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# Sustaining the Quality Development of German Vocational Education and Training in the Age of Digitalization: Challenges and Strategies

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**Abstract:** The digital transformation of the working world has been bringing profound impacts on German vocational education and training (VET). This study analyzes the challenges that German VET is experiencing in the context of digitalization as well as the strategies to overcome these challenges. Based on the concept of sustainable cooperation between vocational schools and companies, this study proposed a theoretical framework for preserving the sustainability of VET in the digital era from three dimensions: the capability of industrial service, attractiveness, and adaptability. Meanwhile, through the content analysis method applied to the study of official research and statistical reports, policy documents, journal articles, etc., three key challenges for German VET are found: the insufficient service capacity of German VET for industrial digitalization, the decreasing attractiveness of VET, and the low level of application of digital competencies. German federal agencies have developed multiple strategies in response, including (1) strengthening the capability of training digital talents through the modernization of the training regulations and framework curricula in 2021; (2) reshaping VET as a more promising track for individuals via information support and expanding development pathways; (3) enhancing the willingness to participate in and the capacity to provide vocational training of companies through financial measures; (4) promoting the digital transformation of VET through the financial support of projects and development of practical assistance.

**Keywords:** digitalization; vocational education; digital transformation of VET; attractiveness; the capacity of industrial service



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## 1. Introduction

The world of work has undergone a digital transformation in terms of working modes, methods, tasks, and qualification profiles [1], causing constantly changing needs in the skills and competencies of the workforce. To fully utilize the inherent benefits of digital transformation for economic growth and social improvement, a highly trained skilled workforce with the skills and competencies demanded by the workplace is essential [2]. By 2025, 50% of all employees will need reskilling, and 40% of current workers are expected to update their core skills in the next five years, according to the World Economic Forum's survey study [3]. The COVID-19 pandemic and ongoing digitalization of the world of work have fundamentally changed the global jobs and skills landscape. The reskilling, upskilling, and redeployment of the workforce will define the "new normal" in future work. Therefore, German education and training must focus on this transformation to cope with the need for new skills [4].

Although the skills shortage in the workforce is not nationwide in Germany, a lack of qualified candidates is noticed in certain areas and sectors, especially in eastern and southern Germany [5]. For example, as shown by the KOFA (Kompetenzzentrum Fachkräftesicherung, Köln, Germany) State profiles, occupations with skill shortages account for 86% and 88% of advertised vacancies in Bavaria and Baden-Württemberg, respectively. Meanwhile, more than one in eight advertised vacancies are occupations with skill shortages in Thuringia, Lower Saxony, and Rhineland-Palatinate [6]. To overcome such shortages, especially in the advanced digital technology areas, and to sustain international competitiveness in the most promising talent, the German High-Tech Strategy 2025 appealed to immediate actions in Germany [7].

Vocational education and training (VET), especially the dual-system VET, has been regarded as one of the pillars of the German skill formation system and a driving force in the success and competitiveness of the German economy [8]. Occupational profiles and qualification requirements (e.g., skills and competencies) are changing with the digitization of the workplace, which has far-reaching effects on VET. Therefore, the reform and modernization of VET are crucial for training high-qualified skilled talents required by the digitalized workplace [9].

The orientation towards the working world is the central starting point for redesigning and upgrading VET in Germany [10]. This is the key factor for the high reputation of German VET, and also a main reason why many countries are transplanting German VET, in particular the dual system of initial VET [11]. With the goal of raising the quality of domestic VET, many countries have paid attention to the reform and innovation of German VET in the context of digitalization [12]. The implications of the workplace's digital transformation for German VET and the ongoing strategies used by German VET to ensure its sustainability are attracting increasing attention. For example, the directions and reform measures of German VET toward Industry 4.0 were discussed by Liu and Spöttl et al. [11,12] Furthermore, Achtenhagen et al., taking the food industry as an example, studied the implications of digital technologies on German VET [1].

Despite a growing amount of studies on the implications of digitalization of German VET, the challenges and strategies for German VET sustaining quality development in the context of digitalization are yet to be explored in greater detail and on a strategic and political level. This study attempted to gain further insights into these aspects based on the available data reports, research reports, and policy documents. Therefore, the research questions we endeavored to address were:

(1) What are the challenges for German VET to sustain quality development in the context of digitalization?
(2) What reform and innovation strategies has German VET adopted to tackle these challenges?

## 2. Literature Review

### *2.1. Digital Transformation of the World of Work: Characteristics and Qualification Requirements*

Continuous digitalization promotes so-called "Work 4.0", which also denotes the digital transformation of the world of work [13]. "Work 4.0" refers to future perspectives, scenarios, and opportunities for reshaping the world of work to benefit humankind and advance the digital economy. The effect of digitalization on the world of work is two-sided. On the one hand, technology takes over those labor-intensive work tasks that are physical, manual, and conventional, and need a low level of skills and qualifications [14]. On the other hand, the creation of new work and the expansion of existing jobs require higher levels of competencies. Schumpeter described this phenomenon as "creative destruction", meaning that emerging technologies destroy existing work and create brand-new ones simultaneously [15]. A recent study made a prediction that compared to 2018, 2,542,000 jobs will disappear by 2030, and 2,768,000 new jobs will be created, which equates to 11.7% of the 45.2 million jobs (around 5.2 million) that will be subject to change. [16]. The advances in digital technology pave the way for the creation of new work by increasing the non-conventional, cross-sectoral, highly skilled work tasks in occupation profiles and

making the working world more intelligent, complex, and networked [17]. Meanwhile, the automatization pyramid and the bureaucratic work structure are gradually eliminated by the networked production processes [14]. As a result, the information flows in digital production circulate both vertically and horizontally, enhancing cooperation between employees of different levels and fields [18]. Additionally, Drahokoupil and Piasna argued that digitalization, especially the development of the "gig economy" or "platform economy", is changing the way people work and communicate and the environment in which they work [19].

Based on the theory of skill-biased technological change, digitalization has caused employment to grow faster in both low-skill and high-skill occupations and to decline in middle-skill occupations [14]. This was supported by the World Economic Forum poll results [20]. Hirsch-Kreinsen further stressed the need for new qualifications as well as the upgrading of existing qualifications given the background of digitalization [21]. Meanwhile, a coexistence of highly digitalized and highly traditional working environments is foreseeable in all economic sectors and leads to a differentiation of qualification requirements as well [22]. These changes shed light on qualifications polarization [23]. According to a survey by the Fraunhofer Institute, 80% of German companies surveyed stated that further vocational training and reskilling were needed for future work [17]. The new hybrid skills and competencies required by new work include using digital technologies and combining them with human dimensions [24].

Additionally, Spöttl et al. expected that, with the advances in digital technologies, cross-occupational competence as well as the competence of understanding and optimizing production processes and systems would become more and more crucial for the digitized working world [13]. Some studies also suggested that comprehensive skilled talents equipped with digital literacy, learning competence, and social and emotional skills would be increasingly significant for the digitalized working world [25,26]. This also shows the dynamic and multidimensional nature of the vocational competencies required of highly skilled workers in the digital world of work.

### *2.2. German VET in the Digitized World of Work*

The main force driving VET's reform and innovation is the challenges brought by the changes in work [10]. The digital transformation of the world of work puts forward a new set of challenges for VET. The World Economic Forum and Seyffer et al. discussed the challenges that vocational schools face in Germany from the perspective of industrial service capability, noting that vocational schools' service capability cannot keep pace with the changing demands of the labor market and limited scope of reform and innovation [20,27]. In addition, Hackel et al. focused on elements of VET such as teaching methods, curriculum content, the cooperation between companies and schools, and the competence of teachers and trainers. They pointed out that vocational schools' teaching did not meet the needs for increasingly individualized teaching and learning methods and was insufficiently equipped with suitable teaching materials that could effectively promote the application of digital media. The low level of school–company cooperation and the shortage of highly qualified teachers with digital competencies are other problems they describe [28].

Attwell and Rauner provided a concise summary of some challenges posed by in-company vocational training, including unfavorable working conditions, insufficient focus on personal and social competencies, outdated training content and examination standards, the shortage of highly qualified trainers, and the inadequate use of digital technologies to reshape teaching and learning methods [29]. Concern about VET's role in helping individuals successfully transition from school to work is raised by the rising number of young people enrolling in higher education [30]. This is mainly due to the historic image of VET as a second-class education and a hopeless choice [31]. Therefore, it is a necessity to further increase individual participation in VET by consistently strengthening its public image and attractiveness.

The study by Anselmann et al. was able to present that continuing VET also faced a series of challenges, including lower motivation in choosing vocational training among individuals and the decreasing participation rates of companies in continuing training (especially in medium and small-size companies), a lack of personalization in training methods and appropriate cost-sharing and compensation mechanisms, and the means of recognizing results in continuing training needed to be modernized [32]. Moreover, Baethge et al. noted that access for disabled people and refugees needs to be further improved, and the methods of teaching and learning need to be reshaped with the help of ICT technologies in the digital age [33]. At the same time, the COVID-19 pandemic can also be seen as a booster for the digitalization of vocational training, which attaches great importance to vocational schools, as the survey of trainees in 2020 by the trade unions showed [34]. This is underlined by the award of the German School Award 2022 to a vocational school that uses digital simulation in the field of nursing training [35]. The term "VET 4.0" was developed to bridge Industry 4.0 and Work 4.0. This referred to new concepts, trends, and goals for future VET reform and innovation in the context of digitalization [36]. Thus, the digital transformation of German VET seems to be increasingly prioritized [37]. Between 2016 and 2018, the Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung, BIBB, Bonn, Germany) and the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF, Berlin and Bonn, Germany) jointly conducted the initiative "VET 4.0 qualifications and skills for tomorrow's digitized work" (VET 4.0 Initiative) as one of the German Federal Government's activities to promote the digital transformation of VET. The VET 4.0 Initiative focused on the analysis and forecast of the characteristics and qualification requirements of the digitized world of work and on the identification and exploration of the challenges and strategies for German VET in the digitized world of work [12]. Esser further argued that digital transformation offers a good prospect of achieving a boost in the attractiveness of German VET [9]. Meanwhile, Dietl and Hennecke also proposed that the benefits of the digital transformation of German VET are wide-ranging and include improving the level of individualized teaching, forming a data-driven quality assessment model, and developing a blended learning model [37]. However, few scholars have systematically explored the challenges and strategies for achieving sustainable and high-quality development in German VET based on the overall context of digitalization.

## 3. Sustainable Cooperation between Vocational Schools and Companies as a Conceptual Framework

The establishment of sustainable cooperative relationships between vocational schools and companies is fundamental for VET to achieve a close match between the supply and demand of skilled talents [38]. Enhancing the capacity of industry services is at the core of VET's aim to build sustainable cooperation relationships with companies [10]. The core of VET's capacity building for industrial service is the timely and effective supply of quality skilled personnel to companies in different industrial sectors. To achieve this, Deissinger noted that it is necessary to achieve a close match between the structure of training occupations and the occupational expectations of potential applicants, especially by adjusting the catalog of training occupations in accordance with changes in work in a timely way [39]. Timely adjustments are also needed in other aspects such as VET training goals, curriculum content, teaching methods, teacher competencies, and the training environment according to the dynamic changes in work content, methods, tools, and environment [40]. Therefore, VET's capability for industrial service in the context of digitalization can be comprehended from two aspects: the matching status of the current VET training market and the availability of digital skill talents.

Sufficient applicants or trainees are the prerequisites for VET to sustainably provide companies with high-quality skilled talents [41]. The cooperation between vocational schools and companies also allows companies to integrate their skills and competence requirements into the concepts and contents of skilled talent training and get potential

employees who meet their specific needs and have a sense of vocational identity. This is a critical reason why companies participate in VET and offer training positions [42]. Companies play multiple roles in sustaining the high-quality development of VET, including as providers of training positions, evaluators of the VET quality, drivers of VET reform, and investors in VET [43]. In view of this, Solga et al. pointed out that to increase the attractiveness of VET, measures should be taken to increase companies' willingness to participate in VET and students' willingness to choose VET actively [44]. Thus, increasing the attractiveness of VET is another significant aspect of maintaining sustainable cooperation between vocational schools and companies.

VET must also effectively cultivate the skilled talents needed for the digital world of work, to gain recognition from companies and support for the digital transformation of itself [45]. This means that VET needs to integrate digital literacy and skills into the curriculum content, develop teachers' and trainers' basic and advanced digital skills [46], and use digital technologies to empower teaching methods, innovate evaluation methods, and update the equipment and environment of VET organizations to strengthen VET's adaptability [47].

In this study, we referenced the concept of sustainable cooperation between vocational schools and companies, and analyzed how the quality of German VET could be sustained in the age of digitalization in the following three dimensions (see Figure 1):

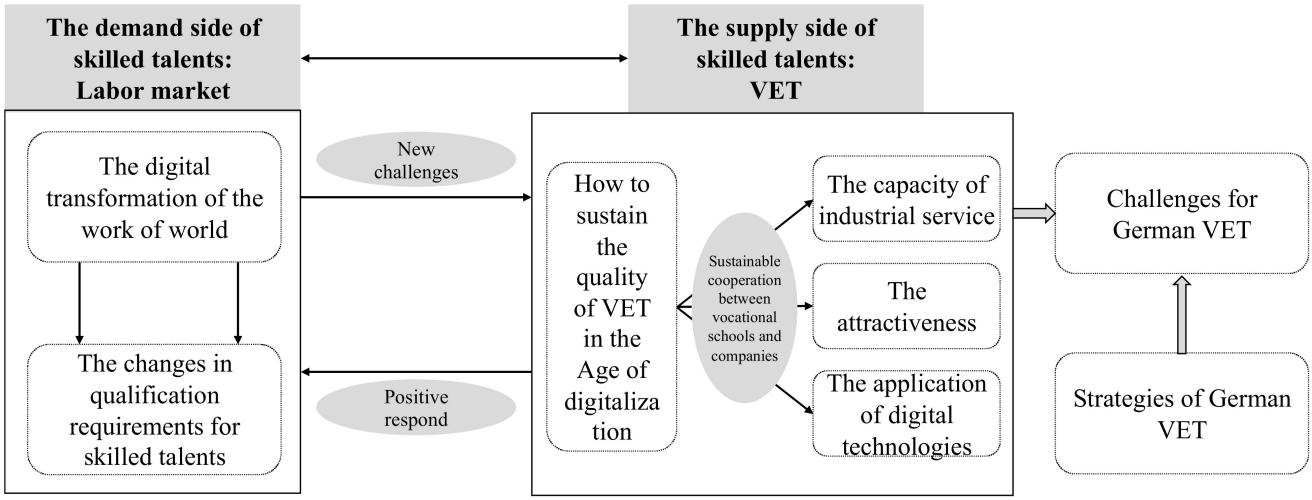


**Figure 1.** The conceptual framework of this study.

(1) The capability of industrial service of VET, i.e., the matching status of the current VET training market and the current supply situation of digital talent by VET.

(2) The attractiveness of VET, including the willingness of companies to participate in VET and students' willingness to choose VET.

(3) The application of digital technologies in VET, which means how VET rationally integrates and uses digital technologies to optimize and update training goals, curriculum content, teaching methods, environmental equipment, and evaluation methods.

## 4. Methodology

This study adopted the content analysis method to analyze at both the macro- and meso-level to find out the challenges and strategies of German VET in the context of digitalization. Content analysis attempts to create structured data by analyzing and summarizing facts that are highly relevant to the research objectives and to the solution of a research question [48]. A set of heterogeneous and unstructured research materials, such as policy documents, data reports, research reports, and journal articles, may be regarded as decomposed and reorganized through the content analysis method into defined research data [49] The method is feasible also because the German official bodies such as BIBB, BMBF, and

European Centre for the Development of Vocational Training (Cedefop), have publicly released a series of annual reports, data reports, and research reports on the development of German VET, which enables us to gain a comprehensive understanding of the current situation of German VET and provides credible data sources to support us in drawing up findings.

### *4.1. Data Collection*

The data collected and used in this study mainly include three types: research reports, statistical data reports, and policy documents. Meanwhile, journal articles are used as a supplement to support the discussion. Thematic searching was used to guide the search for the data, with a focus on the following themes: (1) the qualification or skill requirements of the digitized working world in Germany; (2) the digital transformation of German VET; (3) the VET 4.0 of Germany. To ensure the authority and reliability of the data, most of the data were searched and collected from official agencies' databases and published sources, such as Cedefop, BMBF, the Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, BMWi, Berlin and Bonn, Germany), BIBB, the Federal Ministry of Labour and Social Affairs (Bundesministerium für Arbeit und Soziales, BMAS, Berlin and Bonn, Germany), the Standing Conference of the Ministers of Education and Cultural Affairs (Kultusminister Konferenz, KMK, Berlin, Germany), and the Platform VET-4.0. The annual report of German VET development, the annual data report of German VET, and the relevant research reports of the VET 4.0 Initiative launched by BMBF and BIBB are of special interest. Meanwhile, other trustworthy and important data sources for this study include Eurostat and the research reports of BIBB based on large-scale surveys. Unlike journal articles, these reports are based on the analysis of large-scale survey data on the status of VET in Germany, which can authoritatively and comprehensively reflect the achievements and challenges of VET and, to some extent, indicate the trends and priorities of VET reform. Appendix A outlines the specific data reports, research reports, and policies selected for data analysis.

The first type of data comes from the relevant research reports, with the aim to illustrate the new characteristics and skill requirements of the world of work led by digitalization and the future directions for German VET. Six research reports issued by BIBB, Cedefop, BMBF, and Platform VET-4.0 over the past five years are included for analysis. These research reports are highly practice-oriented, analyzing a large number of authentic practices, and serving the aim of supporting policymakers to figure out the areas of VET in which improvements should be made.

The second type of data is statistical reports on the development of German VET. In this study, 12 statistical reports were collected, including five annual data reports on German VET and two statistical reports on the usage of digital media in German VET launched by BIBB, two reports on the development of German VET published by BMBF, and three country reports on the Digital Economy and Society Index published by EC. For example, BIBB has built a working mechanism for launching data reports on VET to report regularly and systematically on the current situation and the latest developments in German VET. The German VET data report comprises various parts, such as the development of the initial and continuing VET market, challenges and future directions of VET, and the internationalization of VET. The BIBB's annual VET data report is one of the most authoritative and comprehensive information sources to understand the current situation and trends in VET development in Germany.

The third type of data is policy documents issued by German official agencies. Twelve policies issued by BMBF, BMWi, BMAS, and KMK over the past few years are collected for analysis. From such relevant policy documents, this study tries to understand comprehensively the views and intents in the policies regarding the challenges and promising strategies of German VET in the context of digitalization.

### *4.2. Data Analysis*

The data analysis process included the translation and revision of research material, the coding process, and the descriptive presentation of coded results. First, the research materials were translated and revised. The VET 4.0 Initiative research reports and other relevant materials needed to be translated from German into English. The experts who actively participated in the VET 4.0 Initiative's main research report or sub-study reports were consulted during the translation process in case of difficulties in understanding.

Second, the thematic review approach combining single-text analysis and cross-text analysis was conducted in content coding. On the one hand, the single-text analysis focuses on identifying the keywords or critical facts from one data text through thematic analysis of the open coding [50]. This way of coding could help the researcher directly extract the contents from each selected data text, which gives precise answers to the research questions [51]. Specifically, we read all data text collected and selected in this study and manually coded each report text and policy text to mark what was relevant to the research question. The cross-text analysis, on the other hand, compares different types of data to see the frequency of a theme appearing across a set of texts and making a mark on some critical contents and data. It is also beneficial for us to identify the main dimensions in answering research questions through the cross-text analysis of the coded results of the single-text analysis.

Third, the descriptive analysis of research results. The research results and quantitative data collected in this study are transferred into tables, charts, and line charts to make the research results visible and comparable. Complexity is thus reduced once again along the lines of the research interest, and findings are pointed out.

## 5. Findings and Discussion

### *5.1. Question 1: What Are the Challenges for German VET to Sustain Quality Development in the Context of Digitalization?*

#### 5.1.1. The Capacity of German VET for Industrial Service Needs to Be Further Improved

The capacity for industrial service is defined as the actions and strategies of the German VET sector to train skilled talent for the digitized world of work [10]. With a focus on the matching status between the vocational training market and the status of digital talents trained by VET, this study examines the capacity of German VET for industrial service.

On the one hand, due to a continued rise in the proportion of unfilled training places and a consistently high rate of unsuccessful potential applicants for training, the matching problem of the vocational training market is getting worse in recent years. There has been a particular increase in company recruitment problems (Data report No. 5, Appendix A). From the data provided by the German Federal Statistical Office et al., the service sector, especially the health and social service sector, which is estimated to increase from 5.5 million employed persons in 2015 to 6.8 million in 2035, was supposed to account for the main increase in labor market demand [52]. The primary cause of this is the aging of German society [47]. Meanwhile, employment in the sectors of scientific and technical service, education and training, transport and storage, hospitality, and information and communication would also rise considerably. In addition, a reverse development would occur in industries such as manufacturing, trade, maintenance of motor vehicles, and construction. (Data report No. 1, Appendix A).

However, BIBB reported that the German training market's matching problem became more serious from 2010 to 2022 (see Figure 2). That can be characterized by two contradictory developments: on the one hand, the training occupations with the growing demands for skilled workers faced recruitment problems because of the lack of qualified applicants, particularly in medium and small companies and in economic sectors such as IT. On the other hand, some training occupations, the new training occupations in particular (e.g., visual marketing designer, designer for digital media, and photographer), encountered a supply problem, which means that training applicants could not find suitable training places consistent with their target occupations (Data reports No. 1 and 5,

Appendix A). The digital maturity of companies is directly related to the vocational training of emerging occupations in training companies [1]. Meanwhile, the information gap and a strong view discrepancy regarding the occupations between applicants for training positions and training companies also account for the mismatching [2].

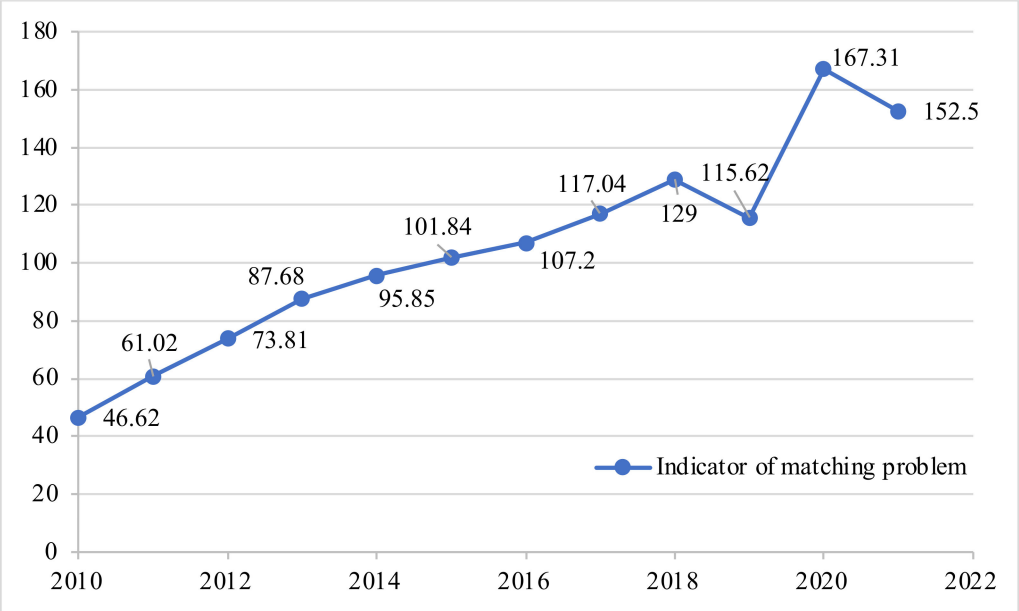


**Figure 2.** The development of matching problems in the training market of the German Dual-VET system between 2010 and 2022 (in %). Note: BIBB uses an Indicator of matching problem to evaluate the matching status of the training market. Indicator of matching problem = the percentage of unfilled training places in the company's training place supply × the percentage of applicants still looking for training places in the training place demand. Source: BIBB. VET Data Report Germany 2022. BIBB: Bonn, Germany, 2022.

On the other hand, digital talent is a significant indicator in defining the digital progress and regional digital competitiveness of countries in the new era [39]. Although the qualification requirements of the digitized working world are still unclear, we already know that digital skills and literacy, as well as social and emotional skills, will gain increasing importance in the future [24,25].

However, the status of digital talents will limit the enhancement of Germany's competitiveness in the regional digital economy and social progress. Germany fell short of the EU average regarding the human capital dimension, ranking 16th among the EU 27 countries, according to the digital economy and society index report (Data report No. 10–12, Appendix A). Within this dimension, 49% of individuals aged 16 to 74 had at least basic digital skills, which is slightly less than the EU average. Only 19% of individuals possess above basic digital skills. Compared to the pre-COVID-19 pandemic level, there has been a decrease of almost 50%, which is less than the EU average by 7%. Meanwhile, ICT graduates account for 4.9% of all graduates (compared with the EU average of 3.9%), and 4.9% of individuals in employment between the age of 15 and 74 are ICT specialists. Additionally, the proportion of female ICT specialists in Germany is 19% (see Table 1). This does not match the goal of securing its leading position both in quality and technology for years to come by combining traditional competitive advantages with the newest technology. As Veres et al. mentioned, to remain a competitive and sustainable development, vocational education needs to help individuals to develop the skills and competencies required by the digital world of work through the digital transformation of itself [24].

**Table 1.** Digital Economy and Society Index Country Report–Germany (Human capital dimension).

| | 2019 | 2021 | 2022 | |
|---|---|---|---|---|
| | **Value (In %)** | **Value (In %)** | **Value (In %)** | **EU (In %)** |
| At least basic digital skills (% individuals) | 68 (*2017*) | 70 (*2019*) | 49 (*2021*) | *54* (*2021*) |
| Above basic digital skills (% individuals) | 37 (*2017*) | 39 (*2019*) | 19 (*2021*) | *26* (*2021*) |
| At least basic software skills (% individuals) | 70 (*2017*) | 72 (*2019*) | 65 (*2021*) | *66* (*2021*) |
| ICT specialists (% total employment) | 3.9 (*2018*) | 4.7 (*2020*) | 4.9 (*2021*) | *4.5* (*2021*) |
| Female ICT specialists (% female employment) | 17 (*2018*) | 18 (*2020*) | 19 (*2021*) | *19* (*2021*) |
| ICT graduates (% graduates) | 4.7 (*2017*) | 4.5 (*2019*) | 4.9 (*2020*) | *3.9* (*2020*) |

Source: These figures come from the German Digital Economy and Society Index Report (2020, 2021, 2022) launched by European Commission. Retrieved from: https://digital-strategy.ec.europa.eu/en/policies/desi (accessed on 17 December 2022).

Meanwhile, the research results of the VET 4.0 Initiative also noted the insufficient focus on personal and social competencies in VET's talent cultivation, which is one of the key competencies that digital talent should have in the digital age (Data report No. 1–3, Table 1). As one interviewee of the VET 4.0 Initiative stated: "Companies need to rethink how to train their apprentices. For example, how to lead them to work and to think independently. That is what has been missed at this moment, which should be promoted in the training centers and vocational schools" (Research report No. 4, Appendix A).

#### 5.1.2. The Attractiveness of German VET Is on the Decline

The attractiveness of VET here mainly refers to the willingness of young generations to choose VET and the willingness of companies to participate in VET. Therefore, these two aspects explain that German VET's attractiveness is on the decline.

On the one hand, young people's willingness to choose VET is decreasing while their willingness to pursue higher education is growing. According to the integrated reporting on vocational training (iABE), in the VET sector, the number of new entries decreased by 39,591 (−5.5%) from 2018 to 2020. Within this sector, the number of dual vocational training new entries decreased sharply from 492,669 in 2018 to 439,300 in 2020 (−10.8%), and the number of other school-based VET new entries fell from 52,244 in 2018 to 51,500 in 2020 (−1.4%). Meanwhile, only the number of new entries into school-based VET in healthcare, education, and social service occupations continuously increased from 178,983 in 2018 to 193,500 in 2020 (+8.1%) (Data report No. 8–9, Appendix A).

However, there is a reverse scenario in the young generation's willingness to choose higher education. The "acquisition of a higher education entrance qualification" sector has reported a rise of 34,377 (+7.6%) from 2005 to 2020. Meanwhile, the number of new entries into the "tertiary studies" sector increased considerably from 366,242 in 2005 to 493,007 in 2020 (+34.6%) (Data report No. 1–3, Appendix A). Previous studies have suggested that such a phenomenon was partly due to the perception that the digitized working world will raise the requirement of specific knowledge for skilled talents [41,53]. Additionally, Fernandez observed that the COVID-19 pandemic was a significant factor in more young people pursuing general education in recent years [54].

On the other hand, German companies' VET participation rate has been continuously falling in recent years. According to the data of BMBF, the rate of German companies providing vocational training continuously fell from 23.3% in 2009 to 19.4% in 2020. By contrast, the total number of companies increased from 2,063,708 in 2009 to 2,171,434 in 2019. As in the previous years, the overall decrease in the companies' VET participation rate was almost entirely due to losses amongst medium and small companies (Data report No. 8, Table 1). The numbers of companies of different sizes that provided vocational training in 2020 as compared to the figures in 2007 showed that the number of micro-companies, small companies, medium-sized companies, and large companies decreased by 6.1%, 5.9%, 2.7%, and 2.9%, respectively (Data report No. 1, 6, Appendix A). One of the reasons these companies withdrew from vocational training was the difficulty in recruiting suitable

applicants [55]. Benassi et al. also noted that small and medium-sized companies lacked sufficient resources and conditions to conduct vocational training by themselves, another reason why many applicants preferred large companies [56]. Berger found that in larger companies, the trade union was more likely to participate in the company, which in turn promoted the companies' willingness to provide vocational training. [53]

Furthermore, the vocational training participation rate of companies by economic sectors also displayed a negative status between 2007 and 2020. In contrast to the previous year, this indicator gradually decreased in most economic sectors in the wake of the COVID-19 pandemic. Other personal related services (−10.3%), agriculture and mining (−8.5%), manufacture of other goods (i.e., food, wood, etc., −8%), research and development (−7.9%), engineering and automobile manufacture (−7.8%), and hotels and restaurants (−7.6%) all saw significant declines in their participation rates of companies compared to 2007(see Figure 3). (Data report No. 1–3, Appendix A)

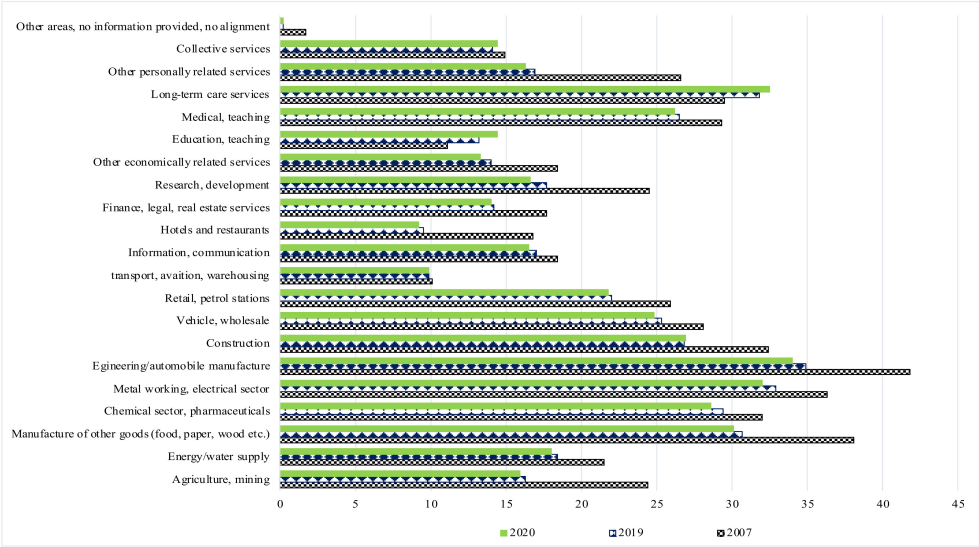


**Figure 3.** The development of companies providing vocational training between 2007 and 2020 by economic sector in Germany (in %). Source: The data in the igure is from the VET Data Report Germany (2020, 2021, 2022) launched by BIBB.

### 5.1.3. The Application Level of Digital Technologies in VET Needs to Be Enhanced

The close connection between the VET organizations and the real working world is the precondition for VET to cultivate highly qualified skilled workers effectively. Digital media are a bridge that can be a link between the close interrelationship between vocational training, knowledge-intensive skilled work, and progressive technological development [57]. Therefore, one of the reform goals for German VET in the digital era is to improve the digital level (Policy No. 3, 5, Appendix A). The degree to which VET organizations update and upgrade VET infrastructures, curriculum contents, teaching and learning methods, etc. against the new challenges of digitalization is referred to as the level of digital media application in VET.

According to the 2020 survey report of BIBB, the techniques and tools used in work have changed from 2015 to 2020, because of the digital transformation of the workplace. In 2019, looking at the mean values of the usage frequency of digital media in the work process, software for work organization (e.g., Outlook, Word, Excel, etc.), messengers (e.g., WhatsApp, Threema), and other information on the internet (e.g., manuals, films, etc.) are most frequently used(94%, 57%, 51%, respectively), followed by the software for internal/external ordering of goods and services, software for ERP, Wikis and online encyclopedias, social networks (e.g., Facebook, XING), and cloud services (e.g., data storage on the internet, online collaboration). There has been a sharp increase in the usage frequency

of digital media in the work process compared to non-digital media in recent years. (Data report No. 4, 7, Appendix A)

The lower level of digital media application of German VET organizations has been exposed in the nationwide survey on digital media usage in the initial and continuing VET conducted by BIBB and TNS in 2019. Taking the in-company initial and continuing training as examples, it was striking that the top four frequently used media formats in in-company initial training were dominated by traditional media formats (see Figure 4). These traditional media formats included the textbook or reference book (3.41), printed materials or manuals (3.29), real teamwork or group work (3.23), and face-to-face teaching in the classroom (2.66). Meanwhile, even in the digital media formats with the highest usage frequency, subject-specific software ranked fifth, followed by learning software on the PC, Wikis, and technical literature in e-book format. Other digital media formats, such as video conferencing, MOOCs, educational games, virtual classrooms, online forums, and simulations/virtual environments were less frequently used for in-company training. (Data report No. 4, 7, Appendix A).

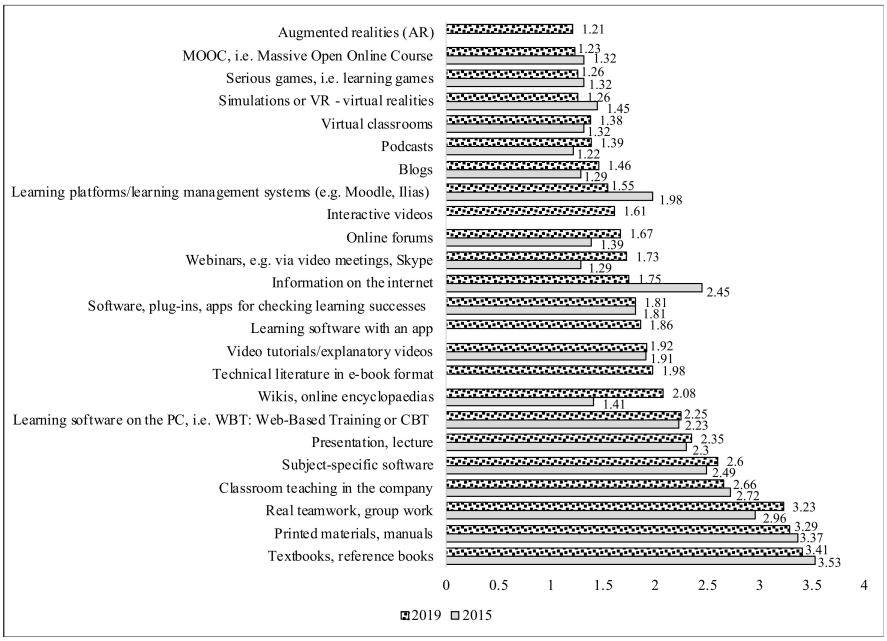


**Figure 4.** The usage status of classic and digital media formats in in-company training (4 stands for the highest usage degree, 1 stands for the lowest usage degree). Source: The data in the figure is from the report of Digital Media in Companies—Today and Tomorrow (2016, 2020) launched by BIBB.

At the same time, taking the continuing vocational training in companies as an example, the BIBB and TNS survey in 2019 showed that the digital media with the highest usage frequency were those for printed materials and manuals (2.87), followed by those aiding real teamwork or group work (2.71) and subject-specific software (2.68). Among the 24 digital media formats BIBB and TNS surveyed in 2019, virtual classrooms, serious games, and augmented realities (AR) were the least used, with respective usage frequencies of 1.24, 1.19, and 1.16. Overall, the traditional and non-digital media formats occupy the dominant position in current continuing vocational training (Data report No. 4, 7, 9, Appendix A).

### *5.2. Question 2: What Reform and Innovation Strategies Has German VET Taken to Tackle These Challenges?*

#### 5.2.1. Strengthening the Capability of Training Digital Talents through the Modernization of Training Regulations and Skeleton Curricula

Training regulations and skeleton curricula are the legally binding guidelines for in-company vocational training and school-based vocational education in the dual system.

On the one hand, as the regulatory framework of training occupations, the training regulations describe the minimum requirements for in-company vocational training [58,59]. Training regulations, particularly the training framework plan, specify learning objectives as minimum requirements for training. They list all knowledge, skills, and competencies that the trainees are to acquire during the training. Additionally, training regulations clarify the examination requirementsand the methods of how trainees have to be taught [58]. It is also possible to teach additional training content if technical or work organization developments result in further requirements for vocational training that are not specified in the training framework plan. On the other hand, the skeleton curriculum is considered to be the content basis for the development of school-based vocational training. To harmonize with the content of in-company training, the skeleton curriculum defines the content structure of vocational school training primarily in the occupational action areas. The skeleton curriculum generally includes the objectives and contents of the vocational school's skilled talent training, the principles of teaching, the learning fields, and a description of the relevant training occupations (Policy No. 7 Appendix A)

The new characteristics and qualification requirements of digitized work require the modernization of training regulations and skeleton curricula (Policy No. 9, Appendix A). A significant step has been taken with the mandatory anchoring of the promotion of digital skills in all training regulations in 2021 [Policy No. 13, Appendix A]. The modernization of training regulations and skeleton curricula involves integrating new work tasks, working rules, qualification requirements, digital technologies, equipment, and software into the training goals, curricula, teaching and learning methods, and the quality assessment standards of VET (Research report No. 5; Policy No. 11, 12, Appendix A). Thus, the modernization of training regulations and skeleton curricula mainly focuses on five aspects:

(1) The updating of the training curriculum. New technologies and knowledge should be integrated into the curriculum content and continuously improve the flexibility and adaptability of the curriculum contents and structures in the digital age [26]. Therefore, it significantly increases the inter-disciplinarity and universality of knowledge and cognitive competencies, digital skills and literacy, advanced technological know-how, and practical skills in the curriculum (Research report No. 5, Appendix A).

(2) The upgrading of teachers' and trainers' qualifications. As the important basis of VET's quality development, the continued development and progress of teachers and trainers depends on their willingness and ability to keep up with evolving technologies and knowledge in their teaching and professional progress [38]. For example, to update and innovate teaching and training methods, instructors need to become proficient in using digital media in a professional and didactically meaningful way (Policy No. 4, 8, Appendix A). This result, based on the analysis of the policy text, is consistent with the opinions of Anselmann et al. [32].

(3) The development of innovative teaching and learning methods with the use of digital media. Digital media not only leads to the emergence of new learning and teaching modes, such as blended learning and computer-based skill training, but also offers opportunities for learners to learn flexibly, personally, continuously, and independently of time and space (Policy No. 3, Appendix A). Specifically, to achieve a better learning effect, work-based learning could take place in a digital media-empowered environment and achieve the intersection between face-to-face classroom-based learning and digital space-based learning (Policy No. 1, Appendix A). Caruncho also noted that it was becoming significant to design teaching methods individually, allowing students barrier-free access and considering the cultural and linguistic diversity of learners in the digital era [2].

(4) The improvement of digital infrastructures. This mainly includes networks (e.g., VET school–company networks), advanced digital equipment and tools, digital resource databases (e.g., online courses, digital textbooks, virtual simulation, etc.), digital learning and teaching platforms, etc. (Policy No. 5, 8, Appendix A). As Liu pointed out, the continuous building of digital infrastructure is an important policy action in Germany to promote the digital transformation of VET in the digital age [11].

(5) Strengthen the cooperation between VET organizations and companies in the digital age. It means that the solid and sustainable cooperation between VET organizations and companies should not only concentrate on the "traditional fields", including the fields of teacher and trainer training, the introduction of new technologies and equipment, and qualification developing and updating. Attention is also needed in the "modern fields", such as the construction of the industry–education network, the sharing of digital production cases and other digital resources, the development community based on the internet, and the deep integration of schools and companies (Policy No. 6, Appendix A).

#### 5.2.2. Reshaping VET as a More Promising Track for Individuals through Information Support and Expanding Development Pathways

To make VET a more attractive option, it is necessary for individuals, especially young people, to perceive the value of VET rationally and to plan their vocational careers correctly. To achieve these goals, the Federal Employment Agency of Germany and BMBF provide more and better-quality information about VET to young people and their parents through digital means [42]. Specifically, the Federal Employment Agency of Germany improves young people's understanding of VET, such as the content and level of the VET programs, entry requirements, examination requirements, and labor market positions and income levels of former trainees, through vocational guidance and career counseling in face-to-face or web-based formats. For example, more than 30,000 young people received career counseling through the program 'Perfect match', which was jointly financed by the BMWi and the European Social Fund (Research report No. 1, Appendix A).

Meanwhile, expanding the levels of the German VET system and promoting the integration of VET with higher education is also important. For example, the amendment of the 2019 BBiG is designed to send a clear political and social signal regarding the equivalence of VET and academic education in response to the trend of young people pursuing tertiary education. In this amendment, the three further vocational training levels (certified professional specialist, professional bachelor, professional master) are directly anchored in BBiG (Policy No. 2, Appendix A). The levels will be provided with consistent, discrete qualification titles that clearly demonstrate their equivalence with university degrees. Thus, VET pathways are upped to EQF levels 6 and 7 and the equivalence to academic education is underlined through new designations (Research report No. 2, Appendix A). It also opens a new path for individuals to pursue higher education on the VET track and enhances the attractiveness of VET to the youth.

#### 5.2.3. Enhancing the Participation Willingness and the Capacity to Provide Vocational Training of Companies through Financial Measures

To build a supportive environment for companies to participate in VET positively, the German federal government has adopted multifaceted financial measures. (i) To strengthen the capability of VET training in professional fields that are confronted with massive staff shortages. For example, in 2018, the German federal government launched a concerted action to strengthen VET in the care and nursing field and recruit more people for careers in this field (Research report No. 4, Table 1). (ii) To improve the VET participation rate of German companies. Since 2009, BMWi and BMBF have issued a directive for funding in-company training centers and invested 71 million euros annually. This program aims to modernize in-company training centers and transform them into competence centers to build a basis for training high-qualified skilled workers required by the digitized workplace (Research report No. 1, Table 1). (iii) To help small and medium-sized companies (SMEs) strengthen their training capacity. Continuous digitalization is accompanied by high costs, which often cannot be borne by small and medium-sized companies. To help them overcome these challenges, different projects were launched, such as KungFu: Plastic goes future or DIGI agrar, which was aimed at supporting and advising SMEs in adapting their training to the challenges of digitalization (Research report No. 1, Appendix A), and the Jobstarter plus program, which was jointly founded by the BMBF and European Social Fund and was designed to support SMEs, in particular micro companies, to provide

training places. More than 500 projects have been put in place since the project started in 2006 (Research report No. 2, Appendix A).

#### 5.2.4. Promoting the Digital Transformation of VET through Comprehensive Strategies

Driven by the digital transformation of the world of work and the modernization of VET, digital transformation has become an inevitable trend and an important strategy for the sustainable development of VET for the future (Research report No. 3, Appendix A). As a result, multiple strategies have been employed to drive the digital transformation of VET.

(1) Supporting VET digital transformation through educational policy. Educational policy is a significant tool for the government to plan and update the development directions, priorities, and reform measures of the different types of education given their specific backgrounds. To assist VET in overcoming new challenges and move towards "VET 4.0", the federal and state governments of German have issued a series of reform policies. In 2016, BMBF launched the "education initiative for the digital knowledge society", which put forward the VET 4.0 initiative to modernize occupational profiles and promote the progress of German VET's digital transformation. KMK launched "vocational school 4.0—further development of the innovative strength and integration performance of vocational schools in Germany in the coming decade" in 2017 to depict the future blueprint for German vocational schools in the digital age. In addition, BMBF and BMWi jointly launched the first national skills strategy in Germany's history in 2019 to address the challenges of continuing VET posed in the digital era and establish the reform and innovation framework for continuing VET from ten action fields (Policy No. 10, Appendix A).

(2) Supporting the digital media application in German VET through special programs. Since 2012, the BMBF's "digital media in vocational training" program has been funding initial and continuing VET in the use of new digital media. The last round of funding ends in 2023. The funding program focused on the improvement of VET's digital infrastructure, digital education resources, and teachers' and trainers' digital media skills (Policy No. 4, 8, Appendix A). In addition, BMBF launched the Special Program on Digitalization in 2016 to help inter-company training centers modernize their training programs and help SMEs provide up-to-date training, which was expanded to provide new funding possibilities and was extended until the end of 2023. Nearly 40,000 new items had been purchased at more than 200 training centers by the middle of 2020, which has already been used by many inter-company training centers to update their equipment. (Research report No. 6, Appendix A).

(3) Supporting VET digital transformation through research. For example, to provide policy suggestions and action recommendations for German VET's digital transformation, the BIBB and BMBF jointly conducted the VET 4.0 Initiative between 2016 and 2018. This initiative mainly focused on analyzing the characteristics and qualification requirements of the digitized working world, the contents of IT and digital media skills, and the challenges and action recommendations for German VET towards tomorrow. The results provide an important reference for clarifying the direction of vocational education reform and updating training regulations in the digital age (Research report No. 4, Appendix A).

## 6. Conclusions

As the digital transformation of the world of work brings a range of new challenges and uncertainties for VET, many countries are actively seeking to explore effective strategies for training high-quality skilled talents. This study aimed at analyzing the challenges and the strategies of German VET to sustain quality in the age of digitalization. For such a study, it is not easy to identify the right selection of sources to consider. In recent times, a great many initiatives and changes have multiple goals at the same time, of which digitization is just one aspect alongside those such as sustainability and overcoming inequality [4]. This study constructed a conceptual framework based on the sustainable cooperation between vocational schools and companies. By applying this conceptual framework and the method

of content analysis, this paper was able to identify and analyze the typical challenges and strategies for German VET from the macro and meso-levels.

These challenges and strategies emerge and are reported in German VET education and training policies, official research reports, and data reports with a proposed theoretical framework. Using the method of content analysis, this study has identified and revealed the prominent challenges for German VET in the digital age. With respect to the challenges of German VET in sustaining quality development in the context of digitalization, the capability of industrial service, attractiveness, and the application of digital technologies were three critical aspects for sustaining the quality development of German VET in the digital era. We can highlight three major challenges of German VET brought about by the digital world of work: (1) the service capacity of German VET for industrial digitalization needs to be further improved; in particular, the matching problem of the vocational training market has grown more serious in recent years, and the regional digital competitiveness in digital talents needs to be further improved; (2) the attractiveness of the VET is on the decline; especially young people's willingness to choose VET is decreasing and the German companies' VET participation rate is continuously falling in recent years; (3) the application level of digital technologies in VET needs to be enhanced.

Thus, how German VET effectively overcomes these challenges by exploring promising strategies and reconstructing a supportive environment in the digital era has become its core task. VET, by virtue of its cross-border nature and the complexity of its governance, determines that the influencing factors are multidimensional. Considering this, the federal government of Germany, BMBF, BMWi, BIBB, etc., jointly took multiple strategies to overcome the challenges brought by digitalization. These strategies include (1) strengthening the capability of training digital talents through the modernization of training regulations and framework curricula; (2) reshaping VET as a more promising track for individuals through information support and expanding development pathways; (3) enhancing the participation willingness and the capacity to provide vocational training of companies through finical measures; (4) promoting the digital transformation of VET through multiple strategies.

This study does not aim to exhaustively explore and analyze all the challenges that German VET faces in the context of the digitized working world from the micro perspective. It also leaves out initiatives and documents initiated by the federal states or regions and specific branches. This study intends to contribute to the theoretical understanding and the practices of the reform and innovation of German VET in the context of digitalization. To get a comprehensive and systematic understanding of the challenges and promising strategies of German VET in the context of digitalization, there is a need not only for continuous observation and analysis and a re-examination of current research findings but also for the exploration of breakthrough points at the micro level. The question of when to use digital media in the design of learning situations in VET is helpful, and when it is more of a hindrance in Germany and elsewhere is yet to be answered. This is what this study needs to focus on in the future.

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**Data Availability Statement:** Table 1 shows detailed information on the data types and links.

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## Appendix A

**Table A1.** The main data types used in content analysis.

| No. | Year | Issuing Unit | Name | Language | Source |
|---|---|---|---|---|---|
| | | | **Data Reports** | | |
| 1 | 2022 | BIBB | VET Data Report Germany 2022 | German | https://www.bibb.de/dienst/veroeffentlichungen/en/publication/show/18019 (accessed on 18 November 2022) |
| 2 | 2021 | BIBB | VET Data Report Germany 2021 | German | https://www.bibb.de/dienst/veroeffentlichungen/en/publication/show/17483 (accessed on 26 September 2022) |
| 3 | 2020 | BIBB | VET Data Report Germany 2020 | German | https://www.bibb.de/dienst/veroeffentlichungen/en/publication/show/16673 (accessed on 11 September 2022) |
| 4 | 2020 | BIBB | Digital media in companies—today and tomorrow 2020 | German | https://www.bibb.de/dienst/veroeffentlichungen/en/publication/show/16751 (accessed on 10 September 2022) |
| 5 | 2022 | BIBB | VET Data Report Germany 2019 | English | https://www.bibb.de/dienst/veroeffentlichungen/en/publication/show/17930 (accessed on 22 November 2022) |
| 6 | 2018 | BIBB | VET Data Report Germany 2016/2017 | English | https://www.bibb.de/dienst/veroeffentlichungen/en/publication/show/9550 (accessed on 5 September 2022) |
| 7 | 2016 | BIBB | Digital media in companies—today and tomorrow 2016 | German | https://www.bibb.de/dienst/veroeffentlichungen/de/publication/show/8048 (accessed on 5 September 2022) |
| 8 | 2022 | BMBF | Report on Vocational Education and Training 2021 | English | https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/FS/31702_Berufsbildungsbericht_2021_en.pdf?__blob=publicationFile&v=3 (accessed on 5 September 2022) |
| 9 | 2019 | BMBF | Report on Vocational Education and Training 2019 | English | https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/FS/31568_Berufsbildungsbericht_2019_en.pdf?__blob=publicationFile&v=7 (accessed on 5 September 2022) |
| 10 | 2022 | EC | Digital Economy and Society Index (DESI) 2022-Germany | English | https://ec.europa.eu/newsroom/dae/redirection/document/88702 (accessed on 5 August 2022) |
| 11 | 2021 | EC | Digital Economy and Society Index (DESI) 2021-Germany | English | https://ec.europa.eu/newsroom/dae/redirection/document/80481 (accessed on 5 August 2022) |
| 12 | 2020 | EC | Digital Economy and Society Index (DESI) 2020-Germany | English | https://ec.europa.eu/newsroom/dae/redirection/document/66916 (accessed on 5 August 2022) |

**Table A1.** *Cont.*

| No. | Year | Issuing Unit | Name | Language | Source |
|---|---|---|---|---|---|
| | | | **Research Reports** | | |
| 1 | 2020 | Cedefop | Spotlight on VET-Germany | English | https://www.cedefop.europa.eu/en/publications-and-resources/publications/8137 (accessed on 16 August 2022) |
| 2 | 2020 | Cedefop | Vocational education and training in Germany: short description | English | http://data.europa.eu/doi/10.2801/329932 (accessed on 16 August 2022) |
| 3 | 2020 | BIBB | VET 4.0—Is vocational education and training on the edge of radical change? | German | https://www.bibb.de/dienst/veroeffentlichungen/de/publication/show/16425 (accessed on 16 August 2022) |
| 4 | 2019 | BIBB | VET 4.0—Skilled worker qualifications and competencies for the digitalized work of tomorrow: Sector and occupation screening | German | https://www.bibb.de/dienst/veroeffentlichungen/de/publication/show/10371 (accessed on 19 August 2022) |
| 5 | 2019 | Platform VET-4.0 | The 4th industrial revolution and it's implication to the VET provision | English | https://www.ifoa.it/wp-content/uploads/2019/02/VET-4.0-Research-Report.pdf (accessed on 19 August 2022) |
| 6 | 2020 | BMBF | Inter-company training—modern, digital, and attractive | English | https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/FS/31632_Ueberbetriebliche_Ausbildung_en.html (accessed on 19 August 2022) |
| | | | **Policies** | | |
| 1 | 2019a | BMBF | Digital Future: Learn. Research. Knowledge | German | https://www.bmbf.de/upload_filestore/pub/BMBF_ Digitalstrateg.pdf (accessed on 9 August 2022) |
| 2 | 2019b | BMBF | The Vocational Education and Training Act (BBiG) | German | https://www.bmbf.de/bmbf/de/home/_documents/die-novellierung-des-berufsbildungsgesetzes-bbig.html (accessed on 9 August 2022) |
| 3 | 2016a | BMBF | Education initiative for the digital knowledge society | German | https://www.bildungforschung.digital/de/einebildungsoffensive-fuer-die-digitalewissensgesellschaft-1715.html (accessed on 9 August 2022) |
| 4 | 2016b | BMBF | Digital media in vocational education and training | German | https://www.bmbf.de/de/digitale-medien-in-der-bildung-1380.html (accessed on 13 August 2022) |
| 5 | 2016 | KMK | Education in the digital world | German | https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2016/2016_12_08-Bildung-in-der-digitalen-Welt.pdf (accessed on 13 August 2022) |
| 6 | 2017 | KMK | Vocational schools 4.0 | German | https://www.kmk.org/fileadmin/user_upload/Erklaerung_Berufliche_Schulen_4.0_-_Endfassung.pdf (accessed on 13 August 2022) |
| 7 | 2019 | KMK | Framework agreement on the vocational school | German | http://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2002/2002_11_07-RV-Fachschulen.pdf (accessed on 13 August 2022) |

**Table A1.** *Cont.*

| No. | Year | Issuing Unit | Name | Language | Source |
|---|---|---|---|---|---|
| 8 | 2017 | KMK, BDA and DGB | Together for powerful vocational schools in the digital world | German | https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2017/2017-05-30_Gem._Erklaerung_KMK-DGB-BDA.pdf (accessed on 19 August 2022) |
| 9 | 2016 | BMWi | Digital Strategy 2025 | English | https://www.bmwi.de/Redaktion/EN/Publikationen/digitale-strategie-2025.html (accessed on 19 August 2022) |
| 10 | 2019 | BMAS and BMBF | National Skills Strategy | English | https://www.bmas.de/EN/Our-Topics/Initial-and-Continuing-Training/national-skillsstrategy.html (accessed on 19 August 2022) |
| 11 | 2017 | BMAS | White Paper: Work 4.0 | English | https://www.bmas.de/EN/Services/Publications/a883-white-paper.html (accessed on 20 August 2022) |
| 12 | 2015 | BMAS | Green Paper: Work 4.0 | English | https://www.bmas.de/EN/Services/Publications/arbeiten-4-0-greenpaper-work-4-0.html (accessed on 20 August 2022) |
| 13 | 2021 | BIBB | The modernized standard occupational profile positions of recognized training occupations | German | https://www.bibb.de/dienst/publikationen/de/download/17281 (accessed on 22 August 2022) |

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