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The development of industrial apprenticeship within the context of digital change in industry

von

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Abstract

The speed and related impact of digitization on our everyday lives has increased in recent years. In the professional context, the digital transformation confronts companies with the challenge of identifying an efficient way to introduce digitization. This also includes the qualification and further education of employees so that they are able and willing to use digital opportunities. Only then digital change will also bring new opportunities for the company.

The aim of the research in this thesis is to find out what influence digitalization has on industrial training and how vocational training departments manage digital transformation.

For this purpose, a qualitative study was conducted as part of this thesis. A total of 13 representatives from 10 companies and institutions were interviewed on this topic. The interview results were summarized and categorized into several aspects so that a comparison was possible.

The analysis of the interviews shows that the intensity of the digital transformation in companies depends on the sector. Nevertheless, the topic of digital transformation has entered everywhere and has already caused some adjustments to industrial training. In the future, training departments will need to continue adapting in order to fulfil the qualification requirements, but also to be able to increase their own efficiency within the training department.

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AI	Artificial Intelligence
BBIG	Vocational Training Act (Berufsbildungsgesetz)
BIBB	Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung)
DEW	Deutsche Edelstahlwerke
HKM	Hüttenwerke Krupp Mannesmann
IG Metall	Industrial Union Metal (Industriegewerkschaft Metall)
ISCO-08	International Standard Classification of Occupations
IT	Information Technology
KLdB	classification of occupations (Klassifikation der Berufe)
PCB	Printed Circuit Board (Leiterplatte)
SME	small and medium sized companies
VDMA	Association of German Mechanical and Plant Engineering Companies (Verband Deutscher Maschinen- und Anlagenbauunternehmen)
VET	Vocational Education Training
ZVEI	Central Association of Electrical Engineering and Industry (Zentralverband Deutscher Elektrotechnik und -industrie)

1 Introduction

The smartphone alarm rings and before getting out of bed, the latest WhatsApp messages are answered. After the usual morning ritual, it is time for work. In the car, the phone connects to the music system so that the latest podcast, an audio book or the personal playlist on Spotify can be listened. Once arrived at the office unread mails are answered and in between relevant news streams are subscribed to on Facebook, Xing and Linked-in. This option ensures that the daily newspaper is compiled according to personal interests. At lunchtime, Siri searches for restaurants in the area. The decision falls on the restaurant with the most positive online ratings. Now the favourite colleague from the end of the corridor can also be messaged via Teams to ask if he would like to come along. At the restaurant, a photo of the meal is posted on the Instagram account. Less than two minutes later, a friend replies to the post: ‘I have to go there soon, too.’ Back in the office, various virtual meetings take place, in which colleagues from the U.S. and China also participate. The documents shown there are stored in the shared Dropbox. In between, a colleague from the mill calls. While talking, he controls the production process from his tablet and, in parallel, also tries to locate a fault in the neighbouring hall. After work, first of all the TV is switched on and another episode of the latest Netflix series is watched. In the evening, a switch is made back to trash TV. Since advertising is still on, this time can be used to make a quick phone call or get something to drink. After a last check of the latest news on the smartphone, the smartphone alarm clock is set for the next day before going to bed.[1]

Such a daily routine will sound familiar to many, but only a few are aware of the constant use of new media and tools. The Internet, smartphones, social media, automated remote processes, smart TVs and other digital tools are not only changing private daily life, but are also having an enormous impact on everyday working life. Digitization is not a trend that can be ignored. If companies do not adapt to the digital age or do not keep pace with the digital transformation, they cannot survive in the long run. Whether it is through the use of communication tools, such as teams to talk to colleagues abroad, or through the

[1] Cf. *Buchenau, P; Fürtbauer, D.*, Digital World, 2015, p. 1-3; *Institute for Digital Business*, Digital Native, 2017.

use of applications that facilitate physical work in the production area, digitization is becoming increasingly important in today's business.

First and foremost, digitization in the business sector is intended to make business processes easier and more efficient. Digitization offers the opportunity to perform activities more comfortably, more quickly and more cost-effectively. As a result, the requirements for employees have changed. Especially in production departments, modern machines and processes are much more complex and require cross-departmental knowledge. A pure investment in equipment is not sufficient if the skilled personnel cannot work with it.[2]

1.1 Problem description

In Germany, the qualification of junior staff in the form of vocational training is an important element within the context of staff training. This is where this master's thesis focuses.

Industrial vocational training is intended to prepare and qualify young people for specific occupations. However, against the backdrop of the digital transformation and the principles of German vocational training, apprenticeship departments are faced with a number of challenges. On the one hand, the digital transformation has already led to a large number of job profiles changing in recent years. Some activities have been replaced by new ones, others have been upgraded, and still others are no longer needed.[3] It is imperative that these changed job requirements and competence profiles are taken up and processed by vocational training so that apprentices can be optimally educated according to company needs. However, a change in training occupations cannot be implemented at a purely company level, as will be explained in more detail in a subsequent chapter. Secondly, the future impact of the digital transformation cannot yet be planned due to the speed of digitization processes.[4] Since vocational training departments qualify apprentices with a lead time of approximately three years, they are faced with the problem that medium- or long-term planning of competence profiles is not feasible. Nevertheless

[2] Cf. *Gebhardt, J; Grimm, A; Neugebauer, L. M.*, Digitization of Work, 2015, p. 49.
[3] Cf. *Hirsch-Kreinsen, H.*, Digitalization in Industry, 2016, pp. 5.
[4] Cf. *Hirsch-Kreinsen, H.*, Industry 4.0, 2014, pp. 31.

the topic has to be focused in order to make the best possible use of digital transformation and thus identify new opportunities for vocational training.[5]

For this reason, the aim of this thesis is on finding out how industrial training is experiencing the digital transformation, reacting to it and how it is preparing for the future.

1.2 Structure of Thesis

On the following, the theoretical background for this topic is explained in detail before the empirical investigation is discussed. First of all digitization in industry is explained through the relevant developments in industry. Starting with the first industrial revolution, through the digital transformation to the predicted Industry 4.0, relevant aspects for the present study will be discussed.

Next, professional education in Germany is examined in more detail. For this purpose, the structure of the German dual training system will be explained on the one hand and the industrial vocational training will be focused on the other hand.

In the next step, the interlocking of the two subject areas is presented in the form of an empirical study, which is introduced with regulations and evaluations that have already been conducted. In order to get a detailed impression of what is happening in industrial vocational training departments, several interviews with various companies from different sectors will be conducted and evaluated in the course of the empirical work.

The aim of this paper is to identify what impact digitization actually has on companies and the respective training department, how training departments deal with the topic of digitization and how they would like to manage the future of vocational training. In the framework of a qualitative research method, a total of 10 expert interviews will be conducted with different companies and institutions. A category system will then be used to answer the mentioned questions on the one hand and to enable a comparison between the companies on the other.

[5] Cf. *Flake, R; Meinhard, D; Werner, D.*, Digitization in Vocational Training, 2019, p.7-9.

2 Digital Change in Industry

2.1 Phases of Industrialization

At the end of the 18th century, the first industrial revolution began in England. Through its colonies, England gained a leading role in foreign trade and thus changed society. Trade and industry became England's new base. In the other countries, such as France and Belgium, trade and industry did not begin to gain importance until the 1830s, while in Germany this revolution did not take place until the 1850s due to its division.[6]

The starting point of the first industrial revolution was the initial commercial use of water and steam power to support mechanical production facilities.[7] The most effected sectors were the textile industry on the one hand and the iron and steel industry on the other.[8] The first industrial revolution enabled an enormously high output of work compared to conventional craft enterprises. However, the purchase and use of such machines was associated with high investments. As a result, many craftsmen could not keep up with the new production and had to sell their labour to larger industries. So they went from being owners to machine operators.[9]

The trigger for the second industrial revolution was the invention of electricity. This triggered a revolution in the world economy. E. Siemens initiated this industrial revolution with his invention of the first electric generator (dynamo). The exchange of steam for electricity became the basis of the electrotechnical sphere and led to a strong improvement in work efficiency. As a result, the second industrial revolution was torpedoed by assembly line and mass production. During this phase of industrialization, the information network, among other things, developed. Telegraphic communication was created around 1830 and became more and more popular. While the first industrial revolution improved the output of work , the second industrial revolution made also an important break in everyday life and simplified exactly that.[10] A kind of golden age dawned for companies. Only a very low level of qualification was required for the mass production line. The ensuing surplus of workers in the labour market led to low wages.

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[6] Cf. *Popkova, E; Ragulina, Y; Bogoviz, A.*, Industry 4.0, 2019, pp. 13.
[7] Cf. *Schönfelder, C.*, Industrial Revolutions, 2018, p. 10.
[8] Cf. *Roth, A.*, Industry 4.0, 2016, p. 19.
[9] Cf. *Schönfelder, C.*, Industrial Revolutions, 2018.
[10] Cf. *Popkova, E; Ragulina, Y; Bogoviz, A.*, Industry 4.0, 2019, pp. 14.

For companies, mass production offered a new opportunity to rethink and optimize workflows and production processes.[11]

After the World Wars numerous publications on the Third Industrial Revolution appeared. The starting point was the use of renewable energies on the one hand and the implementation of computers in production and the associated possibility of automating production processes and making them digital. Economists call this revolutionary phase a new industrial age. Industry 3.0 is based on 3 principles:[12]

- Shifting the focus of profit from the production stages to development and design
- Increased work efficiency with a simultaneous workforce reduction
- the shift from traditional centralized business models to decentralized structures and horizontal interaction

The third industrial revolution brought profound and complex transformations of systems and structures. These had an impact on all institutions, relationships and technologies. Thus, both economic components, such as production and consumption patterns have been changed, as well as interpersonal exchanges and leisure. New scientific inventions and new technologies were able to change machinery, equipment, devices, and services in ways that radically altered local and international divisions of labour. The 'country of origin' can no longer be assigned. Research and development is done in one country, design is developed in another, assembly takes place in a third, and marketing is the responsibility of various others. Competition between companies has become fiercer in the third industrial revolution. The locomotives and electricity of the third industrial revolution are global entrepreneurs trying to win against competitors through the latest achievements.[13] Accordingly, in this phase of industrialization, which is not yet complete, digitization plays a major and driving role.[14]

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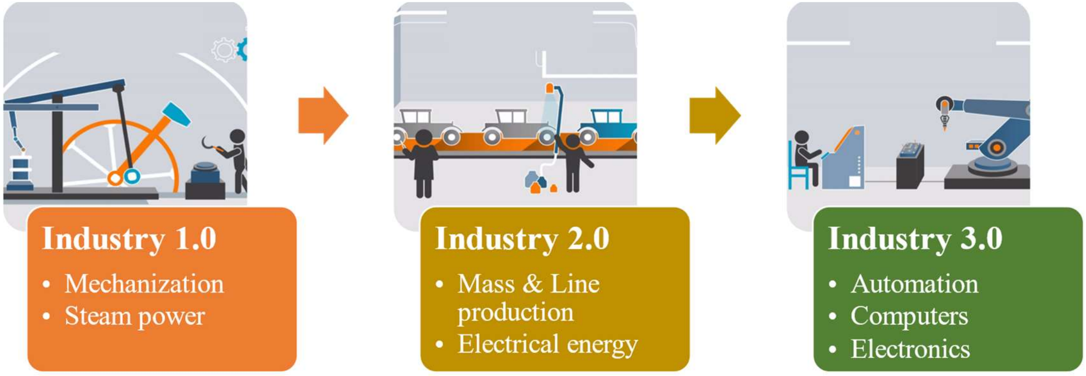
[11] Cf. *Schönfelder, C.*, Industrial Revolutions, 2018. , p. 11.
[12] Cf. *Popkova, E; Ragulina, Y; Bogoviz, A.*, Industry 4.0, 2019, pp. 14.
[13] Cf. *Bauernhansl, T.*, Industrial Revolution, 2017, pp. 2.
[14] Cf. *Lasi, H.* et al., Industry 4.0, 2014, p. 261.

Figure 1 shows the three industrial revolutions in a simplified overview.

Figure 1: Industrial Revolutions



Source: Modelled after *Horváth, B.*, Industrial Revolutions, 2018, p. 75.

2.2 Digital Transformation

The term 'digitization' has been diluted in recent years due to rapid development and now includes terms such as 'Industry 4.0', 'Internet of Things' or 'Artificial Intelligence', which will be explained in more detail in the following chapters.

Digitization in the literal sense describes the transfer of analog data into a discrete system, such as a binary system. If digital data are available, then they can be transported digitally and played back on various end devices.[15]

Digitization in the broader sense has permanently changed both the social and the economic world and will continue to do so in the future.[16] Digitization in the broader sense describes the additional use of digital devices and technologies. Digitization is playing an increasingly important and indispensable role not only in the private sphere, but also in the economic context. From an economic perspective, for example, digitization is used to change business processes in order to achieve higher profits or to develop new products. In recent years, terms such as 'information age' and 'computerization' have also been used to describe digitization. Other buzzwords in this context are[17] [18] [19]

[15] Cf. *Heuermann, R; Tomenendal, M; Bressem, C.*, Digitalization, 2018, p. 8.
[16] Cf. *Bengler, K; Schmauder, M.*, Digitization, 2016, p. 75.
[17] Cf. *Gobble, M.*, Digitization, 2018, p. 56.
[18] Cf. *Bloomberg, J.*, Digital Transformation, 2018.
[19] Cf. *Wolf, T; Strohschen, J.-H.*, Digitization, 2018, pp. 56.

- Big Data
- Smart Data
- Cloud
- Automation

If one tries to formulate the literal definition more broadly, it is then about digitization,

'*when analog service delivery is replaced in whole or in part by service delivery in a digital, computer-manageable model*.'[20]

The use of digitization in companies is also known as digital transformation. Companies expect to achieve higher productivity, better value creation and positive social aspects through the use of disruptive technology in their business processes (table 1).[21]

Table 1: Objectives of Digital Transformation

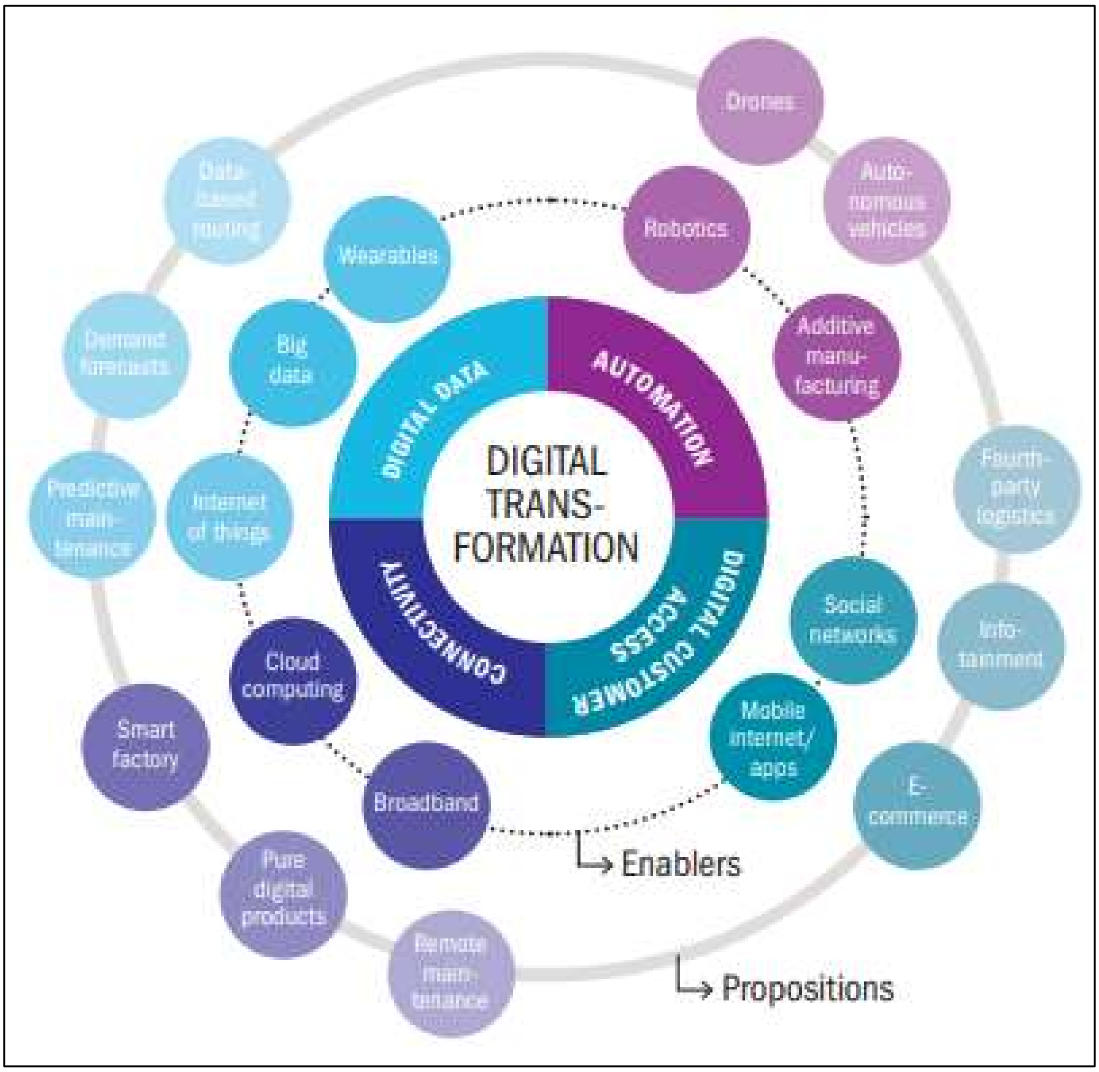
Perspective	Objective
Social	Foster the development of a more **innovative and collaborative** culture in industry and society
	Change the education system to provide new skills and future orientation to persons so that they can achieve excellence in **digital work and** society
	Create and maintain **digital communication infra-structures** and ensure their governance, accessibility, quality of service and affordability
	Strengthen **digital data protection**, transparency, autonomy and trust
	Improve the **accessibility and quality of digital** services offered to the population
Economic	Implement new and **innovative business models**
	Increase **income generation, productivity and value addition** in economy
	Improve the **regulatory framework and technical standards**

Source: Modelled after *Ebert, C; Duarte, C. H.*, Digital Transformation, 2018, p. 16.

[20] *Wolf, T; Strohschen, J.-H.*, Digitization, 2018, p. 58.
[21] Cf. *Demirkan, H; Spohrer, J. C; Welser, J.*, Digitization, 2016, pp. 15.

Digital transformation can be divided into four elements to which the above buzzwords can be assigned: Digital Data, Automation, Networking and Digital Customer Access (figure 2).[22]

Figure 2: Digital Transformation



Source: *Bouée, C.-E; Schaible, S.*, Digital Transformation, 2018, p. 20.

[22] Cf. *Bouée, C.-E; Schaible, S.*, Digital Transformation, 2018, p. 17-21.

Digital Data

The element digital data comprises the collection, processing and evaluation of information. This includes terms such as

- Big Data: Big Data is a simplified description of the possibility of collecting, evaluating and presenting huge amounts of different data with complex structures with the help of new technologies.[23] The special feature is that the usual tools were not able to process this data before big data. In addition, big data promises to provide the right information to the right recipient in the right quantity at the right time.[24]
- Internet of Things: Again, there is no generally applicable definition. The International Telecommunication Union defines the Internet of Things as 'a global infrastructure for the Transformation Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies'.[25]
- Wearables: moving away from the actual meaning of clothing, wearables describe various accessories that allow personalized mobile data to be processed.[26]

Automation

The automation element describes the combination of classical technologies with artificial intelligence (AI). In principle, artificial intelligence occurs whenever machines are developed that attempt to mirror human behaviour through algorithms.[27] It can therefore already be found in gadgets that are indispensable to humans today, such as personal voice assistants or translation aids. Artificial intelligence is already used in many different industries and supports us in everyday or professional tasks. Since artificial intelligence always develops on the basis of human intelligence and the scope of human intelligence is very diverse, the possibilities of artificial intelligence are also far from exhausted. However, AI is not only intended to imitate human intelligence. The goal is also to perform activities faster and better than humans. Gadgets such as drones, robots,

[23] Cf. *Sagiroglu, S; Sinanc, D.*, Big Data, 2013, p. 42.
[24] Cf. *Schermann, M.* et al., Big Data, 2014, p. 261.
[25] *Madakam, S; Ramaswamy, R; Tripathi, S.*, Internet of Things, 2015, p. 221.
[26] Cf. *Park, S; Jayaraman, S.*, Wearables, 2021, p. 3.
[27] Cf. *Ertel, W.*, Artificial Intelligence, 2017, p. 1-3.

3D printers or autonomous vehicles are based on the technical concepts of robotics or additive manufacturing and are thus examples of artificial intelligence.[28]

Networking

Networking encompasses communication between value chains. With the help of data transmission technologies, it is possible, for example, in the industrial sector to access machines and plants digitally and also to enable exchanges between them. The result is that supply chains can be synchronized and thus production times and innovation cycles can be shortened.[29]

Digital Customer Access

The fourth element describes digital customer access. The Internet, mobile apps, and social networks are the main drivers for various ways of interacting digitally with customers, whether through infotainment or e-commerce.[30]

The digital transformation described above, specifically the possibilities of digital networking and the progress of artificial intelligence, is nowadays no longer limited to the area of information technology (IT), but its value is also increasing in the industrial goods business.[31] For Germany in particular, the manufacturing sector plays an important role, as it accounts for the largest share of gross value added alongside the cumulative service sector (figure 3). Consequently the term ‘Industry 4.0” was launched at the industrial trade fair in Hanover in 2011 and has since become established, at least in Germany and also in large parts of Europe.[32]

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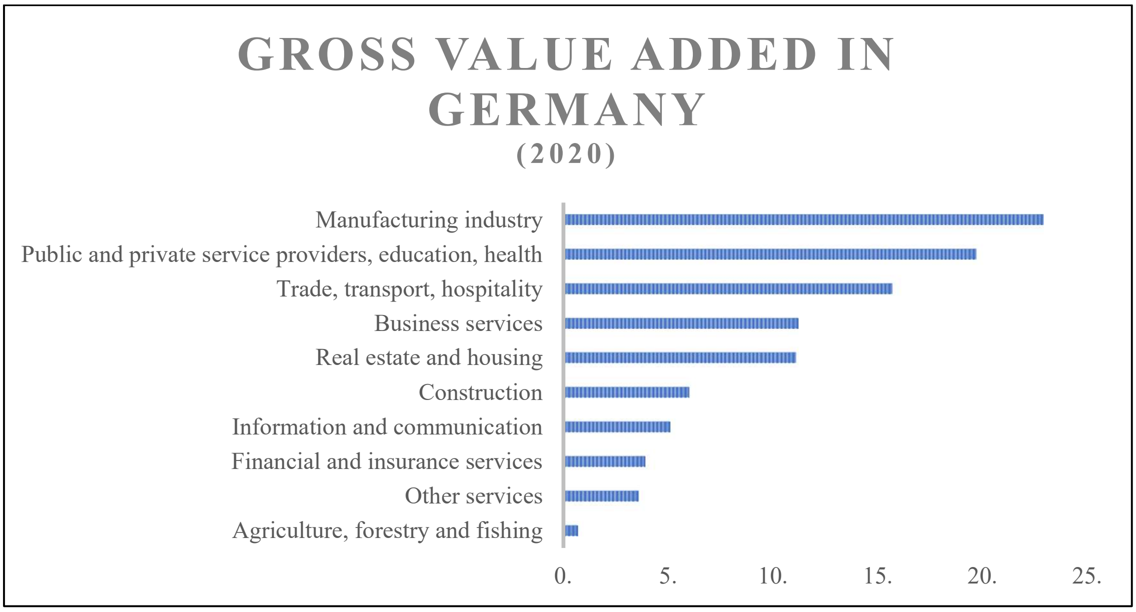
[28] Cf. *Kreutzer, R. T; Sirrenberg, M.*, Artificial Intelligence, 2019, p. 15; *Kreutzer, R. T; Sirrenberg, M.*, Artificial Intelligence, 2019, p. 25.
[29] Cf. *Bouée, C.-E; Schaible, S.*, Digital Transformation, 2018, pp. 23.
[30] Cf. *Kofler, T.*, Digitalization, 2018, pp. 94.
[31] Cf. *Stock, T; Seliger, G.*, Industry 4.0, 2016, p. 536-538.
[32] Cf. *Devezas, T; Leitão, J; Sarygulov, A.*, Industry 4.0, 2017, pp. 1.

Figure 3: Gross Value Added in Germany



Source: Modelled after *Statistisches Bundesamt*, Industry Sectors, 2021, p.11.

2.3 Industry 4.0

In regard to the possibilities that digitization can potentially bring to the future, the term ‘Industry 4.0’ is based on the next industrial revolution. As consequence the fourth industrial revolution does not describe an already tangible development in industries.[33] The advanced digitalization of the third industrial revolution coupled with the possibilities of Internet technologies that enable ‘smart’ objects created a future vision for a new paradigm shift.[34] Using the potentials of innovative technologies will allow some industries to speed up innovation, to be economically efficient with simultaneous individualization, to be flexible, to decentralize organisations and to increase efficiency.[35]

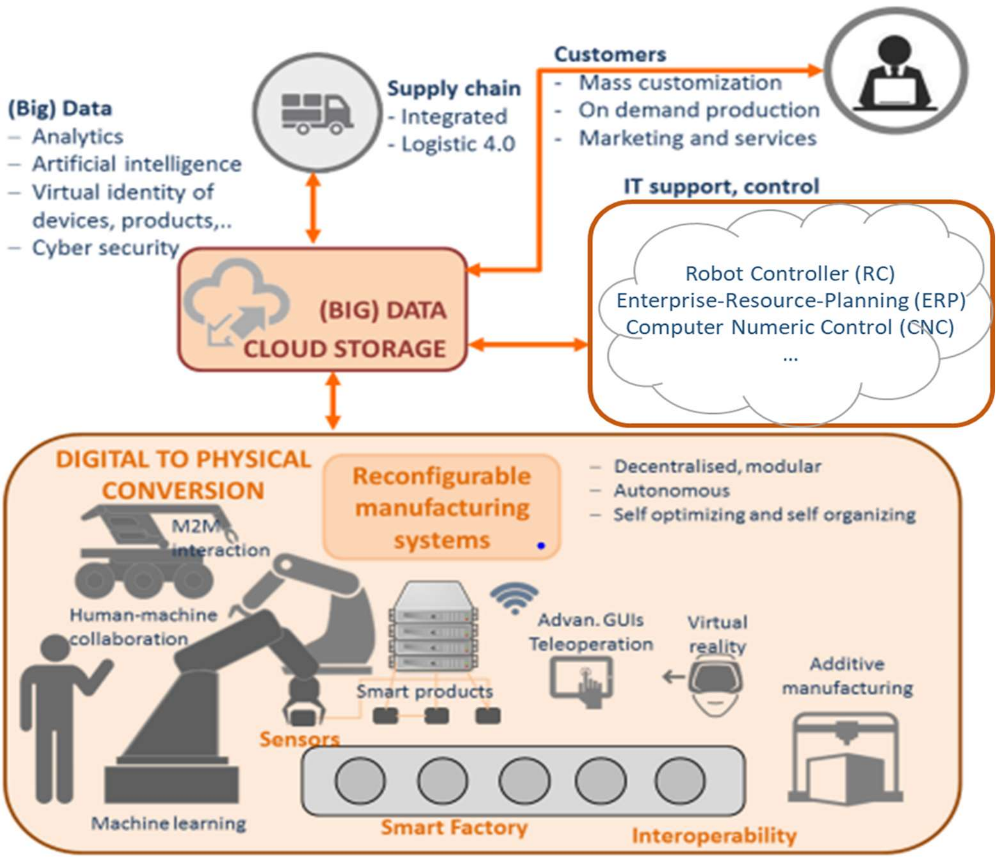
Some examples for concepts of industry 4.0 which companies could exploit are:

- Intensive use of the power of the Internet of Things
- Integration of several innovative processes in business
- Creation of a digital mapping to virtualise the real world
- Establishing smart production and products

[33] Cf. *Lasi, H.* et al., Industry 4.0, 2014., pp. 261.
[34] Cf. *Becker, M.* et al., Industrial Training, 2017, pp. 228.
[35] Cf. *Lasi, H.* et al., Industry 4.0, 2014, pp. 261.

The goal is to create such systems that would allow machines to change production models when the need arises.[36] Figure 4 attempts to illustrate Industry 4.0 by including the mentioned aspects of digital transformation. All process in a company are digitalized. The production of an Industry 4.0 company would be based on a smart factory. This means, that physical activities are replaced by machines, which are connected with each other. Part of this smart factory is the use of additive manufacturing and augmented reality solutions. But not only the Production is digitalized, even all downstream processes. Due to the integration of big data all other departments can use the digital information from the production for their own processes. The vision of industry 4.0 is that through one click, for example through the demand of the customer, all processes within a company will start automatically.[37]

Figure 4: Industry 4.0



Source: *Rojko, A.*, Industry 4.0, 2017, p.81.

[36] Cf. *Popkova, E; Ragulina, Y; Bogoviz, A.*, Industry 4.0, 2019, p. 13-18.
[37] Cf. *Rojko, A.*, Industry 4.0, 2017, pp. 80.

Following on from the first industrial revolution (mechanization), the second industrial revolution (electrification) and the third industrial revolution (computerization and automation), the fourth industrial revolution is about deeper digitization, automation and networking of production, people and value chains.[38]

2.4 Digital change in work

The fact that digitization is of high importance for industry is indisputable, but the consequences for work in industry are still unclear and not necessarily foreseeable. Almost two decades ago, the term informatization was introduced for the digital development assumed at that time. However, informatization predominantly meant the spread of the Internet of People, i. e. the connectivity between people. An Internet of Things was not part of the outlook for the next decades at that time. Nonetheless, digitization proceeded at such an enormous pace that just 10 years later it would be impossible to imagine everyday life in industrialized nations without mobile devices. This dynamic means that it is very difficult to make a forecast for the next few decades, because Industry 4.0 involves, on the one hand, high demands placed on technology and, on the other, impact on human labour.[39] It may be that newly deployed technologies in industry will lead to new opportunities for work and lead to an upgrading of work. But there is a great fear that digitization in industry could lead to polarization of skills or even to a substitution of workforce. There are already several studies that analyse the substitution potential of occupational profiles or individual activities. The results always depend strongly on the assumptions of the study and the method. Whereas one study predicts a substitution potential of approx. 40% of all occupational profiles, another study which analyses individual activities shows an automation potential of only 12%.[40] The greatest automation and thus substitution potential is often identified in activities from the manufacturing sector.[41]

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[38] Cf. *Hirsch-Kreinsen, H; Ittermann, P; Falkenberg, J.*, Digitalization in Industry, 2015, p. 36.

[39] Cf. *Hirsch-Kreinsen, H.*, Industry 4.0, 2014, pp. 31.

[40] Cf. *Kryzywdzinski, M; Jürgens, U; Pfeifer, S.*, Substitution of Work, 2015, pp. 6; *Rajnai, Z; Kocsis, I.*, Work 4.0, 2017, p. 346.

[41] Cf. *Dengler, K; Matthes, B.*, Substitution of Work, 2015, pp. 12.

Even if the development is not predictable, companies must deal with the digital transformation and the consequences for the work in the company.[42] In the following, the idea of substitution is not discussed in more detail.

For the further development of this thesis, the aspects of polarisation and upgrading will be brought more into focus. The consequences of the digital age can be seen in a variety of phenomena. For example, modern technologies make it possible for work to take place flexibly in terms of location and time, whereas in the past there was a need to perform work on site and always at the same time. However, this kind of flexibility does not apply to all employment groups. Industrial workers, who are the focus of this paper, are less affected by the change in the form of work because the fields of the employment concerned are less mobile, at least at present. In other words, it is not so much the change in the way of work that is at issue here, but rather the change in competence requirements. Nevertheless flexibility plays an important role here, too:

'*The flexibility that plants will bring in the future must also support people on the other side. I am convinced that in the future there will be greater networking of human flexibility and the flexibility that a production plant has*.'[43]

But what does this flexibility look like? Before the digital age, production facilities had individual workstations and machines that had to be operated by a human. These workstations required traditional manual tasks, such as drilling, milling, sawing, and punching. With the digital age, however, not only the products for the end customer have changed, but also the machines and processes in the factories. Complex systems are integrated in mills. Computer-controlled and smart technologies are used in modern productions, as explained in the previous chapter.[44] However, the impact on different types of activities varies. While routine and manual activities are becoming less important as they are most likely to be automated, abstract activities are becoming more and more important through the use of modern technology. [45]

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[42] Cf. *Hirsch-Kreinsen, H.*, Industry 4.0, 2014, pp.2.
[43] *Spath, D.* et al., Work 4.0, 2013, pp. 54.
[44] Cf. *Tassey, G.*, Digital Transformation, 2014. , p. 30.
[45] Cf. *Arntz, M.* et al., Changes in Professions, 2016 p. 21-27.

Table 2: Task Classification

Routine	Manual	Abstract
• Measuring, testing or quality control • Writing, correspondence or admin work • Calculating, accounting or bookkeeping • Monitoring or controlling machines, systems or technical processes • Manual activities for the manufacture or production of goods • Transporting, storing or shipping	• Repair, service or maintain • Entertain, serve or accommodate • Caring, nursing or healing • Cleaning, removing waste, or recycling • Securing, protecting or guarding	• Collecting information, research, documentation • Organizing, planning and preparing work processes • Develop, research or constructing • Computer activities, programming • Train, teach, instruct or educate • Shopping, procuring or selling • Advertise, market, publicize, public relations • Hiring personnel, instructing, controlling, evaluating employees

Source: Modelled after *Rohrbach-Schmidt, D; Tiemann, M.*, Specification, 2013, p. 227.

This shift of activities means first and foremost that the demands on employees have changed and employees in production must be qualified to meet the new conditions. For these employees, advanced technical skills, such as qualifications in information and communication technologies, but also soft skills, such as self-management and flexibility, are indispensable.[46] Figure 5 shows other competencies that are part of the new requirements profile for employees.

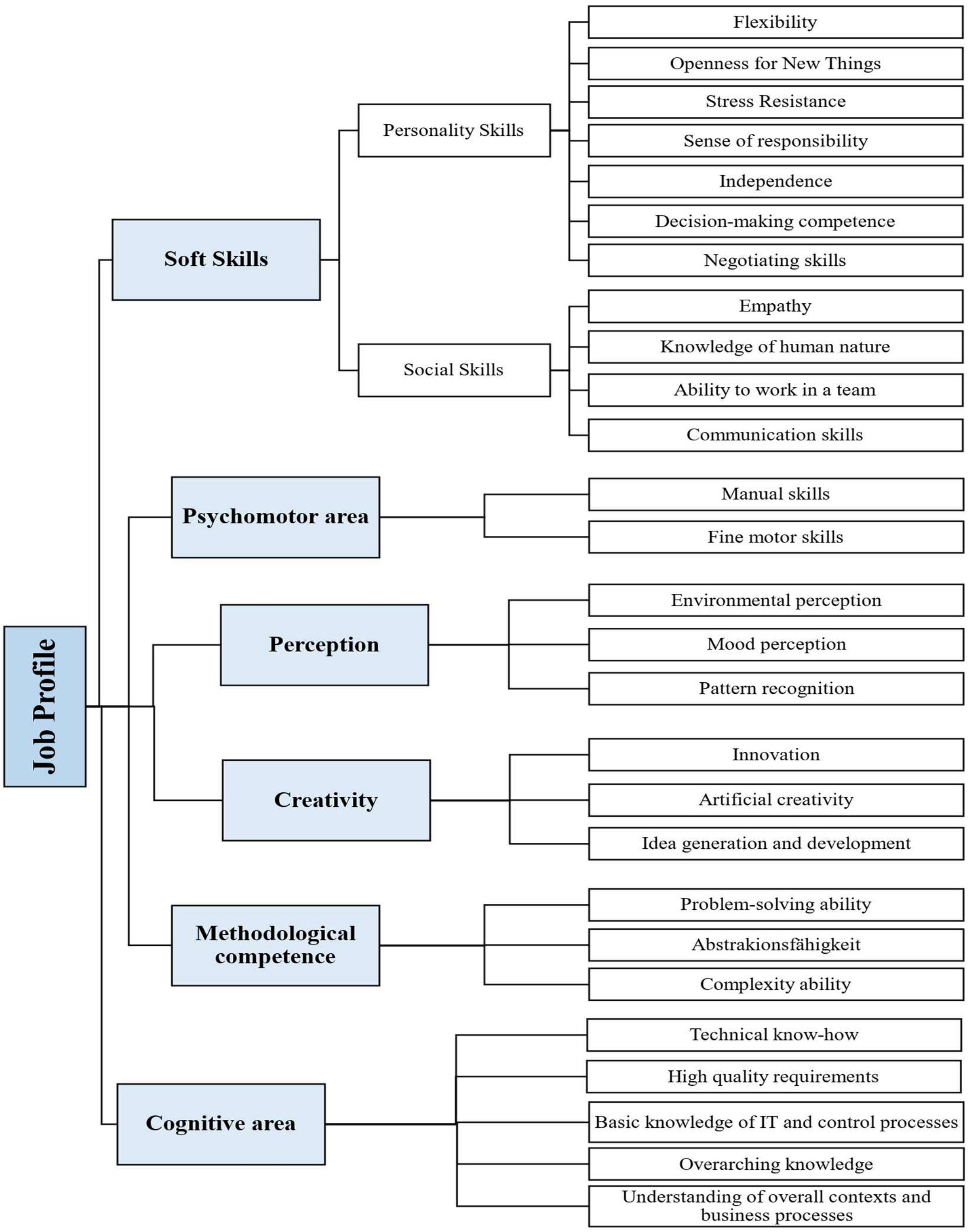
In order for companies to successfully embrace the digital transformation, qualification and continuing training offerings, both within the company and at other educational institutions, must be adapted. These adjustments should include the following points:[47]

- Intensification of scientific, technical and mathematical competencies
- Interdisciplinary training to achieve the necessary flexibility
- Regular adaptation of content and curricula
- new forms of learning, life-long learning, use of online opportunities, cooperation with educational institutions

[46] Cf. *Janssen, S.* et al., Work 4.0, 26/2018, pp. 1.
[47] Cf. *Rajnai, Z; Kocsis, I.*, Work 4.0, 2017, p. 345.

Accordingly, professional education and training plays an important role in the digital transformation. In German companies, not only existing resources are trained further, but also young professionals are also educated from the beginning. The German vocational training system is therefore explained below. In the following, the terms ‘vocational training” and ‘apprenticeship” such as ‘apprentice” and ‘trainee” are used in the same meaning.

Figure 5: Request profile



Source: Modelled after *Hermann, T.* et al., Job Specification, 2017, p. 247.

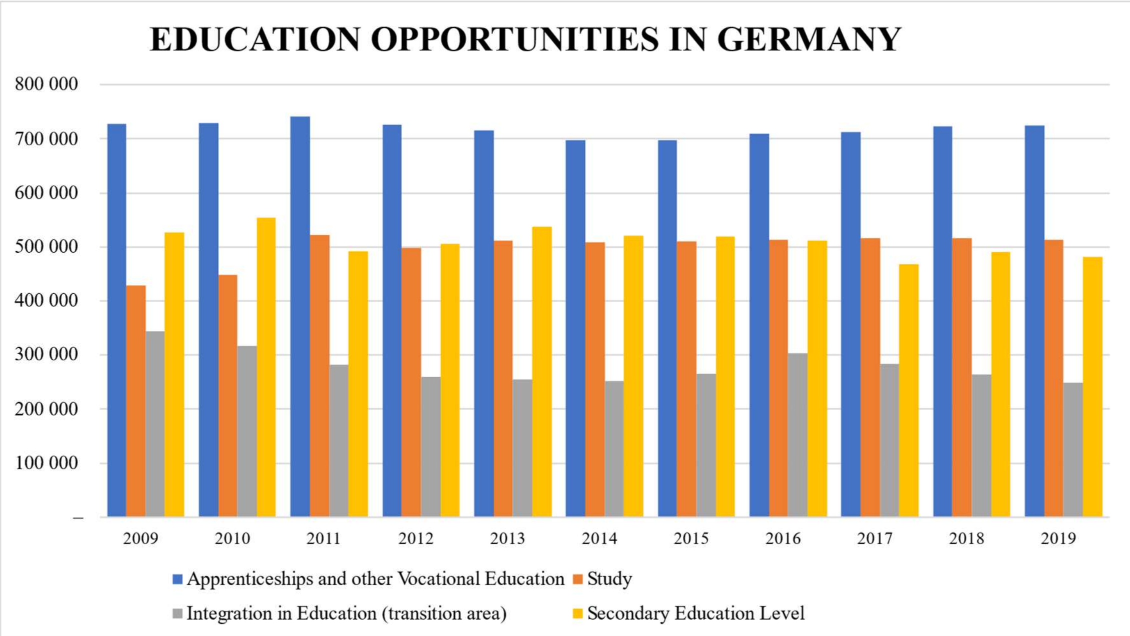
3 Apprenticeships

3.1 Vocational Training in Germany

3.1.1 Vocational Training as Education Opportunity

To understand the importance of German vocational training, the following overview could help:

Figure 6: Education Opportunities



Source: Modelled after *Statistisches Bundesamt*, Education, 2020.

The chart shows the development of educational paths in Germany in simplified form. Of the total number of Germans pursuing an educational pathway, the majority opt for apprenticeships or other vocational training. Although university entrants and those seeking a higher education entrance qualification (secondary education level) are only just behind, vocational training nevertheless plays a crucial role in the German education system. But what exactly does German vocational training look like and why is it also called dual apprenticeship?

3.1.2 Structure and Principles

Whereas the term ‘dual system’ was not introduced until the 1960s, its roots go far back to the craft trades of the 11th century.[48] The essential characteristic of dual vocational training is the duality of learning locations already contained in the name. In Germany, vocational training always takes place at several institutions: usually at a company and a vocational school. In addition to this feature, however, the consensus and occupation principles are also continuous elements of the dual vocational training system in Germany. These two principles have given Germany a kind of special position in international comparison.[49]

The **duality principle** is a historically grown construct, which was only legally anchored in 1969 with the adoption of the Vocational Training Act. The division into school and company leads to a split system with two different legal characteristics. Vocational schools, for example, are solely responsible for the organization of vocational school instruction and only have an advisory function in the vocational training committees. Thus, from the point of view of the consensus principle, they are not an equal partner of the companies. The time shares of school-based and in-company training are also unevenly distributed. On average, apprentices have to attend vocational school for about one or two days a week and spend the rest of the time in the company.[50] Nowadays, it is no longer possible to make a distinction between vocational school and the company in terms of content. On the one hand, more and more application-oriented instruction is taking place in vocational school, and on the other hand, companies are also attaching importance to a theoretical foundation in in-company training. In addition, the two learning venues of company and school have been supplemented in recent years by further educational institutions, so that even a multiple duality was created.[51]

The **consensus principle** stands for the joint responsibility of the state, employer and trade union. Even though according to the Vocational Training Act of 1969, vocational training is the responsibility of the state, the right of the social partners to have a say is laid down in the BBiG.[52] However, this right of co-determination is not specified in

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[48] Cf. *Rothe, G.*, Vocational Education, 2008, p. 4.
[49] Cf. *Eberhard, V.*, Vocational Education, 2012, p. 25.
[50] Cf. *Baethge, M.*, Vocational Training, 2008, p. 546.
[51] Cf. *Konietzka, D.*, Vocational Training, 2008, pp. 277.
[52] Cf. *Schmidt, H.*, Dual Training System, 2005, pp. 14.

concrete terms, which in purely legal terms means that the state theoretically has the sole freedom of decision, for example, to amend training regulations. However, since the involvement of industry in the form of companies and the support of the trade unions are indispensable, in the past draft training regulations were only issued if the social partners also gave their consent.[53] This procedure is often controversial because, on the one hand, it is criticized that it makes innovation procedures longer and less flexible, and on the other hand, it would make the state vulnerable to blackmail.[54] However, the experience of recent years shows that cooperation with the social partners results in all changes having both high practical relevance and acceptance.[55] Another advantage of involving the social partners lies in the fact that both access to vocational training and the offered portfolio are market-driven, i.e. controlled by the companies. This ensures that the apprenticeship is of high quality and is carried out in current and job-relevant occupational profiles.[56]

The **occupation principle** ensures that the qualifications imparted in vocational training are matching with actual occupational requirements, while the social partners can influence which occupational qualifications are currently required. This principle was also laid down in the BBiG in 1969. With the help of the occupation principle, it was enshrined in law that every apprenticeship program in the dual system must educate for an occupational job, whereby this job must be specifically defined. The consequence of this regulation was that, for the first time, a nationally regulated training regulation came into force for every apprenticeship occupation.[57] Since then, recognized training occupations may only be educated in accordance with the training regulations issued. These include the name of the training occupation, the duration of the apprenticeship (at least 2 years), how, when and which skills, knowledge and competencies are acquired and the type of examination requirements. Consequently, these vocational training curricula are the basis of the occupational principle and are at the same time an instrument for quality assurance.[58] Since the labour market is also organized according to the occupational principle, trainees can easily enter it after completion of their

[53] Cf. *Schmidt, H.*, Dual Training System, 2005, pp. 30.
[54] Cf. *Rothe, G.*, Vocational Education, 2008, p. 4..
[55] Cf. *Schmidt, H.*, Dual Training System, 2005, p. 28.
[56] Cf. *Gangl, M.*, Education, 2003, pp. 72.
[57] Cf. *Brötz, R.*, Occupational Principle, 2005, p. 10-13.
[58] Cf. *Kremer, M.*, Occupational Principle, 2005, p. 3-6.

apprenticeship. All in all, the occupational principle ensures that vocational qualifications are actually needed on the downstream labour market.[59]

When comparing the three main principles of training, it is noticeable that, on the one hand, the importance of apprenticeship in Germany is very high and, on the other hand, the adaptation of the vocational training market to the economic framework conditions have a main impact on the organization of apprenticeship.

The recognized training occupations can be classified according to certain criteria and are regularly reviewed and adjusted in the KldB 2010. Thus, each recognized vocational training is found in a so-called main occupational group. Each main occupational group is in turn assigned to an occupational segment. The occupational segments can be subdivided into occupational sectors (table 3). This classification system was developed by the Federal Employment Agency and has been valid since January 01, 2011. It serves to better classify the occupational structures in Germany and is compatible with the international occupational classification ISCO-08[60].[61]

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[59] Cf. *Müller, W; Shavit, Y.*, Education, 1998, pp. 501.
[60] Cf. *Ganzeboom, H.*, Occupation Classification, 2010.
[61] Cf. *Bundesagentur für Arbeit*, Classification of Occupations, 2010.

Table 3: Training Occupations

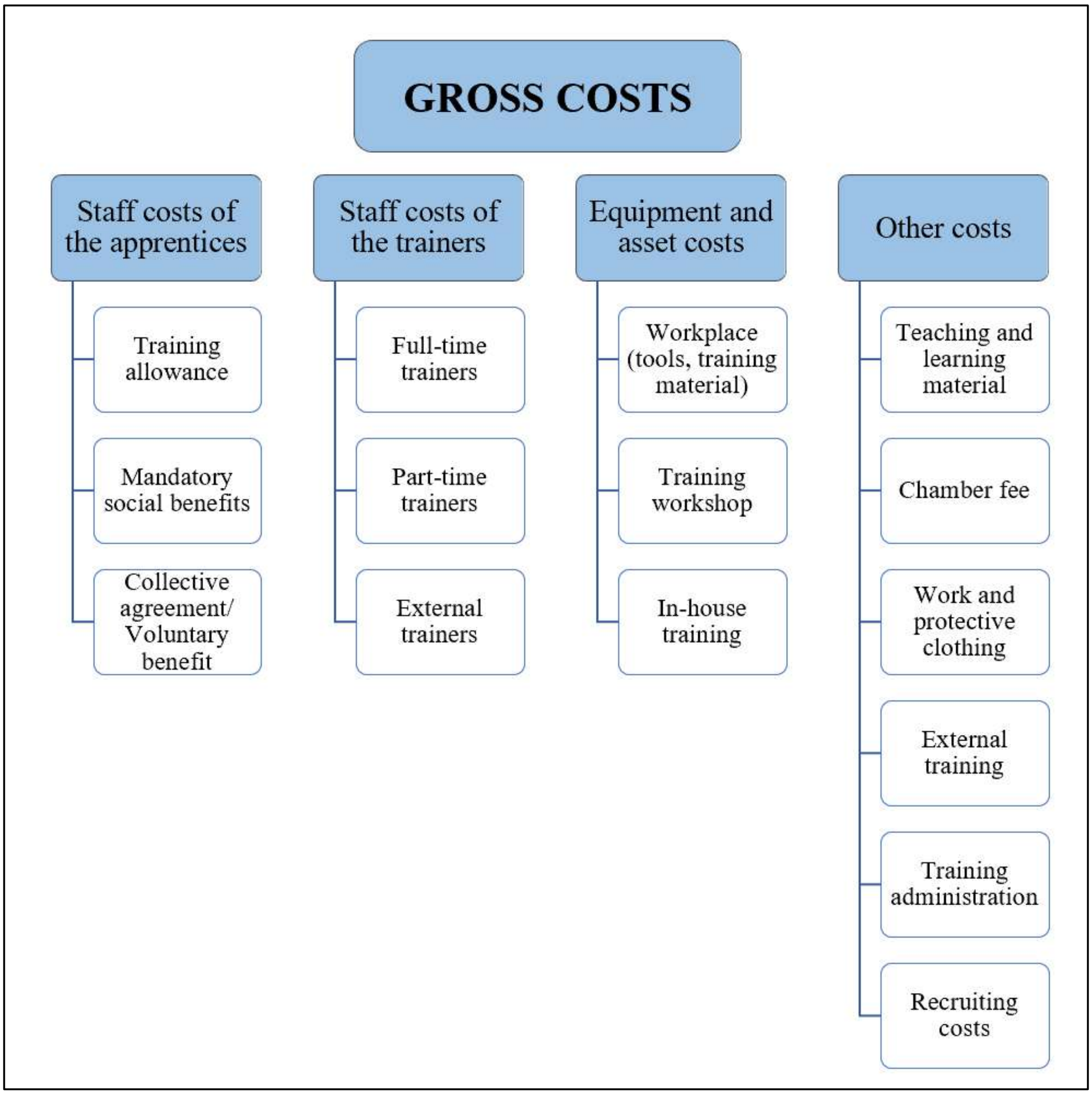
Sector	Title of Occupational Sector	Seg-ment	Titel of Occupational Segment	Main Group	Title of Main Occupational Group
S1	Production Occupations	S11	Agriculture, forestry and horticulture professions	11	Agriculture, animal husbandry and forestry occupations
				12	Horticulture and floriculture
		S12	Manufacturing occupations	21	Raw material extraction and processing, glass and ceramics production and processing
				22	Plastics manufacturing and processing, woodworking and wood processing
				23	Paper and printing professions, technical media design
				24	Metal production and processing, metal construction occupations
				28	Textile and leather professions
				93	Product design and arts and crafts professions, fine arts, musical instrument making
		S13	Technical manufacturing occupations	25	Mechanical and automotive engineering occupations
				26	Mechatronics, energy and electrical occupations
				27	Technical research, development, construction and production control occupations
		S14	Construction and finishing occupations	31	Construction planning, architecture and surveying professions
				32	Building construction and civil engineering occupations
				33	(Interior) finishing occupations
				34	Building and utility engineering occupations
S2	Person-related Service occupations	S21	Food and hospitality professions	29	Food production and processing
				63	Tourism, hotel and restaurant occupations
		S22	Medical and non-medical health professions	81	Medical health professions
				82	Non-medical health, personal care and wellness occupations, medical technology
		S23	Social and cultural service occupations	83	Education, social and domestic professions, theology
				84	Teaching and training professions
				91	Language, literature, humanities, social sciences and business professions
				94	Performing and entertainment professions
S3	Commercial and business-related service occupations	S31	Commercial occupations	61	Purchasing, sales and commercial occupations
				62	Sales occupations
		S32	Business management and organization occupations	71	Professions in business management and organization
		S33	Business-related service occupations	72	Professions in financial services, accounting and tax consultancy
				73	Professions in law and administration
				92	Advertising, marketing, commercial and editorial media occupations
S4	IT and scientific service occupations	S41	IT and scientific service occupations	41	Mathematics, biology, chemistry and physics professions
				42	Geology, geography and environmental protection occupations
				43	Computer science, information and communication technology occupations
S5	Other economic service occupations	S51	Security occupations	53	Protection, security and surveillance occupations
				01	Members of the regular armed forces
		S52	Transport and logistics occupations	51	Transport and logistics occupations (except vehicle driving)
				52	Vehicle and transport equipment operators
		S53	Cleaning occupations	54	Cleaning occupations

Source: Modelled after *Bundesagentur für Arbeit*, Classification of Occupations, 2010.

3.1.3 Added Value of Vocational Training

The German dual vocational training system is thus a long-standing structured system, which, however, is also associated with a high monetary cost for the companies. In the past, several cost-benefit analyses have been conducted on this topic. The costs incurred for vocational training can be divided into four different types of costs (figure 6).

Figure 7: Gross Costs of Vocational Training



Source: Modelled after *Beicht, U; Krekel, E. M; Walde, G.*, Costs, 2004, pp. 39.

A large proportion of the costs are attributable to apprentice salaries and training personnel. The costs incurred are heavily dependent on the size of the company and the associated number of trainees, as well as on the occupations for which training is provided.[62]

However, the costs incurred are also countered by earnings. A distinction is made between three types of benefit:

[62] Cf. *Pfeifer, H; Schönfeld, G; Wenzelmann, F.*, Added Value, 2010, pp. 13.

- Benefits from the apprentice: Productive output of trainees who are deployed in production, for example, and perform there.
- Benefits from the apprenticeship: Increased attractiveness for external stake holders, public image enhancement and added value for continuing education by dealing with apprenticeship issues.
- Benefits of permanent employment after apprenticeship: avoidance of recruitment costs, reduced learning times in production, savings in downtime costs due to lack of skilled workers, avoidance of staff shortages.

The level of returns, especially in terms of personnel recruitment, again depends strongly on the size of the company and the sector in which it operates. Overall, however, there is a financial benefit when the earnings are compared with the costs of vocational training.[63]

Looking at all apprentices in Germany, the following calculation per apprenticeship and year can be made for 2015:

Table 4: Cost Calculation

- Gross costs	-	17,933 €
+ Income		12,535 €
= Net costs	-	**5,398 €**
Net costs	-	**5,398 €**
+ Recruitment costs		8,715 €
= Total costs		**3,317 €**

Source: Modelled after *Jansen, A.* et al., Costs Calculation, 2015, pp. 6.

In addition to the cost-benefit aspect, there are other advantages and benefits of in-house training. As part of a study by BIBB, companies were asked why they provide vocational training:[64]

- Qualifying junior staff in line with company requirements
- Avoiding personnel fluctuation
- Securing the next generation of skilled workers in the region
- Training is a company tradition

[63] Cf. *Pfeifer, H; Schönfeld, G; Wenzelmann, F.*, Added Value, 2010, p. 15-17.
[64] Cf. *Wenzelmann, F.* et al., Industrial Training, 2009, pp. 9.

The added value of vocational training results in high importance of apprenticeship programs for Germany. As already mentioned in chapter 3.1.1. it is one main instruments to educate new workforce. Therefore it necessary to improve and adapt consequently the occupational trainings. The digital transformation with industry 4.0, Internet of Things, etc. inevitably have an impact on all training occupations. However, it is not possible within the scope of this work to examine the change in all training occupations. For this reason, the segments manufacturing occupations and technical manufacturing occupations from the first occupational sector 'production occupations' are discussed in more detail within the empirical research.

3.1.4 Industrial Apprenticeship in Germany

The occupational sector of production occupations plays the most important role for this study, because this sector mainly includes typical industrial and commercial occupations, which represent a large proportion of all newly concluded contracts (figure 7). The digital transformation in industry have thus always had an impact on vocational training in the sectors concerned.

Industrial-technical vocational training in Germany took on the current structure since the first industrial revolution. Certain pre-industrial conditions and the relatively late timing of the first industrial revolution resulted in a very dominant form of industrial-technical training.[65]

Since mass production was predominantly in demand during this first industrial revolution, the demands on skilled workers were not particularly high. This led to the circumstance that the training periods were very short, or not required at all. In specialized areas, however, a certain amount of vocational training with new qualified work tasks became established. The electrical and chemical industries in particular relied more on qualified workers than on rationalization and mass production. The specific need for skilled workers that arose here could no longer be met by simple craft training. Companies therefore started to create their own education programs, which were detached from the traditional craft occupational profiles.[66]

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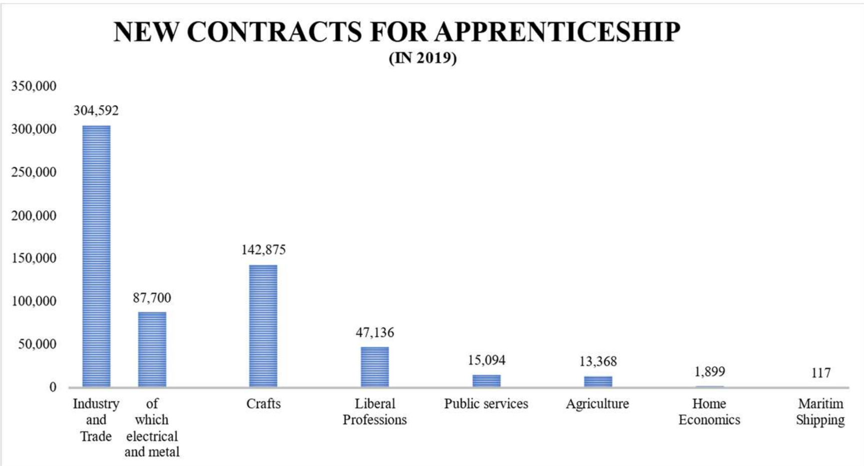
[65] Cf. *Kocka, J.*, Industrial Training, 1987.
[66] Cf. *Behr, M.* von, Industrial Workshop, 1981, pp. 11.

Since these new types of occupations were initially taught rather randomly and without structure, they were standardized and given orderly structures. The new occupations were setup in a completely new, production-related and arbitrary way without the involvement of tradition and culture.[67] The industrial-technical training occupations as we know them today are all a kind of product of

1. training occupations that were relevant in the past,
2. the changes in industries and
3. the associated demands on the labour market.

If the job description of today's industrial mechanic would be taken and traced back historically to its beginnings, the finding would be that although the training occupation was first officially offered by the Chamber of Industry and Commerce in 1987, it is made up of many pre-existing training occupations. A large number of locksmith occupations, the precision mechanic, the metal fabric maker and the system maker rifle were integrated into the training occupation of the industrial mechanic. All the mentioned occupational profiles already existed from around 1935.[68]

Figure 8: New Contracts for Apprenticeship



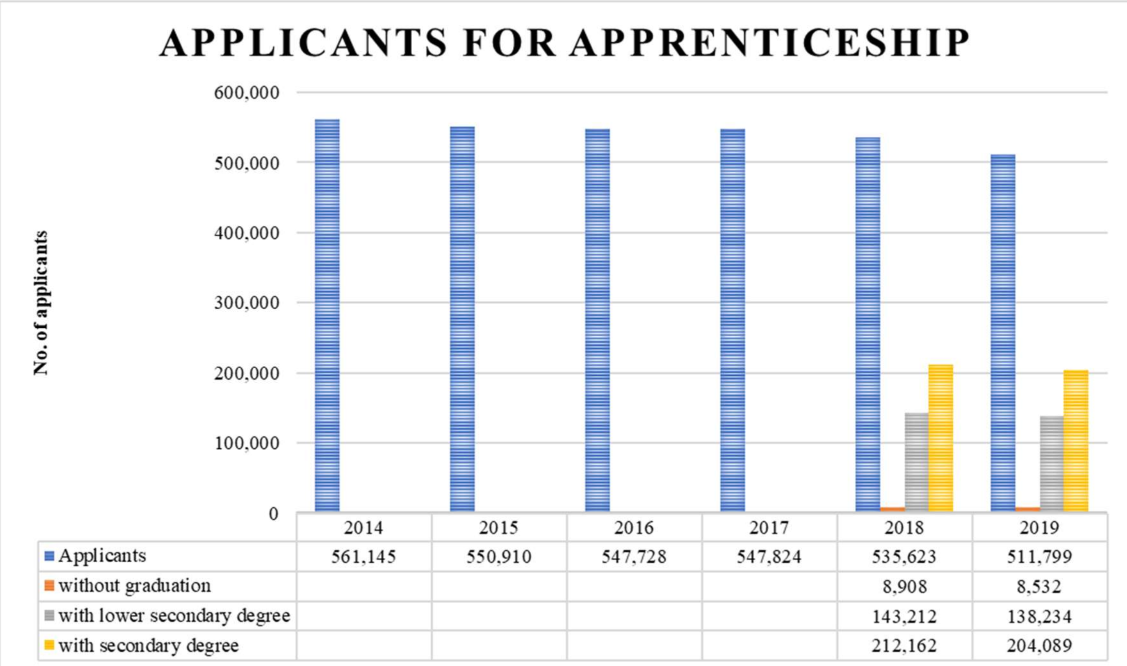
Source: Modelled after *Bundesministerium für Bildung und Forschung*, Education, 2019, p. 34 and *Gesamtmetall*, Contract for Apprenticeship, 2020, p. 27.

[67] Cf. *Hesse, H. A.*, Change in Professions, 1972, n.p.
[68] Cf. *Ehrenberg-Silies, S.* et al., Qualification and Occupation, 2017.

As already described in the previous chapter, the current industrial revolution of digital transformation is also having an impact on the development of apprenticeship occupations. Since electrical and metalworking occupations account for around 25% of the entire industrial sector (figure 8), the focus of this paper is specifically on these occupational groups. These include occupations such as electronics technician and industrial mechanic.[69] Nevertheless, related occupational profiles are also examined in the following.

Even if the share of industrial apprenticeships is still significant today, a decline in the number of applicants has already been noted in recent years. This is not necessarily due to typical industrial occupations as such. Figure 9 shows, on the other hand, that around 24,000 fewer people applied in 2019 for an apprenticeship than in the previous year, and more than half of these are applicants with a secondary degree certificate or lower. This means that there is a decline in the number of applicants in the target group that is typical for industrial training.

Figure 9: Applicants for Apprenticeship



Source: Modelled after *Bundesministerium für Bildung und Forschung*, Education, 2019, pp. 20.

[69] Cf. *ausbildung-me.de*, Training Occupations, 2021.

Digitization and its positive effects in terms of attractiveness for younger generations could lead into an increase of applicants for the mentioned training occupations.

Before delving further into the consequences of the digital transformation in vocational education and training, some foreign vocational education and training models are summarized below as a brief excurses for a completed picture in terms of apprenticeships.

3.2 International Apprenticeship

Various kinds of vocational training also exist abroad. Our neighbouring countries Austria, Switzerland and Denmark, for example, have a dual training system as well. These differ only slightly in some aspects, such as the duration of training, the way of duality and the embedding in the overall system.[70] In other countries, vocational training is based on completely different principles. Some examples of vocational training systems in Sweden, France, UK, the USA and China are briefly described below. These four vocational training systems are interesting because they differ from the German vocational training system in many respects, but also from each other. The systems described below can be found in several countries, sometimes in modified variations.

3.2.1 Sweden

In Sweden, initial vocational training takes place primarily in school-based institutions. After 9 years of basic education, students can choose between 18 different continuing education programs. Out of these, 12 are vocational training programs. All programs last three years, with about 15 weeks of in-company training. Responsibility for vocational training is therefore in the hands of the state, which means that companies have little influence on course content, for example. Overall, almost 50 % of students choose one of the vocational programs. Nevertheless, the value of vocational training is lower than that of academic degrees. However, the latest reforms in Sweden are intended, among other things, to increase the attractiveness of training and to modernize it in terms of digitalization.[71]

[70] Cf. *Ebner, C.*, International Vocational Training, 2013, pp. 58.
[71] Cf. *Kuczera, M; Jeon, S.*, Vocational Training Sweden, 2019, p. 17-21.

3.2.2 France

In France there are also possibilities for vocational education. After the 9th grade, students have the option of taking a general or technical baccalaureate or attending a vocational school for two years. In the vocational school, general subjects are offered on the one hand and specialization subjects on the other. The specialization subjects usually cover industry, commerce or services. However, this does not include any practical in-company practice. After vocational school, graduates either enter the free labour market or continue for another two years for a 'Baccalauréat Professionnel', after which they can go to a university. After the baccalaureate, students can also choose a two-year vocational training pathway. It is not necessarily a dual-track course, rather it is a school-based programme. Here, many practical skills are taught so that students can start their professional career after receiving their diplom 'Brevet Technicien Supérieur'.[72]

3.2.3 UK

The English vocational training is structured in modules. There are thus no fixed occupational profiles that are taught, but rather individually combinable modules that are certified. Since this type of modularisation is also used for adult education, there is no clear separation between initial and further vocational education. This VET system is supervised by the Ministry of Education and Economy and is consequently organised by the state. However, in addition to public vocational training institutions, there are also private education suppliers, so-called 'Training Providers'. In addition to more theoretical vocational training programmes, there are also dual apprenticeships, which are comparable to the German system. The organisational and content framework for such apprenticeship programmes is developed by employer-led institutions, so-called 'Sector Skills Councils and Bodies', in cooperation with companies. Overall, vocational education has a lower status than academic education. Despite the availability of many attractive VET programmes, vocational education and training is still perceived as second-class education.[73]

[72] Cf. *Lamb, S.*, Vocational Training France, 2008, pp. 24.
[73] Cf. *Blöchle, Sara-Julia, Flake, Regina* et al., Vocational Education, 2015, pp. 30.

3.2.4 USA

In the USA, vocational training is either theoretical or practical. In high school, students have the opportunity to pursue a vocational track. For this purpose, either vocational courses are offered in high school or the students switch to a special technical high school that specializes in corresponding vocational fields. High school graduates can then go on to a community college or a technical college. The content taught there prepares students either for further academic training or for entry into the labour market. Both the community college and the technical college cannot be compared one-to-one with a German educational institution. The concept of the adult education center[74] comes closest. Theoretical vocational training in the USA is not the responsibility of state authorities, but is a federal or even local matter. As a result, colleges do not teach a unified curriculum. In-company dual vocational training rarely exists. The alternative to theoretical vocational training is to join directly a company. This path, however, no longer falls under vocational training, since the focus here is on rapid onboarding. Workers are more likely to complete on-the-job training than in-depth and structured education. The digital transformation in the USA is currently leading to some new paths for vocational training. Among others, efforts are being made to promote apprenticeship programs that are similar to the German system in order to combine theoretical education more closely with company practice.[75]

3.2.5 China

The education system in China is structured similarly to that in the USA. However, some of the vocational training begins already in secondary school. Here, farmers or lower skilled workers, who are released directly onto the free labour market after finishing school, are often educated. From the higher levels onward, students can attend various vocational high schools, specialized or technical schools, where theoretical vocational content is taught. Subsequently, graduates have the option of either entering the free labour market or transferring to a higher technical college. The practical components are very short during the school-based training and usually amount to an assignment of a few weeks in a company. Unlike in the USA, the education system in China is controlled and

[74] Adult education center = Volkshochschule

[75] Cf. *Barabasch, A; Rauner, F.*, Education USA, 2012, pp. 78.

coordinated by the authorities. Various ministries and departments are involved. However, the digital transformation is missing in Chinese vocational education, so some reforms have been renewed as well.[76]

The following table (table 5) summarize the main categories of vocational training for the mentioned countries:

Table 5: International Comparison

Category	Sweden	France	UK	USA	China
Predominant VET structure	school-based, only 15 weeks in-company training	school-based,	school based, only low level of dual track training	school-based, some new trends due to digitization	school-based, only short practical training
Attractiveness of VET	avarage	low, acadamic education is more popular	low, 2nd class education	avarage	low to avarage
Responsibility of	state authorities	state authorities	state authorities and private insitutions	federal or local	state authorities
Company commitment	low due to short practical training	low, only in correspending apprenitceship programs	low, only in correspending apprenitceship programs	low, only in correspending apprenitceship programs	low due to short practical training

Source: Own creation.

[76] Cf. *Steward, V.*, Vocational Training China, 2015, p. 14-17.

4 Emperical Research on Digitale Change in Apprenticeship

Consequently, the digital transformation also has an impact on foreign education systems. The Industry 4.0 phenomenon comes along with a high-level technical-productive transformation.

The general consequences of the digital transformation have already been explained in chapter 2.1.1. As the past has shown, technological transformation processes have always had consequences for the associated human work. This is particularly significant in the German-speaking world, where occupational work has become established, i.e. a high-quality form of work implementation, which in turn is coupled with equally high-quality forms of qualification. The institutions of vocational training in particular are currently facing questions as to what reactions will be required on their part, or what anticipations would currently be relevant in order to productively shape implementation of Industry 4.0.[77]

As explained in Chapter 3.1, German vocational training is based on the occupation principle. Due to the coupling between the job title from the training and the job title on the labour market, job-specific competencies must also be added to the training occupations as part of the digital transformation.[78] Changes in vocational training can, as already described, take place on the one hand via new training curricula and on the other hand be initiated internally within the company and within the framework of the legal requirements.[79]

4.1 State of Research

The embedding of digital applications in industrial production processes is already bringing enormous changes. In the past, technological automation processes have already led to an inevitable change in the associated human work. The digital transformation of industry is particularly significant in Germany, where the focus is on occupational work. It is therefore common for a high-quality form of occupation to be linked to an equally high-quality concept of qualification. For this reason, it will be necessary for German vocational training to develop a new concept in order to be able

[77] Cf. *Tenberg, R; Pittich, D.*, Future of Training, 2017, p. 28.
[78] Cf. *Matthes, B.* et al., Work 4.0, 2019, p. 19-21.
[79] Cf. *Zinke, G; Padur, T.*, Future of Training, 2015, p.47.

to productively shape the vocational implementation of Industry 4.0. One of many questions for the institution of vocational training is whether further development of the current training system will be sufficient or whether a completely new concept will be required.[80]

4.1.1 First adjustments to the apprenticeship regulations

In 2004, against the backdrop of Industry 4.0, the first changes were made in the training curricula for five industrial metalworking occupations in total, including industrial mechanic. A reorganization came into force that enables the flexible deployment of skilled workers within companies as well as their professional mobility between occupations, companies, sectors and branches of the metal industry by no longer selecting a specialization but an area of deployment. The result of this change is that common core qualifications are taught during the education period. In addition, the vocational training is geared to operational focal points in the areas of operation of the company, with job-specific qualification requirements coming to the fore (e.g. quality management, customer orientation, use of English technical terms). Overall, both vocational school and the final examination have been made more practical. These reorganizations were triggered not only by the growing range of different products and the use of increasingly diverse technologies, but also by the permanent changes to in organizations. These constantly changing processes require a flexible workforce that can adapt quickly and respond to the needs of a wide variety of customers. After the apprenticeship, therefore, not only broad professional expertise, but also flexibility, teamwork, motivation, quality awareness, language skills and customer orientation are relevant for successful employment within the company and on the labour market.[81]

4.1.2 Project 'Digitization of the World of Work'[82]

In 2015, BIBB and Volkswagen AG launched the 'Digitalization of the world of work' project. The progressive digitization of work is particularly noticeable in the automotive industry and is prototypical for the changes in the job profiles and requirements of skilled workers in the mechanical and plant engineering sector. The aim of the project

[80] Cf. *Tenberg, R; Pittich, D.*, Future of Training, 2017, p. 28.
[81] Cf. *BIBB- Bundesinstitut für Berufsbildung*, Amendment, 2004.
[82] Cf. *Zinke, G.* et al., Future of Training, 187/2017, p. 25.49.

was to record work tasks and activity profiles in the areas of maintenance and service of production systems and to compare these with vocational training profiles. The results were used to identify consequences for the design of apprenticeship within the framework of existing occupations or also for the creation of new occupations. The results of this investigation are divided into various thematic blocks as follows:

- Changed jobs and work tasks:
  The study shows that maintenance in particular is becoming increasingly dependent on IT support. Maintenance teams no longer perform exclusively operational activities, but also participate in strategic decisions. This does not involve a merger of jobs, but rather an expansion of the scope of tasks. It is also obvious that work is much more frequently carried out across departments in order to be able to deal with incidents quickly. In addition, mechanical activities are becoming less important and are being replaced by analysis and reconciliation activities. This development results in higher efficiency, which causes reduction of costs.
- Increasing importance of system understanding and fault diagnosis:
  Against the backdrop of Industry 4.0, a comprehensive understanding of systems is one of the core competencies of maintenance staff. The more precise and detailed the intend holder's knowledge of the systems, the faster faults can be rectified or even prevented.
- New activity profile:
  The job profile should include the following activities in addition to the usual requirements:
    - IT-supported fault diagnosis
    - Testing of interfaces and components
    - Model network structures
    - Capture and manage operational data
    - Create visualization aids
    - Installing IT hardware
    - Apply digital control technology
    - Use technical information systems
    - Use IT-protected documentation systems
    - Interdepartmental coordination, instruction of auxiliary staff

Following the analysis of the workplace, the new requirements were compared with the currently existing training occupations. This revealed that the required job profile did not correspond in this form to any of the recognized training occupations. This led to a discussion about how to ensure a supply of skilled workers in the areas which were analysed. The fitting problem that arose here was examined in more detail. Three main aspects emerged:

1. The problem of fit exists in relation to competencies that are not sufficiently taught in the training framework (e.g. using robotics or network technologies) and in relation to competencies that require fundamentally different approaches to problem solving (e.g. handling Big Data, changed troubleshooting).
2. Required core competencies are part of the training plan, but do not take up the necessary space in the company's training design (e.g. additive manufacturing)
3. Some qualifications taught are outdated and no longer relevant for practice (e.g. technical drawing)

4.1.3 New requirements for industrial apprenticeships[83]

In 2017, four additional apprenticeship occupations were then examined in terms of their digital transformation: Mechatronics technician, industrial mechanic, IT specialist for system integration and technical product designer.

An expert-based foresight approach was used to determine the future competence requirements. The results showed that although the content of the occupational profiles will continue to develop, there is unlikely to be any splitting off of occupational profiles. This assumption is supported by the fact that training regulations and framework curricula allow plenty of room for company-specific emphases without jeopardizing the regular framework. In addition, the training regulations and framework curricula are set up neutrally as far as concrete technologies are concerned. This means that new technologies, such as 3D printing and additive manufacturing, can be more easily incorporated by training departments. Across all four occupational profiles, the following competencies were identified as necessary for the digital future:

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[83] Cf. *Ehrenberg-Silies, S.* et al., Qualification and Occupation, 2017.

1. Knowledge of production processes, operations, market and customers: As digital transformation makes more and more analysable machine data available, it will be necessary in the future to learn how to use suitable tools for process optimization and analysis. In the future, it will also become increasingly important for IT specialists and technical product designers to deal with the analysis and optimization of production processes
2. Overview competence: The focus is on the basic understanding of the entire value-added process. This includes cooperation with other companies during product development as well as customer service after the product has been sold
3. Interdisciplinary competence: as the entire production process is much more interconnected than in the past due to digitization, solutions to problems must also be worked out across the training sector
4. Development expertise: In the course of digitization, product development will be more and more data-based and will take place in highly iterative development cycles, so that even professions that are not involved in development will be increasingly integrated into upstream processes
5. Information management: Information management means the ability to draw conclusions from data. In the course of digitization, data is generated at every step in the manufacturing process and also during use by the customer. This relevant information must be generated in the respective context of use
6. Communication skills: Communication skills and capabilities will be more and more important both inside and outside the company. This includes, for example, multilingualism and intercultural competencies

In addition to these overarching competencies, each of the mentioned job profiles is characterized by specific requirements. However, these are often the manual skills of the respective occupation, which are important regardless of digitization. This suggests that the scope of competencies is in the course of the digital transformation and that new skills are not completely replacing old ones. Nevertheless, certain content is very likely to become less important.

4.1.4 Latest Legal Developments

In 2018, these competencies and qualification profiles for metalworking and electrical occupations were formalized by law. The principles which were described in chapter 3.1 made it possible to incorporate new requirements and content into the vocational training regulations, which came into force on 1st August 2018. The Federal Institute for Vocational Education and Training (BIBB), together with the social partners Gesamtmetall, VDMA, ZVEI and IG Metall and experts from companies, adapted training regulations to new challenges. Digitization, data protection and information security became fixed elements of apprenticeship. Companies also have the option to select suitable additional qualifications for their trainees in order to develop specific skills for the digital transformation.[84]

A total of 11 professions were affected by the changes:

- Industrial electrical occupations
  - Electronics technician* for automation technology
  - Electronics technician* for operating technology
  - Electronics technician* for building and infrastructure systems
  - Electronics technician* for devices and systems
  - Electronics technician* for information and systems technology
- Industrial metal professions
  - Plant mechanic*
  - Industrial mechanic*
  - Construction Mechanic*
  - Toolmaker*
  - Machinist*

Specifically, some core qualifications have been deleted from the vocational training curricula and were replaced by new core competencies. For example, in the case of industrial electrical occupations, the relevance of equipment and diagnostic systems has been included under item 7 'Planning and organizing work, evaluating work results'. In the case of mechatronics technicians, on the other hand, the handling of computer equipment has been exchanged for the handling of IT systems. Industrial metalworkers

[84] Cf. *Schölgens, C.*, Amendment, 2018.

can acquire additional qualification of systems integration. This includes, on the one hand, the analysis of technical orders and the development of suitable solutions and, on the other hand, the installation and commissioning of cyber-physical systems. Furthermore, apprentices have the opportunity to choose various other additional qualifications for digitalization and Industry 4.0. These include modules such as ‘additive manufacturing’ or ‘digital networking’.[85] A complete overview of all changes in the curricula can be found in the appendix.[86]

4.1.5 Apprentices shape the future

In contrast to the company perspective, which has the aim of need-oriented training and the efficient use of apprentices, the organization WorldSkills Germany offers young people the opportunity to develop their visions of education and work in the future and to present these visions to the public within the scope of a competition. This platform is named ‘Digital Youngster’.

The results of the national competition in 2018 showed that apprentices are focusing on people rather than more efficient production for the future. While they also recognize digital transformation as an important driver, they see the effect of digitization in changing vocational training for the benefit of the people concerned.[87]

The final winner was the CANCOM team. They developed an ‘AI Education Cloud’ that can be used independently of time and hardware for efficient teamwork. The integrated artificial intelligence ensures that users can be individually supported by analysing learning behaviour. The cloud solution also enables consistent quality of training across all German regions. The AI-supported efficient time management results in more content being taught in less time.[88]

The future of the world of work is overall characterised by young people as follows:

- School and the workplace will become a virtual space
- Robots, digital education and work-life balance form a common thread
- School and the examinations system are moving into the background

[85] Cf. *Schwarz, A.*, Industrial Training, 2018.
[86] Cf. Appendix 2.
[87] Cf. *Dietl, S. F; Hennecke, M.*, Training 4.0, 2019, pp. 69-71.
[88] Cf. *Dietl, S. F; Hennecke, M.*, Training 4.0, 2019, p. 73.

- Theoretical skills are taught via cloud
- The goal of classroom teaching is to deal with special learning situations
- Not knowing everything, but knowing where to find it
- Virtual collaborative project development
- Solution finding in groups for project community, not for big profit
- High qualification requirements will increase
- Machines will take responsibility for production, maintenance, and retooling; humans will only be on site in special cases.
- Automation will advance, but skilled workers will still be needed
- Alignment with people's social needs

Integrating young professionals into the shaping of the digital future thus opens up new perspectives and portals, which can lead to the company's strategies and visions being adapted and refined.[89]

4.2 Research Questions and Assumptions

4.2.1 Research Questions

Consequently, a great deal of research has already been conducted on the topic of change in vocational training over the past few years, and concrete guidelines have also been enshrined in law and recommendations for action have been issued. However, the question remains open how vocational training departments make use of digital change in apprenticeship in concrete terms. Have the amendments to the vocational training frameworks been sufficient? Do requirements for apprenticeship match requirements from companies? What are the challenges in the digital transformation in vocational training? How does the future of dual apprenticeship look like?

In order to cover all relevant aspects of digitization in the commercial industry, the research question on this empirical study is as follows:

[89] Cf. *Dietl, S. F; Hennecke, M.*, Training 4.0, 2019, pp. 75.

'How has industrial-technical vocational training in selected industrial companies changed against the backdrop of the digital transformation and what consequences will digital transformation have for industrial-technical vocational training in Germany in the future?'

4.2.2 Assumptions

Based on the developments which were described in the previous chapters, it is reasonable to assume that vocational training education is strongly affected by digital transformation. Since it is essential for companies to qualify all employees for new requirements, there is likely to be a strong focus on digital skills in apprenticeship. Assuming that the changes in qualifications and competence profiles elaborated in chapters 4.1.2 and 4.1.3 have occurred, the training departments would already have adapted the training content accordingly. The topic of IT, interdisciplinary competences and typical 4.0 qualifications should then be integrated systematically into the relevant occupational profiles.

The degree of digitization is probably related to many factors. If the company is transforming rather slowly, the degree of digitization is probably also rather low. If it is an innovation-driven company, the training department should also be structured accordingly. Since the degree of innovation in companies is often related to the production lifecycle of products[90], it can be assumed that the degree of digitization also depends on the industry sector. The automotive industry, for example, is developing more quickly in the direction of digital training than the steel industry. However, a certain standard of digitization is likely to be found in companies that educate metal and electrical occupations, as otherwise the requirements of the renewed vocational training curricula could not be met. In this context, due to the consensus principle of dual vocational training, it cannot be assumed that companies were passed over when the curricula were amended. Otherwise, inappropriate changes would probably have already been discarded since 2018.

With regard to the investments that would have to be made for digital transformation, it is also possible that some companies may have difficulties in acquiring modern

[90] Cf. *Hanschke, I.*, Digital Tranformation, 2018, p. 27.

equipment on this point. In addition, acceptance within the workforce could also be a challenge in some traditional companies.

Based on the assumption that a digital standard already exists in vocational training departments, the education system and the associated institutions will presumably continue to develop in the direction of digital transformation or Industry 4.0 in the future. At this point it should be verified if digital transformation has a positive effect on the attractiveness of vocational training.

Moreover there could be the development, that apprentices themselves will be more integrated into the designing process of vocational training, as mentioned in chapter 4.1.4.

4.3 Empirical Research through interviews

In order to obtain a detailed and extensive statement on all relevant aspects to prove the assumptions, qualitative research in terms of expert interviews is a suitable approach. The advantage of this empirical survey is that the actual reality can be represented and processed due to the subjectivity and degree of freedom of the interview partners.

4.3.1 Interview guide

The interview guide used for the interviews is based on the findings of the previous chapters. In addition, further questions were included which, on the one hand, cannot be answered in the literature and, on the other hand, concern future forecasts. Since dual vocational training is a purely German system, the interviews were also conducted in German. The German-language interview guide including the control questions can be found in the appendix.[91]

Table 6: Interview Guide

Guiding Questions	Link to
Can you briefly explain in which company you work and what function do you have?	• Background information
Which job profiles are required in your company and which apprenticeships do you offer?	• Background information

[91] Cf. Appendix 3.

How certain job profiles in your company have changed against the backdrop of Industry 4.0 or digitalization?	• Digitalization and Industry 4.0 • Matching problem between training framework and required qualification • Investigation 2017
To what extent are the training professions affected by the digital transformation?	• see above
Were there specific changes to the training frameworks and were these changes noticeable or helpful?	• Adjustment of training framework in 2004 and 2018
How much influence could and can you exert in adapting the training regulations?	• Structure of dual education • Principles of training
What did your company to adapt the training? Were these individual measures or was it more of a project?	• Research question
What problems or obstacles have you encountered in transforming in-company training?	• Research question
To what extent has the change in training affected the attractiveness of the company?	• Declining number of applicants
Are there competencies taught in vocational school training that are 'outdated' and no longer relevant for company practice, and if so, which ones?	• Basis project VW and BIBB
In your opinion, what changes still need to be done in order to optimally adapt vocational training to the changed conditions in the world of work? (statutory and company)	• Study job profiles 2017
Do you think certain apprenticeships will be completely eliminated in the future?	• Forecast
How will training requirements be reviewed to avoid obsolescence of core competencies? Are company managers also involved in the redesign of training?	• Research question
Do you think dual vocational training as we know it in Germany will continue to exist in the future? Will further development of the current system suffice, or is a completely new form of vocational training necessary?	• Training in international comparison • Forecast
If you had the opportunity to shape vocational training in Germany completely according to your wishes, what would such a system look like?	• Subjective opinion

Source: Own creation.

4.3.2 Choise of interviewees

In order to work on the topic across all industry sectors, the aim was to find interview partners from various industrial companies. Starting with an interview partner from the RWTH in Aachen, it was possible to establish contact with Hüttenwerke Krupp Mannesmann (HKM), Vallourec, ThyssenKrupp Steel and Deutsche Edelstahlwerke Karrierewerkstatt (DEW) in the steel industry. Through other private and social media channels, such as Xing, interview partners were also found at the defense company and automotive supplier Rheinmetall, the aircraft manufacturer Airbus, the automotive supplier ZF Friedrichshafen, the chemical company Evonik and the co-determination, research and study support organization of the German Trade Union Federation, the Hans Böckler Foundation. Some more information on the companies surveyed and the interview partners can be found in the appendix.[92] With the companies mentioned, many high-turnover sectors of industry are already included, even if the entire industrial portfolio is not covered.[93]

4.3.3 Evaluation of the interviews

The interview guide was used in all interviews. Following the interviews, a category system was developed based on Mayring's evaluation model.[94] Even though the basis for this evaluation method is the deductive procedure, i.e. the categories emerge from the links to the theory, the categories that emerged were treated inductively.[95] When editing the individual transcripts, categories were added, moved or renamed. Thus the following category system resulted:

1. Change in production and training
    a. Digitization within the company
    b. Digitization process
    c. Digitization in training
    d. Special projects and measures

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[92] Cf. Appendix 5.
[93] Cf. *Statista*, Industry Sectors, 2020.
[94] Cf. *Mayring, P.*, Interview Analysis, 1994, pp. 161.
[95] Cf. *Bogner, A; Littig, B; Menz, W.*, Interview Methods, 2014, p. 71-75.

2. Social partnerships
    a. Cooperation within the company
    b. Training curricula
    c. Social partnership in training content
    d. Vocational schools
    e. Role model trainer
3. Opportunities and challenges
    a. Positive consequences
    b. Challenges
4. Future forecast
    a. Internal outlook
    b. The future of apprenticeships
    c. Recommendation for action
    d. International comparison
    e. Tips for practice

The interview transcripts were analysed and the contents assigned accordingly. The interview with Tim Graberg from RWTH takes a more specific role in the overall picture, so this was not classified according to the criteria described above.

4.4 Results of Empirical Research

4.4.1 Research report: Competence profiles of the future

Before the interview results from various companies are compared, the findings from the interview with Tim Graberg from RWTH Aachen University will be presented. In this interview, Tim Graberg described a current study that was conducted in cooperation with the Hans Böckler Foundation on the topic of 'Competence Profiles in a Digitally Networked Production' and was accompanied by him.

The study focused on companies from the metalworking industry, as this accounts for almost half of the manufacturing sector in Germany, which in turn represents over 20% of gross value added in Germany.[96] Small and medium-sized companies from various

[96] Cf. *Statistisches Bundesamt*, Industry Sectors, 2021; *Statista*, Industry Sectors, 2020.

industries have been incorporated as well. The aim was to find out how digitally networked production and trends of Industry 4.0 affect the activities and skills requirements of employees.[97] Furthermore, jobs and activities underlying the respective training occupations were analysed. The focus was on the occupations with the highest proportion of trainees: Toolmaker, Machinist and Industrial Mechanic.[98]

The assumption at the beginning of the project was that artificial intelligence (AI) will have an important impact in the next few years, which would make it possible to completely automate manufacturing processes, or augmented reality solutions,

'where one employee can virtually operate an entire machine park by himself with his glasses'.[99]

However, the reality turned out to be different than expected. It turned out that in the near future, the first priority will be to digitally record, store and visualize data and information - in other words, to set up the paperless factory.[100]

Although automation of activities comes along with this change and will continue, Tim Graberg explains that the fields of activity are divided into three areas. In the area where employees are currently only skilled on a low level, there will be no major changes in the next few years, as automating these simple activities would be a too hight effort financially as well as technologically. There are more potential changes in the commercial area, which was, however, outside of the consideration. Two trends were identified among skilled workers. In smaller companies, the trend is toward generalists. Employees are becoming more broadly based and cross-disciplinary in their activities, but have to perform each of them less frequently. At larger companies, the trend is to specialize in specific activities.

Two central requirements for training were derived from these research results. First, trainees must develop an understanding of digital networking. And secondly, in order to be able to develop this understanding, interdisciplinary content must be integrated into training. This is not about dealing with specific applications, but about building a mindset

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[97] Cf. Appendix 4, RWTH, (00:05:02).
[98] Cf. *Schuh, G.* et al., Competence Profile, 2020, pp.14.
[99] Appendix 4, RWTH, (00:07:39).
[100] Cf. Appendix 4, RWTH, (00:07:39).

for 4.0 development.[101] [102] This applies not only to apprentices, but to all employees of the companies concerned. The potential of digital change must be made understandable. Older employees need to be involved in this process as well. Tim Graberg gives an example for a successful involvement from the company HILTI. With the help of a kind of a Raspberry PI device and an Industry 4.0 roadmap with various use cases, the employees were able to experience how software works and what possibilities it can offer.[103]

Even if digitization in companies has not progressed as far as expected, there is still a need for further optimization in some areas of vocational training. The additional qualifications in the training frameworks for electrical and metalworking occupations described in chapter 4.1.5 have already been used in an attempt to bring the level of digitization in vocational training in line with that in companies. Nevertheless, this is not sufficient for some companies. The statement from the companies is that if you want to integrate the topic of digitization or 4.0 applications into apprenticeship, you have to do it yourself.[104]

Due to the different requirements of the individual companies, the problem arises that only slow adjustments can be made to the training framework curricula. Tim Graberg explains this by using the example of technical drawing. Some of the companies which were involved in the study use various digital tools, which means that technical drawing is no longer necessary. The trainees therefore only learn this for their exam.[105] If technical drawing would now be replaced in the training framework curricula by a digital application, companies that are not yet at this digital level would be forced to invest in corresponding resources if the necessary liquidity and willingness to invest were available. Otherwise, consequence would be that apprenticeship positions would be eliminated, as many of the SME companies would simply not be able to meet this requirement.[106] Nevertheless, it cannot be denied that the competence to use digital or Industry 4.0 tools is becoming more and more important and can be decisive on the labour

[101] Cf. *Schuh, G.* et al., Competence Profile, 2020, pp. 79.
[102] Cf. Appendix 4, RWTH, (00:31:38).
[103] Cf. Appendix 4, RWTH, (00:27:44).
[104] Cf. Appendix 4, RWTH, (00:12:29).
[105] Cf. Appendix 4, RWTH, (00:13:41).
[106] Cf. Appendix 4, RWTH, (00:16:11).

market. The companies that are already more advanced admit that they are not willing to hire employees who have not yet learned these skills. The effort to train apprentices in these skills from the beginning would be less than to teach them to recruited employees afterwards. In this context, various solutions were discussed and recommended, such as the use of a central vocational training center in which all apprentices can acquire the required competencies.[107] The full research report can be found under the link in the appendix.[108]

4.4.2 Interview results

The interviews with the other companies lead to a similar overall picture as explained in the study. Nevertheless, there are some developments that are typical for some industry sectors and there are some developments that are independent of the industry sector but specific to the company on the subject of digitization in vocational training. The results of the study were divided into four blocks based on the question categories, as already outlined in chapter 4.3.3. The first block of topics deals with the core of the study and the question of how the interviewees experience digitization in apprenticeship and what specific measures have already been implemented. Here, special projects or actions from the companies interviewed are highlighted and explained. The second block covers the framework conditions regarding the training contents in more general terms, i.e., how the cooperation between apprenticeship companies and social partners is perceived and how they ensure that training content is kept à jour. In the third block, positive consequences are summarized on the one hand and challenges of the digital transformation are elaborated on the other. In the final section, the respondents express their concrete wishes for their own company and their medium- and long-term expectations of the German vocational training system.

[107] Cf. Appendix 4, RWTH, (00:16:11); *Schuh, G.* et al., Competence Profile, 2020, pp. 79.
[108] Cf. Appendix 4, Research Report.

4.4.2.1 Digital Change in apprenticeship

Digitization within the company

As already suspected, the digital transformation is experienced in some parts very similarly, but also very differently by the interview partners. The interviewees from the steel companies, as well as Evonik and ZF, emphasize that digitalization has already been taking place in the company as a whole for several decades.[109] At Vallourec, this development was also noticed in vocational training with the investment in computer-aided CNC machines and the integration of automation technologies in the apprenticeship of electronics technicians.[110] Evonik, as a company, has also been engaged in process optimization and automation for years.[111] Thus, there was no clear starting signal for digitization; it is much more a continuous, inflationary[112] and slowly process[113] in companies. Jan-Paul Giertz, represent from the Hans Böckler Foundation, also agrees with this view. However, he further limits the validity of this statement by tying the process of digitization to the definition of it. He clearly states that digitization has a different dimension in the steel industry than in mechanical engineering companies, for example.[114]

The degree of change therefore depends on the industry sector to which the company belongs. For example, the interviewees from the steel industry agree that the steel industry is making rather slow progress in terms of digitization. The training managers from Deutsche Edelstahlwerke Karrierewerkstatt, Hüttenwerke Krupp Mannesmann and Vallourec explain that only a few items have been changed in this regard.[115] The automotive supplier ZF admits that the company itself is more digital than the vocational training. Nevertheless, apprenticeship at ZF is at a higher level of digitization compared to the other companies, which will be seen in the further course of this chapter.[116] This development underscores Jan-Paul Giertz's statement that digitization takes on a different dimension in other industries. The interviewees from Rheinmetall and Airbus approach

[109] Cf. Appendix 13, Evonik, (00:16:51).
[110] Cf. Appendix 7, Vallourec, (00:03:35).
[111] Cf. Appendix 13, Evonik, (00:10:49).
[112] Cf. Appendix 13, Evonik, (00:10:49).
[113] Cf. Appendix 12, ZF, (00:19:10).
[114] Cf. Appendix 14, Hans Böckler Stiftung, (00:11:02).
[115] Cf. Appendix 9, DEW, (00:16:12); Appendix 6, HKM; (00:11:42); Appendix 7, Vallourec, (00:04:08).
[116] Cf. Appendix 12, ZF, (00:20:31).

the topic of digitization from a different perspective. They do not place technologies or digital hardware in the foreground here, but rather focus on employees.

‘*Digitization begins in the mind*’[117]

Airbus supports this view.[118] Timo Richters explains that the speed of change is increasing. But the reason is not technology, he says, because in aircraft manufacturing, technological innovations are more long-standing. The reason is more the attitude of the employees. Even if this process is not yet complete,

‘but the big success is, we talk about the topic, not daily, but definitely weekly, we talk about digitalization.’[119]

The importance of the attitude toward digitization was also included in the study's recommendation for action. It will also be taken up again at a later stage in this thesis with respect to the role model of trainers.

If the digital progress in the companies surveyed is compared, it also emerges here that the intensity of the digital transformation depends on the industry. At the automotive supplier ZF, for example, the paperless production project was in the focus about four years ago.[120] This project enabled the company, especially the tool making department, to take a big step toward digitalization. The bulletin boards, printed work instructions, etc. were abolished and disposed of.[121] This project could be defined as a starting signal, at least for vocational training, to become more digital, as also described in the study ‘Competence profiles of the future’. The result of the study was that companies will first start with digital information processing in the next few years before integrating 4.0 applications.[122] So if a company will pass the digital transformation, paperless manufacturing is the starting point.[123] In the steel industry, on the other hand, production is also becoming more and more automated, but overall the requirements from the companies have not yet changed noticeably.[124]

117 Appendix 10, Rheinmetall, (00:08:05).
118 Cf. Appendix 11, Airbus, (00:13:17).
119 Appendix 11, Airbus, (00:29:48).
120 Cf. Appendix 12, ZF, (00:19:10).
121 Cf. Appendix 12, ZF, (00:17:26).
122 Cf. Appendix 4, RWTH, (00:07:39).
123 Cf. Appendix 4, RWTH, (00:13:41).
124 Cf. Appendix 6, HKM, (00:17:47), (00:29:57).

Digitization process

So how present is Industry 4.0 really and how far has the digital transformation actually come?

Randy Foster from Rheinmetall believes that the change in job descriptions is ‘a lot of show.’[125] At Rheinmetall, similar to the steel industry, the plants are only slightly automated. Here, Randy Foster sees a discrepancy with the apprenticeship requirements.[126] Aircraft manufacturer Airbus also describes the aircraft industry as a slow process, but he notices that the pace of change is accelerating and attitudes toward digitalization have improved.[127] At Evonik, this development seems to be moving much faster, similar to the automotive manufacturer ZF.[128] Evonik is trying to integrate new needs into current job profiles to keep them up to date.[129] In the chemical industry, such as in the automotive sector, continuous optimization of operational processes is necessary to remain successful in the market.[130] The chemical industry is therefore changing comparatively faster and more comprehensive. To illustrate the development, an example of the extrusion machine is given, which is controlled by only 3 instead of 40 people due to the automation process.[131]

Digital progress in companies thus appears to be strongly industry-dependent. If the industry sector develops rather sluggishly, this leads to a similar picture in vocational training. If the industry thrives on rapid and innovative developments, such as the automotive and chemical industries, then training have to be adapt accordingly.

‘Every profession is different, every company is different, and every apprentice is different, too.’[132]

So how do the vocational training departments deal with the digital transformation in concrete terms?

[125] Cf. Appendix 10, Rheinmetall, (00:12:35).
[126] Cf. Appendix 10, Rheinmetall, (00:09:11).
[127] Cf. Appendix 11, Airbus, (00:09:16).
[128] Cf. Appendix 13, Evonik, (00:13:49).
[129] Cf. Appendix 13, Evonik, (01:12:13).
[130] Cf. Appendix 13, Evonik, (00:19:57).
[131] Cf. Appendix 13, Evonik, (00:33:08).
[132] Appendix 7, Vallourec, (00:13:12).

Digitization in training

For the apprenticeship companies, the starting signal for digitization came at the latest with the amendment of the training framework curricula for the electrical and metal professions and the associated additional qualification of additive manufacturing. In the training workshops, there was increased investment in new CNC technology, simulation systems, augmented reality systems, 3D printers and robotics, such as welding robots, irrespective of the sector.[133] While at ThyssenKrupp Steel these were isolated solutions for 'lighthouse topics', mostly initiated by dedicated trainers[134], and DEW[135] , ZF and Vallourec also invested in the aforementioned technology in response to the new requirements[136], at some of the other companies surveyed the topic was handled as a project. At Rheinmetall, for example, all sites were equipped with 3D printers, digital boards and a robot as part of a digitization project, so that each site can boast a certain digital standard.[137] At Evonik, additive manufacturing was already part of industrial apprenticeship before the introduction of the additional qualifications. Nevertheless, the elective qualifications have now been integrated into the various vocational training groups here as well.[138] Vallourec has prepared its vocational training center for the additional qualifications by using a welding robot and qualifying the trainers, but there was not yet been any demand for them, so the practical experience is still missing.[139]

A significant change in speed was noticeable among all vocational training companies in the spring of 2020. This boost was triggered by the Corona pandemic. Apprenticeship companies were forced to find quick and efficient solutions.[140] [141] [142] Jan-Paul Giertz from the Hans Böckler Foundation specifically draws attention to developments in the steel industry. In the rather slow industry, there was previously only talk of digitization,

133 Cf. Appendix 7, Vallourec, (00:06:10), (00:05:34); Appendix 8, ThyssenKrupp, (00:14:22); Appendix 9, DEW, (00:09:12).
134 Cf. Appendix 8, ThyssenKrupp, (00:15:18).
135 Cf. Appendix 9, DEW, (00:04:50).
136 Cf. Appendix 12, ZF, (00:11:05).
137 Cf. Appendix 10, Rheinmetall, (00:25:10).
138 Cf. Appendix 13, Evonik, (00:12:13), (00:13:49), (00:31:22).
139 Cf. Appendix 7, Vallourec, (00:04:08).
140 Cf. Appendix 10, Rheinmetall, (00:12:35).
141 Cf. Appendix 11, Airbus, (00:68:45).
142 Cf. Appendix 13, Evonik, (00:45:47).

suddenly action had to be taken quickly and the companies reacted successfully with various learning tools, end devices, connections to school and company, etc.[143]

Irrespective of the necessary changes associated with the amendment of the training framework curricula, many of the companies interviewed have also implemented measures and projects whose objectives go beyond simply teaching the content of the courses.

'It's not the amendment that brings innovation to the company, it's the companies themselves'[144]

The training companies are therefore trying to position themselves in a more modern and innovative way, independent of specifications. The Chamber of Industry and Commerce (IHK) is also involved in this and now makes it possible for apprentices to register online for the IHK examination themselves, so that the administrative work for the vocational training companies is eliminated.[145] During the interviews, it quickly turned out that each interviewee has his own idea of digitization and is trying to drive it forward in his own individual way. A few of these specific actions are described in more detail below:

HKM

At HKM, the automation process has progressed so far that the entire application process now is completely digitalized and applications are consequently accepted only online. Applicants need to complete a personnel questionnaire and then take a pre-test from home, which is evaluated automatically. The subsequent on-site test is also evaluated automatically. In addition, the administrative activities, such as writing the acceptance and rejection letters, are automated.[146]

[143] Cf. Appendix 14, Hans Böckler Stiftung, (00:08:30).
[144] Appendix 13, Evonik, (00:18:52).
[145] Cf. Appendix 7, Vallourec, (00:25:41).
[146] Cf. Appendix 6, HKM, (00:08:59).

Thyssen Krupp

At ThyssenKrupp Steel, a project was launched in 2017 that specifically addresses digitization in vocational training: Diga@VT, digitization @ vocational training.

'It's not just about somehow putting a device in everyone's hand and saying you're now doing home office, but it also has something to do with the entire vocational training system.'[147]

This project is divided into three steps:[148]

1. standardization of internal training curricula,

2. modularization and

3. digitization.

DEW

DEW launched a virtual welding project in 2019. This involves an augmented reality-supported welding simulation. So a person get augmented reality glasses on and can simulate and analyse different welding processes with different materials in different environments.[149]

Rheinmetall

Randy Foster from Rheinmetall teaches his apprentices about the Scrum method and design thinking. He has set up a creative corner in the training workshop for this purpose, where a 3D printer, a tabletop robot and a Lego Mindstorm are installed. A two-week workshop is offered for apprentices with certain prerequisites. The first step of the workshop is first to draw and produce something with the 3D printer. In the second step, pallets have to be stacked with the robot. In the third step, a product has to be designed, which is produced exclusively with the 3D printer and fits either with the robot or/and with the Lego Mindstorm. At the end of the workshop, the apprentices have to present and explain their products.[150]

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[147] Appendix 8, ThyssenKrupp, (00:15:18).
[148] Cf. Appendix 8, ThyssenKrupp, (00:16:12).
[149] Cf. Appendix 9, DEW (00:06:21).
[150] Cf. Appendix 10, Rheinmetall, (00:20:14).

Airbus

Training at Airbus has not yet been adapted to any great extent.[151] Even though Airbus does not train for electrical and metal professions, for which an adaptation of the training content was mandatory, robots and robot cells were nevertheless acquired[152] and a Learning & Exploration Factory was set up.[153] In addition, Airbus introduced a digital class within a pilot project. Due to the fact that technology in the aircraft industry changes rather slowly, it was difficult to define specific expertise. So the focus was more on generating an attitude and an acceptance towards digitalization. This pilot class did not start the apprenticeship with courses, basics and knowledge transfer as usual, but began with a project under the topic design thinking. The apprentices got the task to produce a product for an external customer that had to meet certain requirements. This product then had to be developed in small groups and a prototype manufactured. In the process, product development and manufacturing mapped the training content. The apprentices therefore designed their apprenticeship curricula independently on the basis of their requirements.[154] From Timo Richters' point of view, the project was a great success, because the trainees were prepared for the future without being able to say which concrete technologies and competencies would be required.[155]

ZF

At ZF, vocational training benefits from digital progress in some operations. The toolmaking department in particular is described as a pioneer.[156] Here, apprentices are deployed from the second year of their apprenticeship and they are involved in all processes from the very beginning. In toolmaking department, a kind of Wikipedia was introduced with the start of paperless production. The apprentices are mostly given smaller assignments, sometimes larger projects. In this wiki system, the apprentices find all instructions, information and learning content they need. First, they go through a kind of practice mode until they reach a certain status. Then they start drawing real parts that are needed in the respective areas. At the end, they take a kind of final exam, which is

[151] Cf. Appendix 11, Airbus, (00:11:28).
[152] Cf. Appendix 11, Airbus, (00:21:14).
[153] Cf. Appendix 11, Airbus, (00:11:50).
[154] Cf. Appendix 11, Airbus, (00:25:24).
[155] Cf. Appendix 11, Airbus, (00:27:02).
[156] Cf. Appendix 12, ZF, (00:20:31).

also stored in the wiki system. The apprentices then have to do the planning in the work preparation department, for example, derive work plans, and so on. This wiki system is not only used, but also maintained and expanded by the apprentices. Gerd Ringelmann tells about a case, where a trainee was allowed to work on the new 3D printer for two weeks, but in return had to write a new wiki entry. So both the apprentice and the operations department benefited. In the third year of training, the apprentices are deployed in the same areas, but with deeper qualifications. For this purpose, they are assigned to learning or qualification islands. Therefore software was developed that is based on a blended learning concept. In other words, a digital learning companion was developed that accompanies the apprentices throughout an entire process and supports them with safety instructions, learning videos, etc. The apprentices are given a specific task and work through it until the end when they get to the press, for example. The press is then tested and reports various results. The apprentices have to make calculations for the types of faults that have been installed in order to arrive at the cause. If the apprentice causes too many errors, he is disqualified.[157]

Evonik

In addition to the technologies already mentioned, Evonik invested in tablets for all apprentices, thus also creating an opportunity for a kind of Wikipedia. With the help of a media library, a digital learning space was created that can be used in parallel with practical work. In addition to the predefined curricula, the vocational training department at Evonik tries to incorporate new technologies live into the apprenticeship through constant exchange with the companies. Antonius Kappe and Theo Fecher agree, however, that automated plants depend on process and experience knowledge. That's why, on the one hand, the same processes and systems are used in training workshop and in the plant, which leads to greater recognition when the apprentice is at the workplace in the mill, and on the other hand, the apprentices are sent to the operational departments at a very early stage because they can really gain experience only on site.[158]

In the following table (table 7) all results are summarized:

[157] Cf. Appendix 12, ZF, (00:02:38), (00:03:58), (00:04:45).
[158] Cf. Appendix 13, Evonik, (00:19:57), (00:22:05), (00:33:08), (00:35:11).

Table 7: Digitization in Training Companies

	Steel				Defense/ Automotive	Aircraft	Automotive	Chemistry
Aspect	HKM	Vallourec	ThyssenKrupp	DEW	Rheinmetall	Airbus	ZF	Evonik
digitization takes place since several years	/	x	/	/	/	/	x	x
digitization is a continious process	/	/	/	/	/	/	x	x
itensity of digitization	low	low		low	low	low	high	high
digitization process	slow	slow	slow	slow	low	middle	high	high
usage of 3D print, robotics, CNC technology	x	x	x	x	x	x	x	x
implementation of 3D print, robotics, CNC technology	/	ad-hoc decision, lighthous topics	ad-hoc decision, lighthous topics	ad-hoc decision, lighthous topics	digitization project	/	ad-hoc decision, lighthous topics	implemented before new curreiula
Acceleration due to Corona pandemic	/	/	/	/	x	x	x	/
special measures/ projects	application process	relocation of trainign workshop	DIGA@VT	virtuel welding	creative corner	digital class	WIKI in toolmaking	media library

Source: Own creation.

4.4.2.2 Cooperation with social partners

Coordination with companies

The projects and measures described are not a requirement of the training curricula.

'I don't believe that the curriculum is the guarantee for success of the German dual training system. I believe that the guarantee of success is the commitment of the companies and not the outsourcing to some educational institution.'[159]

Partly each vocational training company tries to make apprenticeships more digital and modern, but partly certain requirements come from the operational departments as well.[160] In all companies, regular exchanges take place with respective departments.[161] There is not only a discussion about the quantitative requirements for various apprenticeships, but also about the qualification requirements.[162] This exchange is very important for the vocational training departments in order to understand the customers' needs and to avoid problems. On the one hand, more and more soft skills are being demanded by the companies,[163] and on the other hand, it also happens in some companies

[159] Appendix 8, ThyssenKrupp, (00:10:13).
[160] Cf. Appendix 8, ThyssenKrupp, (00:13:11); Appendix 12, ZF, (00:09:39); Appendix 13, Evonik, (00:18:52).
[161] Cf. Appendix 11, Airbus, (00:33:46); Appendix 12, ZF, (00:30:45); Appendix 13, Evonik, (00:19:57), (00:59:56).
[162] Cf. Appendix 10, Rheinmetall, (00:41:38).
[163] Cf. Appendix 6, HKM, (00:28:27).

that new technical skills are needed.[164] At Vallourec, for example, welding and programming skills with the welding robot are requested[165], at ThyssenKrupp Steel even 'Champions League classes' are formed on certain topics in demand[166]. Rheinmetall was able to establish through close exchange with the companies that a different CNC technology is used in training workshop and rectify the problem for the future. At Airbus, ZF and Evonik, developments at the plants are also regularly taken up and incorporated into apprenticeship.[167] Airbus, for example, takes important topics into the Exploration Factory [168], at ZF the training is integrated into larger projects[169] and Evonik even tries to integrate all new technologies in the training workshop according to industry standards.[170]

What is criticized, however, is that the mill demand certain vocational training occupations and end up disappointed that the apprentices do not have some required qualifications. This is because the requirements from the operations departments do not match the skills profiles of the respective apprenticeship occupations. Rheinmetall is currently trying to counteract this by drawing up such a competence profile for each occupation in order to make the operation departments more responsible in this respect.[171] Involving the mills could also lead to a better determination of requirements for new hires and greater acceptance within the departments.[172]

Training curricula

The needs and the required qualifications in operation departments have consequently changed. However, vocational training departments are also trying to make apprenticeship more digital and modern in some aspects, regardless of the desired requirements, and thus prepare it for the future. Are the official contents from the training curricula therefore too low? Are the training curricula still not sufficiently aligned with the actual needs of the companies?

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[164] Cf. Appendix 11, Airbus, (00:35:33).
[165] Cf. Appendix 7, Vallourec, (00:15:15).
[166] Cf. Appendix 8, ThyssenKrupp, (00:20:57).
[167] Cf. Appendix 10, Rheinmetall, (00:45:11); Appendix 12, ZF, (00:08:35).
[168] Cf. Appendix 11, Airbus, (00:45:56).
[169] Cf. Appendix 12, ZF, (00:31:41).
[170] Cf. Appendix 13, Evonik, (01:02:50).
[171] Cf. Appendix 10, Rheinmetall, (00:38:23).
[172] Cf. Appendix 7, Vallourec, (00:17:48), (00:19:18), (00:20:20).

The interview partners agree first of all that the training framework curricula are designed so flexibly that they can be individualized for the respective vocational training.[173] For the companies from the steel sector, the rather slow adjustments to the training content are also not dramatic, as the requirements could otherwise not be met.[174] Accordingly, the integration of additional qualifications, which can be selected but do not have to be present, is a compatible path for companies in the steel sector.[175] This assessment is in line with the results of the study described by Tim Graberg.

Some companies thus evaluate the partial amendment as very helpful and needs-oriented[176], while Randy Foster from Rheinmetall even described it as rather too fast and too incomplete, since some content was missing and yet others were included but not really implementable.[177] This was also the experience of Henning Düppe, who was still working at another company at the time before he moved to HKM.[178] ZF also confirms the flexibility of the plans, but would like to see more content in mechanical trades in the direction of network technology, fault analysis and databases.[179] Jan-Paul Giertz from the Hans Böckler Foundation confirms, however, that to his knowledge the latest changes in training curricula did not lead to any major upheavals or irritations.[180] Evonik suggests that the automation technology electronics technician is now too strongly influenced by the automotive industry and thus no longer fits in with the chemical industry. However, these discrepancies can be absorbed by the company's mission.[181] At Airbus, the apprenticeship occupations were not affected by the adjustments made in 2018. Timo Richters admits, however, that he does not think an adjustment of processes or technologies is necessary at all.[182] His opinion is:

‘with the mere skill of mastering a programming language or a syntax we don't get anywhere, but rather with the step before that, which is to build up an understanding’[183]

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[173] Cf. Appendix 7, Vallourec, (00:11:07).
[174] Cf. Appendix 9, DEW, (00:16:12).
[175] Cf. Appendix 7, Vallourec, (00:02:01).
[176] Cf. Appendix 8, ThyssenKrupp, (00:04:43), (00:05:41); Appendix 9, DEW, (00:10:54).
[177] Cf. Appendix 10, Rheinmetall, (00:16:21).
[178] Cf. Appendix 6, HKM, (00:17:01).
[179] Cf. Appendix 12, ZF, (00:13:32).
[180] Cf. Appendix 14, Hans Böckler Stiftung, (00:14:13).
[181] Cf. Appendix 13, Evonik, (00:27:53).
[182] Cf. Appendix 11, Airbus, (00:16:40).
[183] Appendix 11, Airbus, (00:17:27).

Social partnership in training content

In the development of the new training framework curricula, most companies felt involved in the process entirely according to the consensus principle, or at least well represented by the committee members. Employees from ZF were even part of the panel. This confirms DEW's statement that southern regions are more likely to be represented on education committees.[184] Evonik's trainers, for example, are represented on the examination task and teaching materials committee, which also allows them to influence more directly on the introduction of the additional qualifications.[185] Nevertheless, Evonik admits that usually larger companies are represented in the committees from the employer side because they have greater political influence.[186] For this reason Airbus has a big influence in the aircraft occupations, while Timo Richters suspects that they will probably be less represented in the mechatronics occupations.[187] Rheinmetall, on the other hand, admits that they had absolutely no influence. [188] However, the majority of the companies surveyed are satisfied with the social partnership between BIBB, trade unions, vocational schools, etc..[189] The entire process would probably be made more difficult otherwise.

'If everyone has an opinion, that doesn't mean that everyone can assert his interests well and that 'quality' will *come out afterwards.'*[190]

However, the consensus principle of the social partnership did not only matter in adaptation of training curricula for electrical and metal professions. HKM reports, for example, that they were also able to exert a great deal of influence when the process technologist was introduced a few years ago,[191] while DEW is involved in the 'NRW goes digital' project of the foundation for young mechanical engineers.[192] Overall, the companies' opportunities to exert influence are available.

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[184] Cf. Appendix 12, ZF, (00:13:49); Appendix 9, DEW, (00:12:02).
[185] Cf. Appendix 13, Evonik, (00:24:06).
[186] Cf. Appendix 13, Evonik, (00:25:17).
[187] Cf. Appendix 11, Airbus, (00:20:07).
[188] Cf. Appendix 10, Rheinmetall, (00:19:14).
[189] Cf. Appendix 7, Vallourec, (00:11:58); Appendix 8, ThyssenKrupp, (00:06:26).
[190] Cf. Appendix 14, Hans Böckler Stiftung, (00:28:11).
[191] Cf. Appendix 6, HKM, (00:23:15).
[192] Cf. Appendix 9, DEW, (00:12:25).

Vocational schools

Cooperation with vocational schools works also very well at almost all companies. There is a lively exchange between the vocational school teachers and the trainers.[193] But here, too, the influence on the school is greater the larger the company is and the more apprentices from the company go to the vocational school.[194] At ZF, the close connection to the vocational school even goes so far that ZF supports the vocational school with hardware, for example, or offers to set up production cells. On the one hand, this has the advantage for ZF that the apprentices are trained in content which is relevant for the company, and on the other hand, the vocational school benefits from newer technologies and methods.[195] Evonik also supports vocational schools in digitization through the Evonik Foundation.[196]

Even though the vocational schools teach relevant subject matter[197], most of the interviewees criticized the equipment, although this depends heavily on the vocational school and the respective region.[198] Jürgen Hengst-Wolf from Vallourec reports that the vocational school is trying to follow the digital path within the framework of the training curricula, for example by already using learning platforms.[199] The Corona pandemic has also forced vocational schools to become more digital. However, the full potential of digital tools has not yet been exploited in the implementation process.[200] The willingness and motivation of teachers at some vocational schools is there, but the financial resources do not allow for up-to-date equipment and additional staff.[201] As a result, some deficiencies have to be made up by the companies in industrial training lessons.[202] Recruiting young teachers also appears to be difficult.[203] The reason for this could be the

193 Cf. Appendix 9, DEW, (00:23:11).
194 Cf. Appendix 8, ThyssenKrupp, (00:24:24); Appendix 13, Evonik, (00:51:28);. Appendix 14, Hans Böckler Stiftung, (00:26:08).
195 Cf. Appendix 12, ZF, (00:29:29).
196 Cf. Appendix 13, Evonik, (00:54:38).
197 Cf. Appendix 7, Vallourec, (00:19:25); Appendix 10, Rheinmetall, (00:30:28); Appendix 11, Airbus, (00:41:19); Appendix 12, ZF, (00:41:31).
198 Cf. Appendix 14, Hans Böckler Stiftung, (00:26:08).
199 Cf. Appendix 7, Vallourec, (00:10:17).
200 Cf. Appendix 11, Airbus, (00:56:53); Appendix 12, ZF, (00:38:59).
201 Cf. Appendix 6, HKM, (00:22:26); Appendix 9, DEW, (00:22:26), (00:26:22), (00:26:53); Appendix 13, Evonik, (00:56:09)
202 Cf. Appendix 8, ThyssenKrupp, (00:25:34); Appendix 9, DEW, (00:24:31), (00:24:52).
203 Cf. Appendix 7, Vallourec, (00:35:45).

comparatively low salary of vocational school teachers.[204] On the other hand, some vocational school teachers still lack the right attitude toward digitization, so teaching methods are outdated and unsuitable.[205] The degree of digitization is therefore increasingly dependent on the teachers.[206]

'It rises and falls on the people who do it. ' [207]

Role model trainer

This statement also applies to the trainers in vocational training departments. The interviewees all agree that the role model of trainer has changed in the context of digital transformation.[208] A completely new role model has emerged, away from the traditional four-step method.[209] There is no longer the all-knowing trainer who teaches young apprentices, the trainer has slipped much more into a kind of learning companion role. [210] Traditional frontal teaching does not fit into these time, so trainers have to adopt new teaching methods and they have to be trained for their new role.[211] At Rheinmetall, for example, trainers are educated how to use digital tools instead of pure traditional frontal teaching.[212] The following table (table 8) summarize the results for the second block:

[204] Cf. Appendix 9, DEW, (00:26:53).
[205] Cf. Appendix 10, Rheinmetall, (00:09:11).
[206] Cf. Appendix 10, Rheinmetall, (00:28:19).
[207] Appendix 11, Airbus, (00:40:33).
[208] Cf. Appendix 14, Hans Böckler Stiftung, (00:09:27); Appendix 8, ThyssenKrupp, (00:17:19).
[209] Cf. Appendix 10, Rheinmetall, (00:09:11).
[210] Cf. Appendix 8, ThyssenKrupp, (00:18:16); Appendix 11, Airbus, (00:29:48).
[211] Cf. Appendix 7, Vallourec, (00:06:10).
[212] Cf. Appendix 10, Rheinmetall, (00:08:05).

Table 8: Cooperation with Social Partners

	Steel				Defense/ Automotive	Aircraft	Automotive	Chemistry
Aspect	HKM	Vallourec	ThyssenKrupp	DEW	Rheinmetall	Airbus	ZF	Evonik
regular exanche with operation departments	x	x	x	x	x	x	x	x
changed requirements from operation department	soft skills	welding/ programming	Champions League classes	/	CNC technology	Exploration Factory	projects for training department	industry standarts in training workshop
new training curricula	flexible, too fast	flexible	needs-oriented	flexible	flexible, too fast	/	flexible, even too weak	flexible
consensus principle	involved in introduction of process technologist	not involved, but well represented	not involved, but well represented	Involved in project 'NRW goes digital'	no influence	influence on aircraft occupations	part of panel	represented on examination task and teaching commitee, larger companies involved
cooperaion with vocational schools	/	/	lively exchange	lively exchange	/	/	lively exchange	lively exchange
content in vocational school	/	relevant	/	/	relevant	relevant	relevant	/
digitalization in vocational school	lack of financial resources	learning platforms	lack of financial resources	lack of financial resources	lack of attitude towards digitization	more digitl through Corona, not enought	more digitl through Corona, not enought	lack of financial resources
role model of trainers	/	learning companion	learning companion	/	learning companion	learning companion	/	/

Source: Own creation.

4.4.2.3 Positive consequences and challenges of the digital transformation

Positive consequences

Overall, all of the interview partners need to have transformed their industrial apprenticeship in recent years. Although automotive and chemical sectors seem to have moved a little faster, it is clear to all respondents that they continue to adapt to changing circumstances in order to keep vocational training up to date on the one hand and to be able to serve internal and external labour market on the other. Some of the interviewees are also sure that a more digital apprenticeship will have a positive effect on the attractiveness of vocational training both internally and externally, even if this effect is not yet scalable.[213] Particularly internally, vocational training has gained importance in recent years. The satisfaction of apprentices who actively experienced digital transformation[214] as well as the demand for apprentices from operating departments seem to have increased.[215] Even if digitization is only one aspect of many in the evaluation of

[213] Cf. Appendix 9, DEW, (00:21:54); Appendix 12, ZF, (00:25:03); Appendix 13, Evonik, (00:42:47).
[214] Cf. Appendix 7, Vallourec, (00:24:02).
[215] Cf. Appendix 8, ThyssenKrupp, (00:22:25); Appendix 10, Rheinmetall, (00:23:09); Appendix 11, Airbus, (00:31:38); Appendix 12, ZF, (00:23:28).

an apprenticeship program, it has some positive effects.[216] A welding robot, for example, not only promotes digitization, but also has positive ecological and, in the long run, economic effects.[217]

Challenges

In addition to all positive aspects, however, there is also criticism. As already pointed out, the steel industry is rather slow when it comes to digitization.[218] This is due, among other things, to the difficult economic situation in the industry sector, which means that the companies concerned are not in a financial position to purchase new machines, devices, etc..[219] The other interview partners also confirm that the digital transformation entails, above all, high investments[220] and that these do not always prove to be successful.[221] Timo Richters from Airbus also criticizes the fact that the mere acquisition of hardware is too quickly labelled as digitization.[222]

However, it is not only the lack of hardware that is criticized at this point, but also the lack of utilization of the available options.[223]

'It's not the technology, it's keeping up to date with those technologies there.'[224]

This is a major problem in vocational schools, for example. But digital tools are also not being used sufficiently in vocational training departments. The reason for this could be rejection by trainers.[225] Some do not feel up to the new role of the instructor[226] or do not accept it.[227] It is also possible that the trainers are afraid that they could lose their status as trainer.[228] At Airbus, the difficulties for the trainers arise from the fact that there are

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[216] Cf. Appendix 13, Evonik, (00:40:47), (00:41:44).
[217] Cf. Appendix 14, Hans Böckler Stiftung, (00:17:45).
[218] Cf. Appendix 6, HKM, (00:11:42).
[219] Cf. Appendix 7, Vallourec, (00:07:15); Appendix 8, ThyssenKrupp, (00:16:12); Appendix 10, Rheinmetall, (00:17:38).
[220] Cf. Appendix 11, Airbus, (00:22:30); Appendix 12, ZF, (00:20:31); Appendix 13, Evonik, (00:35:11).
[221] Cf. Appendix 13, Evonik, (00:36:52); Appendix 14, Hans Böckler Stiftung, (00:22:14).
[222] Cf. Appendix 11, Airbus, (00:42:06).
[223] Cf. Appendix 11, Airbus, (00:42:24).
[224] Appendix 13, Evonik, (00:57:10).
[225] Cf. Appendix 11, Airbus, (00:23:45).
[226] Cf. Appendix 8, ThyssenKrupp, (00:18:16).
[227] Cf. Appendix 11, Airbus, (00:58:46).
[228] Cf. Appendix 11, Airbus, (00:28:44).

no concrete technical changes to manufacturing processes and the digital transformation is therefore not really tangible.[229]

Another problem occurs when the digital transformation in the vocational training department is more advanced than in the company itself. [230]

'They play with the toys for three and a half years or three years and then they go out into manufacturing, into the real world and there they play with wooden cars and with tin cans.'[231]

This development can therefore lead to a situation where some digital tools have been learned but cannot be used in production.[232] As a result, apprentices tend to be disappointed after passing their exams and would rather continue their education in school or university.[233] Another problem is that companies with multiple locations do not have uniform training curricula across all sites, so there is no need to integrate the topic of digitization into the vocational training content beyond existing training framework curricula.[234] The overview for the third block is shown in table 9.

Table 9: Positive Consequences and Challenges

	Steel				Defense/ Automotive	Aircraft	Automotive	Chemistry
Aspect	HKM	Vallourec	ThyssenKrupp	DEW	Rheinmetall	Airbus	ZF	Evonik
positive consequences through digitization	/	higher attractivness internally	higher attractivness internally	higher attractivness	higher attractivness internally	higher attractivness internally	higher attractivness	higher attractivness
financial challanged	high investment costs	high investment costs	high investment costs	/	high investment costs	high investment costs	high investment costs	high investment costs
other challanges	/	/	rejection of trainers	/	different levels of digitization	rejection of trainers	/	/

Source: Own creation.

[229] Cf. Appendix 11, Airbus, (00:11:28).
[230] Cf. Appendix 10, Rheinmetall, (00:12:35).
[231] Appendix 10, Rheinmetall, (00:09:11).
[232] Cf. Appendix 14, Hans Böckler Stiftung, (00:32:15)
[233] Cf. Appendix 10, Rheinmetall, (00:23:09).
[234] Cf. Appendix 10, Rheinmetall, (00:26:49).

4.4.2.4 Industrial training in the future

Internal outlook

The vocational training companies surveyed are nevertheless moving ahead with digital transformation. They are aware of the need to move with the times and also have change requests for the next few years in order to drive digitization forward.[235] On the one hand, it is a matter of bringing in-house training up to current digital standards, for example through an online platform for apprentices[236], an online recruiting process[237] or the acquisition of communication devices that enable apprentices to work on from home[238]. Closer cooperation with operation departments and raising awareness of job profiles are also part of desirable visions for the future.[239] This would also create a basis for offering individual company-specific content and required soft skills more efficiently and possibly across departments.[240] In this way, the education and training department, if it is not already the case, would become the central contact and competence center for knowledge transfer and further training in addition to its education role for apprentices.[241]

The future of apprenticeships

Apart from individual company goals, however, the interview partners are in general agreement that, although the content of current apprenticeship occupations is gradually developing in the direction of 4.0[242] the requirements for some occupational profiles are declining,[243] but many of the occupations which are typical for the industry will not disappear.[244] However, if digitization develops in the direction of substitution of work instead of humanization[245], then occupational profiles that are directly affected could be

[235] Cf. Appendix 6, HKM, (00:32:39); Appendix 7, Vallourec, (00:32:40).
[236] Cf. Appendix 6, HKM, (00:13:13); Appendix 12, ZF, (00:22:02); Appendix 7, Vallourec, (00:08:46).
[237] Cf. Appendix 7, Vallourec, (00:25:41).
[238] Cf. Appendix 6, HKM, (00:13:13); Appendix 11, Airbus, (01:00:27).
[239] Cf. Appendix 7, Vallourec, (00:32:40); Appendix 11, Airbus, (00:31:38); Appendix 14, Hans Böckler Stiftung, (00:32:15)
[240] Cf. Appendix 11, Airbus, (00:36:21); Appendix 11, Airbus, (00:37:46); Appendix 14, Hans Böckler Stiftung, (00:42:21).
[241] Cf. Appendix 11, Airbus, (00:31:38); Appendix 14, Hans Böckler Stiftung, (00:19:35).
[242] Cf. Appendix 7, Vallourec, (00:13:12); Appendix 13, Evonik, (01:05:14); Appendix 8, ThyssenKrupp, (00:08:38).
[243] Cf. Appendix 12, ZF, (00:26:03).
[244] Cf. Appendix 6, HKM, (00:27:31); Appendix 9, DEW, (00:28:25); Appendix 11, Airbus, (00:48:37).
[245] Cf. Appendix 14, Hans Böckler Stiftung, (00:24:09).

threatened with extinction.[246] Specifically, machine and plant operators[247], truck drivers[248] and commercial professions[249] are seen as being at risk.[250] But at this point the opinions differ. Jürgen Hengst-Wolf from Vallourec, for example, assumes that machine and plant operators will continue to be needed, especially for Vallourec, while the demand for construction mechanics would rather decline.[251] In the case of humanization, there will be

'specialization in terms of expertise and generalization in terms of methodological skills.'[252]

The digital transformation could also lead to the elimination of some basic skills in some professions and their replacement by others.[253]

A possible trend in the future could be that universities play a greater role in vocational training. The current trend is for many young people to go to university instead of apprenticeship or even after apprenticeship.[254] At present, most companies are still critical about this type of cooperation. On the one hand, this is due to the fact that cooperative apprentices often cannot be integrated into the company either in terms of time or professionally.[255] On the other hand, dual courses of study tend to train engineers rather than skilled workers. Cooperative apprentices must therefore have other basic qualifications and have higher expectations about their activities in the company. However, most companies currently need both engineers and skilled workers.[256]

Recommendations for action by the companies surveyed

Nevertheless, the interviewees would like to integrate the possibility of modularization as an advantage of cooperative degree programs in vocational training.[257] If they had the chance to change the current vocational training system, they would make it more flexible

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[246] Cf. Appendix 11, Airbus, (00:48:37); Appendix 13, Evonik, (01:08:37).
[247] Cf. Appendix 10, Rheinmetall, (00:34:03).
[248] Cf. Appendix 8, ThyssenKrupp, (00:04:43).
[249] Cf. Appendix 8, ThyssenKrupp, (00:07:15).
[250] Cf. Appendix 13, Evonik, (01:06:21).
[251] Cf. Appendix 7, Vallourec, (00:17:48).
[252] Cf. Appendix 14, Hans Böckler Stiftung, (00:38:22); Appendix 10, Rheinmetall, (00:32:06).
[253] Cf. Appendix 11, Airbus, (00:47:39).
[254] Cf. Appendix 6, HKM, (00:36:49).
[255] Cf. Appendix 13, Evonik, (01:25:19); Appendix 14, Hans Böckler Stiftung, (00:45:12).
[256] Cf. Appendix 7, Vallourec, (00:29:57).
[257] Cf. Appendix 8, ThyssenKrupp, (00:35:00).

and demand-oriented.[258] Accordingly, the apprentices would have a certain basic training that includes, for example, standard modules for the electrical and metal trades.[259] After basic training, apprentices could specialize according to company requirements and even put together interdisciplinary modules.[260] They would also have the option of tailoring their education to their individual needs.[261] Such a system would enable companies to respond more quickly and flexibly to new requirements[262], since occupational profiles could be eliminated to some extent and replaced by competency requirements.[263] In addition, apprentices would have the possibility to take along qualifications from a discontinued study.[264] Moreover, each apprentice would be considered individually and the focus would be more on the individual.[265]

However, cooperation with vocational schools is considered as necessary not only in the case of the modularization scenario, but also if the system remains unchanged. The interview partners would like to see a much closer and more coordinated link between theory and practice in the future.[266] Such a link can be optimally designed by using digital opportunities.[267] With the use of digital tools, such as communication tools for apprentices[268], for example, circuit or exam simulations could lead to a more efficient teaching method.[269] However, as already explained in the category 'vocational schools", this development first requires suitable equipment and sufficiently trained teachers at vocational schools.[270] If the interviewees had the opportunity to intervene in the current education system, they would provide more funding for vocational school equipment[271] and ensure fair salary for vocational school teachers[272].

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[258] Cf. Appendix 10, Rheinmetall, (00:36:04).
[259] Cf. Appendix 10, Rheinmetall, (00:32:06); Appendix 8, ThyssenKrupp, (00:36:25).
[260] Cf. Appendix 10, Rheinmetall, (00:46:40).
[261] Cf. Appendix 11, Airbus, (00:54:15).
[262] Cf. Appendix 9, DEW, (00:34:30).
[263] Cf. Appendix 11, Airbus, (00:50:50).
[264] Cf. Appendix 8, ThyssenKrupp, (00:37:06).
[265] Cf. Appendix 11, Airbus, (00:54:15).
[266] Cf. Appendix 7, Vallourec, (00:34:31); Appendix 11, Airbus, (00:53:31); Appendix 14, Hans Böckler Stiftung, (00:53:41).
[267] Cf. Appendix 14, Hans Böckler Stiftung, (00:55:28); Appendix 12, ZF, (00:37:21).
[268] Cf. Appendix 13, Evonik, (00:45:47).
[269] Cf. Appendix 6, (00:14:38).
[270] Cf. Appendix 13, Evonik, (01:00:09); Appendix 8, ThyssenKrupp, (00:28:50).
[271] Cf. Appendix 9, DEW, (00:24:52).
[272] Cf. Appendix 8, ThyssenKrupp, (00:27:47).

International comparison

In this respect, Germany could learn from the Scandinavian system.[273] Overall, however, the current dual training system is seen as a great strength[274] and a successful system.[275] The structure of the dual system means that the self-interest and commitment of companies in Germany is much higher than abroad.[276] Even if foreign systems have their advantages[277], the interview partners believe that the German dual system is still a flagship [278] and that Germany is considered a pioneer in this respect.[279] Compared to the American system, for example, which is more of an 'on the job training' system (see chapter 3.1.3.3), the German system is considered to be more efficient.[280] Accordingly, foreign countries are more likely to try to learn something from the German dual system than the other way around.[281]

Future of the dual training system

In the future, only the dovetailing of theory and practice and a mixture of generalism and professionalism can lead to a successful education of junior staff.[282] The adage 'Never change a winning team' therefore applies in this case.[283] The important aspect is not to let the value of vocational training decline in the future, so that companies continue to be encouraged to educate apprentices.[284] Overall, however, the dual training system should be retained and expanded.[285]

Tips for practice

As the interviews showed, there is no overall guidance for shaping digital transformation in industrial vocational training. Nevertheless, there are some aspects and tips that can be noted as generally valid:

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[273] Cf. Appendix 8, ThyssenKrupp, (00:29:50).
[274] Cf. Appendix 11, Airbus, (00:53:31).
[275] Cf. Appendix 12, ZF, (00:27:10).
[276] Cf. Appendix 8, ThyssenKrupp, (00:10:13).
[277] Cf. Appendix 14, Hans Böckler Stiftung, (00:39:56).
[278] Cf. Appendix 7, Vallourec, (0:27:52).
[279] Cf. Appendix 6, HKM, (00:30:26); Appendix 9, DEW, (00:29:57); Appendix 13, Evonik, (01:19:00).
[280] Cf. Appendix 10, Rheinmetall, (00:36:04).
[281] Cf. Appendix 12, ZF, (00:27:52).
[282] Cf. Appendix 14, Hans Böckler Stiftung, (00:39:56); Appendix 6, HKM, (00:32:39).
[283] Appendix 7, Vallourec, (00:37:08).
[284] Cf. Appendix 9, DEW, (00:31:36); Appendix 8, ThyssenKrupp, (00:26:17).
[285] Cf. Appendix 10, Rheinmetall, (00:47:29).

‘Digitization should be introduced when it has added value for the company.’[286]

Digitization is therefore not an end in itself. For this reason, the extent of digitization varies from company to company. It depends on the company in which direction digitization is going. For example, if a company educate ‘simple’ industrial or machining mechanics, then it probably makes more sense to invest in equipment for the training workshop, such as CNC machines. In the case of chemical or electrical professions, it might be better to focus on communication equipment, since here theory underpins practice.[287] Timo Richters from Airbus points out once again at this stage that it is not at all important for all skilled workers to be able to program, for example, but that the focus must be on ensuring that all apprentices master the basics of robotics in order to better understand machines and systems in the future.[288]

Cross-faculty aspects must not be neglected in the digital transformation. The company doctor, occupational health and safety department, works council, etc. must be involved for a successful implementation of digital measures.[289]

The most important thing, however, is a transparent process that tries to involve all employees equally. When industrial apprenticeship or the entire company embarks on the digitalization path, it is important to gain the acceptance of all employees. According to the interviewees, older colleagues in particular are quick to reject the idea. Companies must therefore try to build up interest and an understanding of the possibilities of digitization among sceptical employees through training courses, digital cafés or other offers.[290] To do so, however, it is also helpful to know which employees already have the drive for digitization and can support the process as a kind of opinion leader.

‘So I wouldn't so much pick the technology, I would first look at what does my team look like.’[291]

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[286] Appendix 9, DEW, (00:20:48).
[287] Cf. Appendix 13, Evonik, (00:46:55).
[288] Cf. Appendix 11, Airbus, (00:16:40).
[289] Cf. Appendix 14, Hans Böckler Stiftung, (00:24:09)
[290] Cf. Appendix 13, Evonik, (00:49:05).
[291] Appendix 13, Evonik, (01:09:47).

Regardless of the degree of digitization, it should be taken into account that people, social contact and learning in a group continue to be of the utmost importance not only professionally but also for personal development.[292] Table 10 shows a summarized overview of this block.

Table 10: Industrial Training in the Future

	Steel				Defense/ Automotive	Aircraft	Automotive	Chemistry
Aspect	HKM	Vallourec	ThyssenKrupp	DEW	Rheinmetall	Airbus	ZF	Evonik
internal outlook concerning digital transformation	push digitization (e.g. communication devices)	push digitization (e.g. online plattform, recruiting process)	/	/	/	push digitization (e.g. communication devices)	push digitization (e.g. online plattform)	/
internal outlook concerning other aspects	/	closer cooperation with operating department	/	/	/	closer cooperation with operating department	/	/
future of occupations content		4.0 direction	4.0 direction	/	/	no change in industry occupations	4.0 direction, change in requirements	4.0 direction
threatened occupations	no change	construction mechanics	truck driver, commercial professions	no change	machine and plant operator	occupations affected by digitization	/	occupations affected by digitization
role of univesity	possible trend in future	need for engineers and skilled workes	/	/	/	/	/	difficult to integrate in company
cecommendations	/	closer link of theory and pracice	modularization support of vocational schools	modularization support of vocational schools	modularization	modularization closer link of theory and practice	closer link between theory and practice through digital tools	closer link between theory and practice through digital tools, support of vocational schools
international comparison	dual system as pioneer	dual system as pioneer	learn from Scandinavian model, dual system as a pioneer	dual system as pioneer	dual system as pioneer	dual system as pioneer	dual system as pioneer	dual system as pioneer
future of the dual training system	keep dual system	keep dual system	keep dual system	keep dual system	keep dual system	/	/	/
tips for practice	/	importance of human work	/	not an end it itself	/	focus on mindset , create general understanding for basics	/	individual solutions, transparency, importance of social aspects

Source: Own creation.

[292] Cf. Appendix 13, Evonik, (00:58:17); Appendix 7, Vallourec, (00:31:44).

4.5 Discussion

4.5.1 Analysis of Interview Results[293]

Overall, the development in industrial vocational training does not yet correspond to what was assumed at the beginning. Although some steps have already been taken in the direction of digitalisation, there has not yet been a generally systematic integration of the predicted competence and qualification requirements in vocational training.

Sector-specific transformation

Nevertheless the remaining formulated assumptions were confirmed. The digital transformation is noticeable in all vocational training departments which were interviewed, albeit to different degrees. From the interviews with ZF and Evonik, it is clear that production, or in the case of ZF, toolmaking, has already been developing in the direction of digitalization and automation for several years. Since the success of the automotive and chemical industries depends heavily on their ability to innovate, it is inevitable that digital transformation will be driven forward more quickly in such sectors than in others. In such innovative companies, the requirements for employee skills have changed more than in other companies. Chapter 2.1.4 shows that the key to success is the appropriate qualification and further training of employees. Accordingly, the vocational training departments are trying to raise training opportunities in form of devices, but also training content to a similarly high digital level, for example through the operational deployment. Based on the fact that companies in the same industry sector must strive for a similar level of innovation in order to be successful on the market, Evonik and ZF can be defined as sector representatives. Thus, as suspected, the digital transformation in the chemical industry, but also in the automotive supplier industry, is more advanced than in the steel industry, for example. Whether this generalized development of automotive suppliers also applies to the related automotive industry would have to be confirmed by further surveys. Nevertheless, VW's 'Digitization of World of Work' project also showed similar requirement profile changes to those described by ZF, but also Evonik.

However, the digital transformation also led to various adjustments in the other companies surveyed. On the one hand, these were based on the requirements resulting

[293] Cf. Appendix 5.

from the amendment of the training curricula. On the other hand, the responsible trainers also try to prepare the apprentices for the predicted digital transformation by building up an understanding of modern technologies and their effects, even if the specific technical skills are not yet required in the production company. At this point, it is legitimate to ask whether digitization really adds value to the company in such cases. From a personal point of view, the added value is provided by two aspects: On the one hand, the apprentices receive a higher-quality qualification, which makes them more successful on the free labour market, as the Hans Böckler Foundation study shows (Chapter 4.4.1). On the other hand, the training company also receives trained employees who are prepared for the digital transformation and can be deployed immediately. In the future, such employees could also be used as a kind of mentor for colleagues who are still untrained.

The industry disparity in terms of digitization is additionally supported by the economic situation of the respective industry. The reason is, as already outlined in section 4.4.2.3, that digital transformation entails a high need for investment. Companies in a difficult economic situation cannot invest in digitization to the extent they would like. This is confirmed, for example, by the companies from the steel sector. In addition, digital transformation also depends heavily on corporate policy. If the company as a whole decides to invest more heavily in digital transformation, training and development will also be affected by this path. It should be examined whether training and development can have so much influence on corporate policy that the causality is reversed.

Content of Training Curricula

However, the minimum requirement for digitization is specified in the vocational training regulations, irrespective of the company and sector. In view of the fact that digital transformation is sector-dependent, a slow adjustment of the training frameworks and the flexibility they offer is imperative. Otherwise, not all companies would be able to meet the requirements. In this context, the assumption that the consensus principle works well in principle is also underscored, although it is criticized that larger companies with greater political influence have a greater say. From a personal point of view, even greater involvement of more companies would also not necessarily be expedient. The influence of larger companies on issues such as the amendment of the training curricula ordinance may also be related to the fact that larger companies often have the largest number of trainees who would be affected by amendments.

Internal Content

The actions and projects offered by each company beyond the training curricula were surprising. Initiated by motivated trainers, a large number of creative and innovative ideas have been implemented in the companies, which were interviewed. Although some projects, such as the introduction of a digital training tool and the associated purchase of tablets, cannot be implemented without a larger budget, the implementation of a digital class, such as at Airbus, in which the learning methods and teaching content are completely restructured and modernized, involves comparatively lower costs. A creative corner, as at Rheinmetall, can even be initiated for the most part without any financial outlay, because all companies have already made the necessary purchases of robots and 3D printers, as they mentioned in the interviews. However, all models require the components time and manpower, which are not sufficiently available at many companies.

Acceptance

The assumption that the digital transformation is not accepted in part within the workforce is also confirmed. With the digital transformation, a transformation of the role of the trainer has also taken place. The acceptance of trainers for the described role of learning facilitator is an important success factor for apprenticeship. They should thus be familiarized with new learning methods at an early stage. The importance of involving all employees in the process of digital transformation is mentioned several times and defined as a key challenge.

To create greater acceptance, companies need to get creative and launch initiatives tailored to the workforce. Some of the interviewees have already mentioned a few examples for this purpose: digital café, training courses, etc. From a personal perspective, imposing digital ways of working often leads to upheavals. On the one hand, the right teachers have to be used, and on the other hand, the right methods have to be applied in order to launch into goal-oriented communication with sceptical employees. At this point, not all companies can implement financially elaborate measures. Some actions, such as digital coffee, is a charming and cost-effective solution in this context.

Concerning the attractiveness of vocational training the companies interviewed were not able to determine a significant increase. A certain influence is assumed, but cannot be proven, for example, by increasing numbers of applicants. This assumption was therefore not clearly confirmed, but companies should be prepared for the future. The aspect of digitization will become more and more decisive as mentioned by Tim Graberg. Nevertheless the internal acceptance within the company increased through the more and more highly skilled apprentices. Whether this point is due to digital components. would need to be examined in detail as part of another study.

Training professions in future

The assumption of the interview partners that the traditional training occupations will be retained in the future, but will change in terms of content and perhaps also in terms of names, is consistent with the findings from Chapter 3.1.3. Today's training occupations have always been composed of several occupations. For this reason, it would be reasonable to assume that today's occupational profiles will also continue to evolve over the next few years, leading to new or combined training occupations. Nevertheless, there are some training occupations profiles, which could be insecure depending on the level of digitization. Some of these job profiles were already named by the interviewees, for examples a simple machine operator. It is also possible that the structure for training occupations will change in this context. Companies should be prepared or such developments.

Educational system in future

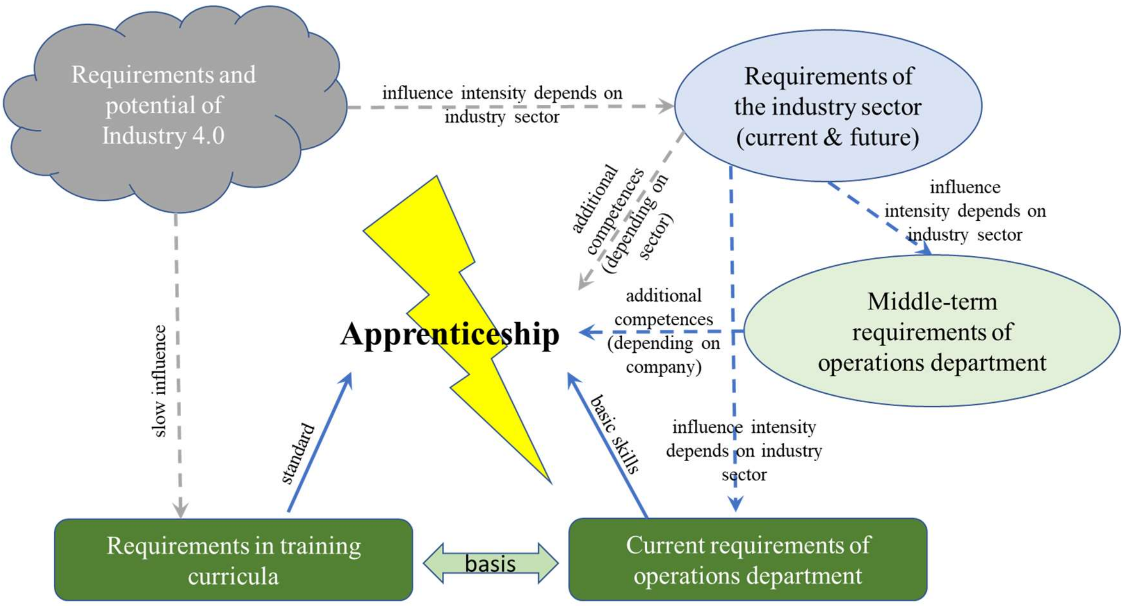
The duality principle of the education system should be retained in the future. However, against the backdrop of digitization, vocational schools, as a social partner, must be promoted and financially supported more. This includes topics such as the payment of vocational school teachers and state-funded projects. From a personal point of view, this goal is worth striving for, but it is difficult to achieve, as a fundamental political decision would have to be made for this, which would trigger a domino effect in many other educational and social areas. Instead of cooperating exclusively with vocational schools, however, increased cooperation with universities could represent an opportunity to increase the level of digitization in school-based vocational training, since universities are often better positioned and more modern. However, as Jürgen Hengst-Wolf from

Vallourec also explained in his interview, a 100% switch to cooperative training, i.e., including an university degree, would not work as long as traditional skilled workers are still needed. In addition, some of the interviewees would like to see a modularization principle instead of the occupational principle. The possibility of putting together competence modules after basic training builds on the familiar university system. The advantages for apprentices and the training company would be, on the one hand, that competence profiles could be individually tailored to the company and the trainee and, on the other hand, that the attractiveness of vocational training would be increased by approximating the university system. This could possibly counteract the trend for studies to drive out vocational training.

4.5.2 Recommendations

As elaborated in chapter 4.4.2.4, digitization in training should not be an end in itself. The task of the training department is first and foremost to find a suitable balance between the requirements of operations department, the training framework curricula and the requirements of the industry sector. This field of tension is summarized in figure 10.

Figure 10: Field of Tension



Source: own creation.

Nevertheless, all companies are bound by the training curricula for the corresponding training occupations. In some cases, these are below the needs of production, so that the vocational training departments have to consider how they can compensate for this discrepancy. Since the training curricula are designed to be relatively flexible, this opens up many possibilities. The danger here, however, is that different training companies will no longer train uniform job profiles, as the training content would only be comparable in its basic features.

In some other cases, the minimum requirements from the training curricula are higher than the requirements of production. This leads to the phenomenon described in section 4.4.2.3, where apprentices use 4.0 applications during their vocational training and then take a step backwards in terms of digitization after their apprenticeship, which could result in a loss of their motivation. If such companies did not give digital transformation any space in the training curriculum, this could result in the situation, that vocational training loose overall value. It would be more efficient to try to use the digital skills of the apprentices as a multiplier. After all, digital progress could be promoted and driven by the use of skilled workers who have been educated already. On the one hand, the company would benefit and, on the other, apprentices would actually be able to apply the skills they learned during their training.

Which path a vocational training department takes depends on several factors that have already been described in the course of this paper:

- general company policy
- economic situation
- degree of digitization in the company as a whole
- type of training occupations
- attitude of the trainers
- possibilities of the vocational school

However, if the vocational training department does not limit its view to its own company, potential opportunities could arise to drive the digital transformation forward. In the study ‘Competence profiles often the future’, for example, the possibility of setting up central training teaching centers was discussed. A similar model is already being implemented by Deutsche Edelstahlwerke. DEW has established a career workshop and provides training there for a variety of companies. The idea behind a central training workshop is that apprentices from a more inert industry will also have the opportunity to work with digital applications. A look at other companies also brings advantages in other places. A more intensive exchange between vocational training departments could lead to them learning from each other. The interviews revealed, for example, that the training department at Vallourec is considering a digital application process in the future. HKM, on the other hand, has already successfully installed one. Training companies could also learn a lot from each other on other topics. While some of the companies which were interviewed would like to see an online learning tool for the apprentices, Evonik, for example, has already introduced some e-learnings. Some of the company projects, such as the Diga@VT project at ThyssenKrupp Steel, could also serve as a model solution for other companies in order to make the first step into paperless factory. With such collaboration, on the one hand the digitization process can be advanced and on the other hand investment costs can also be reduced by avoiding bad investments. In addition, time capacities could also be planed more efficient, as the implementation of such digital measures would not have to be invented from scratch.

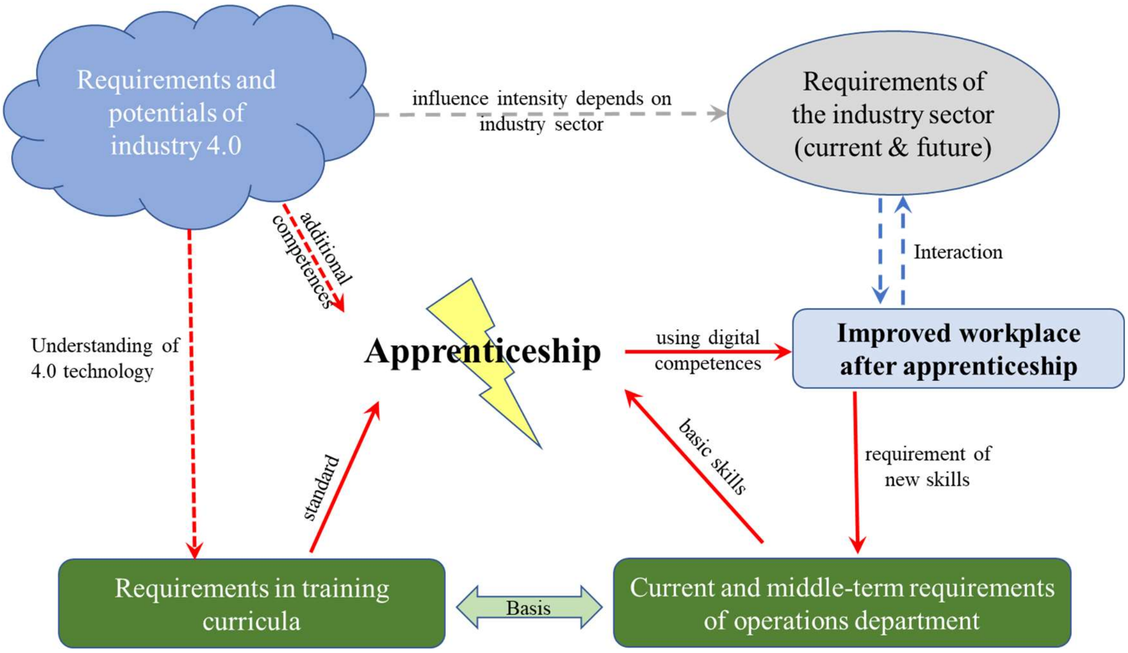
Training departments should focus not on the challenges, but on the opportunities of digitization. On the one hand, digital transformation leads to more efficient processes within the training department, which also bring financial benefits. A digital application process, for example, leads to the elimination of administrative activities and thus cost reductions can be achieved. On the other hand, digital tools are finding greater acceptance among younger generations and could, for example, result in greater learning success through the increased use of online training or virtual simulations.

Since apprentices themselves know best which learning methods or digital tools are most attractive, companies should enable them to participate in designing the digitization process. The project 'Digital Youngster' already provides a preview of what young apprentices can contribute to the digital transformation of companies. Currently, apprentices are often only prepared for the digital transformation. They are transformed into a kind of tool, which fits into the toolbox of the department that receives the new employees after their apprenticeship. Considering the findings from chapter 4.1.5, apprentices should be allowed to help develop the digital process so that the individual output is greater and the company as a whole can also benefit from progress in digitalisation. Airbus' digital pilot class already contained traits of such an idea, but overall apprentices are not integrated into the digitalisation process as much as assumed.

Such an approach could be that the planning of the internal training content no longer has the goal to prepare apprentices for the work in three or four years. Rather, the apprentice would be prepared today to be able to integrate digital opportunities of the day after tomorrow. In their basic education, apprentices would acquire the current and middle-term technical aptitude for their job after the apprenticeship and, in parallel, they would be taught the potentials of the digital transformation. This knowledge can then be integrated into the department after the apprenticeship. In consequence, apprentices would no longer be prepared for digital progress, but would initiate digital progress themselves. On the one hand, this would lead to a faster digital transformation of the company and, on the other hand, the standard of basic education could be raised from one apprenticeship generation to the next. Another effect would be that qualification requirements are no longer set unilaterally by the industry sector. There would be a kind of reciprocity, as the continuous digital progress of companies would also influence the progress of the industry sector as a whole. The prerequisite for such an approach is close coordination between the educational institution and the company and an integration of broader '4.0 knowledge' into the training framework curricula. Concrete technical skills would be less important than establishing an understanding of modern technologies, as some of the interviewees also pointed out. This approach is summarized in figure 11. The role of the mentioned influencing factors in such an approach would have to be identified in a further study.

Overall, however, each company has to find its own way to shape the digital transformation in vocational training. As the interview results show, there is no one right way, but many different ones that are influenced by the factors mentioned above. The important thing is to continue to follow the digital transformation, albeit in small steps, so that we can continue to offer appropriate vocational training in the future.

Figure 11: Approach: Pushing of Digital Transformation



Source: own creation.

4.6 Limitations

The limitation of the present work lies on the one hand in the focus on exclusively industrial training and on the other hand in the time of writing and in the limited number of interview partners.

As some of the interviewees indicated, the digital transformation is currently more noticeable in the commercial professions than in production. In a further study, this thesis should be examined more closely and, if necessary, confirmed or revised.

Due to Corona, the writing of this paper and the survey of the companies took place in purely digital form. Thus, a clear on-site picture could not be made, which may have prevented some aspects from being included in the present work. In addition, the Corona pandemic ensured an acceleration of many measures in the companies surveyed, as was also confirmed in part by the interviewees. For this reason, the development of digitization in training did not necessarily happen against the background of digitization in industry, but is related to the company pandemic measures.

Although the interview partners selected are already from different industries, whereby the majority of these belong to the steel industry, the results cannot be applied without restriction to all industry sponsors. In addition to that there is no tangible proof if the level of digitization is depending on the size of a company. The study which was presented by Tim Graberg analysed SME companies in the metal industry. The presented empirical research includes large companies. Moreover there is no indication if digital transformation is effected by the region. Most of the companies surveyed are located in southern or western regions of Germany.

Furthermore, the term Industry 4.0, which cannot be defined, represents a general limitation. All companies face the problem that, due to the lead time, they must already prepare for developments whose effects cannot be predicted. It is thus not known at the present time whether digital transformation will substitute or support human labour. The extent of both pathways would need to be analysed in further study.

5 Conclusion

This master's thesis focused on how digital transformation has already been integrated into industrial training and how the future of industrial training will be shaped. For this purpose, interviews were conducted with ten selected industrial companies from different sectors, and the results of the interviews were compared and analysed.

The following table (table 11) summarize all discussed findings and recommendations:

Table 11: Findings and Recommendations

Elements	Findings	Recommendation
digitization in industrial vocational training	• expectation not met no generally valid systematic integration of Industry 4.0	• stronger integration of industry 4.0 content in training curricula to improve digitisation process
level of digitization	• the more innovative, the more digital	• Driving digitisation instead of waiting for its arrival focus on opportunities
economic situation	• the more financial resources, the more investment in Industry 4.0 is possible	• cooperation with other companies some measures are possible without great investments some measures results in lower costs
internal training content	• a certain standard of technical equipment is available (3D print, robotics, augmented reality tools) building up an understanding of modern technologies	• Retain and intensify
role model of trainers and school teachers	• learning facilitator acceptance is missing among some trainers and teachers some trainers are afraid	• create transparency and understanding qualify trainers
training curricula	• flexible, build a general standard a too high standard would lead to rejection due to lack of technical equipment	• stronger integration of industry 4.0 content in training curricula to improve digitisation process focus on understanding, not on technical use general improvement of vocational schools

Elements	Findings	Recommendation
increase attractiveness through digitization	• digitization as one aspect among many no significant increase of applicants higher demand within company due to high-skilled apprentices	• focus on future digitization will be more and more important for young generations
vocational school	• close cooperation bad equipment lack of teachers	• political changes needed more cooperation with universities due to better equipment
training occupations	• most occupations will only change but not disappear The risk of an occupation depends on the degree of substitution	• be prepared for disappearing occupations
training principles	• keep dual principle modularization for more flexibility	• from occupation principle to modularization principle
involvement of apprentices	• only visible to a certain extent	• apprentices could sharp digitization process, see figure 10

Source: Own creation.

The transformation of industrial vocational training in the context of digitalization in industry can be drafted depending on the sector and company, but cannot be generalized. All the changes that have been predicted in the direction of Industry 4.0 have not yet been widely applied. Digitalisation must therefore be actively pursued by companies and depends on various factors. Overall, it can be summarised that the degree of digitalisation is strongly dependent on the industrial sector. If the industry lives from fast and innovative changes, then digitisation also takes on a correspondingly important role in the companies. This effect is noticeable in the chemical and automotive (supplier) industries. If a sector is rather sluggish, the digitisation process is analogous.

Due to legal regulations, consistent training curricula can define some standards, such as the use of 3D printers, robotics applications or networked CNC machines, as the lowest common denominator. Beyond that, however, every company tries to integrate tools, projects or actions that have the aim of advancing digitization or at least pushing the mindset for digital transformation. Here, too, the intensity of the topic depends heavily on the financial situation and the digital progress of the company as a whole. In some companies, the competence requirements from the operating departments have already changed, so that the above-mentioned measures for qualifying apprentices are necessary. These include the chemical and automotive industries, which are predestined for faster progress due to their short innovation cycle. But even if the training department is already more advanced than the operating departments, the digital transformation should be driven forward in order to create an advantage for the company as a whole and not jeopardize its attractiveness for potential apprentices.

However, digital changes should be made transparent and accessible to all employees, regardless of the company. The opportunities provided by digitization must be accepted by employees, otherwise digital measures will fail. The same also applies to training personnel. Trainers have to be appropriately prepared for their new role as learning companions. Both technical and methodological skills are equally important.

Despite some challenges, digital transformation will continue to play an important role in the future. Occupational profiles will change in the long or short term in the direction of Industry 4.0, so that regular adaptation will be necessary. The consensus and duality principles of vocational training remain undisputed. The cooperation with an educational institution is perceived as a great strength, although the lack of teaching staff, the lack of technical equipment and outdated teaching methods in vocational schools are strongly criticized. Although companies can support vocational schools in some aspects, political decisions have to be made for fundamental changes.

For the future of the vocational principle, some driving ideas have emerged. The rapid change in some individual activities and the interdisciplinary requirements result in the idea that companies would like to see a modularization principle in vocational training. The competence profile of an apprentice could thus be individually configured according to company and personal needs, so that only basic activities would be included in the profile of an apprenticeship occupation. Overall, however, the German training system remains the pioneer and a role model in international comparisons.

From today's perspective, therefore, it is not possible to produce a universally applicable guide to digital transformation in industrial training. The differences between the various industries, but also between companies in the same industry, are simply too great. There is also no one right approach to starting a digital transformation. However, companies that are just getting started can try to learn from other companies that have already had their first experiences.

When it comes to digital transformation, it should not be forgotten that apprentices have to deal with the consequences of digital measures. It therefore makes sense to include the ideas of apprentices in the creative process in order to achieve acceptance for the digital transformation. As the approach discussed in chapter 4.5.2 shows, digital competences of apprentices could also be systematically integrated into the digitisation process, so that both the company and the training department can continuously benefit from it. However, such a development would require a restructuring of large parts of the education system.

Overall, the digital transformation is definitely noticed, at least in the companies surveyed, and cannot be overlooked. Everyone is aware that adapting to the new conditions is necessary for the success of the training and then also for the success of the company. For this to happen, however, all parties involved will have to work together, all employees will have to be involved, and comprehensive acceptance and motivation for new processes will have to be generated. In today's digital age, no one can avoid digitization and its consequences.

Appendix

Appendix 1: ITM Checklist

Topics	Comments
Economics	Digitization has influence on economic aspects withing a company. The aim of digital transformation is to increase efficiency and reduce costs as a result.
Marketing & Communication	Digitization measures could result in a higher attractiveness of the vocational training due to a modern image and modern working conditions for potential apprentices. Moreover the attractiveness of apprenticeship within the company increases as well.
HR & Leadership Competencies	The development of young skilled workers and the change in qualifications and competencies is a topic for HR.
Corporate Finance	As digital transformation should result in cost efficiency, corporate finance is involved in the whole process.
Strategic Corporate Management	Digitization is a strategic decision for the whole company.
International Business Law	No application
Value Based Controlling & Int. Accounting	The investment in digital tools for the vocational training department has to be coordinated.
Research Methods	the results of the present paper are based on a qualitative research method.
Management Decision Making	Management has to decide about the degree of digitization of the vocational training department
Digitisation	The whole paper includes the topic digitization.
Business Ethics and Sustainability	As digitization results in efficiency, it contribute sustainability. If digitization should develop in the direction of humanization instead of substitution, digital opportunities have to be evaluated under ethical aspects.

Appendix 2: Changes in Training Curricula

IHK-Leitfaden – industrielle Metall- und Elektroberufe und Mechatroniker 2018

Berufsbildposition: Digitalisierung der Arbeit, Datenschutz und Informationssicherheit

Lfd. Nr	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
1	2	3
5	Digitalisierung der Arbeit, Datenschutz und Informationssicherheit (§ 7 Absatz 1 Nummer 5, § 11 Absatz 1 Nummer 5, § 15 Absatz 1 Nummer 5, § 19 Absatz 1 Nummer 5, § 23 Absatz 1 Nummer 5)	a) auftragsbezogene und technische Unterlagen unter Zuhilfenahme von Standardsoftware erstellen b) Daten und Dokumente pflegen, austauschen, sichern und archivieren c) Daten eingeben, verarbeiten, übermitteln, empfangen und analysieren d) Vorschriften zum Datenschutz anwenden e) informationstechnische Systeme (IT-Systeme) zur Auftragsplanung, Auftragsabwicklung und Terminverfolgung anwenden f) Informationsquellen und Informationen in digitalen Netzen recherchieren und aus digitalen Netzen beschaffen sowie Informationen bewerten g) digitale Lernmedien nutzen h) die informationstechnischen Schutzziele Verfügbarkeit, Integrität, Vertraulichkeit und Authentizität berücksichtigen i) betriebliche Richtlinien zu Nutzung von Datenträgern, elektronischer Post, IT-Systemen und Internetseiten einhalten j) Auffälligkeiten und Unregelmäßigkeiten in IT-Systemen erkennen und Maßnahmen zur Beseitigung ergreifen k) Assistenz-, Simulations-, Diagnose- oder Visualisierungssysteme nutzen l) in interdisziplinären Teams kommunizieren, planen und zusammenarbeiten

(identisch für alle 11 Berufe)

Synopse: Änderungen der Inhalte in den Ausbildungsrahmenplänen – hier: Industrielle Elektroberufe

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hier: industrielle Elektroberufe

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
6	Betriebliche und technische Kommunikation (§ 7 Abs. 1 Nr. 6, § 11 Abs. 1 Nr. 6, § 15 Abs. 1 Nr. 6, § 19 Abs. 1 Nr. 6, § 23 Abs. 1 Nr. 6)	a) technische Zeichnungen und Schaltungsunterlagen auswerten, anwenden und erstellen sowie Skizzen an- fertigen b) Dokumente sowie technische Regelwerke und berufsbezogene Vorschriften, auch in Englisch, recherchieren, auswerten und anwenden c) im virtuellen Raum zusammenarbeiten, Produkt- und Prozessdaten sowie Handlungsanweisungen und Funktionsbeschreibungen austauschen d) Gespräche mit Vorgesetzten, Mitarbeitern und im Team situationsgerecht und zielorientiert führen e) Sachverhalte darstellen, Protokolle anfertigen, deutsche und englische Fachbegriffe anwenden f) Dokumentationen in deutscher und englischer Sprache zusammenstellen und ergänzen g) Arbeitssitzungen organisieren und moderieren, Entscheidungen im Team erarbeiten, Gesprächsergebnisse schriftlich fixieren h) Daten und Sachverhalte sowie Lösungsvarianten präsentieren i) Konflikte im Team lösen j) schriftliche Kommunikation in Deutsch und Englisch durchführen

ALT

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufs- spezifischen Fachqualifikationen zu vermitteln sind
~~5~~ 6	Betriebliche und technische Kommunikation (§ 7 Abs. 1 Nr. 5, § 11 Abs. 1 Nr. 5, § 15 Abs. 1 Nr. 5, § 19 Abs. 1 Nr. 5, § 23 Abs. 1 Nr. 5~~, § 27 Abs. 1 Nr. 5~~)	~~a) Informationsquellen und Informationen recherchieren und beschaffen, Datenbankabfragen durchführen, Informationen bewerten~~ ~~b)~~ technische Zeichnungen und Schaltungsunterlagen auswerten, anwenden und erstellen sowie Skizzen anfertigen ~~c)~~ Dokumente sowie technische Regelwerke und berufsbezogene Vorschriften, auch in Englisch, auswerten und anwenden ~~d) Daten und Dokumente pflegen, schützen, sichern und archivieren~~ ~~e)~~ Gespräche mit Vorgesetzten, Mitarbeitern und im Team situationsgerecht und zielorientiert führen ~~f)~~ Sachverhalte darstellen, Protokolle anfertigen, deutsche und englische Fachbegriffe anwenden ~~g)~~ Dokumentationen in deutscher und englischer Sprache zusammenstellen und ergänzen~~, Standardsoftware anwenden~~ ~~h)~~ Arbeitssitzungen organisieren und moderieren, Entscheidungen im Team erarbeiten, Gesprächsergebnisse schrift- lich fixieren ~~i)~~ Daten und Sachverhalte sowie Lösungsvarianten präsentieren ~~j)~~ Konflikte im Team lösen ~~k)~~ schriftliche Kommunikation in Deutsch und Englisch durchführen

NEU **ALT**

hier: industrielle Elektroberufe

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
7	Planen und Organisieren der Arbeit, Bewerten der Arbeitsergebnisse (§ 7 Abs. 1 Nr. 7, §11 Abs. 1 Nr. 7, § 15 Abs. 1 Nr. 7, § 19 Abs. 1 Nr. 7, § 23 Abs. 1 Nr. 7)	a) Arbeitsplatz oder Montagestelle unter Berücksichtigung betrieblicher Vorgaben einrichten b) erforderliche Werkzeuge, Geräte, Diagnosesysteme und sonstige Materialien für den Arbeitsablauf feststellen und auswählen, termingerecht anfordern, prüfen, transportieren, lagern und bereitstellen c) Arbeitsabläufe und Teilaufgaben planen und dabei sowohl rechtliche, wirtschaftliche und terminliche Vorgaben, betriebliche Prozesse beachten als auch vor- und nachgelagerte Bereiche berücksichtigen sowie bei Abweichungen von der Planung Prioritäten setzen d) Aufgaben im Team planen und abstimmen, kulturelle Identitäten berücksichtigen e) Kalkulationen nach betrieblichen Vorgaben durchführen, Lösungsvarianten aufzeigen, Kosten vergleichen f) Rechnerarbeitsplatz unter ergonomischen Gesichtspunkten einrichten, grafische Benutzeroberflächen einrichten g) Auftragsunterlagen sowie technische Durchführbarkeit des Auftrags prüfen und mit den betrieblichen Möglichkeiten abstimmen h) betriebswirtschaftlich relevante Daten erfassen und bewerten i) qualitätssteigernde Einflüsse von Arbeitssituationen, Arbeitsumgebung und Arbeits-verhalten im Team auf die Arbeitsergebnisse erkennen und anwenden j) interne und externe Leistungserbringung vergleichen k) Qualifikationsdefizite feststellen, Qualifizierungsmög-

ALT

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
~~6~~ 7	Planen und Organisieren der Arbeit, Bewerten der Arbeitsergebnisse (§ 7 Abs. 1 Nr. 6, § 11 Abs. 1 Nr. 6, § 15 Abs. 1 Nr. 6, § 19 Abs. 1 Nr. 6, § 23 Abs. 1 Nr. 6, ~~§ 27 Abs. 1 Nr. 6~~)	a) Arbeitsplatz oder Montagestelle unter Berücksichtigung betrieblicher Vorgaben einrichten b) erforderliche Werkzeuge, Materialien für den Arbeitsablauf feststellen und auswählen, termingerecht anfordern, prüfen, transportieren, lagern und bereitstellen c) Arbeitsabläufe und Teilaufgaben ~~unter Beachtung rechtlicher, wirtschaftlicher und terminlicher Vorgaben planen,~~ bei Abweichungen von der Planung Prioritäten setzen d) Aufgaben im Team planen und abstimmen, kulturelle Identitäten berücksichtigen e) Kalkulationen nach betrieblichen Vorgaben durchführen ~~f) Lösungsvarianten aufzeigen, Kosten vergleichen~~ ~~g) IT-Systeme zur Auftragsplanung, -abwicklung und Terminverfolgung anwenden~~ ~~h)~~ Rechnerarbeitsplatz unter ergonomischen Gesichtspunkten einrichten, grafische Benutzeroberflächen einrichten ~~i)~~ Auftragsunterlagen sowie technische Durchführbarkeit des Auftrags prüfen und mit den betrieblichen Möglichkeiten abstimmen ~~j)~~ betriebswirtschaftlich relevante Daten erfassen und bewerten ~~k)~~ qualitätssteigernde Einflüsse von Arbeitssituationen, Arbeitsumgebung und Arbeitsverhalten im Team auf die Arbeitsergebnisse erkennen und anwenden ~~l)~~ interne und externe Leistungserbringung vergleichen ~~m)~~ Qualifikationsdefizite feststellen, Qualifizierungsmöglichkeiten nutzen sowie unterschiedliche Lerntechniken anwenden

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hier: industrielle Elektroberufe

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
		lichkeiten nutzen sowie unterschiedliche Lerntechniken anwenden l) Arbeitsergebnisse kontrollieren, beurteilen und dokumentieren
18	Geschäftsprozesse und Qualitätsmanagement im Einsatzgebiet (§ 7 Abs. 1 Nr. 18)	a) Kunden auf spezifische Angebote hinweisen und beraten, Aufträge annehmen b) Informationen beschaffen und bewerten, Dokumentationen nutzen und bearbeiten, technologische Entwicklungen feststellen, sicherheitsrelevante Unterlagen berücksichtigen c) Ausgangszustand analysieren, technische und organisatorische Schnittstellen klären, Schnittstellen dokumentieren, Auftragsziele festlegen, Teilaufgaben definieren, technische Unterlagen erstellen und an der Kostenplanung mitwirken d) Angebote und Kostenvoranschläge unter Beachtung der betrieblichen Vorgaben einholen, prüfen und bewerten e) Auftragsabwicklung planen und mit vor- und nachgelagerten Bereichen abstimmen, Planungsunterlagen erstellen, die für die Sicherung der betrieblichen Abläufe notwendigen Verbrauchsmaterialien und -stoffe sowie Ersatzteile disponieren und bevorraten f) Fremdleistungen veranlassen, prüfen und überwachen g) Aufträge, insbesondere unter Berücksichtigung von Arbeitssicherheit und Umweltschutz durchführen, Einhaltung von Terminen verfolgen h) Normen und Spezifikationen zur Qualität und Sicherheit der Produkte und Prozesse beachten, Qualitätssiche-

ALT

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
~~17~~ 18	Geschäftsprozesse und Qualitätsmanagement im Einsatzgebiet (§ 7 Abs. 1 Nr. 17)	a) Kunden auf spezifische Angebote hinweisen und beraten, Aufträge annehmen b) Informationen beschaffen und bewerten, Dokumentationen nutzen und bearbeiten, technologische Entwicklungen feststellen, sicherheitsrelevante Unterlagen berücksichtigen c) Ausgangszustand analysieren, technische und organisatorische Schnittstellen klären, Schnittstellen dokumentieren, Auftragsziele festlegen, Teilaufgaben definieren, technische Unterlagen erstellen und an der Kostenplanung mitwirken d) Angebote und Kostenvoranschläge unter Beachtung der betrieblichen Vorgaben einholen, prüfen und bewerten e) Auftragsabwicklung planen und mit vor- und nachgelagerten Bereichen abstimmen, Planungsunterlagen erstellen, die für die Sicherung der betrieblichen Abläufe notwendigen Verbrauchsmaterialien und -stoffe sowie Ersatzteile disponieren und bevorraten f) Fremdleistungen veranlassen, prüfen und überwachen g) Aufträge, insbesondere unter Berücksichtigung von Arbeitssicherheit und Umweltschutz durchführen, Einhaltung von Terminen verfolgen h) Normen und Spezifikationen zur Qualität und Sicherheit der Produkte und Prozesse beachten, Qualitätssiche-

NEU **ALT**

hier: industrielle Elektroberufe

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
		rungssystem anwenden sowie Ursachen von Fehlern und Qualitätsmängeln systematisch suchen, beseitigen und dokumentieren i) Projektablauf dokumentieren, Leistungen abrechnen, Abrechnungsdaten erstellen, Nachkalkulation durchführen j) technische Einrichtungen für die Benutzung frei- und übergeben, Abnahmeprotokolle anfertigen, Produkte und Dienstleistungen erläutern k) Systemdokumentation und Bedienungsanleitungen zusammenstellen und modifizieren l) Soll- Ist- Vergleich mit den Planungsdaten durchführen, Arbeitsergebnisse und -durchführung bewerten m) zur kontinuierlichen Verbesserung von Arbeitsvorgängen im Betriebsablauf und im eigenen Arbeitsbereich beitragen n) Lebenszyklusdaten von Aufträgen, Dienstleistungen, Produkten und Betriebsmitteln auswerten und Vorschläge zur Optimierung von Abläufen und Prozessen erarbeiten

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
		rungssystem anwenden sowie Ursachen von Fehlern und Qualitätsmängeln systematisch suchen, beseitigen und dokumentieren i) Projektablauf dokumentieren, Leistungen abrechnen, Abrechnungsdaten erstellen, Nachkalkulation durchführen j) technische Einrichtungen für die Benutzung frei- und übergeben, Abnahmeprotokolle anfertigen, Produkte und Dienstleistungen erläutern k) Systemdokumentation und Bedienungsanleitungen zusammenstellen und modifizieren l) Soll- Ist- Vergleich mit den Planungsdaten durchführen, Arbeitsergebnisse und -durchführung bewerten m) zur kontinuierlichen Verbesserung von Arbeitsvorgängen im Betriebsablauf und im eigenen Arbeitsbereich beitragen

Synopse: Änderungen der Inhalte in den Ausbildungsrahmenplänen – hier: Industrielle Metallberufe

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hier: industrielle Metallberufe

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
6	Betriebliche und technische Kommunikation (§ 7 Abs. 1 Nr. 6, § 11 Abs. 1 Nr. 6, § 15 Abs. 1 Nr. 6, § 19 Abs. 1 Nr. 6, § 23 Abs. 1 Nr. 6)	a) technische Zeichnungen und Stücklisten auswerten und anwenden sowie Skizzen anfertigen b) Dokumente sowie technische Unterlagen und berufsbezogene Vorschriften zusammenstellen, ergänzen, auswerten und anwenden c) Gespräche mit Kunden, Vorgesetzten und im Team situationsgerecht und zielorientiert auch mit digitalen Kommunikationsmitteln führen, kulturelle Identitäten berücksichtigen d) Sachverhalte darstellen, Protokolle anfertigen; englische Fachbegriffe in der Kommunikation anwenden e) Informationen auch aus englischsprachigen technischen Unterlagen oder Dateien entnehmen und verwenden f) Besprechungen organisieren und moderieren, Ergebnisse dokumentieren und präsentieren g) Konflikte im Team lösen
7	Planen und Organisieren der Arbeit, Bewerten der Arbeitsergebnisse (§ 7 Abs. 1 Nr. 7,	a) Arbeitsplatz unter Berücksichtigung betrieblicher Vorgaben einrichten b) Werkzeuge und Materialien auswählen, termingerecht anfordern, prüfen, transportieren und bereitstellen c) Arbeitsabläufe und Teilaufgaben unter Beachtung wirt-

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
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~~6~~ 7	Planen und Organisieren der Arbeit, Bewerten der Arbeitsergebnisse (§ 7 Abs. 1 Nr. 6,	a) Arbeitsplatz unter Berücksichtigung betrieblicher Vorgaben einrichten b) Werkzeuge und Materialien auswählen, termingerecht anfordern, prüfen, transportieren und bereitstellen c) Arbeitsabläufe und Teilaufgaben unter Beachtung wirt-

NEU **ALT**

hier: industrielle Metallberufe

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
	§ 11 Abs. 1 Nr. 7, § 15 Abs. 1 Nr. 7, § 19 Abs. 1 Nr. 7, § 23 Abs. 1 Nr. 7)	schaftlicher und terminlicher Vorgaben planen und durchführen d) Instrumente zur Auftragsabwicklung sowie der Terminverfolgung anwenden e) betriebswirtschaftlich relevante Daten erfassen und bewerten f) Lösungsvarianten prüfen, darstellen und deren Wirtschaftlichkeit vergleichen g) im eigenen Arbeitsbereich zur kontinuierlichen Verbesserung von Arbeitsvorgängen beitragen h) Qualifikationsdefizite feststellen, Qualifizierungsmöglichkeiten nutzen i) unterschiedliche Lerntechniken anwenden j) Prüfverfahren und Prüfmittel auswählen und anwenden, Einsatzfähigkeit von Prüfmitteln feststellen k) Arbeitsergebnisse kontrollieren, beurteilen und dokumentieren l) Aufgaben im Team planen und durchführen
18	Geschäftsprozesse und Qualitätssicherungs-systeme im Einsatzgebiet (§ 7 Abs. 1 Nr. 18)	a) Art und Umfang von Aufträgen klären, spezifische Leistungen feststellen, Besonderheiten und Termine mit Kunden absprechen b) Informationen für die Auftragsabwicklung beschaffen, auswerten und nutzen, technische Entwicklungen berücksichtigen, sicherheitsrelevante Vorgaben beachten c) Auftragsabwicklungen unter Berücksichtigung sicherheitstechnischer, betriebswirtschaftlicher und ökologischer Ge-

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	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
	§ 11 Abs. 1 Nr. 6, § 15 Abs. 1 Nr. 6, § 19 Abs. 1 Nr. 6, § 23 Abs. 1 Nr. 6)	schaftlicher und terminlicher Vorgaben planen und durchführen d) Instrumente zur Auftragsabwicklung sowie der Terminverfolgung anwenden e) betriebswirtschaftlich relevante Daten erfassen und bewerten f) Lösungsvarianten prüfen, darstellen und deren Wirtschaftlichkeit vergleichen g) im eigenen Arbeitsbereich zur kontinuierlichen Verbesserung von Arbeitsvorgängen beitragen h) Qualifikationsdefizite feststellen, Qualifizierungsmöglichkeiten nutzen i) unterschiedliche Lerntechniken anwenden j) Prüfverfahren und Prüfmittel auswählen und anwenden, Einsatzfähigkeit von Prüfmitteln feststellen k) Arbeitsergebnisse kontrollieren, beurteilen und dokumentieren l) Aufgaben im Team planen und durchführen
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hier: industrielle Metallberufe

NEU:

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
		sichtspunkte planen sowie mit vor- und nachgelagerten Bereichen abstimmen, Planungsunterlagen erstellen d) Teilaufträge veranlassen, Ergebnisse prüfen e) Aufträge, insbesondere unter Berücksichtigung von Arbeitssicherheit, Umweltschutz und Terminvorgaben durchführen f) betriebliche Qualitätssicherungssysteme im eigenen Arbeitsbereich anwenden; Ursachen von Qualitätsmängeln systematisch suchen, beseitigen und dokumentieren g) Prüfverfahren und Prüfmittel auswählen und anwenden, Einsatzfähigkeit von Prüfmitteln feststellen, Prüfpläne und betriebliche Prüfvorschriften anwenden, Ergebnisse dokumentieren h) Auftragsabwicklung, Leistungen und Verbrauch dokumentieren i) technische Systeme oder Produkte an Kunden übergeben und erläutern, Abnahmeprotokolle erstellen j) Arbeitsergebnisse und -durchführung bewerten sowie zur kontinuierlichen Verbesserung von Arbeitsvorgängen im Betriebsablauf beitragen k) Optimierung von Vorgaben, insbesondere von Dokumentationen, veranlassen l) Lebenszyklusdaten von Aufträgen, Dienstleistungen, Produkten und Betriebsmitteln auswerten, Vorschläge zur Optimierung von Abläufen und Prozessen erarbeiten

ALT:

	Teil des Ausbildungsberufsbildes	Kernqualifikationen, die unter Einbeziehung selbstständigen Planens, Durchführens und Kontrollierens integriert mit berufsspezifischen Fachqualifikationen zu vermitteln sind
		sichtspunkte planen sowie mit vor- und nachgelagerten Bereichen abstimmen, Planungsunterlagen erstellen d) Teilaufträge veranlassen, Ergebnisse prüfen e) Aufträge, insbesondere unter Berücksichtigung von Arbeitssicherheit, Umweltschutz und Terminvorgaben durchführen f) betriebliche Qualitätssicherungssysteme im eigenen Arbeitsbereich anwenden; Ursachen von Qualitätsmängeln systematisch suchen, beseitigen und dokumentieren g) Prüfverfahren und Prüfmittel auswählen und anwenden, Einsatzfähigkeit von Prüfmitteln feststellen, Prüfpläne und betriebliche Prüfvorschriften anwenden, Ergebnisse dokumentieren h) Auftragsabwicklung, Leistungen und Verbrauch dokumentieren i) technische Systeme oder Produkte an Kunden übergeben und erläutern, Abnahmeprotokolle erstellen j) Arbeitsergebnisse und -durchführung bewerten sowie zur kontinuierlichen Verbesserung von Arbeitsvorgängen im Betriebsablauf beitragen k) Optimierung von Vorgaben, insbesondere von Dokumentationen, veranlassen

Synopse: Änderungen der Inhalte in den Ausbildungsrahmenplänen – hier: Mechatroniker

NEU **ALT**

hier: Mechatroniker

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	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
1	2	3
6	Betriebliche und technische Kommunikation (§ 3 Absatz 2 Nummer 6)	a) Gespräche mit Vorgesetzten und Mitarbeitern und im Team situationsgerecht führen, Sachverhalte darstellen, deutsche und englische Fachausdrücke anwenden b) Möglichkeiten zur Konfliktregelung anwenden c) IT-Systeme handhaben, insbesondere Software einsetzen, Peripheriegeräte anschließen und nutzen d) Protokolle und Berichte anfertigen
		e) Teil-, Gruppen-, Gesamtzeichnungen lesen und anwenden f) Schaltungsunterlagen von Baugruppen und Geräten der Fluidik lesen und anwenden g) elektrische Pläne, Block-, Funktions-, Aufbau- und Anschlusspläne lesen und anwenden h) Skizzen und Stücklisten anfertigen
		i) technische Pläne von Baugruppen, Maschinen und Anlagen aktualisieren j) technische Regelwerke, Betriebsanleitungen, Arbeitsanweisungen und sonstige technische Informationen, auch in Englisch, anwenden k) Arbeitssitzungen organisieren und moderieren, Ent-

ALT

	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
1	2	3
~~5~~ 6	Betriebliche und technische Kommunikation (§ 3 Absatz 2 Nummer 5)	~~a) Informationen beschaffen und bewerten~~ ~~b)~~ Gespräche mit Vorgesetzten und Mitarbeitern und im Team situationsgerecht führen, Sachverhalte darstellen, deutsche und englische Fachausdrücke anwenden ~~c)~~ Möglichkeiten zur Konfliktregelung anwenden ~~d) EDV-Anlagen~~ handhaben, insbesondere Software einsetzen, Peripheriegeräte anschließen und nutzen ~~e) Daten schützen und sichern~~ ~~f)~~ Protokolle und Berichte anfertigen~~, Standardsoftware anfertigen~~
		g) Teil-, Gruppen-, Gesamtzeichnungen lesen und anwenden h) Schaltungsunterlagen von Baugruppen und Geräten der Fluidik lesen und anwenden i) elektrische Pläne, Block-, Funktions-, ~~Ausbau~~- und Anschlusspläne lesen und anwenden j) Skizzen und Stücklisten anfertigen
		k) technische Pläne von Baugruppen, Maschinen und Anlagen aktualisieren l) ~~elektrische~~ Regelwerke, Betriebsanleitungen, Arbeitsanweisungen und sonstige technische Informationen, auch in Englisch, anwenden

NEU **ALT**

hier: Mechatroniker

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	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
1	2	3
		scheidungen im Team erarbeiten und Gesprächsergebnisse schriftlich fixieren
		l) Präsentationstechniken anwenden m) im virtuellen Raum zusammenarbeiten, Produkt- und Prozessdaten sowie Handlungsanweisungen und Funktionsbeschreibungen austauschen n) Produkte und Arbeitsergebnisse bei Übergabe erläutern und in die Funktion einweisen o) betriebliche Informations- und Kommunikationssysteme nutzen
7	Planen und Steuern von Arbeitsabläufen, Kontrollieren und Beurteilen der Arbeitsergebnisse (§ 3 Absatz 2 Nummer 7)	a) Arbeitsschritte nach funktionalen, fertigungstechnischen und wirtschaftlichen Kriterien festlegen b) Arbeitsabläufe und Teilaufgaben planen und dabei sowohl rechtliche, wirtschaftliche und terminliche Vorgaben, betriebliche Prozesse sowie vor- und nachgelagerte Bereiche berücksichtigen sowie bei Abweichungen von der Planung Prioritäten setzen c) Arbeit im Team planen, Aufgaben verteilen d) Arbeitsplatz planen und einrichten e) Werkzeuge, Geräte und Diagnosesysteme sowie Material und Hilfsmittel auftragsbezogen anfordern und bereitstellen f) Bearbeitungsmaschinen für den Arbeitsprozess vorbereiten
		g) Werkzeuge, Bearbeitungsmaschinen, Prüf- und Messmittel sowie technische Einrichtungen betriebs-

ALT

	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
1	2	3
		m) Präsentationstechniken anwenden n) Produkte und Arbeitsergebnisse bei Übergabe erläutern und in die Funktion einweisen o) betriebliche Informations- und Kommunikationssysteme nutzen
~~6~~ 7	Planen und Steuern von Arbeitsabläufen, Kontrollieren und Beurteilen der Arbeitsergebnisse (§ 3 Absatz 2 Nummer 6)	a) Arbeitsschritte nach funktionalen, fertigungstechnischen und wirtschaftlichen Kriterien festlegen b) Arbeitsabläufe ~~nach organisatorischen und informatorischen Kriterien festlegen und sicherstellen~~ c) Arbeit im Team planen, Aufgaben verteilen d) Arbeitsplatz planen und einrichten e) ~~Material, Werkzeuge und Hilfsmittel auftragsbezogen anfordern und bereitstellen~~ f) Bearbeitungsmaschinen für den Arbeitsprozess vorbereiten
		g) Werkzeuge, Bearbeitungsmaschinen, Prüf- und Messmittel sowie technische Einrichtungen betriebsbereit machen,

NEU

	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
1	2	3
		bereit machen, überprüfen, warten sowie Maßnahmen zur Fehlerbeseitigung einleiten h) eigene und von anderen erbrachte Leistungen kontrollieren und bewerten sowie dokumentieren i) Material, Ersatzteile, Arbeitszeit und technische Prüfungen dokumentieren j) Qualifikationsdefizite feststellen, Qualifikationsmöglichkeiten nutzen sowie unterschiedliche Lerntechniken anwenden
8	Qualitätsmanagement (§ 3 Absatz 2 Nummer 8)	Normen und Spezifikationen zur Qualitätssicherheit der Produkte beachten sowie Qualität bei der Auftragserledigung unter Beachtung vor- und nachgelagerter Bereiche sichern, insbesondere a) Qualitätssicherungssystem in Verbindung mit technischen Unterlagen und dessen Wirksamkeit beurteilen, Verfahren anwenden b) Prüfarten und Prüfmittel auswählen, Einsatzfähigkeit der Prüfmittel feststellen und dokumentieren, Prüfpläne und betriebliche Prüfvorschriften anwenden c) Ursachen von Fehlern und Qualitätsmängeln systematisch suchen, beseitigen und dokumentieren d) zur kontinuierlichen Verbesserung von Arbeitsvorgängen im eigenen Arbeitsbereich beitragen e) Lebenszyklusdaten von Aufträgen, Dienstleistungen, Produkten und Betriebsmitteln auswerten und Vorschläge zur Optimierung von Abläufen und Prozessen erarbeiten

ALT

hier: Mechatroniker

	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
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		überprüfen, warten sowie Maßnahmen zur Fehlerbeseitigung einleiten h) eigene und von anderen erbrachte Leistungen kontrollieren und bewerten sowie dokumentieren i) Material, Ersatzteile, Arbeitszeit und technische Prüfungen dokumentieren
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Synopse: Änderungen der Inhalte in den Ausbildungsrahmenplänen – hier: Mechatroniker

NEU **ALT**

hier: Mechatroniker

NEU

	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
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		e) Teil-, Gruppen-, Gesamtzeichnungen lesen und anwenden f) Schaltungsunterlagen von Baugruppen und Geräten der Fluidik lesen und anwenden g) elektrische Pläne, Block-, Funktions-, Aufbau- und Anschlusspläne lesen und anwenden h) Skizzen und Stücklisten anfertigen
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		g) Werkzeuge, Bearbeitungsmaschinen, Prüf- und Messmittel sowie technische Einrichtungen betriebsbereit machen,

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	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
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		bereit machen, überprüfen, warten sowie Maßnahmen zur Fehlerbeseitigung einleiten h) eigene und von anderen erbrachte Leistungen kontrollieren und bewerten sowie dokumentieren i) Material, Ersatzteile, Arbeitszeit und technische Prüfungen dokumentieren j) Qualifikationsdefizite feststellen, Qualifikationsmöglichkeiten nutzen sowie unterschiedliche Lerntechniken anwenden
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ALT

	Teil des Ausbildungsberufes	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten
1	2	3
		überprüfen, warten sowie Maßnahmen zur Fehlerbeseitigung einleiten h) eigene und von anderen erbrachte Leistungen kontrollieren und bewerten sowie dokumentieren i) Material, Ersatzteile, Arbeitszeit und technische Prüfungen dokumentieren
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'Digitale Vernetzung' (Industrielle Elektroberufe / Mechatroniker)

Lfd. Nr.	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Analysieren von technischen Aufträgen und Entwickeln von Lösungen	a) Kundenanforderungen hinsichtlich der geforderten Funktion und der technischen Umgebung analysieren b) Ausgangszustand der Systeme analysieren, insbesondere Dokumentationen auswerten sowie Netztopologien, eingesetzte Software und technische Schnittstellen klären und dokumentieren c) technische Prozesse und Umgebungsbedingungen analysieren und Anforderungen an Netzwerke feststellen d) Lösungen unter Berücksichtigung von Spezifikationen, technischen Bestimmungen und rechtlichen Vorgaben planen und ausarbeiten, Netzwerkkomponenten auswählen, technische Unterlagen erstellen und Kosten kalkulieren e) die Lösung zur Vernetzung und zu Änderungen am System mit dem Kunden abstimmen	8
2	Errichten, Ändern und Prüfen von vernetzten Systemen	a) Netzwerkkomponenten und Netzwerkbetriebssysteme installieren, anpassen und konfigurieren und Vorgaben für eine sichere Konfiguration beachten b) Datenaustausch zwischen IT-Systemen und Automatisierungssystemen beachten c) Zugangsberechtigungen einrichten d) Sicherheitssysteme, insbesondere Firewall-, Verschlüsselungs- und Datensicherungssysteme, berücksichtigen e) Funktionen kontrollieren, Fehler beseitigen, Systeme in Betrieb nehmen und übergeben und Änderungen dokumentieren	
3	Betreiben von vernetzten Systemen	a) Fehlermeldungen aufnehmen, Anlagen inspizieren, Abweichungen vom Sollzustand feststellen, Datendurchsatz und Fehlerrate bewerten und Sofortmaßnahmen zur Aufrechterhaltung von vernetzten Systemen einleiten b) Anlagenstörungen analysieren, Testsoftware und Diagnosesysteme einsetzen und Instandsetzungsmaßnahmen einleiten c) Systemdaten, Diagnosedaten und Prozessdaten auswerten und Optimierungen vorschlagen d) Instandhaltungsprotokolle auswerten und Schwachstellen analysieren und erfassen	

'Programmierung' (Industrielle Elektroberufe/ Mechatroniker)

	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Analysieren von technischen Aufträgen und Entwickeln von Lösungen	a) Kundenanforderungen hinsichtlich der geforderten Funktion analysieren b) Prozesse, Schnittstellen und Umgebungsbedingungen sowie Ausgangszustand der Systeme analysieren, Anforderungen an Softwaremodule feststellen und dokumentieren c) Änderungen der Systeme und Softwarelösungen unter Anwendung von Design-Methoden planen und abstimmen	8
2	Anpassen von Softwaremodulen	a) Softwaremodule anpassen und dokumentieren b) angepasste Softwaremodule in Systeme integrieren	
3	Testen von Softwaremodulen im System	a) Testplan entsprechend dem betrieblichen Test- und Freigabeverfahren entwerfen, insbesondere Abläufe sowie Norm- und Grenzwerte von Betriebsparametern festlegen und Testdaten generieren b) technische Umgebungsbedingungen simulieren c) Softwaremodule testen d) Systemtests durchführen und Komponenten im System mit den Betriebsparametern unter Umgebungsbedingungen testen e) Störungen analysieren und systematische Fehlersuche in Systemen durchführen f) Systemkonfiguration, Qualitätskontrollen und Testläufe dokumentieren g) Änderungsdokumentation erstellen	

'IT-Sicherheit' (Industrielle Elektroberufe / Mechatroniker)

Lfd. Nr.	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Entwickeln von Sicherheitsmaßnahmen	a) Sicherheitsanforderungen und Funktionalitäten von industriellen Kommunikationssystemen und Steuerungen analysieren b) Schutzbedarf bezüglich Vertraulichkeit, Integrität, Verfügbarkeit und Authentizität bewerten c) Gefährdungen und Risiken beurteilen d) Sicherheitsmaßnahmen erarbeiten und abstimmen	8
2	Umsetzung von Sicherheitsmaßnahmen	a) technische Sicherheitsmaßnahmen in Systeme integrieren b) IT-Nutzer und IT-Nutzerinnen über Arbeitsabläufe und organisatorische Vorgaben informieren c) Dokumentation entsprechend betrieblicher und rechtlicher Vorgaben erstellen	
3	Überwachung der Sicherheitsmaßnahmen	a) Wirksamkeit und Effizienz der umgesetzten Sicherheitsmaßnahmen prüfen b) Werkzeuge zur Systemüberwachung einsetzen c) Protokolldateien, insbesondere zu Zugriffen, Aktionen und Fehlern kontrollieren und auswerten d) sicherheitsrelevante Zwischenfälle melden	

‘Systemintegration’ (Industrielle Metallberufe)

Lfd. Nr.	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Analysieren von technischen Aufträgen und Entwickeln von Lösungen	a) Ist-Zustand von zu verbindenden Teilsystemen analysieren und auswerten und Systemschnittstellen identifizieren b) technische Prozesse und Umgebungsbedingungen analysieren und Soll-Zustand festlegen c) Lösungsvarianten zur Systemintegration erarbeiten, bewerten und abstimmen und dabei sowohl Spezifikationen berücksichtigen als auch technische Bestimmungen und die betrieblichen IT-Richtlinien einhalten d) Vorgehensweise und Zuständigkeiten bei Installationen und Systemerprobungen festlegen	8
2	Installieren und Inbetriebnahmen von cyberphysischen Systemen	a) mit Kleinspannung betriebene Hardwarekomponenten installieren und Softwarekomponenten konfigurieren b) Systeme mittels Software zu einem cyberphysischen System vernetzen c) Systeme mit Hard- und Softwarekomponenten in Betrieb nehmen d) Störungen analysieren und systematische Fehlersuche in Systemen durchführen und dokumentieren e) Systemkonfiguration, Qualitätskontrollen und Testläufe dokumentieren	

‘Prozessintegration’ (Industrielle Metallberufe)

Lfd. Nr.	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Analysieren und Planen von digital vernetzten Produktionsprozessen	a) Produktionsprozesse analysieren b) Anpassung der Produktion sowie der Handhabungs-, Transport- oder Identifikationssysteme planen c) Prozessänderungen planen und hinsichtlich vor- und nachgelagerter Bereiche bewerten sowie die Zuständigkeiten im Team abstimmen d) Spezifikationen, technische Bestimmungen und betriebliche IT-Richtlinien bei Prozessänderungen beachten	8
2	Anpassen und Ändern von digital vernetzten Produktionsanlagen	a) geplante Prozessabläufe simulieren b) Auf- und Umbau von Produktionsanlagen und die datentechnische Vernetzung im Team durchführen c) Steuerungsprogramme im Team ändern, testen und optimieren	
3	Erproben von Produktionsprozessen	a) Produktionsverfahren und Prozessschritte, logistische Abläufe und Fertigungsparameter erproben b) Gesamtprozess kontrollieren, überwachen und protokollieren und prozessbegleitende Maßnahmen der Qualitätssicherung durchführen c) Fehler- und Mängelbeseitigung veranlassen sowie Maßnahmen dokumentieren d) Daten des Konfigurations- und Änderungsmanagements pflegen und technische Dokumentationen sichern e) Prozessvorschriften erstellen	

‘Additive Fertigungsverfahren’ (Industrielle Metallberufe / Mechatroniker)

Lfd. Nr.	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Modellieren von Bauteilen	a) Bauteile durch Programme zum computergestützten Konstruieren (CAD) erstellen b) für digitale 3D-Modelle parametrische Datensätze entwickeln c) Gestaltungsprinzipien zur additiven Fertigung einhalten und Gestaltungsmöglichkeiten nutzen	
2	Vorbereiten von additiver Fertigung	a) Verfahren zur additiven Fertigung auswählen b) 3D-Datensätze konvertieren und für das Verfahren anpassen c) verfahrensspezifische Produktionsabläufe planen d) Maschine zur Herstellung einrichten	8
3	Additives Fertigen von Produkten	a) additive Fertigungsverfahren anwenden und Probebauteile erstellen und bewerten b) Prozessparameter anpassen und optimieren c) Prozesse kontrollieren, überwachen und protokollieren und Maßnahmen der Qualitätssicherung durchführen d) Fehler- und Mängelbeseitigung veranlassen sowie Maßnahmen dokumentieren e) Daten des Konfigurations- und Änderungsmanagements pflegen und technische Dokumentationen sichern f) verfahrensspezifische Vorschriften zur Arbeitssicherheit und zum Umweltschutz einhalten	

'IT-gestützte Anlagenänderung' (Industrielle Metallberufe)

Lfd. Nr.	Teil der Zusatzqualifikation	Zu vermittelnde Fertigkeiten, Kenntnisse und Fähigkeiten	Zeitliche Richtwerte in Wochen
1	2	3	4
1	Planen von Änderungen an Anlagen	a) 3D-Datensätze von Rohrleitungssystemen, Profilen, Anlagenteilen oder Blechkonstruktionen erstellen b) branchenübliche Software zum Erstellen von Aufmaßen, auch auf Basis von Daten zum computergestützten Konstruieren (CAD), anwenden c) Änderungsmaßnahmen anhand von 3D-Modellen planen	8
2	Herstellen und digitales Nachbereiten von Rohrleitungen, Profilen, Anlagenteilen oder Blechkonstruktionen	a) Verfahren zur Fertigung von Rohrleitungen, Profilen, Anlagenteilen oder Blechkonstruktionen auswählen b) für die Herstellung von Rohrleitungen, Profilen, Anlagenteilen oder Blechkonstruktionen 3D-Datensätze konvertieren c) Datensätze über Schnittstellen an Fertigungsmaschinen übertragen d) Prozessparameter anpassen und optimieren e) Prozesse kontrollieren, überwachen und protokollieren und Maßnahmen der Qualitätssicherung durchführen f) Ist-Werte im digitalen Zwilling aktualisieren und dokumentieren	

Appendix 3: Interview guideline

Interviewleitfaden zum Thema Wandel der betrieblichen Ausbildung vor dem Hintergrund der Digitalisierung der Industrie

Je Interview 30 bis 60 Minuten

1. Begrüßung und Vorstellung		
2. Erläuterung des Forschungsprojekts		
3. Einverständnisabfrage zur Aufzeichnung		
4. Leitfragen	**Steuerungsfragen**	**Verknüpfung zu**
Können Sie kurz erläutern, in welchem Unternehmen Sie arbeiten und welche Funktion Sie in diesem ausführen?		- Hintergrundinformation
Welche Berufsbilder werden in Ihrem Unternehmen benötigt und welche Ausbildungsberufe bieten Sie an?	Wie viele Auszubildenden? Fachkräftenachwuchs aus den eigenen Reihen?	- Hintergrundinformation
Wie haben sich bestimmte Berufsbilder in Ihrem Unternehmen vor dem Hintergrund der Industrie 4.0 bzw. Digitalisierung verändert?	Welche Auswirkungen hat das auf die Qualifikationsprofile der Mitarbeiter? Welche neuen Kernkompetenzen sind notwendig?	- Digitalisierung und Industrie 4.0 - Passungsproblem zwischen Ausbildungsrahmenplan und benötigter Qualifikation - Untersuchung 2017
In wie weit sind die Ausbildungsberufe vom digitalen Wandel betroffen?		- s.o.
Wurden die Ausbildungsrahmenpläne konkret geändert und waren diese Änderungen spürbar bzw. hilfreich?		- Anpassung Ausbildungsrahmenplan in 2004 und 2018
Wie viel Einfluss konnte und können Sie bei der Anpassung der Ausbildungsverordnungen nehmen?	Wie ist die Zusammenarbeit zwischen allen Sozialpartnern? Wie viel Einfluss haben die Ausbildungsbetriebe wirklich? Wie viel Gewicht hat das Berufsprinzip?	- Struktur der dualen Ausbildung - Prinzipien der Ausbildung
Welche betrieblichen Schritte wurden eingeleitet, um die Ausbildung anzupassen? Waren es jeweils Einzelmaßnahmen oder handelte es sich eher um ein Projekt?	Über welchen zeitlichen Rahmen sprechen wir? Welche Ausbildungsberufe sind konkret betroffen? Welche Maßnahmen wurden eingeführt?	- Forschungsfrage
Auf welche Probleme oder Hindernisse sind Sie bei der Umgestaltung der betrieblichen Ausbildung gestoßen?		- Forschungsfrage

Inwieweit hat sich die gewandelte Ausbildung auf die Attraktivität des Unternehmens ausgewirkt?	Wie reagierten die Auszubildenden selbst darauf?	- Rückgang Bewerberzahlen
Gibt es in der Berufsschul-Ausbildung vermittelte Kompetenzen, die 'veraltet' und für die betriebliche Praxis nicht mehr relevant sind und wenn ja, welche?		- Grundlage Projekt VW und BIBB
Welche Veränderungen müssen Ihrer Meinung noch folgen, um die Berufsausbildung optimal an die gewandelten Rahmenbedingungen der Arbeitswelt anzupassen? (gesetzlich und betrieblich)		- Untersuchung Berufsbilder 2017
Denken Sie bestimmte Ausbildungsberufe werden in Zukunft komplett wegfallen?		- Prognose
Wie werden die Ausbildungsanforderungen überprüft, um eine Veralterung von Kernkompetenzen zu vermeiden? Werden auch betriebliche Führungskräfte bei der Umgestaltung der Ausbildung einbezogen?	In welchen zeitlichen Abständen werden diese überprüft? Wie agil ist das aktuelle Ausbildungskonzept?	- Forschungsfrage
Glauben Sie die duale Ausbildung, wie wir sie in Deutschland kennen, hat auch in der Zukunft weiterhin Bestand? Genügt eine Weiterentwicklung des aktuellen Systems oder ist eine komplett neue Form der Berufsausbildung erforderlich?	Auch im internationalen Vergleich? Wird die duale Ausbildung irgendwann vom Studium abgelöst? Mögliche Vorteile der Ausbildungsarten im Ausland?	- Ausbildung im internationalen Vergleich - Prognose
Wenn Sie die Möglichkeit hätten die Berufsausbildung in Deutschland vollkommen nach Ihren Wünschen zu gestalten, wie würde ein solches System aussehen?		- Subjektives Meinungsbild
5. Verabschiedung		

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