴⁾.

In April 2018, BIBB organised a conference on „Text Mining on Job Advertisements - Strategies for discovering valuable information from large corpora“. The conference focused on data mining as complex and partly interdisciplinary process, including text mining, machine learning, information extraction, data science and natural language processing. The different tasks and methods of extraction discussed were automated classification and coding of job ads, rule based systems vs. machine learning approaches, linguistic aspects, deep learning strategies and challenges to cope with big corpora ⁽⁶⁵⁾.

4.4. ASCOT+ initiative of skills assessment in VET

The initiative ‘ASCOT+ technology-based assessment of skills and competences in VET’ started in April 2017 ⁽⁶⁶⁾. The initiative aims to transfer into VET practice the results of the research project ASCOT (2011-15), which developed computer-based procedures for measuring vocational skills (technical and social) of apprentices.

The ASCOT initiative has developed skills models and valid test instruments for selected occupational fields (industrial, technical, commercial and healthcare occupations) and tested them nationally with partners working in practice in these areas. The programme has developed and implemented more than 800 test tasks, 560 of them IT-based. ASCOT has demonstrated that these testing processes are serviceable, even in large samples, and produce valid results. Computer-based testing formats and procedures can also enhance the objectivity of examinations because they minimise the influence of test administrators and the testing environment ⁽⁶⁷⁾.

The follow-up ASCOT+ programme will apply and further develop these assessment methods in teaching and learning processes, learning progress monitoring as well as in examination procedures: for example, digital teaching-

⁽⁶⁴⁾ Hermes, J.; Schandock, M. (2016)
<https://www.bibb.de/veroeffentlichungen/en/publication/show/8146>
<http://spinfo.phil-fak.uni-koeln.de/index.php?id=27853>
<http://dh.uni-koeln.de/37089.html>

⁽⁶⁵⁾ <https://www.bibb.de/de/72009.php>

⁽⁶⁶⁾ <http://ascot-vet.net/index.php> Period: 2017-21, Budget: 6,4 million Euros.

⁽⁶⁷⁾ BMBF VET report 2018, p. 109.

learning media, virtual simulations in exams, computer-controlled test formats and workflows to increase the objectivity of exams.

CHAPTER 5.

VET 4.0 learning practices

Under its ‘Digital pact for schools’⁽⁶⁸⁾ programme, the Federal Government is funding the digital infrastructure needed across all German schools (including vocational schools) to promote the uptake of digital skills. Increasing digitalisation is making new demands on vocational training that requires an appropriate upgrading of equipment as well as innovative teaching and learning concepts in inter-company vocational training centres (Section 5.1) and in training companies, especially in SMEs (Section 5.2). Section 5.3 focuses on new learning scenarios and modern initial and continuing training courses promoting the acquisition of digital media competence. To reach this goal, digital qualification of in-company trainers and VET-school teachers is essential (Section 5.4).

5.1. Digital transformation in training centres

Inter-company vocational training centres (überbetriebliche Berufsbildungsstätten, ÜBS) are designed to supplement in-company training, since SMEs are often unable to provide all the stipulated learning content. In the meantime, ÜBS have developed into multifunctional centres of education, providing also advanced training and continuing education (including master craftsman programmes), as well as career guidance and preparation. These training centres are often sponsored by autonomous bodies in the relevant sectors of industry. The BMBF supports sponsors with investment subsidies (for buildings and infrastructure)⁽⁶⁹⁾. The BIBB is responsible for promoting inter-company training centres and supporting the planning, establishment and development of these facilities⁽⁷⁰⁾.

Increasing digitalisation is making new demands on vocational training that requires an appropriate upgrading of equipment in inter-company vocational training centres and their competence centres. Through the special ÜBS digitalisation programme⁽⁷¹⁾, the BMBF and BIBB are helping to accelerate the digitalisation of processes in the training of apprentices in the context of ‘VET 4.0’. The special programme consists of two lines of funding:

- (a) funding is provided so that ÜBS can purchase selected digital equipment (digital devices, machines, systems and software, such as smart home technologies,

⁽⁶⁸⁾ <https://www.bildung-forschung.digital/de/der-digitalpakt-schule-kommt-2330.html>;
<https://www.bmbf.de/de/wissenswertes-zum-digitalpakt-schule-6496.html>

⁽⁶⁹⁾ <https://www.bmbf.de/de/ueberbetriebliche-berufsbildungsstaetten-1078.html>

⁽⁷⁰⁾ <https://www.bibb.de/de/741.php>

⁽⁷¹⁾ Period 2016-21; funding: 84 million Euros (in addition to the regular funding provided for ÜBS). <https://www.bibb.de/uebs-digitalisierung>

- industrial robots, 3D printers and digital teaching and learning media, such as tablets and touchscreens), in order to modernise the training of apprentices, especially for those trained by SMEs;
- (b) the programme also funds eight pilot projects in competence centres ⁽⁷²⁾ that identify the impacts of digitalisation on the vocational activity profiles and determine requirements and consequences resulting from this for the qualification of skilled staff and training personnel. In a second step, they develop innovative teaching and learning concepts for VET 4.0 and disseminate them as multipliers. The aim is to ensure that outcomes are transferable, and that there is a broad range of application.

5.2. Supporting SMEs to provide training 4.0

The changes brought about by the automated and digitised 'Economy 4.0' are particularly affecting the SME sector. However, SMEs often need external support and advice in order to further develop their education and training and adapt it to digitalisation. They are faced with complex questions:

- (a) the interfaces between the various divisions of the company and the corporate IT as well as relationships with suppliers and customers must be managed. What competences does this require in the medium and long term?
- (b) how can dual VET be expanded in the company to master technological change and remain competitive in the long term?
- (c) how can the change in job profiles, associated with increasing digitalisation, be used to attract apprentices and skilled staff?

The BMBF programme JOBSTARTER plus ⁽⁷³⁾, which aims to strengthen dual VET, has added a specific funding priority on VET 4.0 ⁽⁷⁴⁾ from 2017 to 2020: 20 JOBSTARTER plus projects in ten federal states are implementing strategies to face the challenges of digitalisation in SMEs (BMBF, 2017). JOBSTARTER plus projects provide services for SMEs, helping them meet the personnel requirements associated with the digital transformation process as early as possible. For example, they help identify the company's need for support, inform about existing regional initiatives and programmes, develop and test consulting services for VET in SMEs, provide methodological and didactic advice to trainers. Further, they support companies in filling vacant training places, develop and apply additional

⁽⁷²⁾ https://www.foraus.de/html/foraus_5000.php; <http://www.cedefop.europa.eu/en/news-and-press/news/germany-digitisation-inter-company-vocational-training-and-competence-centres-0>

⁽⁷³⁾ <https://www.jobstarter.de/>

⁽⁷⁴⁾ Period 2017-20; funding volume (ESF+BMBF): 109 million Euros.
<https://www.bibb.de/veroeffentlichungen/de/bwp/show/8285>, p. 36;
<https://www.bibb.de/veroeffentlichungen/de/bwp/show/8772>, p. 29.

qualifications in dual VET, initiate and support joint vocational training, and initiate as well as moderate regional sector-specific SME networks.

5.3. Digital media in vocational training

The 'Digital Media in VET' initiative is part of the umbrella initiative 'VET 4.0' (Section 2.2) and covers the 2012-22 period ⁽⁷⁵⁾. Several sub-programmes with different funding priorities are funding national digital training projects that develop new learning scenarios and modern initial and continuing training courses promoting the acquisition of digital media competence. The "digital media in vocational training" web portal ⁽⁷⁶⁾ has provided information since 2015 on the use of digital media in VET and selected project findings. The web portal provides a project database and map including 207 projects ⁽⁷⁷⁾ classified in the following seven categories ⁽⁷⁸⁾: didactics/methodology; learning in the work process; creation of content; learning location cooperation; competence assessment and documentation; mobile learning and web 2.0. The portal also features a selection of products ⁽⁷⁹⁾ developed by the funded projects and who are supporting digital key competences. Representatives of the funded projects can meet once a year at the status conference eQualification ⁽⁸⁰⁾.

The initiative ensures greater sustainability and innovation by promoting the use and effective transfer of project outcomes into VET practice, for example with a roadshow ⁽⁸¹⁾. Since December 2016, the funding priority 'Transfer networks for digital learning in vocational education and training' (DigiNet) promotes the establishment of sector-specific or regional structures for the implementation of digital learning in networks of companies, chambers and universities. In total, more than 110 companies and organisations, many of them small and medium-sized enterprises, will be funded until 2022 to support the development of digital skills in VET. Further, with the funding priority 'Inclusion through digital media in vocational education and training', the BMBF wants to reduce barriers for people with disabilities in vocational education. The use of digital media should make it easier for people with disabilities to take part in IVET and CVET programmes.

⁽⁷⁵⁾ Funding: up to 152 million Euros (incl. EST co-financing).

⁽⁷⁶⁾ <https://www.qualifizierungdigital.de/>

⁽⁷⁷⁾ <https://www.qualifizierungdigital.de/de/projektdatenbank-27.php>

⁽⁷⁸⁾ <https://www.qualifizierungdigital.de/de/praxisbeispiele-28.php>

⁽⁷⁹⁾ <https://www.qualifizierungdigital.de/de/produkte-29.php>

⁽⁸⁰⁾ <https://www.qualifizierungdigital.de/equalification-2019-3853.php>

⁽⁸¹⁾ <https://www.qualifizierungdigital.de/bmbf-roadshow-2018-digitale-medien-im-ausbildungsalltag-1600.php>

In the framework of the initiative, the BIBB study 'Using and producing media – development of media competency in vocational education and training' ⁽⁸²⁾ provides a comprehensive cross-sectional analysis of the importance of media competence across occupational and sector boundaries and devises a classification of the aspects and dimensions of media competence under the German Qualification Framework (DQR) categories. The BIBB begins by redefining the concept of media competence in a vocational context. Not only technical aspects are included, but also those relating to collaboration, communication, learning, and to the framework conditions when working with media ⁽⁸³⁾.

Here are recent funding priorities (2018) of the digital media in VET initiative:

- (a) the promotion of digital media in VET in the medical professions 'DigiMed' ⁽⁸⁴⁾,
- (b) the promotion of research projects on virtual and augmented reality in VET ⁽⁸⁵⁾.

5.4. Digital qualification for trainers and teachers

Crucial for high quality IVET and CVET programmes are trainers and teachers with corresponding professional digital competences. This comprises the vocational or technical, but also the didactic field.

5.4.1. Qualification of in-company trainers

The BIBB research project 'Digital media in VET – media appropriation and media use in the everyday practice of company-based training staff' (DiMBA) ⁽⁸⁶⁾ investigated the challenges faced by company-based training staff in this regard. The main issues were as follows:

- (a) how do company-based training staff select digital media for everyday initial and continuing training practice?
- (b) how are digital media integrated into initial and continuing training processes?
- (c) what support do company-based training staff require in order to be able to integrate digital media into training in the best possible way?

⁽⁸²⁾ https://www.bibb.de/en/pressemitteilung_59739.php#

⁽⁸³⁾ <https://www.bibb.de/veroeffentlichungen/en/publication/show/8048>

<https://www.bibb.de/veroeffentlichungen/en/publication/show/8275>

<https://www.qualifizierungdigital.de/de/neue-bibb-publikationen-zu-medien-und-it-kompetenz-sowie-distance-learning-distance-education-3769.php>

⁽⁸⁴⁾ <https://www.qualifizierungdigital.de/de/foerderung-von-zuwendungen-fuer-digitale-medien-in-der-beruflichen-bildung-in-den-gesundheitsberufen-digimed-3659.php>

⁽⁸⁵⁾ <https://www.qualifizierungdigital.de/de/foerderung-von-forschungsprojekten-zur-virtuellen-und-erweiterten-realitaet-vr-ar-in-der-beruflichen-bildung-vrabb-2997.php>

⁽⁸⁶⁾ https://www.foraus.de/html/foraus_media-pedagogical-competence-of-company-based-training-staff.php

These questions were investigated via a cross-domain approach in the occupations of vehicle mechatronics technician, management assistant for retail services and geriatric nurse. Alongside the definition of terms ⁽⁸⁷⁾, BIBB developed a model of media-pedagogical competence for training personnel ⁽⁸⁸⁾. The results were published in Härtel et al. (2018). The research on the implications of digitalisation for skills needs and teachers' and trainers' competence requirements was presented in Leipzig ⁽⁸⁹⁾ in 2017 and in Bensberg ⁽⁹⁰⁾ in 2018.

The VET 4.0 initiative and some of its funding guidelines are also relevant for continuous professional development (CPD) of in-company trainers, especially the BMBF initiative 'Digital media in vocational training' ⁽⁹¹⁾ (Section 5.3). The guidelines focus on:

- (a) promoting critical media competence in vocational qualifications;
- (b) promoting the use of open educational resources ⁽⁹²⁾;
- (c) training of trainers that can act as multipliers;
- (d) promoting digital learning networks in VET, especially among SMEs.

For example, the 'competence workshop' toolbox ⁽⁹³⁾ contributes to in-company trainer CPD: the project is focused on providing conceptual and digital support to training in companies, at vocational schools and at inter-company vocational training centres. Under the title 'Training in a practically-oriented way', it has made a cross-media series of instruments available to training staff and teachers. The aim is to foster competences and work process-oriented training. Another funded project, 'Perspective 2.0' ⁽⁹⁴⁾, is developing an online tutorial course in social media addressing trainers, educators and consultants working in the field of job application and career entry.

In the framework of the BMBF initiative VET 4.0, BIBB research investigates the impact of digitalisation and industry 4.0 on emerging skills requirements for employees and also for teachers and trainers ⁽⁹⁵⁾. More individual learning, increased use of learning platforms, social media or virtual classrooms will imply different ways of teaching and require staff to have increased IT and media

⁽⁸⁷⁾ <https://www.bibb.de/veroeffentlichungen/en/publication/show/9223>

⁽⁸⁸⁾ <https://www.bibb.de/de/87594.php>

⁽⁸⁹⁾ https://www.bibb.de/en/pressemitteilung_72287.php#

⁽⁹⁰⁾ <https://www.bibb.de/en/87878.php>

⁽⁹¹⁾ <https://www.qualifizierungdigital.de/de/berufsbildung-24.php>

⁽⁹²⁾ <https://www.qualifizierungdigital.de/de/bibb-beteiligt-sich-weiterhin-an-oerinfo-4076.php>

⁽⁹³⁾ <https://www.qualifizierungdigital.de/kompetenzwerkstatt-1930.php>

⁽⁹⁴⁾ <https://www.qualifizierungdigital.de/de/perspektive-2-0-273.php>

⁽⁹⁵⁾ https://www.foraus.de/html/foraus_3328.php

competence ⁽⁹⁶⁾. On the BIBB web portal www.foraus.de, addressing specifically VET teachers and trainers ⁽⁹⁷⁾, 'digitalisation in VET' is a main issue ⁽⁹⁸⁾. Since 2019, BMBF has been funding the development and testing of further training concepts for in-company trainers (Qualification Initiative Digital Change - Q 4.0). For example, MIKA seminars promote basic media pedagogical competence of trainers and Network Q 4.0 training modules (industry- and region-specific) promote adaptation of the training process to digitalisation ⁽⁹⁹⁾.

5.4.2. Qualification of vocational school teachers

The vocational schools (and their teachers), attended by apprentices for approximately one third of their training time (German dual VET system), are governed by the federal states (*Kultusministerkonferenz, KMK*), which are participating in the modernisation process with the strategy 'Education in the digital world' ⁽¹⁰⁰⁾ and the resolution 'Vocational schools 4.0' ⁽¹⁰¹⁾. The strategy addresses VET specifically: 'The goal of vocational education and training is the acquisition of a comprehensive set of competences for action, whereby the acquisition of these competences should be designed as an interdisciplinary cross-sectional task within the context of digital working and business processes. These competences are addressed in the context of the craft sector, industry and economy 4.0.' Some fields of action described in the strategy are:

(a) development of education plans, teaching and curricula ⁽¹⁰²⁾;

⁽⁹⁶⁾ https://www.bibb.de/en/pressemitteilung_54914.php ;
<https://www.bibb.de/en/59571.php>;
<https://www.bibb.de/veroeffentlichungen/en/bwp/show/8772>

⁽⁹⁷⁾ https://www.foraus.de/html/foraus_index.php

⁽⁹⁸⁾ https://www.foraus.de/html/foraus_digitale-medien-in-der-betrieblichen-Berufsbildung.php; https://www.foraus.de/html/foraus_3317.php;

Films: https://www.foraus.de/html/foraus_7004.php

⁽⁹⁹⁾ <https://www.bmbf.de/de/qualifizierungsinitiative-digitaler-wandel---q-4-0-10065.html>

⁽¹⁰⁰⁾ <https://www.kmk.org/themen/bildung-in-der-digitalen-welt/strategie-bildung-in-der-digitalen-welt.html>;
https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2018/Strategie_Bildung_in_der_digitalen_Welt_idF_vom_07.12.2017.pdf

⁽¹⁰¹⁾ <https://www.qualifizierungdigital.de/de/berufsschule-4-0-kmk-benennt-zentrale-handlungsfelder-in-der-beruflichen-bildung-3016.php>;
<https://www.qualifizierungdigital.de/de/digitalisierung-der-berufsschulen-bvlb-fordert-gesamtstrategie-und-qualifizierungsinitiative-3915.php>;
https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2017/2017_12_07-Berufliche-Schulen-4_0.pdf

⁽¹⁰²⁾ https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2017/KMK_Kompetenzen_in_der_digitalen_Welt_neu_26.07.2017.html

- (b) initial and continuing education of teachers ⁽¹⁰³⁾;
- (c) infrastructure and equipment;
- (d) educational media ⁽¹⁰⁴⁾.

Since December 2018 (Digitalisation II) ⁽¹⁰⁵⁾, the Federal government is providing funding for projects that seek to identify strategies for designing learning processes that use the potential of digital media to support successful learning, both for individuals and groups. From 2020, the Federal Government and the federal states will supplement the "Quality Initiative for Teacher Education" with a new funding guideline. Funding will focus on the topics "Digitisation in teacher education" and/or "Teacher education for vocational schools" ⁽¹⁰⁶⁾.

The Baden-Württemberg initiative and funding programme 'Learning Factories 4.0' ⁽¹⁰⁷⁾ is an example of good practice at state level. Learning Factories 4.0 are laboratories that are organised and equipped similarly to private-sector facilities, featuring automated solutions and professional equipment, where IVET and CVET learners can learn how to use technologies and processes in practice.

⁽¹⁰³⁾ <https://www.kmk.org/themen/bildung-in-der-digitalen-welt/veranstaltung-zur-bildung-in-der-digitalen-welt-im-schulbereich.html>

⁽¹⁰⁴⁾ https://www.kmk.org/fileadmin/Dateien/pdf/Gemeinsame_Erklaerung_KMK_VBM_v._14.06.2018.pdf

⁽¹⁰⁵⁾ <https://www.bmbf.de/foerderungen/bekanntmachung-2157.html>

⁽¹⁰⁶⁾ <https://www.qualitaetsoffensive-lehrerbildung.de/de/zusaetzliche-foerderrunde-2070.html>

⁽¹⁰⁷⁾ for example:

<https://www.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/neue-foerderrunde-fuer-lernfabriken-40/>

<https://www.lernfabrik.karlsruhe.de/>;

https://www.industrie40.ihk.de/produktmarken/qualifizierung/Die-Lernfabrik-4_0/2736766

CHAPTER 6.

Adapting to AI and automation

This section presents recent policy efforts in Germany to adapt to the challenges of artificial intelligence (AI) and automation, developing and adopting:

- an AI strategy (Section 6.1);
- national initiatives and activities with specific focus on understanding the implications of AI in VET and occupations (Section 6.2);
- national programmes for staff affected by automation (Section 6.3).

6.1. German AI strategy

Following Industrie 4.0, AI has come to the fore (*Künstliche Intelligenz, KI*). The Science Year 2019⁽¹⁰⁸⁾ was dedicated to AI. The German government has formulated a strategy on AI⁽¹⁰⁹⁾ in November 2018⁽¹¹⁰⁾. The BMBF, BMAS and BMWi took the lead.

Field of Action 5 is about ‘shaping structural change in the world of work and labour market’, among others with CVET measures and the development of a national continuing education or skills strategy by mid-2019⁽¹¹¹⁾. Moreover, a programme funding innovation spaces to test AI applications in the world of work will be established. Staff could co-determine the introduction of AI applications in their work.

Field of Action 6 is on ‘strengthening vocational training and attracting skilled labour and experts’, among others by funding initial and further training programmes, taking into account the specific features of sectors, such as healthcare or the food supply chain. Further, basic AI knowledge is to be anchored as firm element of curricula in sciences subjects and integrated into initial and continuing vocational training programmes, where needed, for example with the Learning Factories 4.0⁽¹¹²⁾ funding programme.

The German AI strategy is accompanied by a **platform on learning systems**: ‘Plattform Lernende Systeme – Germany’s platform for artificial intelligence’⁽¹¹³⁾

⁽¹⁰⁸⁾ BMBF. <https://www.wissenschaftsjahr.de/2019/>

⁽¹⁰⁹⁾ BREG. <https://www.ki-strategie-deutschland.de/home.html>

⁽¹¹⁰⁾ BMBF. <https://www.bmbf.de/de/strategie-kuenstliche-intelligenz-offiziell-auf-digital-gipfel-vorgestellt-7488.html>

⁽¹¹¹⁾ <https://www.bundesregierung.de/breg-de/themen/digital-made-in-de/nationale-weiterbildungsstrategie-1546656>;

<https://www.bmbf.de/de/fuer-eine-neue-weiterbildungskultur-in-deutschland-7311.html>

⁽¹¹²⁾ Industrie 4.0. <https://industrie40-live.de/index.php/en/learning-factory>

⁽¹¹³⁾ Plattform lernende Systeme. <https://www.plattform-lernende-systeme.de/home-en.html>

brings together leading experts in self-learning systems and AI from science, industry, politics and civic organisations. In specialised focus groups, they discuss the opportunities, challenges and parameters for developing self-learning systems and using them responsibly. They derive scenarios, recommendations, design options and road maps from the results. One of the platform's aims is to strengthen skills for developing and using self-learning systems and one working group is dedicated to 'work and skills' (¹¹⁴).

AI was also the main topic of the fifth international TASKS conference: '**TASKS V: robotics, artificial intelligence and the future of work**' (¹¹⁵), which took place on 7-8 February 2019 in Bonn. The TASKS V Conference examined possible implications of digitalisation of the world of work. The event acted as a platform for academic research networking on the future of work (¹¹⁶).

6.2. Initiatives on implications of AI in VET and work

How will digitalisation and automation affect jobs and occupations and what qualifications and skills will be required in the future in a digitised and automated world of work? Several activities try to figure out possible consequences for the VET system. The issue BWP 3/2019 *Digitalisation and artificial intelligence* (¹¹⁷) of BWP magazine examines skills and qualifications requirements as well as further developments of learning within the work context. The topic of artificial intelligence has the potential to play a particular role in this regard. How will machines able to improve themselves and act autonomously change the world of work? What will this mean for the vocational training of skilled workers? The articles in BWP try to provide initial answers.

These questions are also addressed by the BIBB in its new series of events entitled "Digitalisation of the world of work and occupations - Practical implementation examples". Together with the ABB Training Centre, BIBB hosted the kick-off event "Vocational Education and Training in the Field of Artificial Intelligence

https://www.plattform-lernende-systeme.de/files/Downloads/Publikationen/AG1_Whitepaper_280619.pdf

(¹¹⁴) <https://www.plattform-lernende-systeme.de/wg-2.html>; <https://www.plattform-lernende-systeme.de/work-and-skilling.html>

(¹¹⁵) Jointly organised by the BIBB, the Institute for Employment Research (IAB) and the Centre for European Economic Research (ZEW) <https://www.bibb.de/en/81599.php>

(¹¹⁶) <https://www.bibb.de/en/91849.php>

(¹¹⁷) BIBB (2019). BWP 3/2019. <https://www.bibb.de/en/26729.php>
<https://www.bibb.de/veroeffentlichungen/en/bwp/show/10086>

and Digitisation" on 29/30 October 2019 ⁽¹¹⁸⁾. Further events planned in this series will take place throughout the year 2020. It will present ground-breaking projects and implementation examples from various occupational fields, e.g. from the textile industry, training personnel 4.0, reorganisation of IT occupations, agricultural/construction machinery technology and commercial occupations. The event "Textile goes digital - learning in the digital vocational school" will take place on 12 February 2020 at the Textilakademie NRW in Mönchengladba . ⁽¹¹⁹⁾.

How can IVET learners adapt to AI?

Initiatives in the field of initial vocational education and training

- Additional qualifications

Since the amendment of the Vocational Training Act in 2005 ⁽¹²⁰⁾, there is the possibility of providing so-called 'codified additional qualifications' in the context of apprenticeship. This includes 'additional vocational skills, knowledge and qualifications (...) to supplement or broaden vocational competence' (BBiG 2005 Section 5 (2) No. 5), which are anchored in the training regulations and go beyond the training occupation profile. The training regulations are supplemented by these additional qualifications. In addition to these codified additional qualifications, which are linked to a training regulation, there are numerous additional qualifications. For the mechatronics engineers alone, there are almost 400 optional additional qualifications ⁽¹²¹⁾. This instrument seems to gain more relevance by providing additional flexibility for shaping the learning content of the apprenticeships.

Additional qualifications allow for a flexible shaping of in-company training with regard to the qualification requirements in the company. This enables companies to respond promptly to changing skills needs, which is becoming increasingly important due to developments in digitalisation and automation. At the same time, it is an attractive opportunity for young people to upgrade their vocational qualifications. Training companies and vocational schools primarily provide additional qualifications. Furthermore, the Chambers of Commerce and Industry as well as the Chambers of Crafts and their training centres are among the major providers of additional qualifications.

⁽¹¹⁸⁾ BIBB. Events VET 4.0. <https://www.bibb.de/de/neue-veranstaltungsreihe-berufsbildung-4-0-digitalisierung-und-kuenstliche-intelligenz-96682.php> +
<https://www.bibb.de/de/113546.php>

⁽¹¹⁹⁾ BIBB. Textile goes Textile – Lernen in der digitalen Berufsschule
<https://www.bibb.de/de/116427.php>

⁽¹²⁰⁾ BBiG. https://www.gesetze-im-internet.de/bbig_2005/BBiG.pdf

⁽¹²¹⁾ See AusbildungPlus database

<http://www.ausbildungplus.de/webapp/suche?typ=zq&neuesuche=true>

For example, the project "Additional qualifications for digital competences in training and further education" is developing an approach to prepare apprentices, skilled workers and educational staff for the digitised and automated world of work ⁽¹²²⁾. The transfer office of the project is funded by the Berlin Senate Department for Integration, Labour and Social Affairs and implemented by k.o.s GmbH in partnership with the ABB Training Centre.

- **Vocational schools**

The digitalisation of vocational schools is increasingly moving into the focus of educational research and politics as well (especially with regard to the "Digital Pact"). It all began two years ago with the "Monitor Digital Education" ⁽¹²³⁾ on vocational training in the digital age. BIBB also addressed this topic in studies and at several events. The Telekom Foundation recently launched a project on "Vocational School Digital". Supported by Bremen's IFIB, the project aims to clarify by the end of 2019 "which cross-occupational and occupation-specific digital skills vocational school students need to learn and which conditions vocational schools need in order to be able to integrate digital media profitably into their teaching and everyday life" ⁽¹²⁴⁾.

⁽¹²²⁾ Kompetenz Digital. <https://kompetenzen-digital.de/>

⁽¹²³⁾ Schmid, U.; Goertz, L.; Behrens, J. (2016). https://www.bertelsmann-stiftung.de/fileadmin/files/BSt/Publikationen/GrauePublikationen/Studie_Monitor-Digitale-Bildung_Berufliche-Ausbildung-im-digitalen-Zeitalter_IFT_2016.pdf

⁽¹²⁴⁾ mmb institute. <https://www.mmb-institut.de/blog/berufsschule-4-0-wo-steht-die-digitale-transformation-des-beruflichen-bildungssystems/>

How can employees adapt to AI?

Initiatives in the field of in-company learning for employees

- Innovation Spaces

The AI strategy was adopted end of 2018 ⁽¹²⁵⁾. Since then, some projects have been implemented countrywide, as the Innovations Spaces (*KI-Experimentierräume*). In a guideline, the Federal Ministry of Labour and Social Affairs (BMAS) has created the prerequisites for the promotion of in-company "learning and innovation spaces" for the operational application of AI-based systems ⁽¹²⁶⁾. The aim is to give companies, employees and social partners the opportunity to test the human-centred application of artificial intelligence in their companies. At the same time, the transfer of technologies to companies will be promoted and the participation of employees supported. To support the networking and exchange the BMAS has created the online platform www.experimentierraeume.de, where companies are able to present their Innovation Spaces and can learn about each other's projects. In these Innovation Spaces, businesses and public sector agencies can take their first steps towards the future world of work.

- KI Campus - the learning platform for artificial intelligence

The Federal Ministry of Education and Research (BMBF) has been funding the pilot project "KI Campus - the learning platform for artificial intelligence" ⁽¹²⁷⁾ since October 2019. Five institutes implement the project jointly ⁽¹²⁸⁾. The three-year pilot phase is dedicated to the research-oriented and flexible development of a digital learning platform specialised in AI, based on the ideas of openness and networking. The content programme of the KI-Campus consists of two pillars: On the one hand, learning offers are developed within the framework of own productions and contests designed specifically for the KI-Campus; on the other hand, existing offers are to be given more visibility and greater scope.

For example, the event NEXTLEARN 2020 in Berlin on 18 February 2020 offers a multi-faceted programme for beginners and advanced digital learners for all those responsible for training who would like to advance the digitalisation of vocational training in their companies. The mmb Institute ⁽¹²⁹⁾ and the Federal Institute for

⁽¹²⁵⁾ BMBF. Artificial Intelligence. <https://www.bmbf.de/de/kuenstliche-intelligenz-5965.html>

BMAS. AI strategy. <https://www.bmas.de/DE/Presse/Pressemitteilungen/2019/ein-jahr-ki-strategie.html>

⁽¹²⁶⁾ Experimentierraeume. Innovation spaces. <https://www.experimentierraeume.de/die-idee/> <https://www.experimentierraeume.de/info/english/>

⁽¹²⁷⁾ KI/AI Campus. <https://www.ki-campus.org/>

⁽¹²⁸⁾ Stifterverband, the German Research Centre for Artificial Intelligence (DFKI), the Hasso Plattner Institute (HPI), NEOCOSMO and the mmb Institute

⁽¹²⁹⁾ mmb institute. <https://www.mmb-institut.de/>

Vocational Education and Training (BIBB) are supporting the training certifier AUBI-plus ("Best place to learn") in organising the one-day information event.

Initiatives in the field of continuing education and training

Adult further education centres in Germany (*Volkshochschulen* - VHS) are also cooperating within supra-regional Digicircles (¹³⁰) to develop and implement digitally supported course concepts and innovative learning opportunities.

Digitally supported learning promises to increase individual motivation to learn, better adapt learning content and pace to personal needs and democratise access to education. The online platform www.digitalisierung-bildung.de bundles activities from school to lifelong learning and offers with its regular blog contributions a forum for mutual exchange.

6.3. **Initiatives and programmes for staff affected by automation**

The **Qualification Opportunities Act** (*Qualifizierungschancengesetz*) was adopted in December 2018 and came into force on 1 January 2019 (¹³¹). The Act introduces the right of people in work to have access to CVET funding regardless of their qualifications, age or company size, if they need CVET because of automation and digital structural change or are affected by structural change in any other way. The expansion of support also addresses those who are striving for further training in a shortage occupation. The funding covers the CVET costs as well as salary compensations, subjected to co-financing by the employer and proportional to the size of the company. Social partners, Länder and federal ministries were involved in the preparatory phase.

In November 2018, the Federal Ministry of Labour and Social Affairs (BMAS) and the Federal Ministry for Education and Research (BMBF) launched a Committee to develop a National CVET Strategy (*Nationale Weiterbildungsstrategie*). The Committee formulated answers to the digital change and automation in the world of work. The focus is on SMEs, micro-enterprises and people who need help to increase their opportunities on the labour market. The strategy does not only address the question of CVET provision, but also how the company and individual demand for continuing training can be increased. Social partners took part in the Committee.

(¹³⁰) VHS. <https://www.vhs.cloud/wws/9.php#/wws/zusammenfassung-evaluation-dc.php>

(¹³¹) Sources:

- BMAS. <https://www.bmas.de/DE/Schwerpunkte/Qualifizierungsoffensive>

- BMAS. <https://www.bmas.de/DE/Service/Gesetze/qualifizierungschancengesetz.html>

The **national CVET strategy** ⁽¹³²⁾ (or Skills Strategy) was jointly adopted in June 2019 by the Federal Government, federal states (*Länder*), industry, trade unions and the Federal Employment Agency. In this new strategy, all partners are pooling their efforts to use CVET as a response to digital transformation. The overall goal is to establish a new CVET culture in Germany: more than in the past, occupational CVET has to be seen as a matter of course and as a lifelong necessity. This has to be organised in a way that meets the changing needs of the labour market and is beneficial for the individual, the economy and society. Irrespectively of age, the efforts of all employees to develop their own competences and qualifications will be supported. A report on the state of implementation of the strategy will be published in spring 2021 ⁽¹³³⁾.

⁽¹³²⁾ BMBF. National CVET Strategy. <https://www.bmbf.de/de/nationale-weiterbildungsstrategie-8853.html>

⁽¹³³⁾ Sources:
- BMBF. <https://www.bmbf.de/de/fuer-eine-neue-weiterbildungskultur-in-deutschland-7311.html>
- BMAS. <https://www.bmas.de/DE/Schwerpunkte/Nationale-Weiterbildungsstrategie/nws-artikel.html>

CHAPTER 7.

Conclusion: Challenges in the digital age

The umbrella initiative VET 4.0 described in this article has helped identify the requirements arising from digitalisation and promote innovation in order to continue to develop the German VET system. Occupational screening, skills forecasting, promoting digital media competence for apprentices/trainers and new design of in-company teaching/learning processes will be continued. In parallel, training centres and SMEs continue to receive support for the digitalisation process. Training regulations will be further updated and new regulations developed.

A particular challenge will be to provide measures for the qualification of training personnel at all learning locations: in companies, at training centres (ÜBS), and especially for teachers at vocational schools. Under its Digital Pact for schools programme, the Federal government is willing to provide funding for the digital infrastructure needed across all German schools (including vocational schools) to promote the uptake of digital skills. Another challenge is the need for further training: employees need new skills in order to be able to meet the requirements. This is to be promoted by the National CVET Strategy, which has been developed by the Federal government and the social partners in close cooperation with the federal states in 2019.

To conclude, we will cite Prof. Dr. Friedrich Hubert Esser, President of the Federal Institute for Vocational Education and Training (BIBB), about seizing the digitalisation of the world of work as an opportunity: *'Economy 4.0 is the outstanding opportunity to make vocational education and training more attractive and future-proof.'*

Abbreviations and acronyms

AI	artificial intelligence
ASCOT	Technology-based Assessment of Skills and Competences in VET
BIBB	Bundesinstitut für Berufsbildung [Federal Institute for Vocational Education and Training]
BITKOM	German Association of Information Technology, Telecommunications and New Media
BMAS	Bundesministerium für Arbeit und Sozialordnung [Federal Ministry of Labour and Social Affairs]
BMBF	Bundesministerium für Bildung und Forschung [Federal Ministry of Education and Research]
BMWi	Bundesministerium für Wirtschaft und Energie [Federal Ministry of Economic Affairs and Energy]
CPD	continuous professional development
CVET	continuing VET
DESI	Digital Economy and Society Index
DGB	Deutscher Gewerkschaftsbund [Federation of German Trade Unions]
DQR	Deutscher Qualifikationsrahmen [German Qualifications Framework]
IAB	Institut für Arbeitsmarkt- und Berufsforschung [Institute for Labour Market and Occupation Research]
IT	information technology
IVET	initial VET
KI	Künstliche Intelligenz = AI
KMK	Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [Standing Conference of Ministers for Education and Cultural Affairs of the States]
KWB	Employers' Organisation for Vocational Training
QuBe	Qualification and occupational fields projections
RBS	reference company system (Referenz-Betriebs-System)
SME	small and medium enterprises
TASKS	Technology, Assets, Skills, Knowledge, Specialisation
VET	vocational education and training
ÜBS	Überbetriebliche Berufsbildungsstätte [inter-company vocational training centre]
VDI	Association of German Engineers
VDMA	Association of German mechanical engineers
ZEW	Centre for European Economic Research
ZVEI	Association of electronic engineers

Bibliography

URLs accessed 20.12.2019

- BIBB (2017). *Berufsbildung 4.0*. BWP 2/2017. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/de/bwp/show/8285>
- BIBB (2018a). *Ausbildungspersonal*. BWP 3/2018. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/de/bwp/show/8772>
- BIBB (2018b). *Datenreport zum Berufsbildungsbericht 2018*. Bonn: BIBB.
<https://www.bibb.de/datenreport/>
- BIBB (2018d). *Modernisierte Ausbildungsberufe 2018*. Bonn: BIBB.
https://www.bibb.de/de/berufeinfo.php/new_modernised_occupations_by_year
- BIBB (2018c). *Verzeichnis der anerkannten Ausbildungsberufe 2018*. Bonn: BIBB.
https://www.bibb.de/dokumente/pdf/verzeichnis_anerkannter_ausbildungsberufe_2018.pdf
- BIBB (2018d). *VET Trends 2018*. BWP special edition. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/en/bwp/show/8488>
- BIBB (2019a). *Digitalisierung und künstliche Intelligenz*. BWP 3/2019. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/en/bwp/show/10086>
- BIBB (2019b). *VET Trends 2019*. BWP special edition. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/en/bwp/show/10407>
- BMAS (2017). *Skill and vocational development needs over the period to 2030 - A joint situation report by the partnership for skilled professionals*. Berlin.
https://www.bmas.de/SharedDocs/Downloads/EN/PDF-Publikationen/skill-and-vocational-development-needs.pdf?__blob=publicationFile&v=3
- BMBF (2017a). *Ausbildung im digitalen Wandel – Strategien für kleine und mittlere Unternehmen*. Dietrich, Dresen, Asmuth, JOBSTARTER. Bonn: BIBB.
https://www.bmbf.de/pub/Ausbildung_im_digitalen_Wandel.pdf
- BMBF (2017b). *Berufsbildung 4.0 – den digitalen Wandel gestalten Jobstarter*. Flyer. Bonn: BIBB/BMBF. <https://www.bmbf.de/de/berufsbildung-4-0-3246.html>
- BMBF (2018). *Berufsbildungsbericht 2018*. Bonn, Berlin: Bundesministerium für Bildung und Forschung. <https://www.bmbf.de/de/berufsbildungsbericht-2740.html>
- BMBF/BIBB (2018). *Fachkräftequalifikationen und Kompetenzen in der digitalisierten Arbeit von morgen. Im Kontext von Berufsbildung 4.0*. Bonn: BIBB. <https://www.bibb.de/de/dapro.php?proj=7.8.154>

- European Commission (2017). *Germany: Industrie 4.0*.
https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf
- Frey, C.; Osborne, M. (2013). *The future of employment: how susceptible are jobs to computerisation?* Working Paper. Oxford: University of Oxford.
- Härtel, M.; et al. (2018). *Digitale Medien in der betrieblichen Berufsbildung – Medienaneignung und Mediennutzung in der Alltagspraxis von betrieblichem Ausbildungspersonal*. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/de/publication/show/9412>
- Helmrich, R.; et al. (2016). *Digitalisierung der Arbeitslandschaften - Keine Polarisierung der Arbeitswelt, aber beschleunigter Strukturwandel und Arbeitsplatzwechsel*. Bonn: BIBB.
<https://www.bibb.de/veroeffentlichungen/de/publication/show/8169>
- Hensen, K.A.; Hippach-Schneider, U. (2016a). *Key competences in vocational education and training – Germany*. Cedefop ReferNet thematic perspectives series. http://libserver.cedefop.europa.eu/vetelib/2016/ReferNet_DE_KC.pdf
- Hensen, K.A.; Hippach-Schneider, U. (2016b). *Supporting teachers and trainers for successful reforms and quality of vocational education and training: mapping their professional development in the EU – Germany*. Cedefop ReferNet thematic perspectives series.
http://libserver.cedefop.europa.eu/vetelib/2016/ReferNet_DE_TT.pdf
- Hermes, J.; Schandock, M. (2016). *Stellenanzeigenanalyse in der Qualifikationsentwicklungsforschung - Die Nutzung maschineller Lernverfahren zur Klassifikation von Textabschnitten*. BIBB Fachbeiträge im Internet. <https://www.bibb.de/veroeffentlichungen/en/publication/show/8146>
- Hippach-Schneider, U.; Huismann, A. (2019). *Vocational education and training in Europe – Germany*. Cedefop ReferNet VET in Europe reports. https://cumulus.cedefop.europa.eu/files/vetelib/2019/Vocational_Education_Training_Europe_Germany_2018_Cedefop_ReferNet.pdf
- Hippach-Schneider, U.; Huismann, A. (2017). *VET in Europe: country report 2016 Germany*. (Cedefop/BIBB).
http://libserver.cedefop.europa.eu/vetelib/2016/2016_CR_DE.pdf
- Kollmann, T.; Schmidt, H. (2016). *Deutschland 4.0 - Wie die Digitale Transformation gelingt*. <https://www.springer.com/de/book/9783658119812>
- KMK. *Bildung in der digitalen Welt. Strategie der Kultusministerkonferenz*. https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2018/Strategie_Bildung_in_der_digitalen_Welt_idF_vom_07.12.2017.pdf
- Langenkamp, L.; Linten, M. (2019). *Auswahlbibliografie Industrie 4.0 – Wirtschaft 4.0 – Berufsbildung 4.0*. Bonn: BIBB.

- https://www.bibb.de/dokumente/pdf/stabpwi_auswahlbibliografie_201906_industrie40_v6.pdf
- Lukowski, F.; Neuber-Pohl, C. (2018). Digital technologies make work more demanding. In: BIBB (2018). *VET trends 2018*. BWP special edition. Bonn: BIBB. <https://www.bibb.de/veroeffentlichungen/en/bwp/show/8488>
- Schmid, U.; Goertz, L.; Behrens, J. (2016). *Monitor Digitale Bildung - Berufliche Ausbildung im digitalen Zeitalter*. Mmb Institut; Bertelsmann Stiftung. https://www.bertelsmann-stiftung.de/fileadmin/files/BSt/Publikationen/GrauePublikationen/Studie_Monitor-Digitale-Bildung_Berufliche-Ausbildung-im-digitalen-Zeitalter_IFT_2016.pdf
- Tiemann, M. (2016). *Polarisierung von Tätigkeiten in der Wirtschaft 4.0 – Fachkräftequalifikationen und Fachkräftebedarf in der digitalisierten Arbeit von morgen*. Kurzexpertise im Auftrag des BMBF, Arbeitspaket 1 https://www.bibb.de/dokumente/pdf/AB22_Polar_Polarisierungsthese-Frey_V2.1.pdf
- Weber, E. (2017). *Digitalising the economy: The future of employment and qualification in Germany*. IAB-Forum. <https://www.iab-forum.de/en/digitalising-the-economy-the-future-of-employment-and-qualification-in-germany/>
- Wolter, M.I.; et al. (2018). *Wirtschaft 4.0 und die Folgen für Arbeitsmarkt und Ökonomie - Szenario-Rechnungen im Rahmen der fünften Welle der BIBB-IAB-Qualifikations- und Berufsprojektionen*. BIBB (vorläufige Fassung). https://www.bibb.de/dokumente/pdf/qube_welle5_W4.0_final.pdf
- Zika, G.; et al. (2019). *BMAS-Prognose "Digitalisierte Arbeitswelt": Kurzbericht*. Forschungsbericht / Bundesministerium für Arbeit und Sozialordnung BMAS, Bonn. <https://www.bmas.de/SharedDocs/Downloads/DE/PDFPublikationen/Forschungsberichte/fb526-1k-bmas-prognose-digitalisierte-arbeitswelt.pdf>
- Zinke, G. (2019). *Berufsbildung 4.0 – Fachkräfte-qualifikationen und Kompetenzen für die digitalisierte Arbeit von morgen: Branchen- und Berufescreening. Vergleichende Gesamtstudie*. WDP 213. BIBB, Bonn. <https://www.bibb.de/veroeffentlichungen/en/publication/show/10371>
- Zinke, G. et al. (2017). *Berufsausbildung und Digitalisierung – ein Beispiel aus der Automobilindustrie*. WDP 186. Bonn: BIBB. <https://www.bibb.de/veroeffentlichungen/en/publication/show/8329>

Weblinks

URLs accessed 20.12.2019

- Acatech. <https://www.acatech.de/Publikation/kompetenzen-fuer-industrie-4-0-qualifizierungsbedarfe-und-loesungsansaeetze/>
- ASCOT+ initiative. <http://ascot-vet.net/index.php>
- AusbildungPlus database. Additional IVET qualifications and higher VET.
<http://www.ausbildungplus.de/webapp/suche?typ=zq&neuesuche=true>
- Baden-Württemberg initiative and funding programme Learning factories 4.0.
<https://www.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/neue-foerderrunde-fuer-lernfabriken-40/>; <https://www.lernfabrik.karlsruhe.de/>
- BBiG. Bundesberufsbildungsgesetz (Vocational Training Act). https://www.gesetze-im-internet.de/bbig_2005/BBiG.pdf
- Bertelsmann Foundation. <https://www.bertelsmann-stiftung.de/cps/rde/xchg/bst>
- BIBB. Ausbildung aus Sicht der Jugendlichen. <https://www.bibb.de/de/11148.php>
- BIBB. BWP 3/2018. <https://www.bibb.de/veroeffentlichungen/en/bwp/show/8772>
- BIBB congress 2018. <https://kongress2018.bibb.de/kongress/online-dokumentation/index.html>
- BIBB. DaPro. <https://www.bibb.de/de/dapro.php?proj=7.8.146>
- BIBB. DaPro. Results of the online survey 2016.
www.bibb.de/voruntersuchung_itberufe
- BIBB. Digitalisation of the world of work. <https://www.bibb.de/de/76955.php>
- BIBB. Digitale Medien in Betrieben.
<https://www.bibb.de/veroeffentlichungen/en/publication/show/8048>
- BIBB. Documentation of conference VET 4.0 – the future opportunities of digitalisation. www.bibb.de/de/65876.php
- BIBB. Events VET 4.0. <https://www.bibb.de/de/neue-veranstaltungsreihe-berufsbildung-4-0-digitalisierung-und-kuenstliche-intelligenz-96682.php> + <https://www.bibb.de/de/113546.php>
- BIBB. Exertenmonitor. <https://expertenmonitor.bibb.de/index.php>
- BIBB. Foraus web portal. https://www.foraus.de/html/foraus_index.php
- BIBB. Foraus. Digitalisation in VET. https://www.foraus.de/html/foraus_digitale-medien-in-der-betrieblichen-Berufsbildung.php;
https://www.foraus.de/html/foraus_3317.php; Films:
https://www.foraus.de/html/foraus_7004.php
- BIBB. Foraus.de. Media-pedagogical competence of company-based training staff.
https://www.foraus.de/html/foraus_media-pedagogical-competence-of-company-based-training-staff.php
- BIBB. Foraus.de. Training for the Industrie 4.0.
https://www.foraus.de/html/foraus_3328.php

- BIBB. Foraus.de. Sonderprogramm zur Digitalisierung in ÜBS
https://www.foraus.de/html/foraus_5000.php
- BIBB. Forum I (IVET and CVET in the digital age).
<https://kongress2018.bibb.de/kongress/online-dokumentation/forum-i/index.html>
- BIBB. Forum II (learning places with a future: cooperative and digital).
<https://kongress2018.bibb.de/kongress/online-dokumentation/forum-ii/index.html>
- BIBB. Launch of pilot initiative for VET 4.0. <https://www.bibb.de/en/49603.php>
- BIBB. Medien anwenden und produzieren.
<https://www.bibb.de/veroeffentlichungen/en/publication/show/8275>
- BIBB. Medien- und IT-Kompetenz als Eingangsvoraussetzung.
<https://www.bibb.de/veroeffentlichungen/en/publication/show/9223>
- BIBB. Media-pedagogical competence for training personnel.
<https://www.bibb.de/de/87594.php>
- BIBB. Podium discussion at didacta 2017. <https://www.bibb.de/en/59571.php>
- BIBB. Polarisation 4.0, Robert Helmrich, 7 June 2018, Berlin.
https://kongress2018.bibb.de/wp-content/uploads/2018/06/forum_i_helmrich_tag_1_final_dok.pdf
- BIBB. Press release. Learning to use media in training.
https://www.bibb.de/en/pressemitteilung_59739.php#
- BIBB. Press release on 12 updated occupations.
https://www.bibb.de/en/pressemitteilung_64609.php
- BIBB. Press release on 25 updated occupations.
https://www.bibb.de/en/pressemitteilung_82427.php
- BIBB. Press release on population growth with low unemployment.
https://www.bibb.de/en/pressemitteilung_87651.php
- BIBB. Press release on industrial metal and electrical professions.
https://www.bibb.de/en/pressemitteilung_81176.php
- BIBB. Press release, symposium in Leipzig. 2017
https://www.bibb.de/en/pressemitteilung_72287.php#
- BIBB. Press release. Economy 4.0 needs education 4.0.
https://www.bibb.de/en/pressemitteilung_54914.php
- BIBB. QuBe. https://www.bibb.de/en/qube_datenportal.php
- BIBB. QuBe – qualifications and occupations in the future.
<https://www.bibb.de/en/11727.php>
- BIBB. Referenz-Betriebs-System. <https://www.bibb.de/de/12471.php>
- BIBB. Results and recommendations for action presented at the Symposium on VET 4.0, November 2018. <https://www.bibb.de/en/87878.php>
- BIBB. Sonderprogramm ÜBS-Digitalisierung. <https://www.bibb.de/uebs-digitalisierung>
- BIBB. Symposium in Bensberg 2018. <https://www.bibb.de/en/87878.php>
- BIBB. TASK V conference of 07-08/02/2019. <https://www.bibb.de/en/81599.php>
- BIBB. Textile goes Textile – Lernen in der digitalen Berufsschule

<https://www.bibb.de/de/116427.php>

BIBB. ÜBS. <https://www.bibb.de/de/741.php>

BIBB. VET 4.0. <https://www.bibb.de/en/49603.php>

BIBB. VET for the digitised working world's award Hermann-Schmidt-Preis 2017. <https://www.bibb.de/de/72331.php#>

BIBB./BauA. <https://www.bibb.de/arbeit-im-wandel>

BIBB/IAB. Erhebungen. <https://kooperationen.zew.de/dfgflex/links/datensaetze-deutschland/bibbiab-erhebungen.html>

BIBB/IAB/ZEW. BIBB/ Institute for Employment Research (IAB)/ Centre for European Economic Research (ZEW) <https://www.bibb.de/en/81599.php>
<https://www.bibb.de/en/91849.php>

BitKom. German association of information technology, telecommunications and new media. https://www.bitkom.org/de/markt_statistik/806.aspx

BMAS. Arbeiten 4.0. Work 4.0. <http://www.arbeitenviernull.de/>

BMAS. AI Strategy. <https://www.bmas.de/DE/Presse/Pressemitteilungen/2019/ein-jahr-ki-strategie.html>

BMAS. Monitoring of skilled labour force. <https://www.bmas.de/DE/Themen/Arbeitsmarkt/Fachkraeftesicherung/daten-und-fakten.html>

BMAS. National CVET Strategy. <https://www.bmas.de/DE/Schwerpunkte/Nationale-Weiterbildungsstrategie/nws-artikel.html>

BMAS. Qualifizierungschancengesetz. <https://www.bmas.de/DE/Service/Gesetze/qualifizierungschancengesetz.html>

BMAS. Qualifizierungsoffensive. <https://www.bmas.de/DE/Schwerpunkte/Qualifizierungsoffensive>

BMAS. White paper work 4.0. <https://www.bmas.de/EN/Services/Publications/a883-white-paper.html>

BMBF. AI Strategy. <https://www.bmbf.de/de/strategie-kuenstliche-intelligenz-offiziell-auf-digital-gipfel-vorgestellt-7488.html>

BMBF. Artificial Intelligence. <https://www.bmbf.de/de/kuenstliche-intelligenz-5965.html>

BMBF. Artificial intelligence. <https://www.bmbf.de/de/kuenstliche-intelligenz-5965.html>

BMBF. Artificial intelligence event November 2018. <https://www.bmbf.de/de/strategie-kuenstliche-intelligenz-offiziell-auf-digital-gipfel-vorgestellt-7488.html>

BMBF. BIBB beteiligt sich weiterhin an OERinfo. <https://www.qualifizierungdigital.de/de/bibb-beteiligt-sich-weiterhin-an-oerinfo-4076.php>

BMBF. Competence workshop. <https://www.qualifizierungdigital.de/kompetenzwerkstatt-1930.php>

BMBF. Digital pact for schools. <https://www.bildung-forschung.digital/de/der-digitalpakt-schule-kommt-2330.html>

BMBF. Digital pact for schools. <https://www.bmbf.de/de/wissenswertes-zum-digitalpakt-schule-6496.html>

BMBF. Digitalisation II project. <https://www.bmbf.de/foerderungen/bekanntmachung-2157.html>

BMBF. Digitalisation of vocational schools. <https://www.qualifizierungdigital.de/de/digitalisierung-der-berufsschulen-bvlb-fordert-gesamtstrategie-und-qualifizierungsoffensive-3915.php> BMBF hightech strategie. <https://www.bmbf.de/de/die-neue-hightech-strategie-86.html>

BMBF. Digitale Zukunft. <https://www.bildung-forschung.digital/index.html>

BMBF. Digitale Zukunft. DigitalPakt Schule. <https://www.bildung-forschung.digital/de/der-digitalpakt-schule-kommt-2330.html>

BMBF. eQualification 2019 conference. <https://www.qualifizierungdigital.de/equalification-2019-3853.php>

BMBF Industrie 4.0. <https://www.bmbf.de/de/zukunftsprojekt-industrie-4-0-848.html>; https://www.bmbf.de/pub/Industrie_4.0.pdf

BMBF initiative 'Digital media in vocational training'. <https://www.qualifizierungdigital.de/de/berufsbildung-24.php>

BMBF investment subsidies. <https://www.bmbf.de/de/ueberbetriebliche-berufsbildungsstaetten-1078.html>

BMBF. KI-Strategie. <https://www.qualifizierungdigital.de/de/ki-strategie-wir-setzen-auf-talentierte-menschen-und-die-richtigen-strukturen-3998.php>

BMBF. National CVET Strategy. <https://www.bmbf.de/de/nationale-weiterbildungsstrategie-8853.html>

BMBF. National CVET Strategy. <https://www.bmbf.de/de/fuer-eine-neue-weiterbildungskultur-in-deutschland-7311.html>

BMBF. Neue BIBB publikationen zu Medien- und IT Kometenz. <https://www.qualifizierungdigital.de/de/neue-bibb-publikationen-zu-medien-und-it-kompetenz-sowie-distance-learning-distance-education-3769.php>

BMBF. Praxisbeispiele. <https://www.qualifizierungdigital.de/de/praxisbeispiele-28.php>

BMBF. Presse. Für eine neue Weiterbildungskultur in Deutschland. <https://www.bmbf.de/de/fuer-eine-neue-weiterbildungskultur-in-deutschland-7311.html>

BMBF. Project database. <https://www.qualifizierungdigital.de/de/projekt Datenbank-27.php>

BMBF. Project Perspective 2.0. <https://www.qualifizierungdigital.de/de/perspektive-2-0-273.php>

BMBF roadshow. <https://www.qualifizierungdigital.de/bmbf-roadshow-2018-digitale-medien-im-ausbildungsalltag-1600.php>

BMBF. Science Year 2019. <https://www.wissenschaftsjahr.de/2019/>

BMBF. Selection of products. <https://www.qualifizierungdigital.de/de/produkte-29.php>

- BMBF. VET in the medical professions, DigiMed.
<https://www.qualifizierungdigital.de/de/foerderung-von-zuwendungen-fuer-digitale-medien-in-der-beruflichen-bildung-in-den-gesundheitsberufen-digimed-3659.php>
- BMBF. Virtual and augmented reality in VET.
<https://www.qualifizierungdigital.de/de/foerderung-von-forschungsprojekten-zur-virtuellen-und-erweiterten-realitaet-vr-ar-in-der-beruflichen-bildung-vrabb-2997.php>
- BMWi. Industrie 4.0. <https://www.bmwi.de/Redaktion/EN/Dossier/industrie-40.html>
- BMWi. Plattform Industrie 4.0.
<https://www.bmwi.de/Redaktion/EN/Publikationen/plattform-industrie-4-0-digital-transformation.html>
- BREG. AI Strategy. <https://www.ki-strategie-deutschland.de/home.html>
- BREG. National CVET Strategy. <https://www.bundesregierung.de/breg-de/themen/digital-made-in-de/nationale-weiterbildungsstrategie-1546656>
- DESI. Digital Economy and Society Index <https://ec.europa.eu/digital-single-market/en/desi>
- Digital media in vocational training web portal.
<https://www.qualifizierungdigital.de/>
- Digital summit, Dortmund, 28-29/10/2019.
<https://www.de.digital/DIGITAL/Navigation/DE/Service/Digital-Gipfel/Digital-Gipfel.html>
- Europass Certificate Supplement.
https://www.bibb.de/tools/berufesuche/index.php/certificate_supplement/en/kaufmann_im_e-commerce_e.pdf
- Experimentierraume. Innovation spaces.
<https://www.experimentierraume.de/die-idee/>
<https://www.experimentierraume.de/info/english/>
- Federal Government. Digital agenda 2014-17.
https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/it-digitalpolitik/digitale-agenda.pdf;jsessionid=15E031BD7C007EC213E4E34DF5504ECF.2_cid373?__blob=publicationFile&v=4
- Federal Government. Platform for artificial intelligence.
<https://www.bundesregierung.de/breg-de/themen/digital-made-in-de/nationale-weiterbildungsstrategie-1546656>
- Federal Government. Digital-made-in.de. <https://www.bundesregierung.de/breg-de/themen/digital-made-in-de>
- Federal Government. Digital Strategy. <https://www.bundesregierung.de/breg-de/themen/digital-made-in-de/die-digitalstrategie-der-bundesregierung-1549554>
- Friedrich-Ebert Foundation. <https://www.fes.de/>
- Federal Government. Hightech-Strategie 2025. <https://www.hightech-strategie.de/de/hightech-strategie-2025-1726.html>
- Federal Government. KI strategie. <https://www.ki-strategie-deutschland.de/home.html>

FreQueNz. <http://www.frequenz.net/>

German Bundestag. <https://www.bundestag.de/ada>

German statistical office. <https://www.destatis.de/DE/Startseite.html>

German Statistics portal. <https://de.statista.com/>

Germany: Digitalisation in inter-company vocational training and competence centres. <http://www.cedefop.europa.eu/en/news-and-press/news/germany-digitisation-inter-company-vocational-training-and-competence-centres-0>

Hans-Böckler Foundation. <https://www.boeckler.de/index.htm>

IAB, Institute for Employment Research. <https://www.iab.de/de/befragungen.aspx>

IAB TASKS conference of 17-18 May 2010 .
<https://iab.de/de/veranstaltungen/konferenzen-und-workshops-2010/tasks.aspx>

IAB Arbeitsmarktbarometer, a future-oriented labour market monitoring system.
<https://www.iab.de/de/daten/arbeitsmarktbarometer>

Industrie 4.0. Learning Factories. <https://industrie40-live.de/index.php/en/learning-factory>

Industrie 4.0. Platform. <https://www.plattform-i40.de/I40/Redaktion/EN/Standardartikel/Working-Groups/working-group-05.html>

Jobstarter plus. <https://www.jobstarter.de/>

KI/AI Campus. <https://www.ki-campus.org/>

KMK competences in the digital world.
https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2017/KMK_Kompetenzen_in_der_digitalen_Welt_-neu_26.07.2017.html

KMK. Gemeinsame Erklärung der KMK und des Verbandes Bildungsmedien.
https://www.kmk.org/fileadmin/Dateien/pdf/Gemeinsame_Erklaerung_KMK_VBM_v._14.06.2018.pdf

KMK. Initial and continuing education of teachers.
<https://www.kmk.org/themen/bildung-in-der-digitalen-welt/veranstaltung-zur-bildung-in-der-digitalen-welt-im-schulbereich.html>

KMK resolution 'Vocational schools 4.0'.
<https://www.qualifizierungdigital.de/de/berufsschule-4-0-kmk-benennzentrale-handlungsfelder-in-der-beruflichen-bildung-3016.php>

KMK. Strategy Education in the digital world.
<https://www.kmk.org/themen/bildung-in-der-digitalen-welt/strategie-bildung-in-der-digitalen-welt.html>

KMK. Vocational schools 4.0.
https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2017/2017_12_07-Berufliche-Schulen-4_0.pdf

Kompetenz Digital. <https://kompetenzen-digital.de/>

Konrad-Adenauer Foundation. <https://www.kas.de/>

Lernende Systeme. A brief history of AI. <https://www.plattform-lernende-systeme.de/home-en.html>

Lernende Systeme. WG2 Future of work and human-machine interaction.
<https://www.plattform-lernende-systeme.de/wg-2.html>

Lernende Systeme. Work and skilling. <https://www.plattform-lernende-systeme.de/work-and-skilling.html>

mmb institute. <https://www.mmb-institut.de/>

mmb institute. Vocational Schools 4.0.
<https://www.mmb-institut.de/blog/berufsschule-4-0-wo-steht-die-digitale-transformation-des-beruflichen-bildungssystems/>

OECD. Employment Outlook 2019
<http://www.oecd.org/germany/Employment-Outlook-Germany-EN.pdf>

Plattform Industrie 4.0. <https://www.plattform-i40.de/I40/Navigation/EN/Home/home.html>

Plattform Lernende Systeme. <https://www.plattform-lernende-systeme.de/home-en.html>
https://www.plattform-lernende-systeme.de/files/Downloads/Publikationen/AG1_Whitepaper_280619.pdf
<https://www.plattform-lernende-systeme.de/wg-2.html>; <https://www.plattform-lernende-systeme.de/work-and-skilling.html>

Südlicher Oberrhein. Die Lernfabrik 4.0.
https://www.industrie40.ihk.de/produktmarken/qualifizierung/Die-Lernfabrik-4_0/2736766

University of Cologne. <http://spinfo.phil-fak.uni-koeln.de/index.php?id=27853>
<http://dh.uni-koeln.de/37089.html>

VDI. Association of engineers. <https://www.vdi.de/presse/publikationen/>

VHS. Volkshochschule. Adult Education Centres. Cloud.
<https://www.vhs.cloud/wws/9.php#/wws/zusammenfassung-evaluation-dc.php>

Working life of the future. <https://www.wissenschaftsjahr.de/2019/>;
<https://www.wissenschaftsjahr.de/2018/uebergreifende-informationen/about-the-science-year/>