Trends and Issues of Digital Learning in Germany

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Abstract

The description of the German educational system reveals that fostering specific education in schools and other educational institutions is not easy for the national government due to the fact that education is up to the federal states of Germany. This chapter reveals that many different approaches to digital learning have been developed by the states and the schools, and introduces which changes have been made so far to achieve digital learning. A categorization of the different levels of K-12 schools according to their stage on the journey to digital transformation is provided in this chapter. The "Digital Pact" ("Digitalpakt," see below), which is Germany's most important initiative to enhance the digital competences of young people by boosting digital education with an historic funding program, is explained. It is shown how this program accelerated digitalization in German and why it came at the right time to provide an effective means of dealing with the coronavirus pandemic. On the basis of the Digital Pact, many innovative programs could be funded, and digital learning could be fostered in a sustainable way. It is claimed that school and teacher attitudes changed, and interest in digital learning increased. It is argued, however, that the digital change led to overload for teachers because concepts and technical administration is up to them, besides all of the teaching tasks. Additionally, the national government did not announce if and when the Digital Pact will be continued when it expires in 2024. Will the positive proceedings of the digital learning of recent years come to a turning point soon?

Keywords: digital learning in Germany, German education system, political influence on education, Digital Pact

Introduction

Germany consists of 16 federal states and therefore is officially called "The Federal Republic of Germany." It has about 84 million inhabitants and the population of the federal states ranges from 0.6 million (the city state of Bremen) to 18.1 million (the state of Nordrhein-Westfalen). It is most likely to be historically argued that educational sovereignty lies with the federal states themselves and not with the Republic of Germany. The states have their own governments and ministries and regulate many of their affairs autonomously, including education. There are many specific features in the 16 states. As a consequence, no standardized curricula exist in Germany. Therefore, one could claim that Germany has not one, but 16 education systems. Yet the states are not entirely free in their decisions concerning their educational affairs. They are comparable in various aspects and can be considered as one system. This is done in the following section, where differences between the 16 systems are also discussed when they become relevant.

For example, the 16 states have in common that the internationally used eight ICSD levels are divided into five educational levels. The German education system distinguishes elementary, primary, lower secondary, upper secondary, and tertiary education. There are various transition options between the levels. Overall, the system strives for a high degree of transferability. This is intended to enable every citizen to achieve the highest possible level of education in several ways and via different educational pathways without the education system itself setting limits. In addition to demographic effects, it is probably also attributable to this educational transferability that the number of college beginners rose from one third in 2000 to more than a half in 2010 (Turulski, 2023).

Every child must attend school for at least 9 years, in some states even longer. This time is sufficient to obtain a lower secondary school leaving certificate,

which is the lowest education degree necessary for entering any vocational education program. Many options with pathways for general education or vocational education allow the achievement of higher educational qualifications, provided that the personal disposition is appropriate.

Any educational program offered by public schools is available for completion at no cost. In certain instances, however, it may be necessary for students to bear the expenses of educational materials. Relatively low fees may be charged at tertiary level universities and universities for applied sciences. Some trade and technical schools provide qualifications at ISCED level 6 that can be attended on a part-time basis. These programs are subject to a fee and must be paid for by the student or an employer. Students may apply for state subsidies to reduce their expenses for education.

There are about 32,200 public schools of general education in Germany, which is nearly 8,000 schools less than 20 years ago. This reduction can be justified by demographic effects and by the drive to form larger schools. In 2019, 14% of general education schools were privately run, but the trend is positive, and the majority of schools in Germany are public. Private schools may receive funding from the state, but they must essentially finance themselves. They often offer a range of conditions, such as smaller courses, additional mentoring and leisure activities, or boarding school accommodation, which are not available at public schools. Nonetheless, their educational programs that lead to an official degree must be accredited by the education ministry. Private schools charge fees depending on the school's requirements so that they may only be afforded by particularly high-income parents. The attendance of private schools correlates with household income. In 2016, only 3.6% of students from low-income households attended a private school, while 18.7% of private school attendees were from millionaire income households (Grossarth-Maticek et al., 2020). As a consequence, private schools are often seen as schools for elites, even though many private schools make efforts to attract

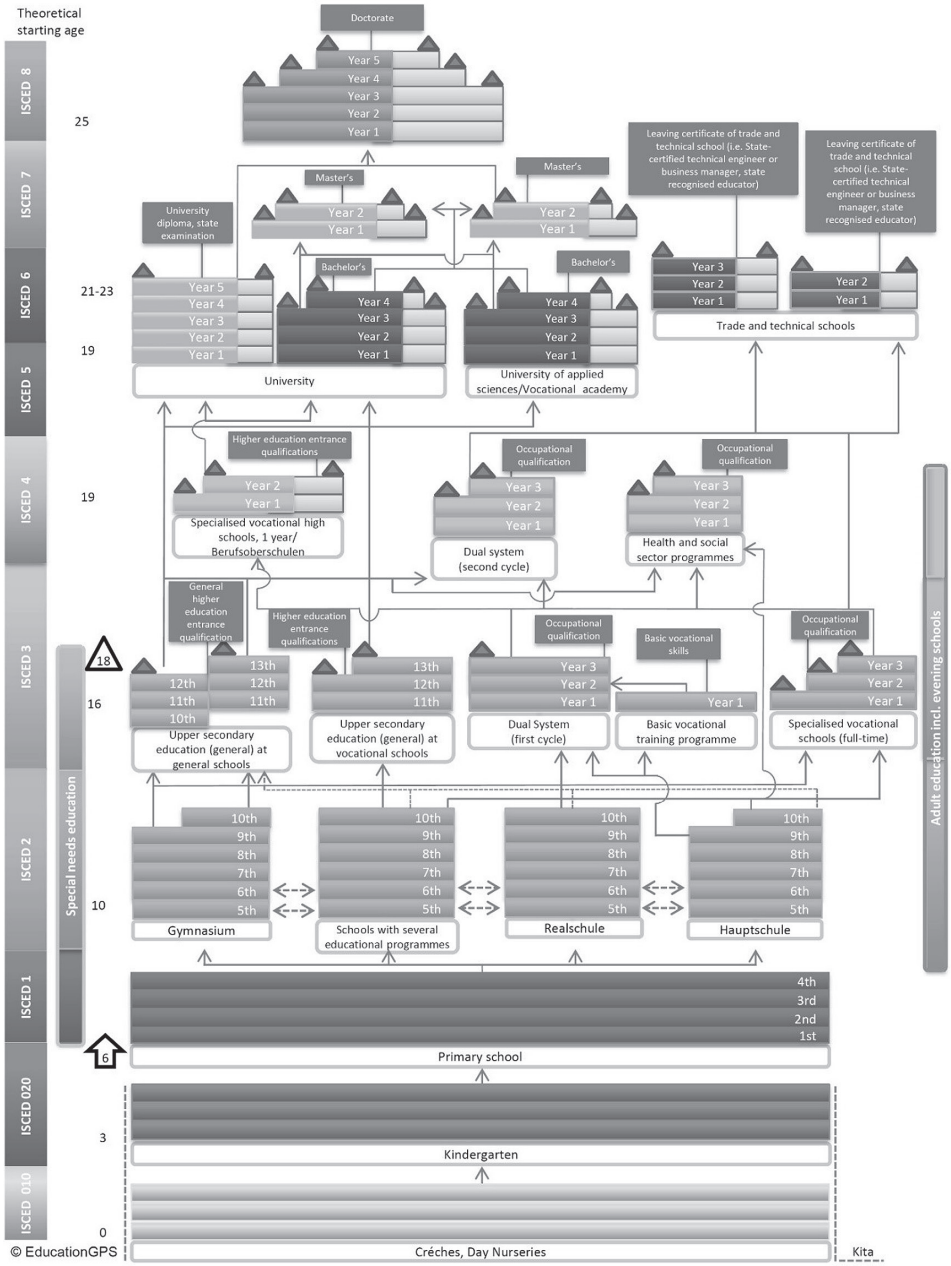
students from non-elite backgrounds, for example by awarding scholarships.

The German education system

The common structure of the German educational system is defined by national law and therefore is homogeneous across the country. The following diagram has been released by the OECD and shows

- the range of school types from elementary level (ISCED 0) to doctoral level (ISCED 8),
- the assignment of German school types to the ISCED levels, and
- the possible education pathways (OECD, 2020).

Figure 1 The German Education System



Source: OECD, 2020.

In the following section, the specific school types will be explained in more detail for each of the eight ISCED levels.

Elementary education (ISCED 0)

The elementary sector provides services for children up to 6 or 7 years of age, which is the regular age for entering primary school. Typical institutions are childcare centers like crèches and day nurseries for children up to 4 years (ISCED 010) and kindergartens for older children (ISCED 020). Assignment to programs at this ISCED level is not obligatory, but they are in high demand. Having childcare is a fundamental necessity for many parents who participate in the labor market. However, it can be very difficult to get a place for children even though many new child daycare facilities have been built in Germany in recent years. In March 2021, there were 55,000 daycare centers, which is almost 1,800 facilities more than 2 years before. Since 2006, about 9,400 new facilities have been established (Autorengruppe Bildungsberichterstattung, 2022). Elementary education institutions are seen as educational facilities and not just as care institutions. The children learn social competencies and acquire fundamental expertise by participating in learning activities such as pedagogical games, role plays, and theater, and they may attend preschool classes.

Primary education (ISCED 1)

The first obligatory school is the primary school. In most federal states, it covers Grades 1 to 4, depending on the federal state, but it may go up to Grade 6. Based on the students' accomplishments, a recommendation for secondary school is given at the end of elementary school. However, the decision is ultimately made by the parents. In the majority of its federal states, Germany regularly adopts an inclusive philosophy. Therefore, disadvantaged children are included in heterogeneous learning groups at regular schools. If this is not realistically achievable, attending a special school is an option.

Lower secondary education (ISCED 2)

After Grade 9 or 10, pupils complete educational programs that lead to the "first school-leaving certificate" (9 years) or the "intermediate school-leaving certificate" (10 years), or they prepare for a higher certification program. Qualification and school titles vary across the states. There are schools that only provide one of the two qualifications (Hauptschule and Realschule), as well as schools that offer two or three programs (with the possibility of obtaining a higher education entry qualification called “Abitur”). There are integrated comprehensive schools in some states where students can choose between multiple levels of course difficulty and get a certificate depending on the chosen classes and their accomplishments. There is a high school type called “Gymnasium” in every state where lower secondary school-leaving qualifications are obtained after 9 or 10 years as a by-product on the way to the “Abitur.”

Upper secondary education (ISCED 3)

Students in upper secondary school attend full-time vocational or general education schools. The “Abitur” can be achieved after the 12th or 13th grade at a “Gymnasium” or another type of upper level general education school. Some vocational schools lead to the “Abitur” by providing upper secondary education for graduates of lower secondary schools.

Several vocational qualifications are available at the ISCED 3 level through the German Vocational Education System in three distinct sectors.

- Specialized educational schools
  Like in most European countries, this sector provides training occupations that take place exclusively at full-time Specialized Educational Schools. Programs in this sector take up to 3 years to complete and have to be legally recognized as vocational training programs by the responsible ministry. Training takes place exclusively at the school, although

practical phases in the form of company placements are also provided. The school-based training programs end with final examinations that evaluate the suitability for the future professional activity. Unlike dual vocational training, the content of these courses is regulated at the state level and is not uniform throughout Germany. With 80%, most of these programs correspond to the field of social and health service professions. STEM professions (to which professions in information and communication technologies are reckoned) have a small share, as they are preferably learned in the dual system (Schultheis et al., 2021). In this small share, the profession of “informatic assistant” is quite popular (Bundesagentur für Arbeit, 2023). However, this profession has only a proportion of 2.5% of all vocations educated in specialized educational schools.

- Dual system

  This sector is referred to as "dual" because training takes place in two educational locations: the company’s workplace and a vocational school. The practical training is covered by the training company, while the theoretical elements are taught at the vocational school. The educational content is centrally regulated by the responsible national ministry. Due to that, they are standardized nationwide. The dual education takes 3 years for most professions, though for some vocations it may take 2.5 or 3.5 years. Because the trainee is working in a company, she or he receives pay. In 2019, about 47% of all people above the age of 15 in Germany had obtained their highest vocational qualification through the dual system. Summing up all students of this sector reveals that more than 50% of adults in Germany have received a vocational training degree in the dual system, and so the dual system is a very relevant education concept for Germany. The demand for education in information and communication technology in the dual system has been rising since the last decade (Bundesagentur für Arbeit, 2023).

- Basic vocational education programs
  Compared to other vocational education sectors, the sector called “the transition system” is relatively new and has been installed primarily to support young people to get into the vocational education system. In 2006, the National Education Report summarized a number of educational programs "that are below a qualified vocational training and do not lead to an official training qualification, but aim at improving the individual competences of young people to take up training or employment or also enable them to catch up on a general school leaving qualification" (Konsortium Bildungsberichterstattung, 2006). For young people and adults transitioning from school to the workforce, this sector offers training courses lasting up to a year. The goal is to increase their chances of obtaining a school- or workplace-based education choice by providing various courses to meet individual needs. Due to that, no formal education, in particular no higher school certificate, can be received in this sector. It is quite diverse, with several regional variations throughout Germany. Some of these may be accepted for the dual system's training phases, while others help young people with learning disabilities get ready for further educational programs.

In 2019, 26.3% of the entries in the vocational training system were attributed to the “transition system” sector (Maier, 2021). Before the coronavirus pandemic and up to 2021, the trend was slightly downwards (Statistisches Bundesamt, 2022). However, events of major significance (for instance economic crises) influence the demand for programs in this sector. Demographic trends and developments in immigration to Germany also have an impact on the transition system (Dohmen, 2020). Even though classes of this sector suffered in the same way like all other events that require physical presence of participants, the demand is excepted to rise due to the pandemic, for instance because of cancelled job interviews (Barlovic et al., 2020). Cancelled information events have a particularly strong impact on young people with a mi-

gration background, as they have fewer contacts with potential employers and fewer individual counseling or job application training sessions (Schwarz et al., 2020).

Post-secondary non-tertiary education (ISCED 4)

Depending on the state, programs at this level offer additional education based on an upper secondary (general or vocational) certificate, and can be obtained at a number of schools. They specialize in specific areas (such as the social or health sectors) or dual-system careers where admittance requires a diploma from an upper secondary school. Programs to get an entry qualification for higher educational programs at the tertiary level are offered by several special vocational high schools.

Short term tertiary education (ISCED 5)

At this qualification level, there are no established nationwide programs; nevertheless, some states may have unique programs for special cases.

Bachelor's or equivalent level education (ISCED 6)

At universities, colleges of applied sciences and vocational academies (trade and technical schools) in Germany, students can choose from a wide variety of study options. In 2019, more than 300,000 students received this level of graduation (Autorengruppe Bildungsberichterstattung, 2022). Even though the majority of the studies have been reformatted and internationally standardized as part of the Bologna Process, there are still some national-specific degrees, such as state examinations or diplomas, in addition to the widely recognized bachelor's degree. Vocational academies offer programs that, without attending a university or university of applied science, result in a degree equivalent to ISCED level 6 in particular professions. Many of these vocational courses are offered at evening schools on a part-time basis.

Master's or equivalent level (ISCED 7)

The Master's degree is often completed in a university and is the second degree in higher education. However, several applied science universities also provide master's degree programs.

Doctoral or equivalent level (ISCED 8)

Doctorate degrees in most cases are awarded by universities. They are considered as evidence of the ability to conduct independent scientific research. Since the Bologna Process, certain states have permitted doctorate programs at universities of applied sciences.

Digital transformation

In the following, the status of digitalization in the German K-12 schools will be described for ISCED level 0 to level 3. This will be done in accordance with a model of digitalization stages pointed out by Lou and Wee (2021). This model has been designed for companies to clarify their current status of digitalization and to provide an orientation for adjusting their business strategies for the future. It divides the status of digitalization into three stages, and digital transformation is characterized as a journey from the lowest to the highest stage. The primary goal is business success, which is expressed in successful products and a good positioning in the economic market.

Even though educational institutions are mostly driven by the state and therefore do not strive for commercial profit maximization, they must deal with numerous financial affairs to keep their educational business running. In addition, there are privately operated schools that have the pressure to generate financial income and which in this perspective are comparable to commercial companies. But in the end, education institutions are not classical commercial businesses. Even though they offer services that can be summarized as education, there is no economic market where education can be traded following the

usual laws of supply and demand. The relationship of educators and students is different from the relationship between companies and customers. However, Lou and Wee's model can still be adapted to educational contexts if the economic aims of commercial companies are replaced by educational goals.

Further, education institutions can not only focus on their core aims of education such as teaching, training, educating or nurturing children and adults, they also need to administer these processes. The administration tasks are basically quite comparable to those of economic companies. Many data are to be processed. Some are shared and communicated with externals and some data are very sensitive and must not be shared with others; this concept of data security is very important. Administration processes need documentation and quality management. All in all, there is a great deal of potential for digitalization in these processes. The stage of digital transformation might be different regarding administration and education processes.

- Stage I: Digitization
  "Digitization means converting non-digital records and information into digital format" (Luo & Wee, 2021). To do this, digital devices must be available and the participants, no matter whether they are the teacher or student, must be able to operate the device. Characteristic of this stage is that activities with these devices are not connected to other activities pedagogically. In administration contexts, this stage seems to be quite insufficient. Working with digital devices like computers and digital data has been obligatory for many years. On the education side, the question of digitization is not as simple to answer because digital technologies have not been used for decades ubiquitously and in a self-evident way. Before the coronavirus pandemic, this stage was the state-of-the-art in most K-12 schools. Single digital solutions were used, for instance software for learning vocabulary, taking measurements (in sciences), generating a drawing or getting information from the world

wide web. A general strategy for digital educational aspects does not exist at this stage. Teachers and students may use digital technologies if this is an appropriate means, but there is no connecting concept to digital literacy.

- Stage II: Digitalization
  "Digitalization includes the conversion of processes or interactions into their digital equivalents" (Luo & Wee, 2021). At this stage it is necessary to connect digital solutions to gain a benefit, that is more than just the sum of the specific involved digital solutions. By integrating digital solutions into processes of education with a concept, the digital solutions support the education process in a way that is not just running a technical service. The education process will be enriched and elaborated, and enhanced learning and teaching possibilities will be enabled. For instance, learning platforms do not just provide the location-independent availability of learning material or the possibility for asynchronous communication between teachers and students. They afford new learning scenarios by supporting students with additional information and learning activities they may use whenever needed. In this way, enhanced options to supply students with individual support in the context of heterogeneous learning groups are given. To reach this stage, the education institution needs to know more than just "how to operate hardware and software products"; it needs some elaborated competences about the possibilities to conduct digital solutions, teaching and learning. Due to that, having further educated staff becomes of elementary importance.

- Stage III: Digital transformation
  "Digital transformation refers to an innovative and disruptive business transformation, where strategic decisions are made with the support of digital technologies" (Luo & Wee, 2021). This stage implies a transfor-

mation of business. For this purpose, new outcomes (products or services) must be provided. Adapting this to schools and other educational institutions raises the question of what kind of products or services they have. Basically, they offer educational programs. In Germany, these programs are predefined at an abstract level by the state of Germany and the federal state (as described above). Further on, educational facilities have to deal with the financial and infrastructural conditions set by the local authorities. As a consequence, the influence on transforming educational services is limited, but there is some freedom for schools to produce digitally transformed services and curricula. This way, digitalization can be integrated into the curriculum and can form a core learning objective in single subjects or even at the interdisciplinary level. Next to the pre-defined educational programs, there are other services like child care, extracurricular classes, workshops and other services that are extra-curricular and have the freedom to address the students' interests and demands much more directly than classical education courses. Due to the fact that schools compete with each other in the way described above, they tend to shape a school profile that appeals to students and those who have to choose between school options in the near future.

The three stages of digital transformation will be regarded separately for education and administration purposes. On the administrative side, the educational institutions are comparable. For many years digital information technologies have been used to facilitate and enhance administration like in many other business fields. Most of the educational institutions are in the public's hands. This means that superordinate authorities often specify the requirements for administration processes, and sometimes even the tools which have to be used for administration. Even though there are strict frame conditions, and the authorities in Germany do not have a reputation for being particularly innovative, the lower institutions do a professional job of administration. A

large part of the data is available in digital format and is also processed digitally with the corresponding hardware and software. On the other hand, in some cases German authorities still operate in an analog way and adhere to classical, paper-based data. The reasons for this are not obvious and may be caused by the complexity of the administration process that includes many different people and authorities with different responsibilities, by reasons of data security, or simply by the aversion to change that authorities are often said to have. Anyway, digital data are omnipresent in public and privately-run education institutions. Therefore, there is no question that the prerequisite for stage I is a given.

By using networks, authorities began to connect databases for making the processing easier and faster. By sharing data via the internet, hardware and software components of different authorities can communicate nearly in real time, making the transfer of data by post unnecessary, thus greatly accelerating processing. Some services can be made use of via the internet without needing to visit the office in person. By developing the way of processing (digital) data in an efficient way, the authorities in general have become much more customer-oriented in recent years, and therefore they reached stage II of digital transformation for the most part. When considering the administration of education institutions, this is not so clear. Administration is not the core business of educational facilities where there are often just a few staff for administration tasks. In many cases pedagogical staff must perform administrative tasks on the side. When data have to be transferred to a higher authority, the tools for realizing this are predetermined and cannot be chosen by the institution. As a consequence, possibilities for innovating the administration are very limited. Instead of this, innovation is to be focused on the educational part of business. If we want to state it in a positive way, we can say that educational institutions are on their way to stage II. Some are further along than others. In summary, however, it must be stated that stage II is still far from being achieved across the entire country and to a satisfactory degree.

Stage III of digital transformation implies that there is a drive and a demand for generating new services. Public authorities do not offer their services in an open market, and clients have no choice when it comes to administration services by authorities. Due to that, clients are not customers in the classical sense. They do not demand an administrative service like they demand a product or service hosted by an economic company. Public administration is not a product, it is more like a means to a wanted end (for instance, the registration of a car). Therefore, public administration is not at stage III and it is not even heading towards it in general. The same can be said for the administrative side of educational institutions.

On the educational side, the stage of digital transformation needs to be regarded in more detail, because the educational business varies greatly regarding the specific education institutions of K-12 schooling. Because of that, the stages of the digital transformation process will be described for each ISCED level separately. It should be considered that there are many variations of digitalization in the different states and even in different institutions in the same district. The following descriptions therefore describe the state that most closely corresponds to the average at each ISCED level.

Institutions of elementary education (ISCED level 0)

In general, K-12 includes preschool education of children at the age of 5 or 6 years. At this age, children in Germany regularly pass the last year in kindergarten. Due to that, day nurseries or crèches for younger children will not be described any further in this section. K-12 education begins with kindergarten, which is part of child-care-services (Kita) before children get to primary school at the age of 6 or 7 years. In general, in kindergartens children learn by doing, often by playing and interacting with the environment and other children. Exploration is how young infants learn because they use their senses to investigate, figure out how things work, and interact hands-on with their surroundings. The last year of kindergarten is specifically to prepare the children

for entering school education in primary school (preschool year). The children get in touch with new learning approaches like concentrating on given tasks, working with school typical media, listening to educators for longer amounts of time, and knowing basic cultural concepts like numbers or letters. By doing this, they may use digital devices like intelligent pens (interaction with talking pens that react to what the child is pointing at with the pen). They may even work with tablet computers and pedagogical applications in some contexts. However, there is also the viewpoint that existing concepts and offerings in daycare centers should be meaningfully enriched by digital elements (Lepold, 2022). In this way, two basic competences should be fostered:

- Gaining abilities and experiences in practical use of digital media (for instance taking photos, video clips or audio records with a tablet computer)
- Understanding medial code systems (for instance formats of files and programs, reality and fiction) (Lepold, 2022)

In 2004 the "Standing Conference of the Ministers of Education and Cultural Affairs" (Ständige Kultusministerkonferenz [KMK]) published the "Common framework of the federal states for early education in day care facilities for children." This national framework has been updated continuously and claims in the current issue that it is a central challenge to enable children to deal with media of all kind, so that they can take advantage of additional opportunities for social participation. The use of digital devices and components of information technology is given as an example of sufficient media education for early education (Kultusministerkonferenz, 2022). However, this framework is just an abstract description of what should be. In reality the available devices differ greatly between the specific kindergartens. The use of digital media in kindergarten's preschool year is more sporadic and isolated from other educational concepts. This corresponds to the finding that even at home, children between 3 and 6 years use digital media on only one day per month (Autorengruppe Bildungsberichterstattung, 2022). According to the digital transformation pro-

cess, the kindergarten preschool education at ICSED level 0 accords to stage I of Lou and Wee's digital transformation concept. At the interface between educational pedagogy and administration, there is a range of digital tools that simplify the gathering and documentation of kindergarten children's competencies (Reichert-Garschhammer et al., 2021). Provided these tools become widespread and their results are fed back into pedagogical work, preschool education in kindergartens may reach stage II in the future. In some specific cases, this level may have already been achieved.

Institutions of general primary, lower and upper and secondary education (ICSED levels 1 to 3)

Even though there are different types of school for general education, they share some overall characteristics when it comes to digital transformation. As already described, the educational landscape is very heterogeneous. Depending on individual conditions at schools, they may approve digital innovation more or less fast and often. Most schools can only purchase digital equipment when external funding is provided, for instance by companies or foundations. Not every school succeeds in recruiting external funds. As a consequence, the state of digitalization differs greatly between schools. The Digital Pact may have further escalated the problem. Even though its overarching goal is to spread digitization to all schools, numerous pilot projects have emerged that directly benefit only a few schools. This means that other schools are not enhanced directly by the Digital Pact. For them, the only hope is that at least parts of the pilot projects will eventually be extended to other schools. In 2019, a teachers' union conducted a survey asking teachers and students to give their school's digital equipment a school grade. On average, only the grade "satisfactory" was given, which, according to the German school grading system, is the worst grade with which you can just barely pass an exam. In 2017, a foundation provided a survey that revealed five central findings (Schmid et al., 2017):

- Schools failed to recognize the educational potential of digitization. Only 15% of the teachers were experienced users of digital media. Not even one in four teachers believed that digital media help to improve the learning success of their students.
- There was a lack of concepts and strategies for digital education. Only 8% believed that digitalization may be of strategic relevance. The teachers decided individually if and how digital media were used in classes. They had to engage in further education on their own initiative.
- Schools suffered from insufficient infrastructure. More than half of teachers were dissatisfied with the IT infrastructure (wireless LAN, IT support, specific training).
- Video was the most popular digital learning media, followed by wikis and standard office software. Another study even pointed out that standard media like presentation software, office applications, videos and PDF-files were the most often used by teachers, even though these media were not specifically designed for pedagogical use (Anders, 2018).
- Digital learning content was particularly used if it was for free and verified. About 50% of teachers complained that searching for good content takes too much time.

The survey was released just before the government implemented the Digital Pact, and revealed the initial conditions for the pact. In addition, the COVID-19 pandemic emphasized the importance of digital education.

Primary education (ICSED level 1)

Primary schools have specific problems in gaining digital education. Since they are often smaller than secondary schools and have fewer students, they get less money from the school authorities. The Digital Pact seems to have improved the situation at primary schools at least in some cases. Zhilisbayev (2023) claimed that the equipment of elementary schools with digital (end) devices has progressed as a result of the pact. This impression was confirmed by

several reports of primary schools (Norddeutscher Rundfunk, 2022; Trogisch, 2019). In contrast, Zhilisbayev pointed out that the conceptual aspect of digitality in primary schools is still underdeveloped. Studies show that the didactic use of digital devices and the question of teaching content remain largely unresolved, and the objectives are inconsistent. The intended school-based "digital basic education" and the acquisition of basic media skills are thus in danger of being missed in many cases (Schmeinck et al., 2023). Often, the IT installation, administration, and reparation are up to the teachers themselves, because no technical staff exist at many schools (Deutscher Philologenverband, 2021). The affinity of primary school teachers is often more oriented towards the pedagogical than to the scientific-technical level. Due to that, there are fewer human resources and less digital development in primary schools (Rohde & Wrase, 2022). To sum up, digitalization is heterogeneous in primary schools, but as an effect of the pandemic most of them seem to have and use the equipment and infrastructure, but it often lacks the connecting concepts, and there are still schools that have a lot of catching up to do. Due to that, on average primary schools are at stage I, “digitization.”

Lower and upper secondary education (ISCED levels 2 and 3)

There are different paths in the German education system to achieve the German equivalent of K-12 graduation, the “Abitur.” On some paths, students have to change school when progressing from lower to upper secondary level. The classic way means staying at the gymnasium for both levels. In this case, there is no difference between the levels because both take place at the same school. In general, the differences between lower and upper secondary level are not significant on average. Indeed, the variations between specific schools (even at the same level) may be much more relevant and depend on where the specific school is located and how the local authorities foster digitalization in schools (Hirsch, 2022). In addition, a study in 2021 highlighted the fact that digitization-related developments in the federal states continue to take place at

different speeds and with different emphases. Thus, the educational opportunities of children and young people in the area of digital education as well as the framework conditions for teaching and learning continue to vary despite nationwide strategies (Lorenz et al., 2021). A generalized, nationwide description is also difficult for secondary schools because of the disparity between schools and states. However, studies reveal that secondary schools like gymnasium and comprehensive schools are often more digitalized than primary schools (Rohde & Wrase, 2022). As a consequence, the results of the 2018 International Computer and Information Literacy Study (ICILS) showed that, on average, eighth-graders at schools with upper secondary level were more digitally literate than those at schools with lower secondary level only (Eickelmann & Drossel, 2020). Because the students of secondary schools are older, they have more differentiated options for using digital devices as a tool for the achievement of higher-level goals. Accordingly, the device is not just a tool for learning directly supported content that must be provided by someone (like an application that helps learning how to calculate). Instead, it becomes a universal tool that can be useful for generating new content that must not be pregenerated by someone else. Older children are able to use applications that are not designed as a learning aid, but as a professional tool for multiple purposes. Due to that, it can be assumed that the connection of specific digital solutions is much easier to realize and can be integrated into pedagogical concepts that are not bound to specific content.

This effect also benefits the upper secondary vocational schools at ICSED level 3. The vocational gymnasium is open for all who graduate from lower secondary school with the completion of 10 grades. It combines general school subjects with career-oriented subjects of specific vocational fields, for instance technology or business. Despite the different subjects, it is quite similar to the upper secondary part of the general gymnasium; in particular there is no training on the job and no longer internship in companies. Specialized vocational full-time schools lead to a vocational degree that qualifies for a profession,

but not for admission to a university or university of applied sciences. At the vocational schools that belong to the dual system, the content and the equipment are more focused on occupational activities. If these activities belong to the field of information technology, the school may provide more digital education than others, because the focused profession includes digitalization. In other vocational fields, the stage of digitalization is comparable to any other school at the upper secondary level.

There may be some schools that use digitalization for sharpening a school profile to be more attractive compared to others so that they would be supposed to be at stage III, "digital transformation." However, on average, lower and upper secondary schools are supposed to be at stage II, "digitalization," with upper secondary level schools appearing to be slightly more advanced.

The Status of Digital Learning

Contexts of digital learning

The national government of Germany has only a limited influence on the specific realization of the education system in the states, because many aspects of realizing education like releasing policies, allocating funds, installation of school subjects and making superordinate digital infrastructure and services available are the responsibility of the federal states and the local authorities. This even leads to different school subjects, diverse curriculums and various pedagogical approaches. For instance, there are very different approaches in lower secondary education. Some states divide the students according to their scholastic performance in three different types of school (Hauptschule, Realschule, Gymnasium) that lead to different graduations that enable students to follow different paths in upper general or vocational education programs. Other states just have gymnasium and comprehensive schools, both of which can offer paths to "Abitur" (lower degrees are awarded if the "Abitur" cannot

be achieved and the school career ends after 9 or 10 years). Of course, there are different regulations for different concepts of education.

But even the states cannot directly control any specific aspect of school education. Another relevant decision-making stakeholder is the local authorities. They realize the funding of the associated education institutions and may have control over the infrastructure schools have to use. This way, they do indirectly influence the digital infrastructure by investing in or limiting funds, and they can directly influence it by binding the education institutions to specific IT solutions. Instead of this, tertiary education institutions (like universities and universities of applied sciences) are quite free to design their own digital infrastructure and curricula, because they are institutions of the state and they are financed directly by it. As such, the local authorities have much less influence.

Depending on how strict the regulations of the municipalities are, schools and other education entities can be quite free in their decisions when it comes to IT solutions in hardware and software. Therefore, schools in the same locality may use completely different IT equipment for administration and education. Each school in Germany is setting up its individual curriculum for its classes, including subjects that are relevant for digital education. Furthermore, teachers may have the option to choose between different curricular content depending on the specific conditions of courses. The provided subjects of schools form the school's profile and depend on local impacts like availability of (IT) infrastructure and teachers, local traditions, demand of students, supposed attractiveness, and the expertise and personal inclinations of the school's teaching staff. In some way, schools compete with each other because the more students they get every year, the higher the funding they receive. Providing a good digital education can become an important advantage in this competition these days. The multiple responsibilities for educational affairs at the national level, the states, the local authorities, the specific schools and the teaching staff re-

sult in a very heterogeneous educational landscape in Germany concerning infrastructure as well as curricular content. This is particularly the case when it comes to relatively new issues such as digital infrastructure and digital education concepts.

At the federal level there are just a very few aspects of general school education regulated by law (German basic law). For unifying vocational education, there is a specific national law (vocational education law). All other regulations are given to the states. An important stakeholder when it comes to educational affairs is the "Standing Conference of the Ministers of Education and Cultural Affairs" (Ständige Kultusministerkonferenz [KMK]), which specifies numerous aspects for education at the state level. These requirements relate, for example, to the basic structure of the education system or to curricular requirements at an abstract level like a framework, to which the states must adhere (Kultusministerkonferenz, 2021b). The KMK never issues specific regulations in detail. This way the states have some liberty when generating specific policies on the basis of the KMK specifications. The KMK for instance is responsible for standardization of school curriculums. There are KMK standards for most school subjects, but they are so abstract that any state can set up individual curriculums or delegate the writing of specific curriculums to the schools.

Currently and in recent years two important investment programs for digital education have been released by the national government, the "Quality Offensive Teacher Education" and the "Digital Pact."

Quality offensive teacher education

In Germany, becoming a teacher at any school from ISCED level 1 needs a master's degree that has to be achieved at a university. In 2013, long before the coronavirus pandemic and in no connection to the Digital Pact, the government set up the "Quality Offensive Teacher Education" to foster teacher

education at the universities. A total of 500 million euros were provided which universities could apply for with innovative projects that should enhance for instance the structures of teacher studies, the connection to teaching practice at schools, and teacher student consulting. In 2018, an addition emerged to foster the digitalization in teacher education exclusively between 2020 and 2023 (Bundesministerium für Bildung und Forschung, 2022). Even though some projects assessed or improved specific aspects that are even connected to the efforts of the coronavirus pandemic, the "Quality Offensive Teacher Education" was inappropriate for short-term interventions to address the pandemic situation. The projects focused on universities and teacher education, so it is very difficult to evaluate the direct impact on the specific situation in schools.

The Digital Pact

To illustrate how difficult it is for the German state to gain specific changes in the approximately 32,200 schools in Germany, and how the coronavirus pandemic impacted the educational system, the emergence of the biggest digital education program in the history of Germany is described here briefly. In 2014, the German national government announced a new education offensive in its "Digital Agenda 2014-2017" (Die Bundesregierung, 2014). In October 2016, the national Ministry for Education and Research released a strategy paper called "Education offensive for the digital knowledge society" (Bundesministerium für Bildung und Forschung, 2016), whereby an investment program for the enhancement of the digital infrastructure with a simultaneous commitment of the federal states to foster the digitization of the education system was announced. Just 2 months later, the KMK released an important strategy paper for digital education. The paper, "Education in the Digital World," describes a concept of action in which learning in the context of the increasing digitalization of society and the working sphere as well as critical reflection on this are becoming integral components of education in any education path on any ISCED level from level 1 (Kultusministerkonferenz, 2016). Hence, digital competencies are becoming an integral part of the subject curricula of all sub-

jects. The paper defined six competence areas and set a deadline of 2026 for realization by the states. To achieve this ambitious goal, it claims five fields of action for school education (for instance further teacher education, digital learning platforms, cooperation with partners from industry and other school-externals). Then it took 2.5 years to change the German basic law, which was necessary to enable the national authorities to invest money in the educational institutions at all, which are the states' and local authorities' responsibility. In May 2019, the Digital Pact finally came into effect, and the government made 5 billion euros available, which educational institutions could apply for via school authorities and the federal states. In addition, the local authorities and the states were also allowed to apply for funding for projects. In some projects, several states could be involved. Because of the complicated and lengthy application process, initially significant funds could be paid out. Apparently, many institutions shied away from this effort, and concerns arose that the funds would not be fully accessed. It has to be mentioned that this happened prior to the pandemic conditions. There was no acute pressure on the schools to quickly become digital.

Just one year later, the coronavirus pandemic reached Germany. In March 2020, schools had to close down and were unable to teach in person as usual. From one day to the next the Digital Pact became much more relevant, especially for schools. To provide fast support for schools and to shorten the time-consuming application process, the national government made three supplements of the amount of 500 million euro each. In July 2020 the "Immediate equipment" supplement was provided to enable schools to purchase devices and software licenses and carry out distance learning services via the internet. In November 2020, a supplement for administration of equipment and services was issued, because many schools had a lack of specific competence and staff. In January 2021, another supplement was realized to enable schools and school authorities to provide their teachers with mobile digital devices like laptops, notebooks, and tablets. It is important to realize that a leading

industrialized country like Germany had not equipped its teachers with mobile devices before 2021! But even after that, many teachers were forced to use their private devices for teaching because not all teachers could be equipped simultaneously, and the devices would quickly go out of date, or restrictive administration requirements would prevent flexible use. In December 2021, still with the presence of the coronavirus pandemic, the KMK published another supplementary recommendation. In its paper "Teaching and Learning in the Digital World," the KMK focused on the necessary digital school development processes and on the qualification of teachers in didactic and technical terms (Kultusministerkonferenz, 2021c). While the first paper fostered the initialization of the digital transformation by setting up the infrastructure, this paper aimed to improve the quality of education by making more use of the infrastructure in the process of teaching and learning, and to make the options of digitalization usable in pedagogical contexts. Currently all funds of the "Digital Pact" (6.5 billion euros) are scheduled and committed, and the pact ends in 2024. At the moment, there is a lot of debate about whether and when the pact will be continued. It seems that a new pact will not start before 2025, so there will probably be a funding gap. Some even fear that there will not be a continuation at all (Kuhn, 2023).

Many projects have been enabled by the Digital Pact, and some of them run at the national level and connect the states. For instance, SODIX / MUNDO aims at systematizing the many different open educational resources by analyzing via AI, setting keywords and assigning them to different curricula. It is providing an interface and exchange platform for educational media. MUNDO is an open access library that checks these media and makes them easily accessible for education. Those media that are not open will be usable with the help of VIDIS, which connects all users of any school learning platform to didactical media like learning apps or digital school books. The project TBA (Technology-Based Assessment) is in the process of developing a testing infrastructure for the development, administration, and evaluation of online-based diagnostic

and performance assessment procedures.

Digital education is a cross-cutting task across all states. The KMK recommends that digital education be taught integratively, which means that all subjects must be concerned with it. However, the states are also free to set up corresponding school subjects. Some states already reacted to these recommendations and made adjustments to their curricular frameworks (Kultusministerkonferenz, 2021a). The states are realizing digital education very individually. This becomes obvious when regarding the school subject, "informatics" (internationally often referred to as computer science). In the state of "Mecklenburg-Vorpommern," "informatics" is an obligatory subject from Grades 5 to 10 (ISCED level 2) in any type of school. In contrast to this, the state of Hessen and the city state of Bremen have not implemented any informatics education in these grades so far, not even as an optional subject or as an integrated Focus in other subjects (Schwarz et al., 2022). The Association for Informatics issued an overview of digital education in the 16 federal states. Eight states have digital education as a specific subject or as a combined subject as an obligatory class in all or at least in two grades of lower secondary level. In six states there are optional classes, and two states have not yet embedded any digital education in the school subjects. At the upper secondary level, 13 states have optional and three have obligatory classes (Gesellschaft für Informatik, 2022).

Digital learning infrastructure

Current literature consistently emphasizes that the infrastructure at individual schools varies greatly and correlates to a large extent with the financial strength of the respective state and the responsible authorities. There are pilot schools that are very advanced, as well as "digital deserts" (Anders, 2018; Class, 2023; Hirsch, 2022; Kuhn, 2023; Lorenz et al., 2021; Rohde & Wrase, 2022; Schmid et al., 2017). Due to that, it is very difficult to describe the infrastructure on average. Nonetheless, the following table attempts to show this

according to the six categories of digital learning infrastructure (Fox et al., 2021).

Table 1 Digital Learning Infrastructure

Leadership and budget	The leadership is up to the head of school, but it is also influenced by the local authorities and the state. The realization of digitalization is often delegated to the teachers. The authority allocates the budget, but external funding is possible.
Course design and delivery	There is no general documentation about the learning content (courses), because the schools specify individual curriculums according to the state's and the KMK's standards. The delivery is up to the school; the authority or the state may provide some infrastructure.
Student success for digital learning	The access to devices, learning materials and support varies a lot in Germany. The situation is better in gymnasiums than in other schools.
Evaluation and analytics	Some learning platforms provide evaluation services. The national project "TBA" will certainly enhance the situation across Germany.
Teacher and staff professional development	Administration staff are in high demand at schools. The further education of teachers has become a focus but is still very different between the states.
Technology infrastructure	Depending on the financial power of the state and the local authorities, it varies a lot. There are very well-equipped schools as well as schools that lack technology infrastructure. WLAN, Internet access, digital whiteboards, tablets and a learning platform are considered good infrastructure.

The coronavirus pandemic showed some trends in school education. In 2021, it prompted many teachers to become more involved with digital education and to use it more frequently. As a result, the use of digital media increased, and that had a positive effect on teachers' media-related skills. In 2017, only 15% of teachers were competent users of digital media (Schmid et al., 2017).

Teachers stated that during and even after the pandemic there was a higher motivation to use it more often. Compared to 2017, in 2021 the fostering of students' digital competencies did not vary on average, even though there are significant differences between the states. The constant level of digital competencies was confirmed by the International Computer and Information Literacy Study in 2018; German students were considered to have scientifically higher competences than the international average. However, one third had only rudimentary digital competencies (Bos et al., 2019). Unfortunately, the ICILS report 2023 is not yet available. In 2021, teachers could partially confirm that the investment programs were having an effect. The IT equipment is still in deficit; only 57% of teachers consider the equipment to be sufficient. This is true even for basic infrastructure. About 39% complained about the lack of wireless LAN connectivity in the classroom, and 46% pointed out that the internet connection in their school was not sufficient. Finally, there are noticeable differences in the training courses for teachers on digitization (Lorenz et al., 2021). In 2022, a digitization push at schools and among teachers was described by Rhode and Wrase. Nevertheless, there are still significant gaps in the basic digital infrastructure of German schools. Especially in primary and lower secondary schools, wireless LAN, learning management systems or networked collaborative tools are not available (Rohde & Wrase, 2022).

Features of digital learning

Comparing the German K-12 education with other countries or with German colleges reveals some features of digital learning in Germany. A very special feature that is characteristic of German K-12 education is the curricular freedom of any single school. The KMK as well as the states are just defining frameworks at the abstract level. Each school is free to define its own curriculum for each subject. This way, the learning content over a school year is never the same between two schools. What makes it very difficult for overall reporting is a feature in the perspective of the schools, because they have the opportunity to integrate local aspects into their curriculums. Another feature is

the freedom to teach subjects with different intensity and in different grades. There are even subjects that can be taught optionally. This way, the schools can adapt their teaching program to the local conditions, for instance to the availability of teachers for digital education classes or to the demand resulting from voluntary courses. The funding of digital education in Germany can also be seen as a feature in some way. For a long time there has not been a special funding program besides some smaller programs in the states. In recent years, however, a huge amount of money has been invested in funding digitalization in schools. By setting up the Digital Pact, the digital transformation got a strong initial impulse and an enormous acceleration. The program came just in time to enable schools to react to the conditions given by the coronavirus pandemic. The three extensions restored teaching capability as quickly as possible, and the schools were able to purchase what they most needed for a fast transition to online teaching. In that sense, the pandemic and the program complemented each other perfectly and really have been a game changer. Both were very relevant for the rapid digitization progress of recent years.

Trends and Issues in Digital Learning

Trend 1: Teachers' interest in digital learning is rising

Before the coronavirus pandemic, many schools and teachers had no need to set digital education as a high priority. Developing digital learning concepts, applying for funding and supporting digital solutions were an avoidable option. During the pandemic, classical teaching was suddenly no longer possible, and there was an acute need to address digital media with high priority. The Digital Pact also provided the necessary funding, so the need and opportunity were there at the same time. As a result, there has been a rapid rise in interest in digital education. Many teachers gained (initial) experience and learned

about the possibilities and limitations of digital media. In the meantime, digitization has become a matter of course, and it is hard to imagine most schools without it. Overall, interest in digital education among teachers has gone up sharply.

Trend 2: Change in school culture

Just a few years ago nearly no general school used a digital platform, and digital media were mostly used as additional presentation media. All communication between students and teachers, and between parents and teachers was paper-based. Nowadays, digital communication via a platform is state-of-the-art. It is more flexible, more reliable and much faster. Even bidirectional communication is easily possible. The use of these services essentially changed the fundamental school culture. Schools are not ponderous authorities any more but are seen as innovative institutions. This trend is now unstoppable, as a lasting commitment has been created. The projects ongoing through the Digital Pact will make new and advanced services available, so this trend is likely to continue.

Trend 3: Digitalization delivers options for diverse groups

Digital media make it possible to present different types of content in parallel and thus meet the individual needs of students. In this way, different levels of proficiency can be addressed. The use of different modal channels also makes it easier for students with special needs to learn. However, profitable use is associated with a change in school learning cultures, especially when face-to-face teaching and digitally supported learning are combined. This is one of many new fields of research in the context of digital learning.

Trend 4: Informatics as a rising school subject

The association for informatics pointed out that digital education must be viewed from a technological, socio-cultural and application-related perspec-

tive (Gesellschaft für Informatik, 2016). Due to this, informatic education is not just done by programming computers. More and more countries have started to offer informatic education by implementing the subject "informatics." In this way, digital education will be achieved in most of Germany's states.

Trend 5: Teacher education and further education is being renewed

The changed conditions in schools must also be reflected in the training and continuing education of teachers. Teachers are increasingly demanding training in digital education. The range of training courses on offer is being adapted accordingly. The federal states have realized that digital education can only work well if the teaching staff are educated in the technology and didactics of digital education. The same change of further education can be claimed for universities. The teacher education here is also updating its curriculums to integrate digital education in teacher education programs.

Issue 1: Innovation in education is very time consuming

Compared to other developments, the changes in digital technologies occur very frequently and fast. For instance, the release of ChatGPT in November 2022, that uses artificial intelligence to deliver a chatbot service, had a huge impact on economics and society. Just 2 months after its release, it has been used by more than 100 million users worldwide (Heaven, 2023). Educational innovations are time consuming because introducing a technology in an educational context is much more than just getting the technical solution running. The work on pedagogical concepts is just starting after the solution is already working. Because the schools are so different, approaches must be tested and experiences must be had. After that, the solution may have to be modified or pedagogical compromises may have to be found and accepted. This process can take years because the innovation does not take place in a laboratory under ideal conditions but in real courses and in regular classes. There is a danger that education will no longer be able to keep pace with technical development.

The many responsibilities for educational affairs in Germany delay innovations even more.

Issue 2: A lack of teachers

There is a shortage of skilled workers in many industries. This is particularly the case in IT professions, where many positions cannot be filled and orders cannot be processed. Teachers are also in demand in Germany. There is a shortage of teachers, especially in the STEM subjects, and not all positions can be staffed anymore. Not only the teaching hours, but also all the other tasks that teachers perform have to be divided among fewer staff. Since there are rarely any additional staff at schools, 92% of teachers are overworked and have even less time and energy for innovations in digital education; 79% need to work on weekends, 50% do not comply with the legally prescribed rest period, and every fifth person is even working at night very often (Sichma et al., 2022). It is obvious that the overload of teachers has negative impacts on any innovation process in school, including digital education.

Issue 3: Limitations due to data protection

Germany has strong privacy regulations. It is up to the states to ensure that in schools, privacy is ensured, too. Therefore, they released specific data protection policies. There is a lot of personal data in schools that need to be secured and must not be disclosed to third parties. Information that is not mandatory requires written consent, which often has to be given by the parents. Teachers are liable to criminal prosecution if they do not obtain these consents prior to use, which is often not easy in practice. Many internet services that we use in everyday life as a matter of course collect a wide variety of data. These are often stored on servers that are not affected by EU data protection law, so that the further processing of these data cannot be prevented. Services that require an individual user account are also a matter of concern under data protection laws. Due to that, digital education in Germany needs many individual techni-

cal solutions which have to be developed (for instance in the context of the Digital Pact) and implemented. This needs additional time and funds. From this perspective, the privacy policies inhibit the progress of digital education.

Issue 4: Funding is in question

As described above, the government funded digital education and flexible solutions during the pandemic with the Digital Pact. The progress of recent years would not have been possible at all without it. Before the pact, digitalization in education was only a marginal phenomenon in most schools. There has been just a little advancement. Currently, it looks like the funding will not be continued without a gap, and the national government is giving no guarantee at all if and when the next Digital Pact will emerge. This may have two effects: A discontinuation of the pact would have a negative effect on the existing infrastructure that has been installed in recent years because costs of operation, maintenance and replacement cannot be carried by the states and local authorities (Kultusministerkonferenz, 2023) on their own. If further investments and innovations are to be drastically reduced, the digital transformation would come nearly to a standstill.

Issue 5: The distribution of funds is unfair

It has been mentioned several times already: The status of digital education varies significantly between the individual schools and the federal states. The better the financial situation of a state, the more money it can give to the local authorities, and richer districts can invest more in the digital education of schools. Some schools are very well equipped because they participated in a pilot program, have a sponsor or they regularly get high funds. Only the successful schools are reported by the press and the school ministries again and again. In fact, there are many "black spots" all over Germany where digital education is deficient. Despite the huge shortage of skilled workers, especially in IT professions, Germany is not providing adequate quality digital education

throughout the country. As such, a lot of potential is getting lost.

Conclusion

It is hard to imagine that an industrialized country like Germany has so little direct control over its educational system. The states have wide latitude and the schools implement the policies very differently. This can be a strength on the one hand, because in this way regional aspects can be taken up in the school curriculum. On the other hand, this can be a weakness when it comes to megatrends that need the education at all schools to be updated. In such situations, the national government lacks direct influence on the educational system. While the KMK can prescribe new frameworks for states, the specific implementation is left to the federal states and their schools individually. Moreover, as elsewhere, implementation is also a question of money. In terms of finances, the states and the municipalities differ significantly, so that the implementation of innovations in schools also varies enormously.

Digital education is unfortunately a very expensive innovation, as it requires threefold effort:

- Infrastructure must be purchased and its operation incurs ongoing costs. Many existing IT solutions cannot be adopted in schools without enormous effort due to strong restrictions of privacy policies.
- In addition, pedagogical concepts have to be developed to ensure the full potential of digital education. Therefore, in-job teachers have to be further educated and the teacher education has to be updated.
- Aside from that, the digital technology standards develop very fast, so technical solutions as didactical concepts become outdated or insufficient and have to be renewed.

These costs cannot be covered seriously without changing the way of funding schools. The national government did this by updating the basic law of Germany to be able to implement the biggest education investment program in Germany's history: The Digital Pact. It was a stroke of luck that funding was available when the coronavirus pandemic occurred because the need and the option arose at the same time. This constellation significantly accelerated digital education in Germany. It went from stage I, "digitization," to stage II, "digitalization," in most educational institutions. Right now, there is a spirit of further innovation and many projects fostered by the Digital Pact suggest that in the future the education system can reach stage III, "digital transfer," even though the digital education is still at different stages depending on the specific local conditions. However, teachers are suffering due to overload. The lack of supporting technical staff and the administration overheads are pushing them to their limits. The Digital Pact 2.0 has to improve the situation and has to be aware that teachers must once again have an attractive profession to deal with the general professionals' shortage, which even causes a lack of teachers.

Full of hope, all in education are awaiting the continuation of the Digital Pact. Still, the national government hesitates to announce the future of the Pact, and a funding gap seems to appear. The present spirit and many innovations that enhance learning so far are threatened, and the digital transformation could grind to a halt. Now it is up to the government to decide what priority it gives to digital education in times of multiple crises.

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