Learning site cooperation 4.0

A guideline for implementing a collaborative learning environment in the context of Industry 4.0

Dillenburg, 22nd May, 2023

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Co-funded by the Erasmus+ Programme of the European Union

This project has received funding from the European Union's Erasmus+ program under the registration number 2020-1-DE02-KA202-007393. This document reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains

Inhalt

1. Learning site cooperations in vocational education

The digital transformation has a diverse impact on the cooperation between learning sites in dual vocational education and training. The establishment of new technologies and the demand for corresponding competencies to meet the new requirements necessitate a redesign on one hand. At the same time, networking and mobile devices provide opportunities to redefine or intensify the cooperation between learning sites. The potential is significant since companies, vocational schools, and other stakeholders in the regions or higher education sector can better tackle the challenges of digitalizing vocational education when working together. Through a binding cooperation between learning sites, with mutual technical and practical support, training partners generate synergies that benefit the learners, particularly through cross-site and cross-disciplinary projects, as well as the shared use of learning platforms and resource-intensive infrastructure such as learning factories.

Successful vocational training requires well-established cooperation between learning sites, including companies, vocational schools, and other educational institutions such as inter-company training centers. The Vocational Training Act (BBiG) demands that "learning sites collaborate in implementing vocational education and training" (cf. § 2, para. 2 BBiG). Cooperation and coordination between learning sites in terms of theory-practice integration are not only a prerequisite for successful training of learners and students but also a success factor for enhancing the performance of the predominant dual system in Germany. It is crucial to implement this cooperation in a legally binding manner to ensure the success of vocational training.

Intensive cooperation in educational processes provides apprentices and students with the opportunity to develop competencies in handling new technologies at an early stage, even if their own company environment does not allow for it. Technological knowledge, as well as material and personnel resources, can be pooled across learning sites, processed through intensive exchange, and made available to the learners. Challenges related to digitalization or even within the context of Industry 4.0 can be better addressed through this closely coordinated cooperation between learning sites.

2. The Gewerblichen Schulen Dillenburg as a learning site partner

Vocational schools have the goal of preparing students for successful careers in various professional fields through comprehensive initial and further education. This includes both theoretical knowledge and practical skills and techniques to ensure that they acquire the necessary competencies to succeed in their chosen field. In this context, vocational schools ensure that students obtain a suitable qualification that meets the requirements of the job market. They also promote the development of social competencies and the personal growth of learners.

In the education and training of students, vocational schools must ensure the delivery of the subject-specific theoretical content outlined in the curriculum and deepen the general education of the students. This is implemented in all school forms and professional fields at Gewerbliche Schulen Dillenburg. Even in the context of career preparation, the guidelines of the Kultusministerkonferenz (Standing Conference of the Ministers of Education and Cultural Affairs) are followed, focusing on the acquisition of basic competencies and career orientation in different professional fields.

Gewerbliche Schulen Dillenburg, as a vocational school, also serves as a dual learning site and is an important pillar in terms of vocational training. Here, the theoretical part of the skilled worker or journeyman training, i.e., the theory in different learning areas, is imparted in a competency-oriented manner. Furthermore, general education is continued. In the further education of state-certified technicians, Gewerbliche Schulen Dillenburg has the task of consolidating theoretical knowledge and skills in learners and promoting the expansion of students' professional knowledge. Additionally, social and communication skills relevant to their future role as technicians, such as teamwork, project management, and presentation techniques, are also taught.

Regardless of the vocational career path pursued by students at Gewerbliche Schulen Dillenburg, the cooperation between learning sites and the close collaboration with regional partners play an important role in their vocational education. The focus will now shift to dual vocational training and further education for state-certified technicians, examining the concept of implementing learning site cooperation in both areas.

2.1. Concept for implementing learning site cooperation at Gewerbliche Schulen Dillenburg in initial and further education

As mentioned earlier, learning site cooperation plays a crucial role in dual vocational training and further education for state-certified technicians. It enables close collaboration between the learning sites of the company and the vocational school, ensuring that theoretical knowledge is taught in a practical context and, conversely, practical experiences are incorporated into the classroom. In the following, the implementation of learning site cooperation in dual vocational training and in the field of further education for technicians will be explained. Furthermore, success factors for a successful collaboration between the learning sites and possible approaches for implementing the concept will be presented.

Learning site cooperation in dual vocational training: Learning site cooperation in dual vocational training is achieved through close collaboration between the vocational school and the training company. Apprentices alternate between phases at the vocational school and in the company, allowing them to combine theoretical knowledge with practical skills. The vocational school provides the theoretical foundation, while the company enables the practical application of the acquired knowledge. Joint agreements, coordinated curricula, and regular exchange between the learning sites are essential in this regard.

Learning site cooperation in further education for state-certified technicians: Learning site cooperation in further education for state-certified technicians often takes the form of classes at the vocational school, either full-time or part-time, combined with practical phases in the company. Participants acquire theoretical knowledge at the vocational school and can apply and deepen it in their professional activities in the company. The close exchange between the learning sites enables practical training and promotes the applicability of the acquired knowledge.

Success factors for successful learning site cooperation:

- Open communication: Regular exchange between the vocational school and the company to ensure close coordination of the training content and define common goals.
- Joint planning: Alignment of curricula, learning materials, and examination requirements to enable a seamless integration of theory and practice.
- Qualified teachers and trainers: Well-trained teachers and trainers with subject expertise and pedagogical skills are necessary to successfully implement learning site cooperation. The instructors should participate in ongoing training and professional development to stay up-to-date with the latest technology.
- Practical equipment: Providing modern technologies and tools in both the vocational school and the company enables realistic training.

Implementation of Learning Site Cooperation:

- Establishment of cooperation structures: Determining responsibilities and contact persons in vocational schools and companies to facilitate collaboration.
- Joint projects and practical phases: By conducting joint projects and practical phases, learners can apply their acquired knowledge in real work environments and gain practical experience. This promotes the integration of theory and practice and strengthens the participants' ability to take action.
- Internship and training plans: Aligning internship and training plans between vocational schools and companies enables targeted planning of practical training phases. This allows learners to develop and deepen their skills and knowledge in various work areas.
- Joint professional development and further education: Organizing joint professional development and further education for teachers and trainers promotes the exchange of subject knowledge and pedagogical approaches. This enables teachers and trainers to enhance their competencies and provide high-quality training to learners.
- Use of digital media and learning platforms: Utilizing digital media and learning platforms facilitates flexible and asynchronous communication and collaboration between vocational schools and companies. Teaching materials, assignments, and learning resources can be provided and shared online.
- Feedback and evaluation: Regular feedback and evaluation of learning site cooperation enable continuous improvement of the concept. Feedback from learners, teachers, and trainers helps identify strengths and weaknesses and allows for appropriate adjustments.

In conclusion, successful learning site cooperation in vocational schools requires close collaboration, open communication, clear structures, and professional exchange. By connecting theoretical knowledge with practical application, learners can develop their competencies effectively and be prepared for the demands of the job market. Continuous evaluation and development of learning site cooperation ensure high-quality training.

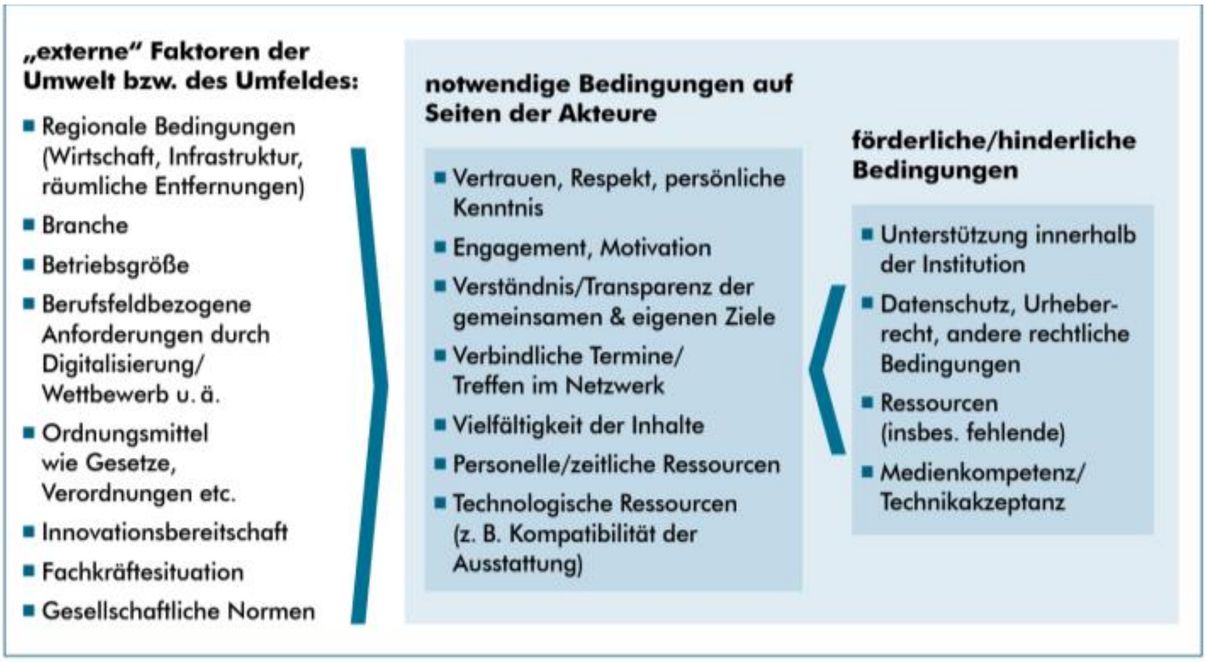


Abbildung 1: Schematische Darstellung der Gelingensbedingungen der Lernortkooperation

A successful learning site cooperation is evident in various projects, fairs, and forums taking place at or in collaboration with Gewerbliche Schulen Dillenburg. This includes, among others, the project fair showcasing the final works of the students from the Technical School. In their final semester at the vocational school, the learners participate in a learning site cooperation where they work on an assignment provided by a local company. These assignments typically involve projects directly related to the company's production and/or workflow planning. The students are tasked with optimizing, innovating, or addressing problems arising from the company's work processes. During the mentioned project presentation at Gewerbliche Schulen Dillenburg, the students present their findings and also have the opportunity to establish contacts with other companies in the region. The attached article provides further information on the current project fair (see Appendix 1.1).

A successful learning site cooperation depends on various parameters. The following table illustrates the characteristics and conditions of a successful learning site cooperation:

Dimension	Charcteristics	Conditions
Actors	○ Committed staff at all learning sites ○ Clearly defined goals and concepts communicated transparently by all actors (companies, vocational school, and potentially other learning sites)	The interests of all actors are reflected and taken into account to the best extent within the learning site cooperation. The agreed strategic goals of the actors define the medium- and long-term direction of the cooperation.
Themes/Content	○ Broad thematic diversity with occasions for mutual communication, coordination, cooperation, and collaboration	An intensive learning site cooperation not only involves occasion-specific exchange regarding the performance and

		problems of learners but also includes didactic and curricular exchange on a content level. Innovations are implemented as quickly as possible.
Relationships	○ Close, trusting relationships with regular contact among the participating actors of the learning site cooperation ○ Contact persons for different topics are known and accessible to all actors	Regular appointments are scheduled for intensive, open exchange to take place. A culture of mutual support develops.
Resources	○ Synergy effects are created and utilized in the form of mutual relief ○ Network partners' resources can be used together	Resources include not only material resources (technologies, facilities, etc.) but also personnel resources such as technical support, observation, substantive input (e.g., for technical questions), etc.
Management	○ Transparent control mechanisms and clearly defined responsibilities and accountabilities	Sustainable network structures and network management enable transparent work between the learning sites in the learning site cooperation.

In times of technological change and digital transformation, especially in the context of Industry 4.0, vocational education and training are undergoing significant upheaval. The following will outline the impacts of digitalization on vocational education and training, with a particular focus on the concept of Industry 4.0. Additionally, approaches to address this technological change will be presented.

3. Digitization as an educational mission

The rapid advancement of new technologies and the ongoing process of digitization have brought about a fundamental paradigm shift in various sectors of our society, including the field of education. In order to adequately implement digitization in education and develop corresponding didactics, it is essential to first clarify the concept of digitization, which is far from being clearly defined.

The term "digitization" is associated with everything related to the use of information technology and computer science to create and transform products and processes, as seen in debates about "Industry 4.0" and its broad application to concepts such as "Craftsmanship 4.0," "Economy 4.0," "Work 4.0," "Vocational Training 4.0," and "Learning Venue Cooperation 4.0." To define the term, it is important to determine what and how we learn about and with digitization and how educational processes in this context should be structured. It is evident that digitization means something different for various target groups in society and the educational landscape.

This section aims to examine the connections between vocational education, with a focus on technical and trade professions, as well as the subject matter of specialized work, the further education of skilled workers, and the necessary competencies involved.

In 2016, the Standing Conference of the Ministers of Education and Cultural Affairs (KMK) in Germany defined an educational mission for vocational education in its strategy paper "Education for the Digital World." This mission is expressed through seven requirements or educational objectives:

- Utilization of digital devices and work techniques
- Personal and professional competence
- Self-management and self-organizational skills
- International thinking and acting
- Project-oriented forms of collaboration
- Data protection and data security
- Critical handling of digitally networked media and the consequences of digitization for life and work (cf. KMK 2016, pp. 15-16)

Here we see a consciously chosen high level of abstraction in these objectives (cf. ibid., p. 15). This is intended to provide "teachers of the respective educational pathway or profession with orientation of long-term relevance" (ibid.), without restricting their scope of action. At the same time, appropriate consideration of digitization is demanded in the forms of learning and in the future design of curricula.

In the framework curricula for newly organized professions since 2017, aspects of digitization are now also included, particularly the explicit consideration of "digitization of work, data protection, and information security" (cf. KMK 2018, p. 6) as cross-sectional qualifications. Depending on the profession, newly emerging areas of responsibility related to digitization are also taken into account. This is evident, for example, in the case of IT specialist informatics experts with the newly created specializations "Data and Process Analysis" and "Digital Networking" since 2020. In contrast, the industrial metal and electrical professions, which were partially revised in 2018 with additional qualifications (cf. Grimm et al. 2018), do not include the newly added optional qualifications in the framework curricula.

Currently, the debate on digitization in teacher education is largely limited to the use of digital teaching and learning resources. This includes the use of tablets in the classroom, working with learning platforms, and utilizing digitized teaching materials (cf. Forschungsgruppe Digitaler Campus 2017). Some federal states define expanded orientation frameworks for teacher education, which are based on the five fundamental tasks of teaching: "instructing, educating, advising, supporting, and developing schools" (cf. NRW 2020). This leads to a broadening of the narrow perspective of media education and also acknowledges the need for subject-specific reflection (ibid., p. 13), although specific subject-related clarifications are not apparent.

The project "Vocational Education and Training in the Working World 4.0" (VET 4.0) provides more specific results that focus on the competencies resulting from changes in the working world due to digitization (cf. Müller & Nannen-Gethmann 2020). However, media didactics often remain the only educational content that is addressed and elaborated on. Therefore, the following section aims to provide a more precise clarification of the "learning subject digitization."

3.1. The object of learning: Digitization

Let us first return to the introductory issue discussed in the previous chapter: What does digitization mean from a definitional perspective?

"[...] Digitization is nothing more than the conversion of analog data and processes into digital formats; that is, formats that can be processed by computers. However, what characterizes the present time is not this fact, but the influence on our actions and specifically, in terms of work in vocational schools in initial and further education, the influence on work and learning [...]" (Becker, 2022, p. 24).

In the field of computer science, the following working definition has been developed to precisely define the breadth and significance of the term "digitization": "We speak of digitization when analog service provision is completely or partially replaced by service provision in a digital, computer-handled model" (Wolf & Strohschen, 2018, p. 58). When this understanding is applied to areas such as work, economy, vocational education and training, craftsmanship, industry, and society, it gives rise to numerous working definitions as published in countless publications. "[...] For Industry 4.0, the focus is on service provision in production through cyber-physical production systems (CPPS): 'Cyber-Physical Systems (CPS) are characterized by a connection between real (physical) objects and processes with information-processing (virtual) objects and processes via open, partially global, and always interconnected information networks' (VDI 2013, 2; cf. Geisberger & Broy 2012). The vision of 'self-regulating production' is central, which is associated with the individualization of products down to batch size 1, as well as the flexibility and decentralization of business and work processes [...]" (Becker, 2022, p. 24).

As a subject of education in vocational training, the term "digitization" is ambiguous (according to Becker, 2022, p. 24):

- The objects that realize digitization and are made accessible through digitization (especially computers, smartphones, microelectronics).
- The products that are infused with digitized objects (equipment, systems, so-called embedded systems, but also any product equipped with RFID chips).
- The media that are made accessible and structured through digitization (documents, media technology, educational software, the internet, learning platforms).
- The actions that are transferred between the real, physical world and virtual worlds using digitization and vice versa (programming, simulation, CAD, CNC, process visualization and control, augmented and virtual reality, remote diagnostics, automation/robotics).

As educators in our daily teaching activities, we encounter these subjects of education as computer didactics, media didactics, or didactics of computer science or information technology. Consequently, learning processes are often focused on computers, media, information technology, programming/computer science, or actions such as computer-aided designing, manufacturing, diagnosing, etc. In vocational education and further training, the transitions between actions in physical and virtual worlds, with a focus on those actions that impact the real world, play an important role. In this context, computerization and automation take center stage, constituting a significant part of the training in technical fields. A fundamental element of learning in this context is automation, which involves replacing human actions with machine actions. While in the past (during the CIM era), the focus was on replacing skills with "machines" (cf. Baukrowitz et al., 2006), what is new in today's digitization is the replacement of cognitively shaped actions with automatisms/artificial intelligence, which we refer to as "smart" (smart grids, smart factory, etc.). Additionally, there is an expansion of effects through the interconnectivity of objects, products, media, and actions (according to Becker, 2022, p. 24).

3.2. Didactics of digitized work processes

The core of the didactics of digitization lies in the realization and design of both physical and virtual work processes by individuals (with the help of digitization), rather than focusing solely on the digital artifacts (objects, products, media). The didactics of digitized work processes is evolving towards a process-oriented approach (see Becker, 2020), which goes beyond a didactics focused solely on media, tools, and technology as learning subjects and incorporates them as cross-cutting competencies of learners (see Spöttl & Becker, 2006; see Figure 1).

Figure 1 presents a taxonomy or gradation of actions on the left side, ranging from operation to design. Within the circles, the objects of digitized vocational education are listed, including digital media, tools, technology systems, and work processes. The arrangement as integrating circles aims to emphasize that the domains of operation, handling, processing, and design must always be connected to the respective digitized learning subject. Thus, it should be analyzed inclusively and not in isolation. Overall, media didactics become a part and a (possibly necessary but not sufficient) prerequisite for handling digitized tools, processing digitized technology or technical systems, and ultimately designing work processes. On the other hand, work processes always involve (digitized) technology systems, tools, and media. By examining the dimensions of process-oriented didactics in terms of their educational significance for the educational goal of vocational action competence, and particularly with the help of vocational didactic analysis (see Becker, 2020, pp. 373-374), work processes can be prepared for teaching.

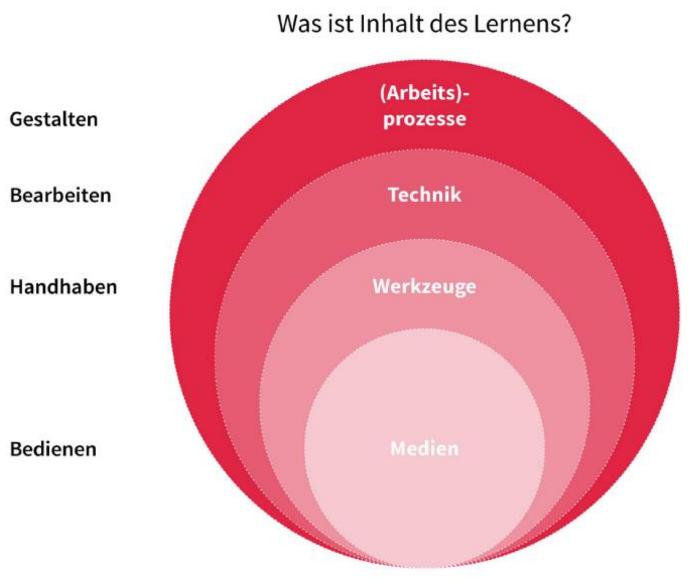


Abbildung 2: Inhalt des Lernens einer Didaktik der Digitalisierung als Didaktik digitalisierter Arbeitsprozesse (Quelle: eigene Darstellung)

In summary, the didactics of digitized work processes focuses on the realization and design of physical and virtual work processes, taking into account the interconnectedness of digital media, tools, technology systems, and the competencies required for operating, handling, processing, and designing these elements. By integrating process-oriented didactics into vocational education, educators can effectively prepare learners for the challenges and demands of digitized work environments, equipping them with the necessary skills and competencies for success.

3.3. Key challenges

In summary, it can already be observed that digitization, upon closer examination, is always a component of concrete action and never exists in isolation; it is always a cross-cutting content. For vocational education and training, this means that the content to be learned, at least in terms of professional action, is never the digital medium itself, the digital tool, or the digital technology. Instead, it is always what gives meaning to the action: the specific task and the specific work process with its requirements and other dimensions. Therefore, it is hardly surprising that teaching and learning experiences consistently show that there are no "digital natives" as such. Even proficiently operating a smartphone does not guarantee learners' ability to use it as a digital tool for remote diagnostics on an electrical system or a vehicle.

Given the interconnections outlined above, the following aspects emerge as key challenges for didactics focused on work processes. These aspects need to be analyzed and addressed in vocational education and training:

- Working with representations of reality (simulation, virtualization, and replicas instead of physical objects: AR, VR, process visualization).
- Working with and on smart systems and tools with artificial intelligence (expert systems, diagnostic systems, knowledge management systems, smart maintenance).
- Working with abstraction, global data, transparency, in flexible structures, and networked environments as inherent conditions for carrying out all work and business processes.
- Automation (now also of cognitive tasks) and dealing with it.
- Interfaces (technical and organizational) and human-machine and human-problem area interactions.
- High innovation speed and renewal cycles.

These challenges highlight the need to address the integration of digital technologies, the development of digital skills, and the ability to adapt to rapid technological advancements. Vocational education and training must prepare learners to effectively navigate the complexities of working with digital tools, smart systems, automation, and the interconnectedness of processes. By addressing these challenges, educators can equip learners with the necessary competencies to thrive in a digitalized work environment.

3.4. Implementation of the didactics of digitized work processes at the Gewerbliche Schulen Dillenburg

Digitalization and its associated developments are transforming the working world in the metal and electrical industry. The focus is on the changes described under the term Industry 4.0 in industrial production. The guiding principle of Industry 4.0 is the concept of adaptable and interconnected production and logistics processes that enable highly efficient and highly flexible production, integrate customer demands in real-time, and allow for individual product variations.

Industry 4.0 is considered the fourth stage of industrialization, characterized by the intelligent networking of resources, information, objects, and people based on cyber-physical systems (CPS). In companies, this can be seen, for example, in the digital representation of processes and the use of tablets and modern control centers. Intelligent sensors within the facilities ensure that entire process chains, including material flows, are coordinated and optimized. They are operated with the support of IT and enable proactive maintenance and intervention in processes.

With the changing working world, the qualification requirements for skilled workers are also changing. This requires flexibility and broad qualifications. Not only are new "digital" technical skills demanded, such as increased abstraction ability, process understanding, and system understanding, but methodological, social, and personal competencies are also important for mastering interconnected systems. Today, complex digitized production processes can no longer be controlled by individual skilled workers. To develop, build, and operate these systems with confidence, interdisciplinary teams collaborate across the entire value chain.

Due to the increasing complexity of interconnected systems and the shortening innovation cycles of new technologies, the demands on problem-solving and self-learning competencies of all employees are also increasing.

Industry 4.0 requires Education 4.0 and Cooperative Learning Environments 4.0!

The following types of schools and educational offerings currently provide "Industry 4.0 content" at the Gewerbliche Schulen Dillenburg:

Vocational Schools: Vocational schools at the Gewerbliche Schulen Dillenburg offer specialized training programs that incorporate Industry 4.0 topics. Students receive practical instruction and theoretical knowledge related to digitalized work processes, cyber-physical systems, and the use of advanced technologies in the metal and electrical industry.

Further education and training: Technical schools focus on providing comprehensive education in various technical fields. They integrate Industry 4.0 concepts into their curricula, enabling students to understand and apply digitalization principles in their specialized areas of study.

Cooperative Education Programs: The Gewerbliche Schulen Dillenburg collaborate with local companies to offer cooperative education programs. These programs combine classroom instruction with practical training in companies, allowing students to gain hands-on experience in working with Industry 4.0 technologies and processes.

Continuing Education Courses: The school also offers continuing education courses for professionals in the industry. These courses cover advanced topics in digitalization, cyber-physical systems, and the application of Industry 4.0 principles in the workplace.

By incorporating Industry 4.0 content into their educational programs, the Gewerbliche Schulen Dillenburg ensure that their students are well-prepared for the demands of the digitalized working world and possess the necessary skills to thrive in the metal and electrical industry.

Vocational School for Metal, Electrical, and IT Technology	According to the framework curricula in various variations
Further vocational education - Specializations in Mechanical Engineering and Electrical Engineering	Consistent teaching principles in accordance with the framework curricula
Further education and training	Technical specialization: Consistent teaching principles in accordance with the framework curricula
Elective Course "Digital Manufacturing Processes"	In-depth content specialization. Offered to apprentices in technical professions
Elective Course "Technology for Business Professionals"	Offered to apprentices at the Commercial Schools in Dillenburg.
Career Orientation Workshops	Offered to students in the E-phase at Wilhelm-von-Oranien-Schule Dillenburg.
Adaptation Qualification: "Fit for Industry 4.0"	Offered to employees of local companies. Offered in cooperation with IHK Lahn-Dill.Angebot in Kooperation mit der IHK Lahn-Dill

3.5. New School Building - New Equipment - New Possibilities

In our new school building, apprentices in the fields of metal technology, electrical technology, mechatronics, and IT technology, as well as students in the further vocational education specializing in electrical engineering and mechanical engineering, will be taught. In addition to the architectural features, it is of immense importance for a modern vocational-technical school to have technical equipment that is up to date and future-oriented. It is our school's obligation to embrace technological advancements early on and prepare future professionals to the best of our abilities. This is aimed at promoting and securing the employability of skilled workers and technicians in the local region. Hence, the task ahead is to convey the complex concept of Industry 4.0 in a practical and student-engaging manner, which means reducing and making it understandable from a didactic perspective.

As part of the cooperation between Gewerbliche Schulen Dillenburg and training partners in the region, the future project "Industry 4.0 = Education 4.0" (IA4.0) is being implemented to fulfill this task. The common goal of the regional educational partners in the coming years will result in even stronger networking and the continuation of joint projects to ensure practical and innovative training. This practical implementation aims to make the abstract concept of Industry 4.0 understandable through a suitable teaching concept delivered by the educators and supported by the appropriate equipment.

The following will explain the three-stage Industry 4.0 concept of Gewerbliche Schulen Dillenburg, along with the corresponding equipment.

3.6. Industry 4.0 – School concept

The school concept of Gewerbliche Schulen Dillenburg revolves around effectively integrating the principles of Industry 4.0 into the educational environment. This three-stage concept is designed to provide students with a comprehensive understanding of Industry 4.0 and prepare them for the challenges of the digitalized working world. The concept is supported by the appropriate technical equipment to facilitate hands-on learning experiences.

Stage 1: Foundation and Awareness

In the initial stage, students are introduced to the fundamental concepts of Industry 4.0. They develop an understanding of the technologies, processes, and systems that underpin the fourth industrial revolution. The emphasis is on creating awareness and building a strong foundation of knowledge.

Image 3: ETS-Basics

To support this stage, the school is equipped with modern teaching materials, including interactive displays, multimedia resources, and simulation tools. These resources allow students to explore and grasp the basic principles of Industry 4.0 in a practical and engaging manner.

Stage 2: Application and Integration

In the second stage, students delve deeper into the practical application of Industry 4.0 in various vocational fields. They learn how to integrate digital technologies, such as automation, artificial intelligence, and data analytics, into real-world industrial processes. The focus is on hands-on projects and collaborative problem-solving.

Image 4: ETS Facility as a center for applying learning situations in the field of advanced automation

To facilitate this stage, the school provides advanced equipment, such as programmable logic controllers (PLCs), industrial robots, virtual reality (VR) systems, and sensor networks. These tools enable students to work on authentic Industry 4.0 projects and gain valuable practical experience.

Stage 3: Innovation and Entrepreneurship

The final stage aims to nurture innovation and entrepreneurial skills among students. They are encouraged to think creatively, develop new ideas, and explore opportunities for technological advancements within the context of Industry 4.0. Students learn about agile project management, prototyping, and the implementation of innovative solutions.

Image 5: CP-Factory

To support this stage, the school fosters a culture of innovation and provides access to advanced technologies, such as 3D printers, rapid prototyping tools, and collaborative workspaces. Students have the opportunity to apply their knowledge and skills to create their own projects and prototypes, fostering an entrepreneurial mindset.

Overall, Gewerbliche Schulen Dillenburg's school concept for Industry 4.0 aims to provide a comprehensive and practical education that equips students with the necessary knowledge, skills, and mindset to thrive in the digitalized working world. The combination of a well-structured curriculum, qualified teachers, and state-of-the-art technical equipment ensures that students receive a high-quality education that meets the demands of the industry.

In addition to that, the Gewerbliche Schulen Dillenburg work closely with the company Rittal, which has implemented the concept of Industry 4.0 in a smart factory within its manufacturing processes. Through various projects and training programs, apprentices and students at GS Dillenburg, as well as employees of Rittal, can benefit from this collaboration. The cooperation covers a range of topics, from the fundamentals of Industry 4.0 to the implementation of application-oriented tasks in various learning situations. The following overview illustrates the implementation of the school's concept for the field of Industry 4.0 at the Gewerbliche Schulen Dillenburg.

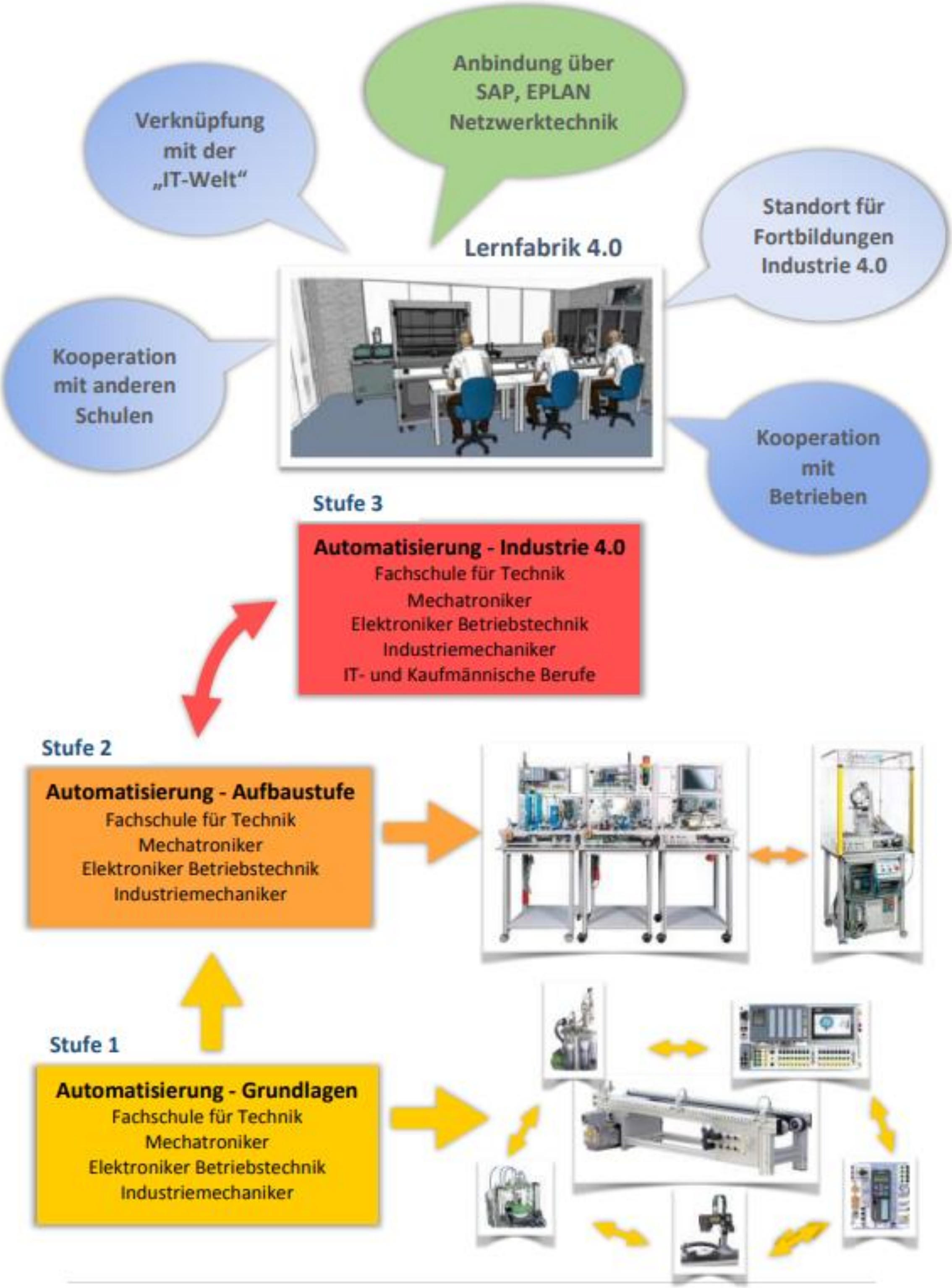


Image 6: Implementation of the Concept in the Field of Industry 4.0 at the Gewerbliche Schulen Dillenburg

4. Examples for the implementation of Learning Location Cooperation 4.0:

4.1. Learning site cooperation 4.0 - Requirements for IT infrastructure and service

Preface

Prior to the commissioning of a new building in spring 2018, the future information technology (IT) of GSD (name of the organization) was already planned long-term from autumn 2016. An IT concept for the expansion and migration of the existing IT infrastructure was designed with the assistance of an external service provider commissioned by the school administration. The school administration explicitly approved and accepted this concept both technically (media center) and substantively (school commissioner), providing additional funding as initial financing for its implementation. However, the funding for the subsequent expansion phases II and III is only secured until 2020 and mainly pertains to the central part of the IT infrastructure (e.g., servers, backup). Currently, expansion phase II has been realized, but the following discussion also refers to the strategic final expansion phase, as it more completely represents our IT concept.

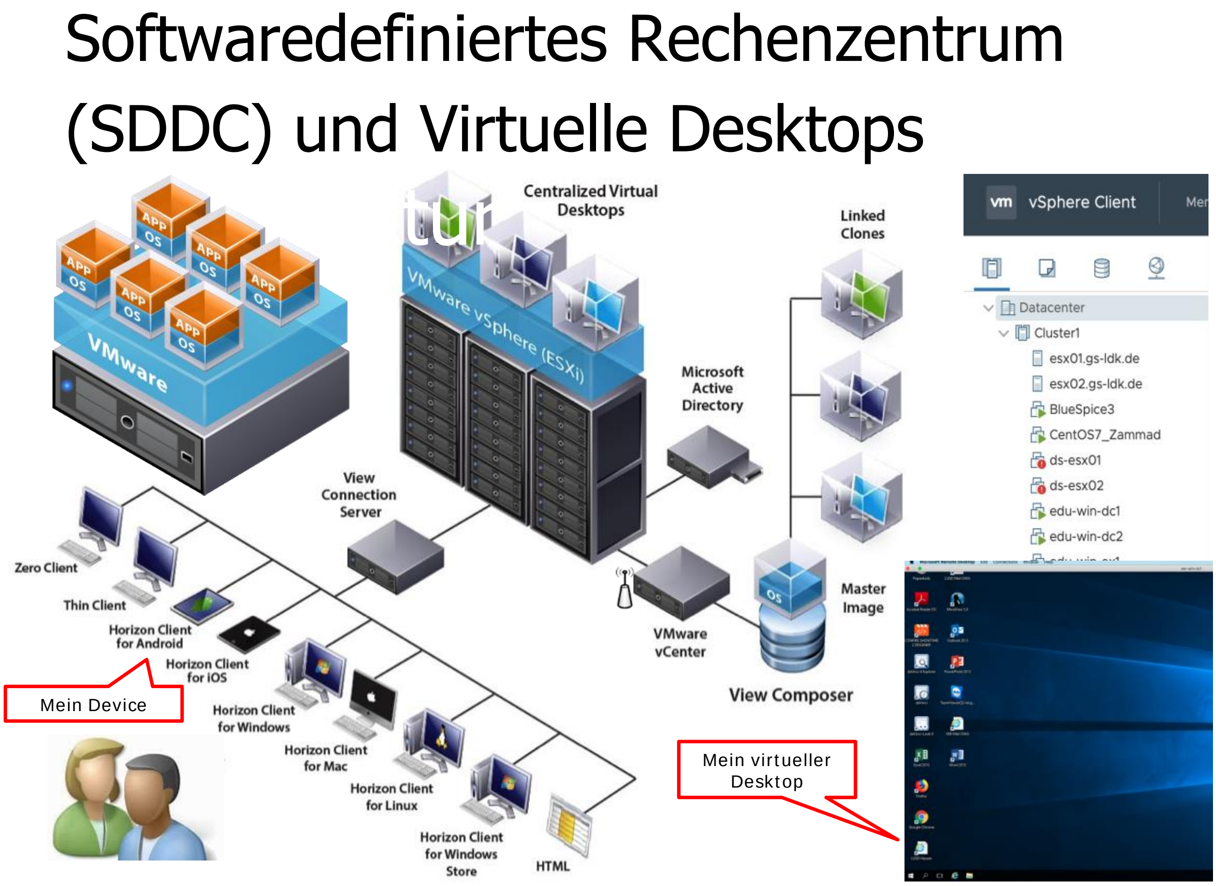
Introduction and Objective

The school program of Gewerbliche Schulen Dillenburg focuses on the mission of being a "regional service and competence center for vocational training and further education." Instead of relying on a fixed and relatively rigid school program established over the years, we base our school development on specific areas of action. In contrast to general education schools, these areas require a particular focus on the demands of advancing digitalization and a changing work environment (Industry 4.0, Internet of Things, Learning Site Cooperation 4.0).

Beyond the resolution of the KMK conference on December 8, 2016, which emphasized the acquisition of general key competences for digital education, Gewerbliche Schulen, as a vocational and technical school, face the challenge of not only implementing these competences in a media-pedagogically appropriate manner but also providing an IT infrastructure that is conceptually future-proof. Therefore, in order to define appropriate objectives, it is necessary to first describe digital competences that transcend specific subjects, learning fields, or school types and form a higher-level, abstract level. For this reason, we have developed a simplified digital competence model that describes foundational and advanced competences across different school types and defines specialized competences specific to each school type.

At these levels of competence, the technical requirements and applications are also described in terms of quantity. It is important to consider that the students at Gewerbliche Schulen Dillenburg have both highly diverse "starting competences" and varying degrees of technological equipment. Therefore, strategies such as LYOD (Leave Your Own Device) and BYOD (Bring Your Own Device) need to be integrated, and an IT infrastructure must be provided to compensate for these differences, ensuring that each student has access to a comparable IT platform as a learning environment. Ideally, this IT platform should be independent of the end device and the learning site. We are also convinced that the isolated use of media and applications in the classroom does not lead to sustainable learning outcomes if they are not equally accessible at home and in the workplace.

This is the case when digital competences can only be experienced within the direct classroom context because the necessary devices and access to applications and files outside of school are not equally available. Furthermore, the assumption that acquiring as many laptops/PCs/tablets as possible through the Digital Pact will lead to a modern media school is an illusion. Without considering the specific educational applications, it is not sustainable, and the installation, configuration, and ongoing maintenance of the devices consume too much time and bandwidth



(downloads, updates!).

It is also costly and inflexible, as end devices, operating systems, and applications need to be constantly renewed.Our "IT philosophy" transcends the common practices of 1990s IT and aligns with the future model of the software-defined data center (SDDC). In SDDCs, all elements of an IT infrastructure are abstracted, consolidated, and automated. The use of SDDCs supports the utilization of conventional hardware, especially in end devices (BYOD!), and the establishment of an automated, scalable, and highly agile network environment. SDDCs are what many professionals refer to as the true realization of IT-as-a-Service (ITaaS).

SDDC and ITaaS for School Administration and Instruction

ITaaS, provided through an SDDC, enables a consistent alignment of IT with the needs of users regarding their administrative or instructional and learning applications. It offers tremendous flexibility with virtualized resource pools and pre-configured building blocks that can be combined and deployed with just a few clicks. In the example above, a "user" with any "device" receives a predefined "virtual desktop" regardless of the location (school, home, workplace) that corresponds solely to their role (teacher, student, administrative staff, principal, etc.). In this setup, the operating system, applications, and user data are always located in the local data center, secured in compliance with GDPR regulations, and subject to continuous backup.

SDDC and ITaaS in Concrete Instructional Scenarios:
Student Environment

Scenario: Students bring their own devices, or the school provides them during class time. A predefined virtual desktop or terminal server is accessed with a single click once a student is connected to the Wi-Fi. With a personalized login, each student can access their applications and data.

Strategy	BYOD / LYOD-Client	SDDC-Infrastructure
Device	Tablet, Laptop, Thin Client, PC, Panel in the classroom	LAN, WLAN, Host, SAN, VMWare Horizon, MS-Windows Server 2016
OS/APPS	Local or Terminal Server or VDI	Access via RDP / Horizon Client

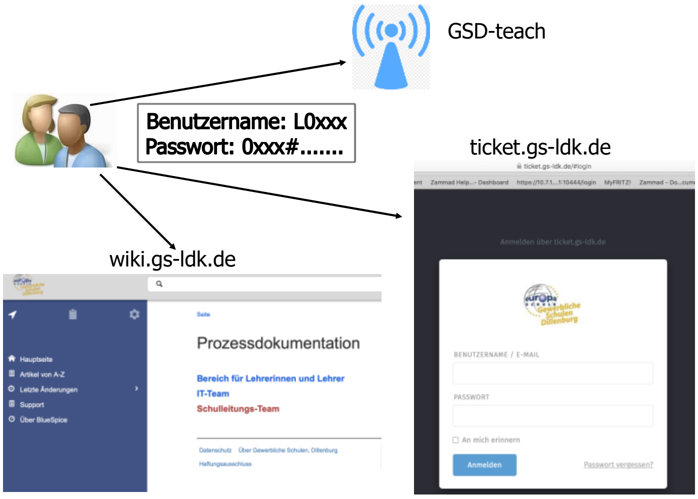
Scenario: Same as above, but for certain applications, a high-performance workstation is required: SolidWorks, Siemens NX, FluidSIM, EPLAN, Siemens TIA-Portal. A license server is necessary for loaning licenses to students. For FST (Fachschule für Technik) students and IT students, servers are required as virtual machines: CISCO APIC-EM, Hackathon Server, Ubuntu, CHECKMK, Win10 with IT tools, Ubuntu (CyberSecurity Essentials), Kali Linux, Metasploitable, etc.

Strategy	BYOD / LYOD-Client	SDDC-Infrastructre
End device	Laptops, Thin Clients (TC), PCs, Workstations	LAN (Local Area Network), WLAN (Wireless Local Area Network), Host, SAN (Storage Area Network), VMWare (Horizon)
OS/APPS	Local installation or access via Terminal Server or VDI (Virtual Desktop Infrastructure)	Access Methods: Remote Desktop Protocol (RDP), Horizon Client, SSH (Secure Shell)

In a teacher environment, SDDC (Software-Defined Data Center) and ITaaS (IT-as a Service)

Scenario: Teachers use an ActivePanel as an electronic whiteboard. They bring their own device or the school provides one for the duration of the class. Optionally, a pre-defined virtual desktop or terminal server can be accessed with a click once a teacher is connected to the Wi-Fi. With a personalized login, each teacher can access their applications and data, even from their home desks. Students use the ActivePanel for presentations, introducing assignments, sharing lesson results, conducting polls, and so on.

Strategy	BYOD / LYOD-Client	SDDC-Infrastrure
End device	Laptop, All-in-One PC, Integrated PC, Panel, Document Camera, Tablet	LAN, WLAN, Host, SAN, VMWare (Horizon), MS-Windows-Server 2016
OS/APPS	Lokal or TS / VDI	RDP / Horizon Client

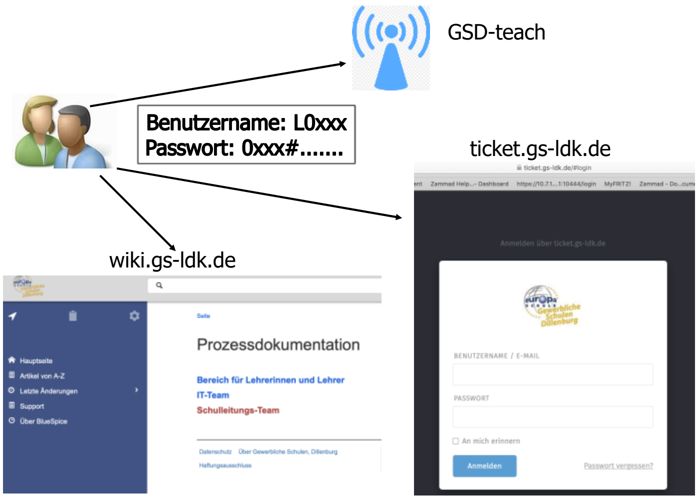


With Single Sign-On (SSO), teachers have access to the WLAN, servers, process documentation, and ticket system. The class schedules can be viewed through an app called Da-Vinci.

SDDC and ITaaS in the school administration

In the school administration, SDDC (Software-Defined Data Center) and ITaaS (IT-as-a-Service) can be utilized to streamline various processes. The staff members including secretaries, department heads, principals, and their deputies have access to the LAN, servers, process documentation, and ticket system through Single Sign-On (SSO).

The class schedules are managed using the DaVinci application, while appointments and emails are handled through the MS-Exchange-Server. File storage and organization are well-defined. The local devices are primarily used to connect to a terminal server, which can be accessed from the internet via a DMZ (Demilitarized Zone) without the need for a VPN (Virtual Private Network).



Strategy	BYOD / LYOD-Client	SDDC-Infrastructure
End device	Laptop, PC, Thin-Cient, Tablet	LAN, WLAN, Host, SAN, VMWare (Horizon), MS-Windows-Server 2016
OS/APPS	Lokal or TS	RDP / Horizon-Client

The file storage follows the following systematic approach:

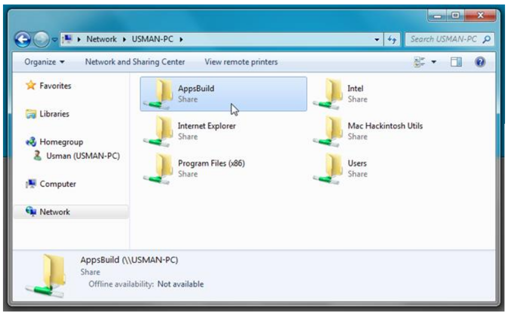
User policy: Clear guidelines and rules for file storage are established through a user policy.

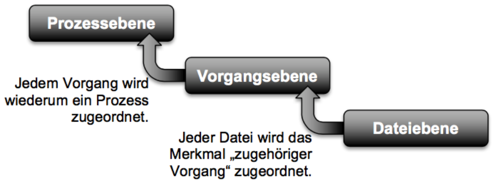
Uniform school-wide folder structure: A standardized folder structure is implemented across the entire school to ensure consistency and ease of navigation.

Standardized folder and permission concept: A predefined folder and permission concept is in place, ensuring that access rights are granted consistently and according to the established rules.

Centralized file storage with Active Directory (AD) support: The file storage is centrally managed, and the Active Directory is utilized to facilitate efficient organization and access control.

Process-oriented file storage: Files are stored in a manner that aligns with specific processes, ensuring that they are logically categorized and easily retrievable based on their relevance to different workflows or tasks.



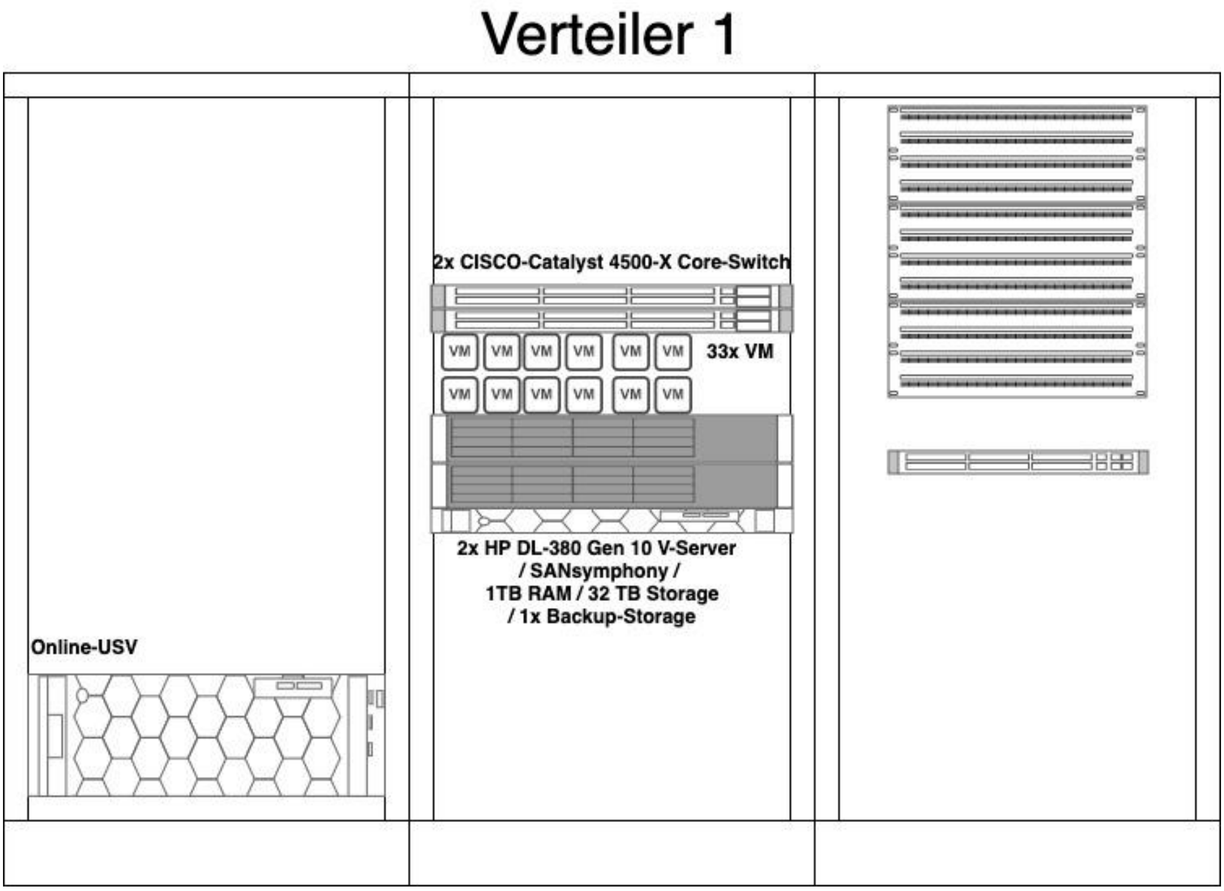


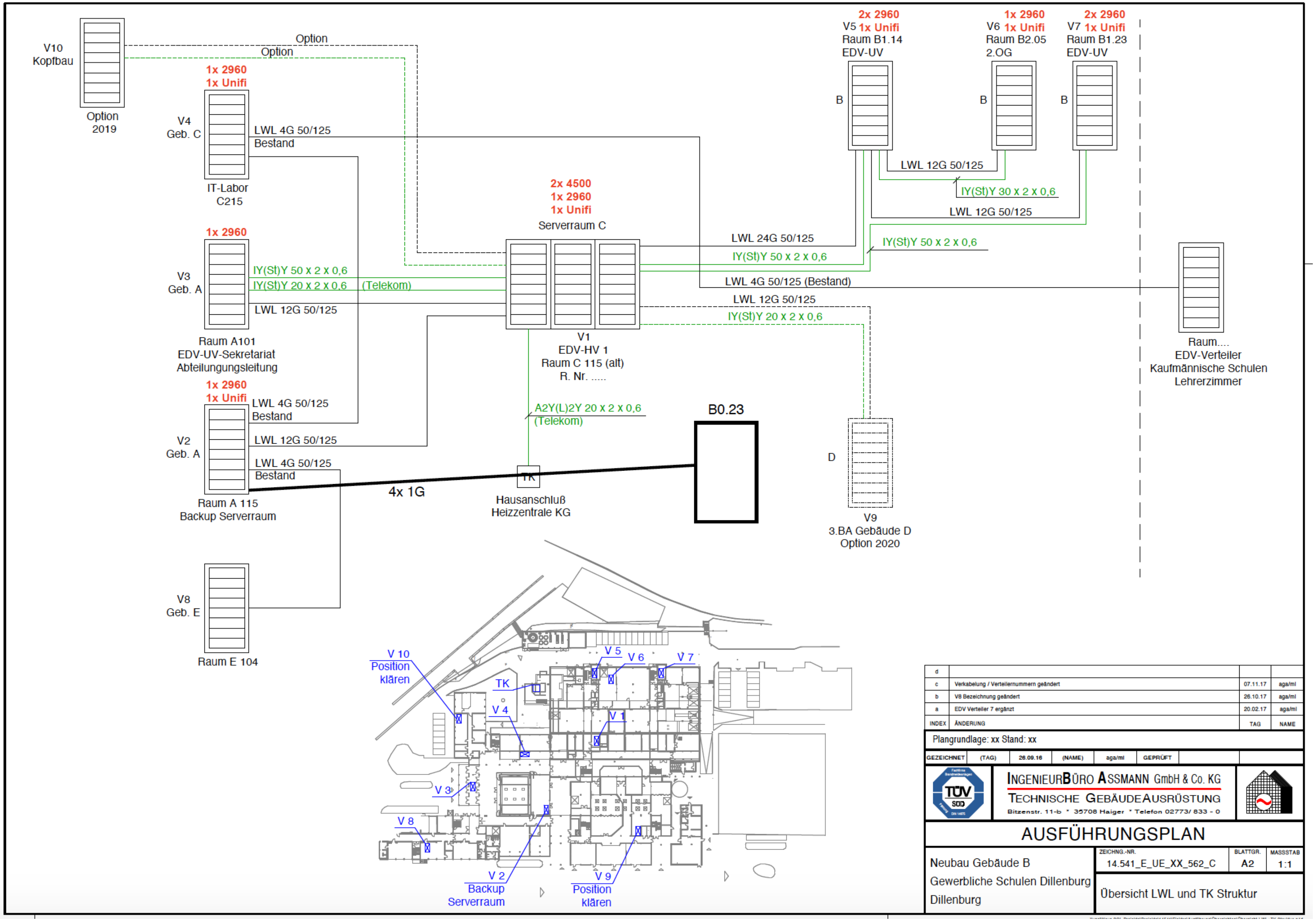
SDDC (Software-Defined Data Center) and ITaaS (IT-as-a-Service) of the IT infrastructure and structured building cabling/WLAN (Wireless Local Area Network) in an organization.

The building cabling of the Gewerbliche Schulen Dillenburg has evolved since the 1990s, primarily focused on room-based installations for IT and computer rooms, known as tertiary cabling. In the 2000s, two building distributors were established in the C and A wings, connected by a primary cabling infrastructure using fiber optic cables. This infrastructure was further expanded in the 2010s to include the E wing and KSD (an area within the organization), leveraging their existing DSL connections due to poor internet connectivity. In 2017, with the construction of a new workshop, a vendor-neutral building cabling system compliant with EN50173 was planned and implemented for both the new construction and the existing infrastructure (primary and secondary cabling) in the older buildings (refer to the figure on the next page). As a result, the GSD now has two dedicated server rooms (distributors 1 and 2) equipped with uninterrupted power supply (UPS) and professional climate control.

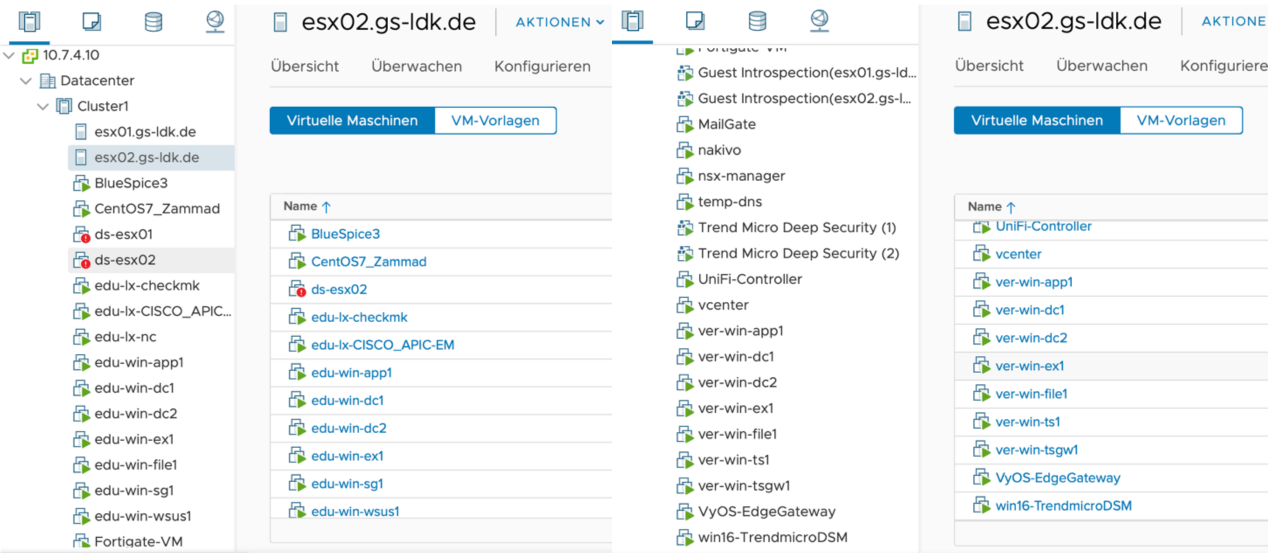
The fiber optic connections to the main server room (distributor 1) follow the design of a collapsed backbone, where the passive fiber optic section from each distributor is directly connected to the core switches. The FTTH (Fiber to the Home) connection is routed through a conduit to the home termination point (HÜP), and the GfTA (currently allowing for 6 connections) terminate at distributor 5, from where they can be distributed further to the UTM

(Unified Threat Management) device via VLAN-ID. For mobile devices such as smartphones, tablets, laptops, and printers, a WLAN infrastructure has been implemented based on IEEE 802.11ac standard, which is currently available throughout the new construction and selected central teaching areas due to cost considerations (67 access points in Dillenburg and 3 access points at the Neumühle location).

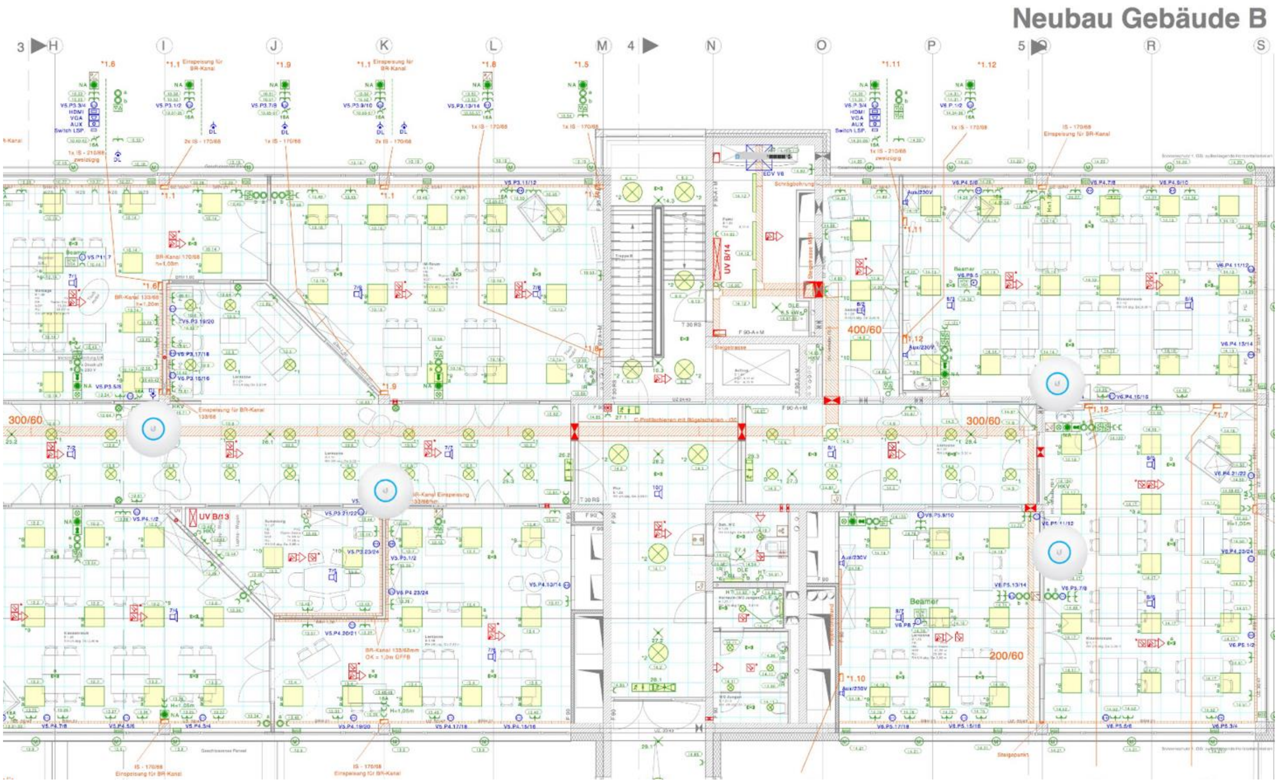



V10
Kopfbau
Option
2019
Option
Option
1x 2960
1x Unifi
V4
Geb. C
IT-Labor
C215
LWL 4G 50/125
Bestand
1x 2960
V3
Geb. A
IY(St)Y 50 x 2 x 0,6
IY(St)Y 20 x 2 x 0,6
(Telekom)
LWL 12G 50/125
Raum A101
EDV-UV-Sekretariat
Abteilungsleitung
1x 2960
1x Unifi
V2
Geb. A
LWL 4G 50/125
Bestand
LWL 12G 50/125
LWL 4G 50/125
Bestand
Raum A 115
Backup Serverraum
4x 1G
V8
Geb. E
Raum E 104
2x 4500
1x 2960
1x Unifi
Serverraum C
V1
EDV-HV 1
Raum C 115 (alt)
R. Nr. .....
A2Y(L)2Y 20 x 2 x 0,6
(Telekom)
TK
Hausanschluß
Heizzentrale KG
B0.23
2x 2960
V5 1x Unifi
Raum B1.14
EDV-UV
1x 2960
V6 1x Unifi
Raum B2.05
2.OG
2x 2960
V7 1x Unifi
Raum B1.23
EDV-UV
B
B
B
LWL 12G 50/125
IY(St)Y 30 x 2 x 0,6
LWL 12G 50/125
LWL 24G 50/125
IY(St)Y 50 x 2 x 0,6
IY(St)Y 50 x 2 x 0,6
LWL 4G 50/125 (Bestand)
LWL 12G 50/125
IY(St)Y 20 x 2 x 0,6
D
V9
3.BA Gebäude D
Option 2020
Raum....
EDV-Verteiler
Kaufmännische Schulen
Lehrerzimmer
V 10
Position
klären
TK
V 4
V 5
V 6
V 7
V 1
V 3
V 8
V 2
Backup
Serverraum
V 9
Position
klären
d
c Verkabelung / Verteilernummern geändert 07.11.17 aga/ml
b V8 Bezeichnung geändert 26.10.17 aga/ml
a EDV Verteiler 7 ergänzt 20.02.17 aga/ml
INDEX ÄNDERUNG TAG NAME
Plangrundlage: xx Stand: xx
GEZEICHNET (TAG) 26.09.16 (NAME) aga/ml GEPRÜFT
TÜV SÜD
INGENIEURBÜRO ASSMANN GmbH & Co. KG
TECHNISCHE GEBÄUDEAUSRÜSTUNG
Bitzenstr. 11-b * 35708 Haiger * Telefon 02773/ 833 - 0
AUSFÜHRUNGSPLAN
Neubau Gebäude B
Gewerbliche Schulen Dillenburg
Dillenburg
ZEICHNG.-NR.
14.541_E_UE_XX_562_C
BLATTGR.
A2
MASSSTAB
1:1
Übersicht LWL und TK Struktur

The basis of the SDDC (as shown in the diagram for distributor 1) is a virtualization infrastructure that currently consists of two redundant, high-performance servers, a backup storage, and two redundant 10G switches with VXLAN support (VMWare NSX) as location distributors. The servers are set up as virtual machines in a cluster on the two V-servers (esx01.-/esx02.gs-ldk.de). The significance of each virtual machine (VM) is briefly explained in the table on the following pages.



The WLAN infrastructure (as shown below) is based on a virtualized WLAN controller (Unifi-Controller) that manages the Ubiquity access points at both school locations. The authentication for accessing the WLAN is done through Single Sign-On (SSO) with RADIUS authentication for teachers, students, and staff members

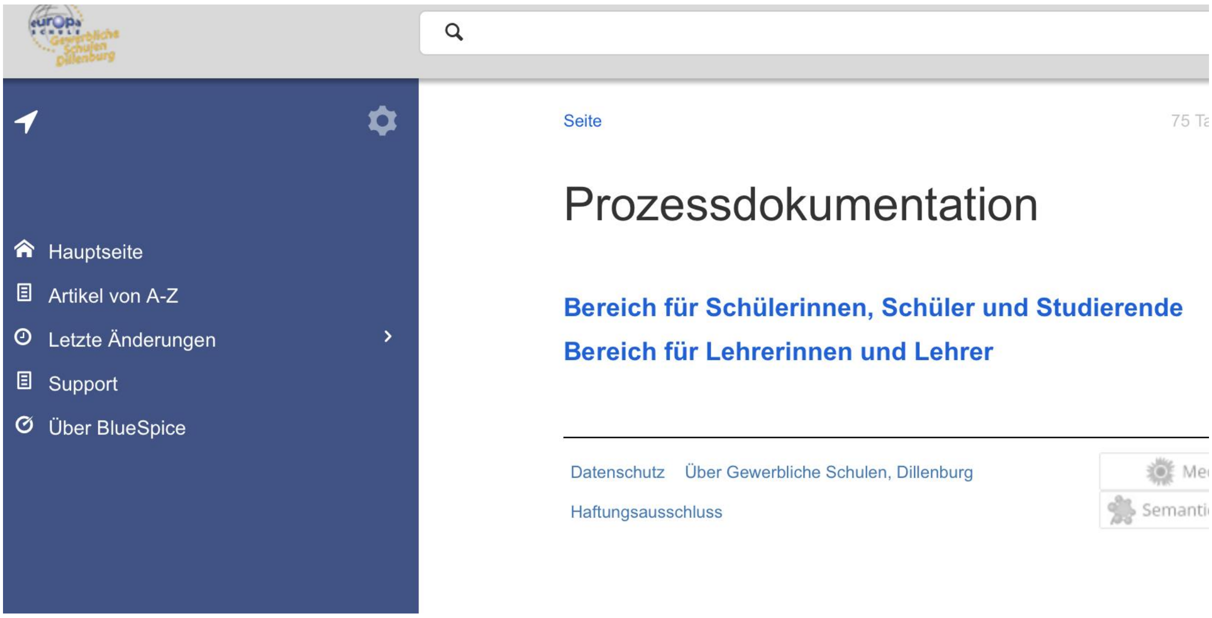

Neubau Gebäude B
300/60
400/60
300/60
200/60
UV B/13
UV B/14

Name der VM	Betriebssystem	Verwendung als	Zweck
BlueSpice3	Debian 9	Prozessdokumentation	Dokumente für Unterrichts- und Verwaltungsprozesse beschreiben und zum Download bereitstellen (Verwaltung,Lehrer,SuS). wiki.gs-ldk.de
CentOS7_Zammad	CentOS 7	Ticket-System	Support-Prozesse abbilden (IT, Hausverwaltung, Netzwerk-Überwachung) ticket.gs-ldk.de
ds-esx01	Win2016-Server Std.	SANsymphony-VSAN	Verwaltet den Storage von ESX01
ds-esx02	Win2016-Server Std.	SANsymphony-VSAN	Verwaltet den Storage von ESX02
edu-lx-checkmk	Ubuntu 18	Netzwerkmanagement	Überwacht die Verfügbarkeit von Netzwerkkomponenten und stellt die Auslastung dar. Schülerprojekt! info.gs.ldk.de
edu-lx-CISCO_APIC-EM	Grapevine	Application-Policy-Infrastructure-Controller	Automatisiertes Deployment von Policies / QoS / IOS und Infrastruktur-Überwachung (CISCO-Switches). Schülerprojekt!
edu-lx-nc	CentOS 7	Next-Cloud	DSGVO-konforme Speicherung von Daten im eigenen Rechenzentrum cloud.gs-ldk.de
edu-win-app1	Win2016-Server Std.	Lizenz-Server	für EPLAN, FluidSIM, Siemens NX, Solid Works, FESTO-MES
edu-win-dc1	Win2016-Server Std.	Primärer Domänencontroller	Active Directory mit Benutzern und Objekten der EDU-Domäne
edu-win-dc2	Win2016-Server Std.	Sekundärer Domänencontroller	Active Directory mit Benutzern und Objekten des EDU-Domäne
edu-win-ex1	Win2016-Server Std.	Exchange-Server	Groupware- und E-Mail in EDU-Domäne
edu-win-file1	Win2016-Server Std.	File-Server	Datei und Verzeichnisdienste in EDU-Dom.
edu-win-wsus1	Win2016-Server Std.	WSUS-Server	WindowsUpdate-Dienst in EDU-Domäne
edu-win-sg1	Win10-Professionell	Test-Rechner	Test-Client in EDU-Domäne
Fortigate-VM	FortiGate-VM64 v6.0.6	UTM-Server	Next-Generation-Firewall
Guest- Introspection esx01.gs-ldk.de	VMware Photon	VMware NSX	lagert die Verarbeitung von Antivirus- und Anti-Malware- Agenten auf eine dedizierte sichere

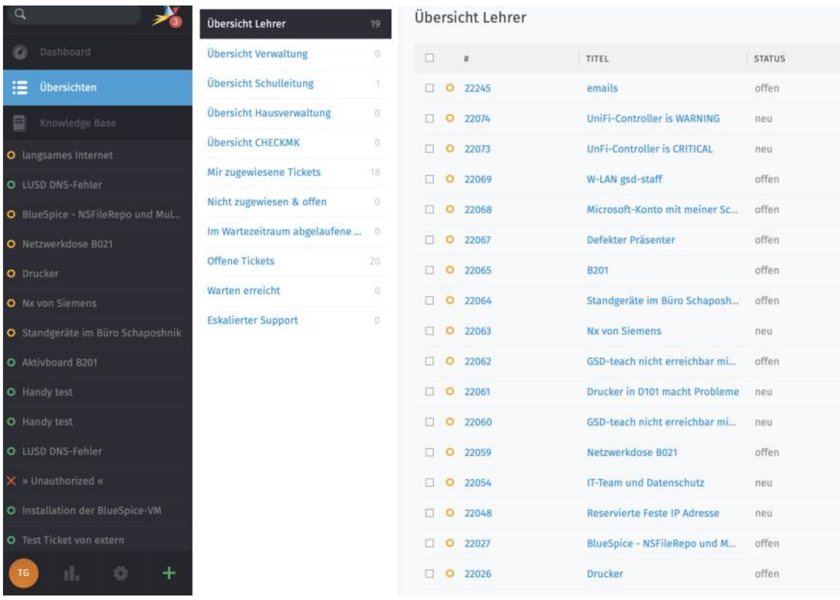
			virtuelle Appliance aus
Guest- Introspection esx02.gs-ldk.de	VMware Photon	VMware NSX	lagert die Verarbeitung von Antivirus- und Anti-Malware- Agenten auf eine dedizierte sichere virtuelle Appliance aus
mailgate	CentOS 7	E-Mail-Gateway	E-Mail-Proxy
nakivo	Ubuntu 18	Backup-Server	Erstellt und überwacht automatische Backups aller VMs
nsx-manager	Virtual Appliance	GUI/REST-APIs	für die NSX-Komponenten
temp-dns	Ubuntu 18	DNS-Server	für lokales DNS
Trend Micro Deep Security (1)	CentOS 6	Zentrale Verwaltung und Schutz physikalischer, virtueller und cloudbasierter Services esx01	Die Lösung nutzt eine Reihe richtlinienbasierter Sicherheitsfunktionen, um VMs automatisch vor Netzwerkangriffen und Schwachstellen zu schützen, Malware und Ransomware zu stoppen und nicht autorisierte Systemänderungen zu erkennen.
Trend Micro Deep Security (2)	CentOS 6	s.o., esx02	s.o., esx02
Unifi-Controller	Ubuntu 18	WLAN-Controller	Zentrales Management der Accesspoints
vcenter	VMware Photon	VCenter-Server	Zentrales Management der Virtualisierung
ver-win-app1	Win2016-Server Std.	Applikations-Server	für die Verwaltung z.B. DaVinci
ver-win-dc1	Win2016-Server Std.	Primärer Domänencontroller	für die Verwaltung
ver-win-dc2	Win2016-Server Std.	Sekundärer Domänencontroller	Für die Verwaltung
ver-win-ex1	Win2016-Server Std.	Exchange-Server	Groupware- und E-Mail in VER-Domäne
ver-win-file1	Win2016-Server Std.	File-Server	Datei und Verzeichnisdienste in VER-Dom.
ver-win-ts1	Win2016-Server Std.	Terminal-Server	Terminal-Dienst für Verwaltung
ver-win-tsgw1	Win2016-Server Std.	TS-Gateway	in DMZ für Zugriff ohne VPN
VyOS-EdgeGateway	Debian 9	Virtueller Router	Routing zwischen VLANs / Subnetzen
win16-TrendmicroDSM	Win2016-Server Std.	Deep Security Manager	Mit dieser zentralen Verwaltung können Administratoren Sicherheitsprofile erstellen und diese auf Server anwenden, Warnmeldungen überwachen und vorbeugende Maßnahmen gegen Bedrohungen durchführen, Sicherheitsupdates auf Server verteilen und Berichte erstellen.

SDDC and ITaaS: Process Documentation / IT Support / Secure File Exchange

Initiated by the "Digitalization" steering committee, wiki.gs-ldk.de serves as a documentation platform for both teachers (LuL) and students (SuS). This platform is regularly maintained by the administration and teaching staff, providing a structured and descriptive documentation of various school processes categorized by school types and typical administrative areas. It includes links to forms and documents related to each process. Teachers and administration members can access the platform through Single Sign-On (SSO) or LDAP integration using the EDU and VER domains.



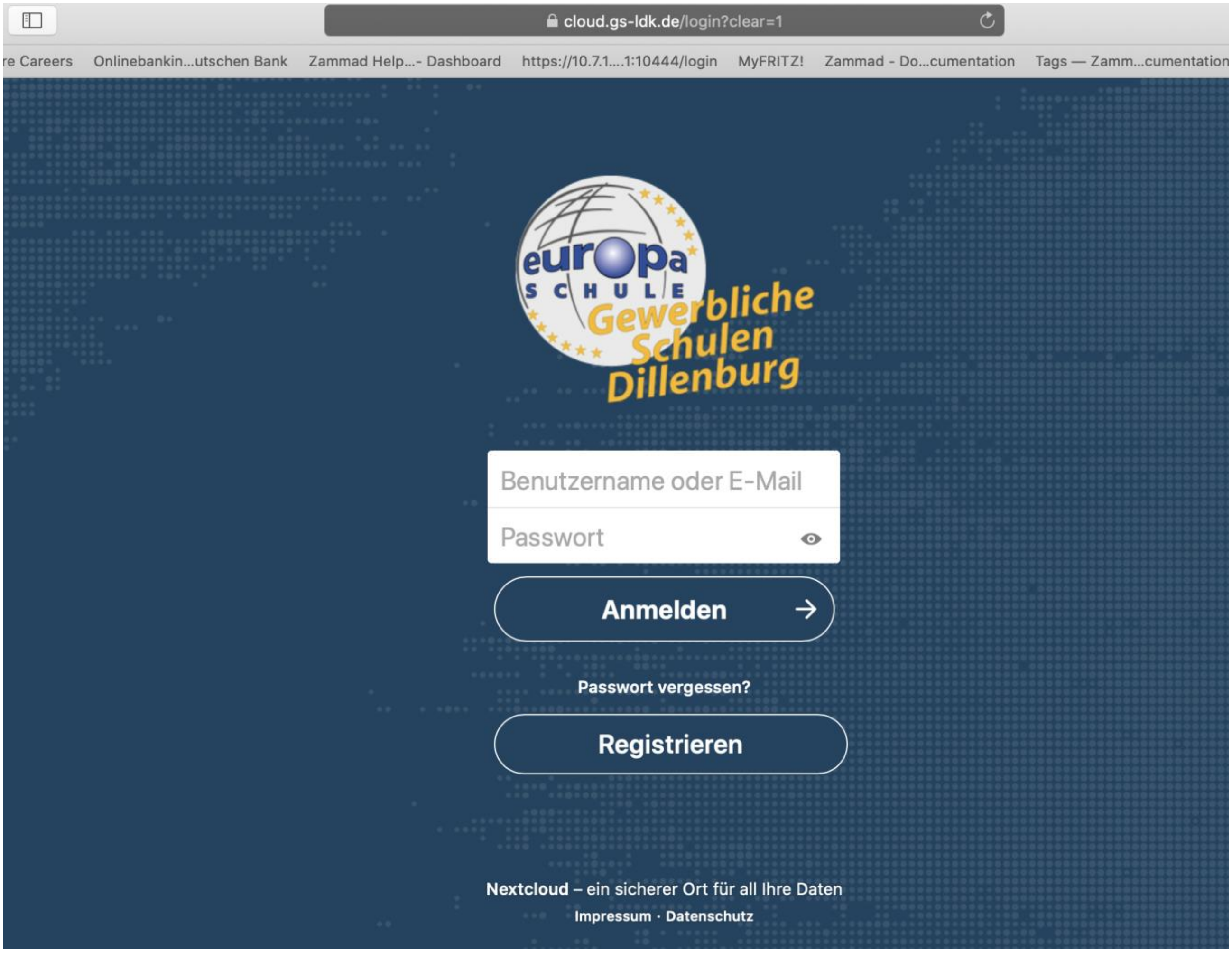
To enhance service quality, transparency, and effort estimation, the IT team has established a ticketing system at ticket.gs-ldk.de. Customers can open tickets via email or the website and track the progress of their resolutions. The network management solution, "CheckMK," is also integrated into the system to ensure the availability of critical IT components. SSO/LDAP integration is implemented here as well, facilitating seamless authentication for users.



Due to the General Data Protection Regulation (GDPR) and the resulting guidelines from the Hessian Data Protection Commissioner, it is mandatory to securely store personal data such as grades, evaluations, certificates, and personal information. To overcome the legal and administrative challenges of storing student-related data on private teacher PCs, teachers (LuL) have access to a cloud-based central storage solution within their own SDDC (data center) at GSD.

This storage solution is implemented using the open-source software "NextCloud," which is also utilized by the "Bundescloud" (federal cloud) and various ministries. Teachers authenticate themselves using SSO/LDAP integration, and they have the option to enhance security by enabling two-factor authentication, such as using an app like Authy on their smartphones.

By utilizing NextCloud within the SDDC, teachers can securely store and manage files, ensuring compliance with data protection regulations. This centralized and cloud-based approach helps alleviate the risks associated with storing sensitive student data on individual teacher's private PCs.



SDDC and ITaaS: Requirements for IT Infrastructure in IT Professions

The vocational schools (Gewerbliche Schulen) have been serving as specialized class locations for IT professions in the Lahn-Dill-Kreis area and the former IHK districts since 1998. Since summer 2022, they have also become the regional class location for the vocational training of "Data and Process Analysis Specialists" and "Digital Networking Specialists." The student enrollment numbers have been steadily increasing in recent years, and classes are now conducted with three parallel streams. With the curriculum revision as of August 1, 2020, two new IT professions were added, and the learning content was adjusted and expanded to include topics such as cybersecurity, cyber-physical systems, virtualization, data security, big data, internet of things, etc.

As a Cisco Academy since 2007, GSD has focused on recognized industry certifications in the internet and networking sector. The virtualization systems and resources provided by an SDDC have become standard for successful training in these courses as well as for the old and new curriculum content.

Auslastung Ubiquiti

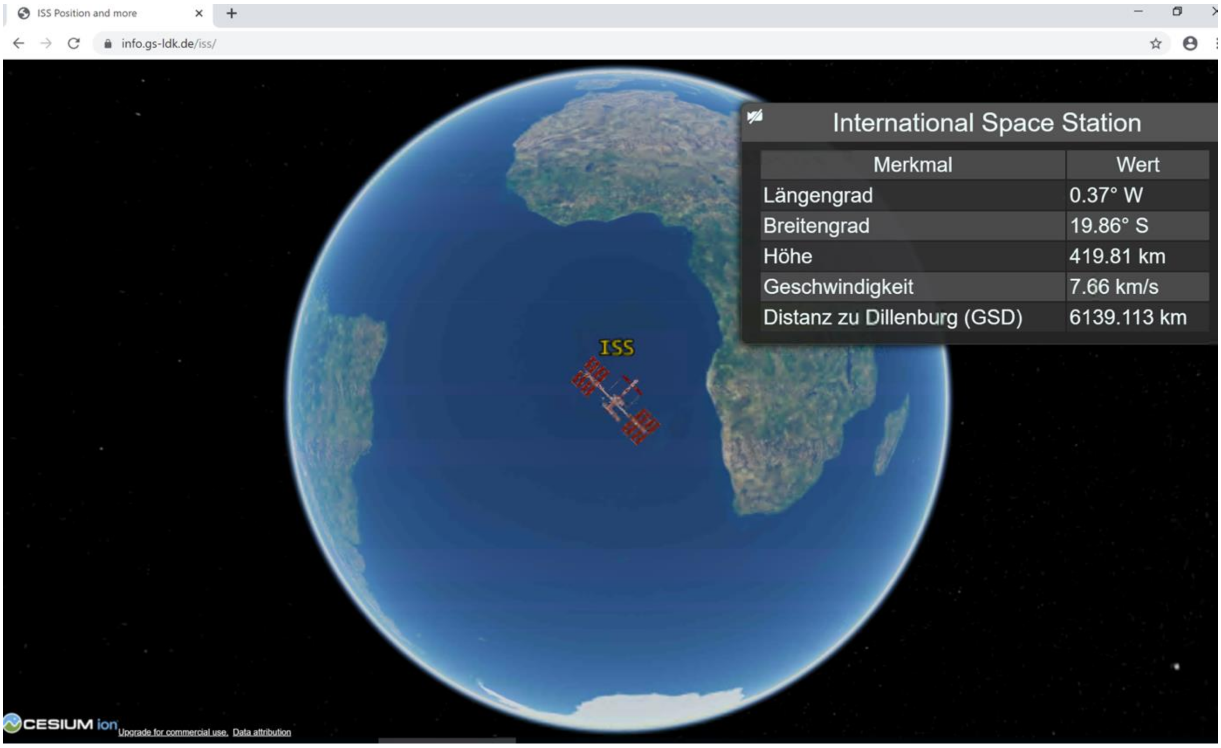
Auslastung

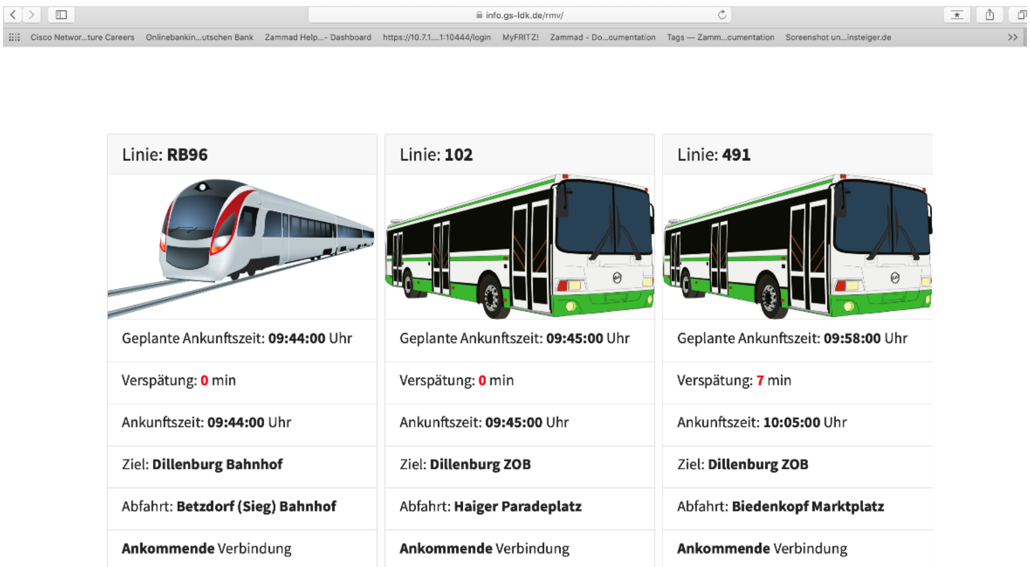
Name	Model	Firmware	Geräte	Laufzeit	Empfangene Daten
AP-D203-HP-Switch-D215	U7HD	4.0.66.10832	22	01M 01d 07h 18m 15	132.79 MB
AP-A001-V2.P2.11	U7HD	4.0.66.10832	13	01M 10d 01h 44m 36	115.05 MB
SW-Unifi_VT01-1	US16P150	4.0.66.10832	13	01M 03d 02h 52m 29	1.23 GB
SW-Unifi_E104	US16P150	4.0.66.10832	10	01M 03d 02h 46m 28	1.36 GB
AP-A112-V2.P3.12	U7HD	4.0.66.10832	9	01M 10d 12h 29m 08	202.97 MB
AP-B201-V5.P8.10	U7HD	4.0.66.10832	8	01M 12d 11h 43m 31	91.02 MB
AP-C316-V4.P5.19	U7HD	4.0.66.10832	8	01M 10d 12h 23m 00	72.86 MB
AP-D204-HP-Switch-D215	U7HD	4.0.66.10832	7	01M 01d 07h 17m 59	123.81 MB
AP-B121-Sued-V5.P8.09	U7HD	4.0.66.10832	7	01M 10d 11h 50m 19	489.21 MB
AP-D101-V2.P1.P14	U7HD	4.0.66.10832	6	01M 11d 11h 39m 39	268.86 MB
AP-B209-210-V6.P4.05	U7HD	4.0.66.10832	6	01M 12d 12h 16m 53	104.11 MB
AP-D107-HP-Switch-D107-P7	U7HD	4.0.66.10832	6	01M 10d 00h 52m 26	68.42 MB
AP-B207-V6.P4.02	U7HD	4.0.66.10832	6	01M 11d 12h 23m 07	125.44 MB

An example of the benefits and outstanding solutions for our school can be seen in the programming examples available at info.gs-ldk.de. These projects display the real-time utilization and status of central IT infrastructure components through REST APIs. The output is displayed on info monitors located on the campus.

The following project positions Dillenburg in relation to the current position of the International Space Station (ISS), making it the "navel of the world." It presents the real-time position of the ISS on the globe using the ISS REST API. The SDDC provides resources for all these projects.

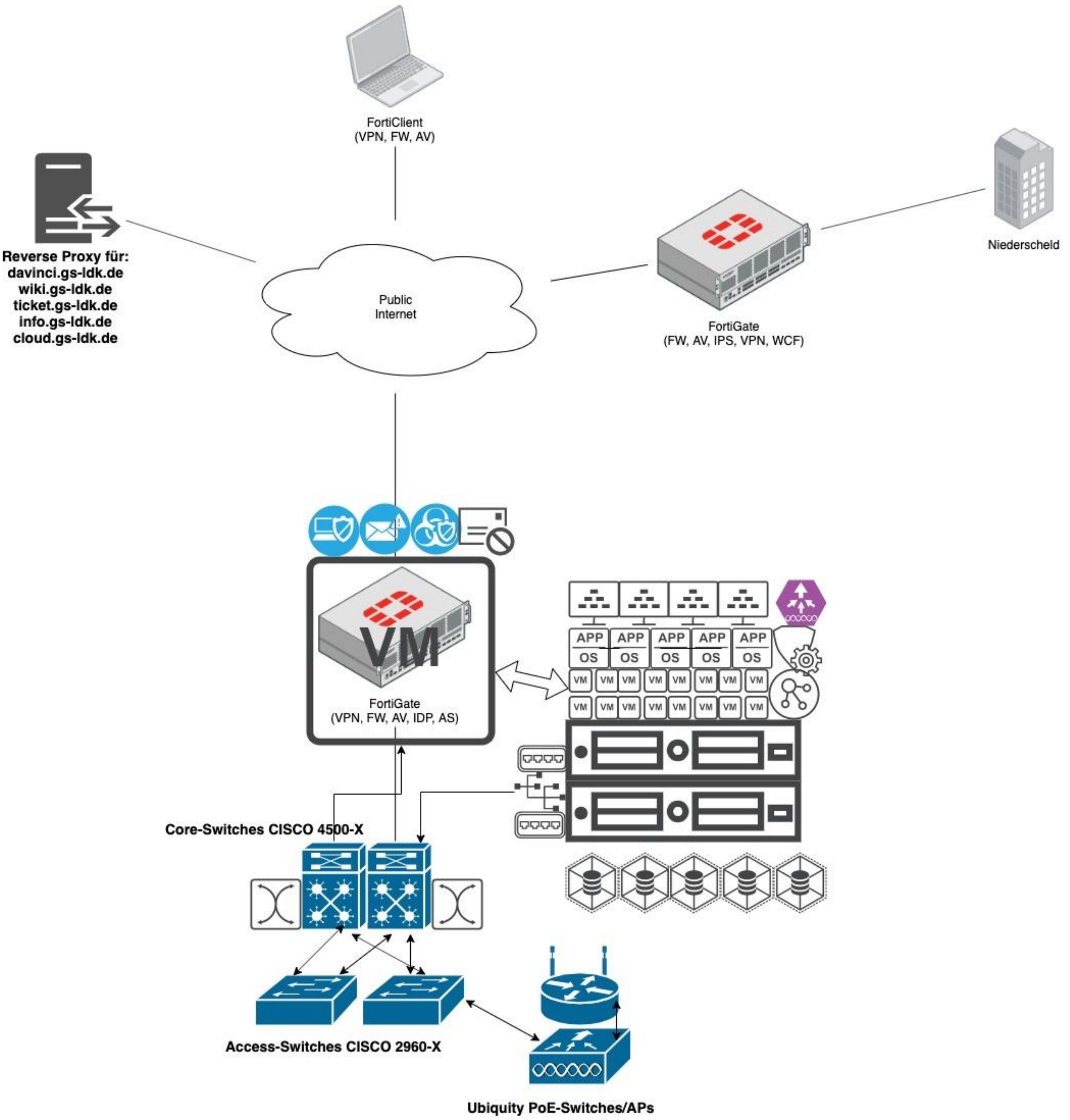
The availability of public transportation is of central importance for our students (SuS). All connections are read in real-time via the RMV (Rhein-Main-Verkehrsverbund) API and displayed on info monitors within the school.





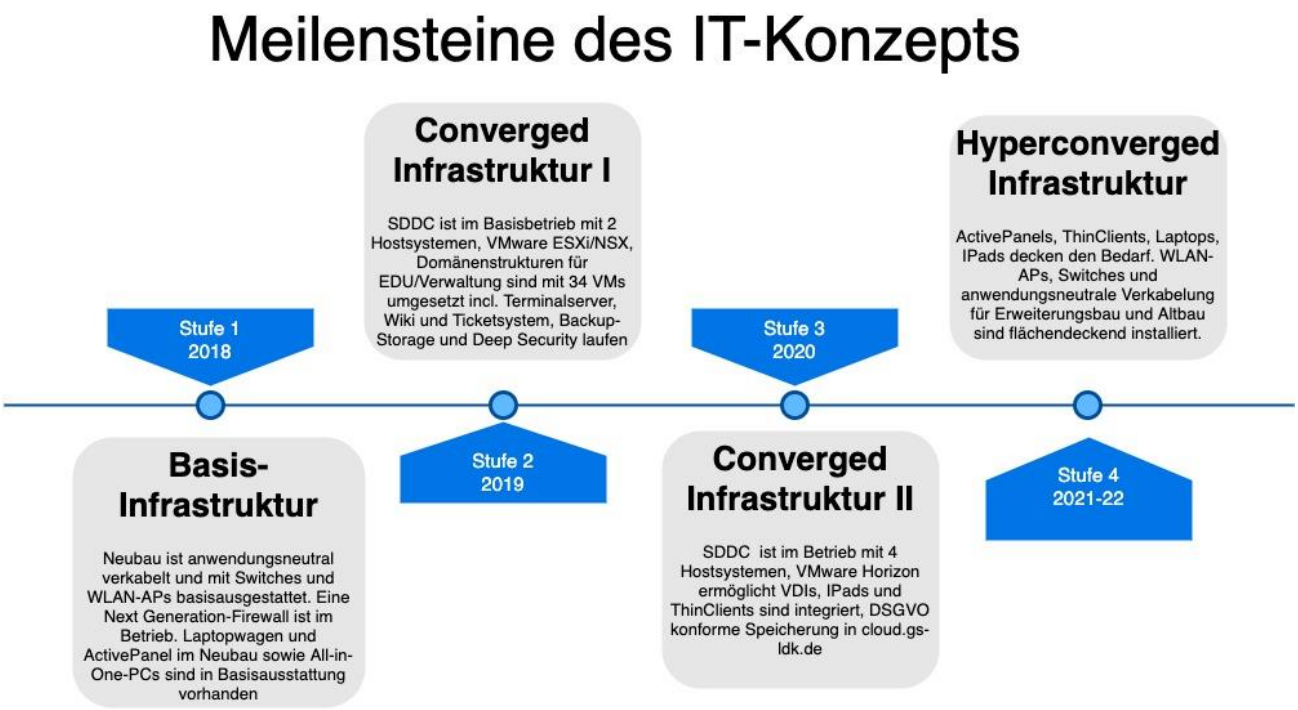
SDDC and ITaaS, the network infrastructure, security, and internet connectivity

The complexity of our network topology is depicted below, simplified to the essential elements. For detailed information, please refer to the complete IT concept.



SDDC and ITaaS: Current State/Future State in Milestones

The development and expansion of the IT and media landscape underwent a fundamental conceptual realignment in 2018, consistently following the SDDC strategy. The expansion up to Stage 3 is not yet fully funded. Additional funds, particularly for Stage 4, will be required under the Digital Pact initiative.



SDDC and ITaaS: Support Needs and Training Measures

The first-level IT support is based on our ticketing system, ticket.gs-ldk.de, and is handled by the IT team of GSD. The additional workload is supported through service contracts, a functional position, and an IT assistant funded by the association. The second-level support for telecommunications is provided by the LDK Media Center, while the IT infrastructure is supported through a service contract with Salutec GmbH, Haiger. The annual costs associated with these services are separately outlined in the external planning table. This also applies to the necessary training measures, which are submitted annually by the training officer and allocated from the training budget by the headmasters of the school.

4.2. How can a cross-location simulation software (FactoryIO) be effectively used for vocational education in the classroom?

The Software Factory I/O allows the simulation of a 3D factory to teach automation technologies. The virtual factory is built with a selection of common industrial parts. Factory I/O includes many scenarios inspired by typical industrial applications, ranging in difficulty from beginner to advanced.

The most common scenario is to use Factory I/O as an PLC training platform since Programmable Logic Controllers (PLCs) are the most commonly used controllers in industrial applications. However, microcontrollers, SoftPLCs, Modbus, and many other technologies can also be used.

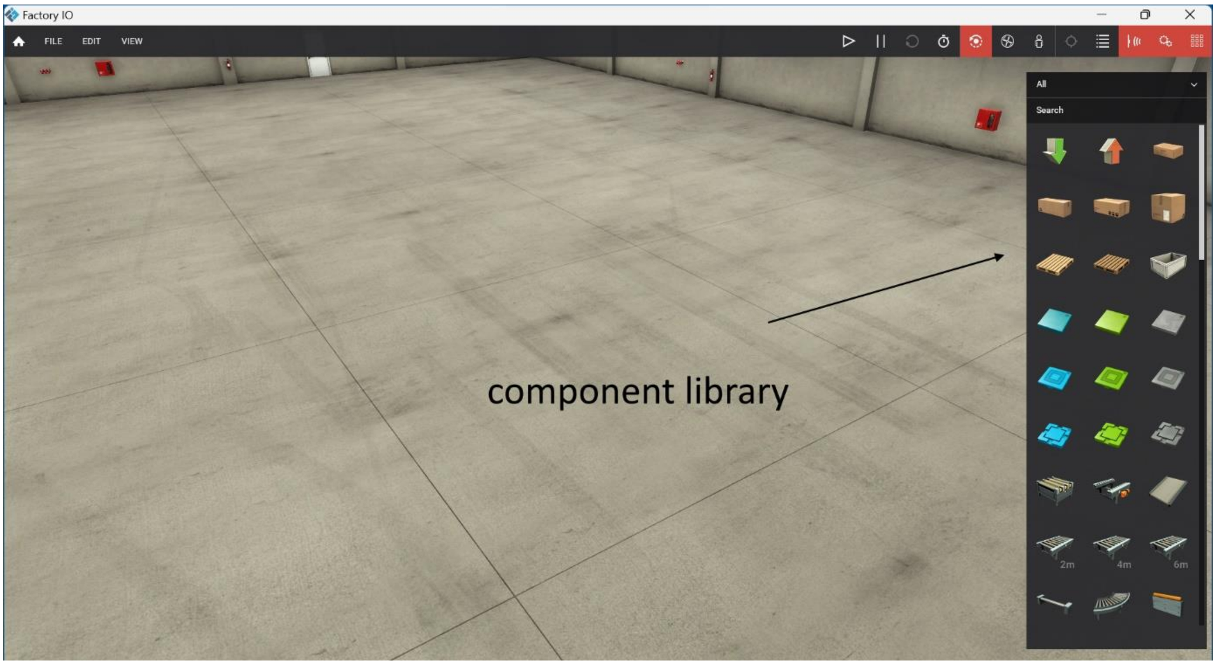
The Software Factory I/O consists of two parts. In the first part, a virtual industrial facility (Factory) is created, complete with corresponding machines, sensors, actuators, and devices. The second part (Control I/O) involves programming the PLC associated with the industrial facility. Factory I/O provides a variety of PLC options depending on the version. The following programming approach uses function blocks as it is independent of the PLC and focuses on pure logic connections. The PLC and the manufacturing facility exchange information bidirectionally. Changes made in the PLC are immediately reflected in modified operations in the production process. Changes in sensors, actuators, etc., in the manufacturing facility also result in corresponding changes in the PLC.

Two workshops were conducted to teach the basics of using Factory I/O. A hands-on approach was implemented, allowing participants to independently solve problems after receiving input from the instructor.

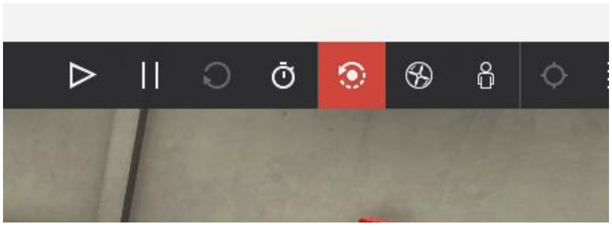
Image 7: Task in the area of the factory

After pressing the start button, it should remain illuminated continuously, and the conveyor should transport the box. When the retroreflective sensor is triggered, the transport should stop. Pressing the stop button should also halt the transport.

The conveyor, including the motor, is available in the product library of Factory IO. The start button, stop button, and retroreflective sensor need to be mounted. Afterwards, the transport box should be added. All these objects are included in the library.

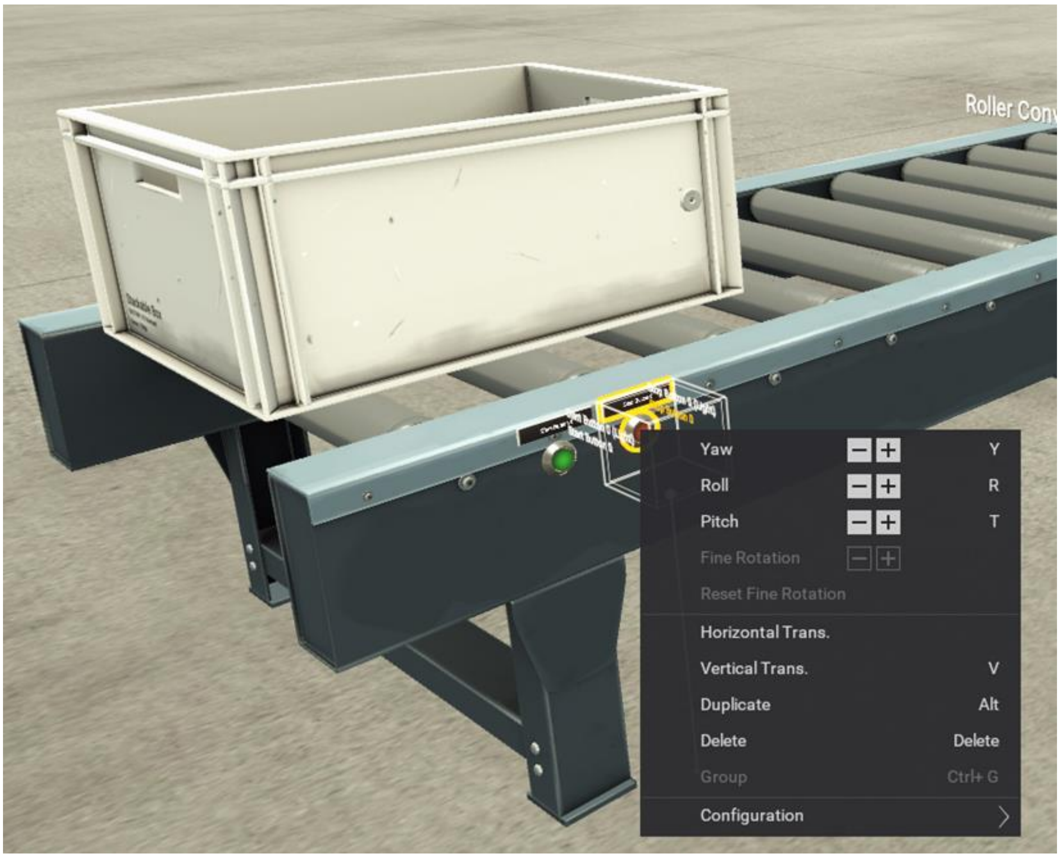


For the creation of a manufacturing facility, effective navigation in three dimensions is essential. The choice of an orbital camera is highly beneficial in this regard.



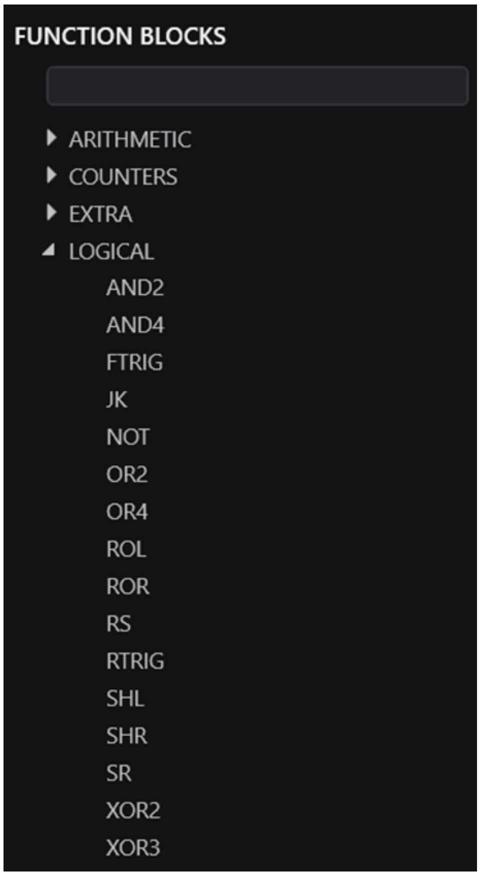
Orbit camera selected

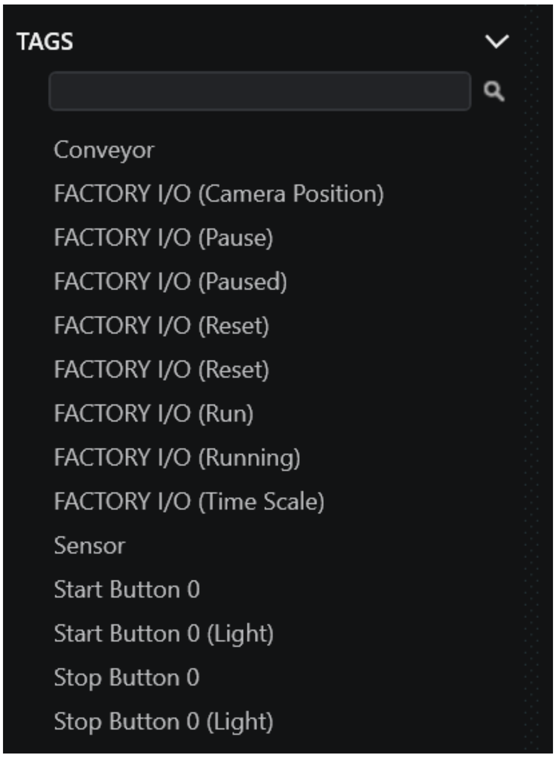
To rotate an object around a fixed point, which greatly facilitates object assembly, the fixed point is set by double-clicking the left mouse button. With the right mouse button, the object can be rotated around this point (indicated by a white spot). The scroll wheel is used for zooming, and pressing the third mouse button allows for object movement. Free positioning of objects in three-dimensional space can be challenging when all three dimensions are active. Therefore, the object to be positioned is clicked with the right mouse button, which opens the context menu shown below. Now, a vertical or horizontal translation can be selected. Additionally, a rotation around one of the three rotational axes can be chosen. This approach significantly facilitates precise positioning and orientation.



2. Creation of the PLC in Function Block Language

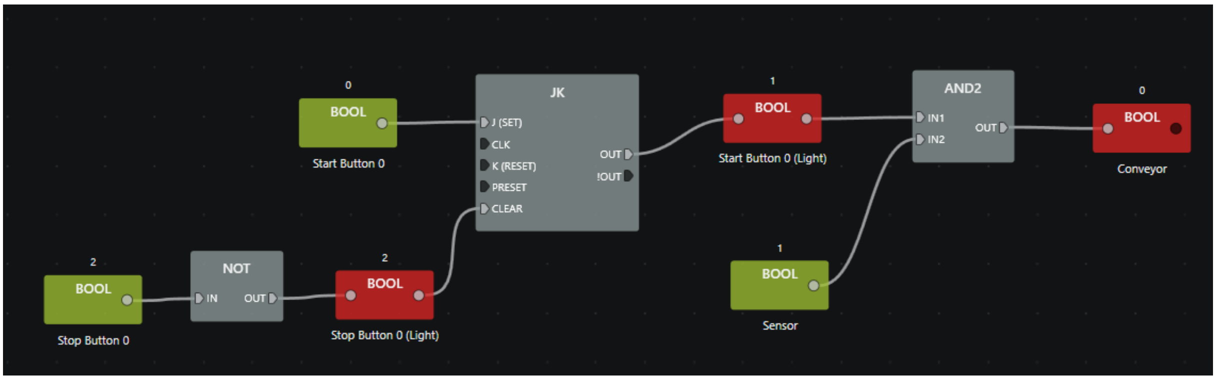
The software section of the PLC is accessed by selecting File/Drivers/Control IO in the main menu. Two areas are of particular relevance. The **Tags** section displays all the sensors and actuators installed in the factory. For programming purposes, the Function Blocks are selected, with the **Logic Blocks** being sufficient for the simple task at hand.





Example for solving the task:

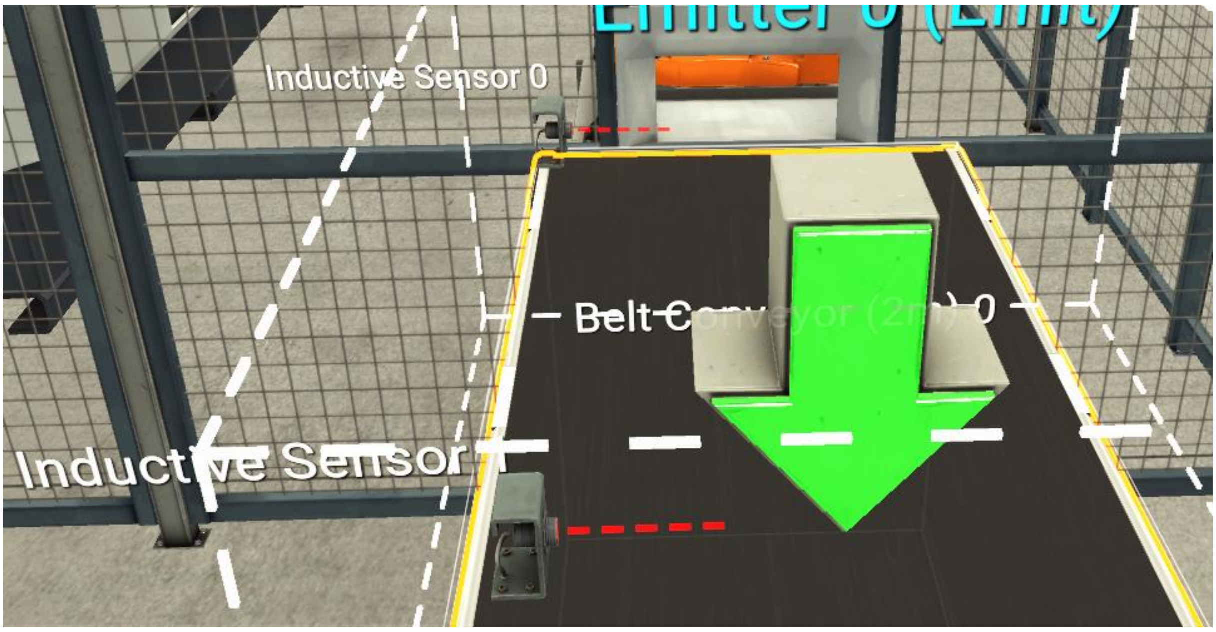
It should be noted that the stop button is typically implemented as a normally open contact, so its output signal must be negated. Instead of the JK flip-flop used here, a simpler SR flip-flop can also be used.



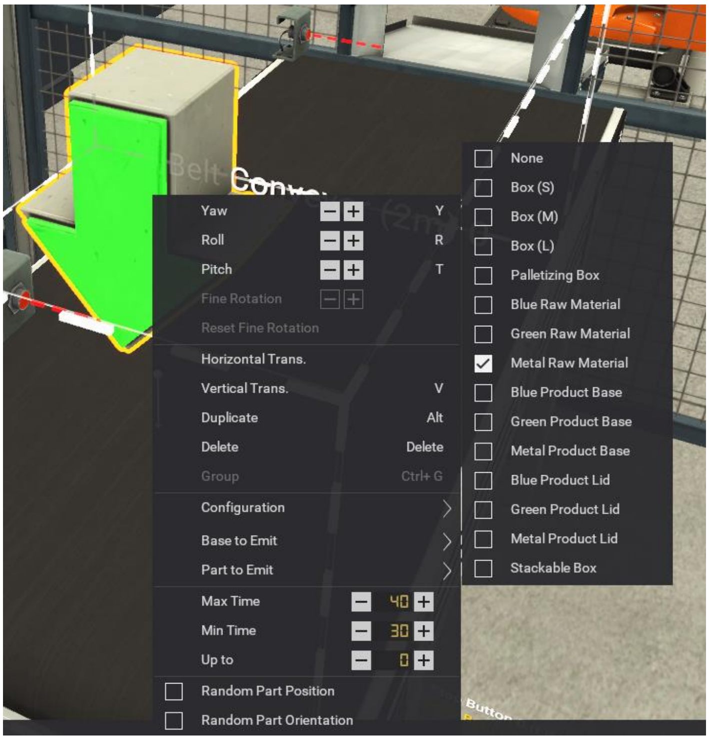
To start the simulation, the Play button must be pressed while the controller is loaded.

3. Application of the previous fundamentals to a more complex task.

The CNC machine is to be loaded with raw metal parts by an articulated robotic arm.
After the milling process, the robot removes the finished product. The raw parts are supplied by a conveyor belt. The conveyor belt can be started by either the start button or inductive sensor 1. Inductive sensor 0 starts the machine center. The emitter provides the raw parts. After manufacturing, the products are removed by a remover. It should be noted that the entire production cell, including the robot, forms a single unit. The start of the robot is controlled by a built-in camera in the cell, which is programmed to initiate the manufacturing process only when raw material is delivered. If a finished product is supplied, the process does not start.

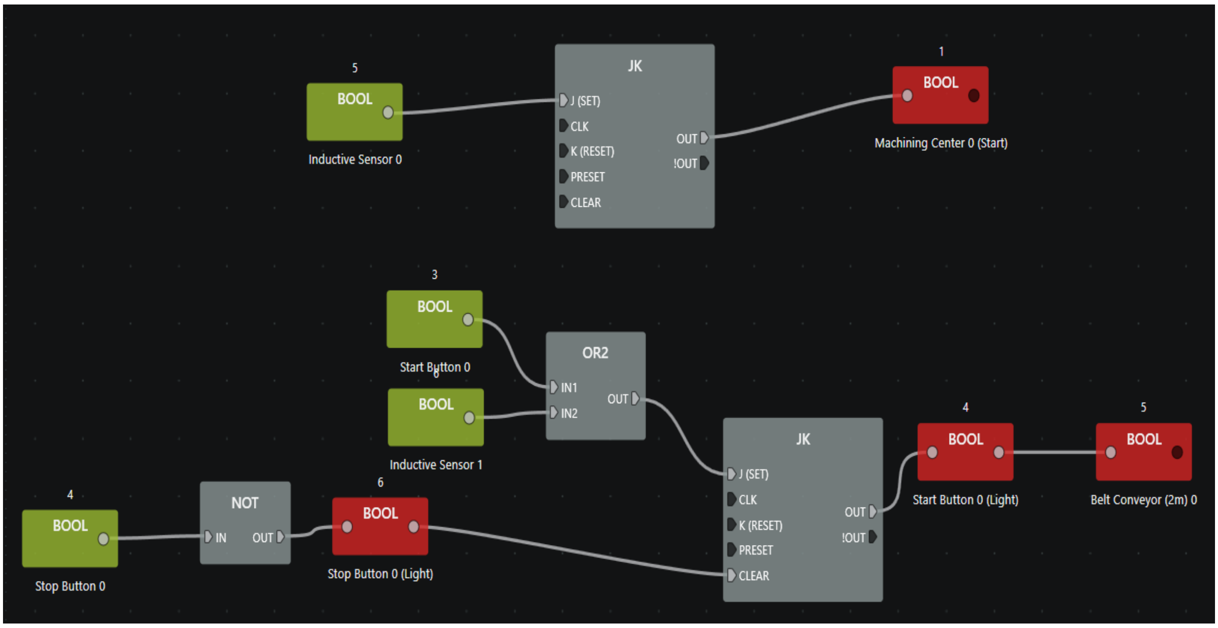


Configuration of the emitter:

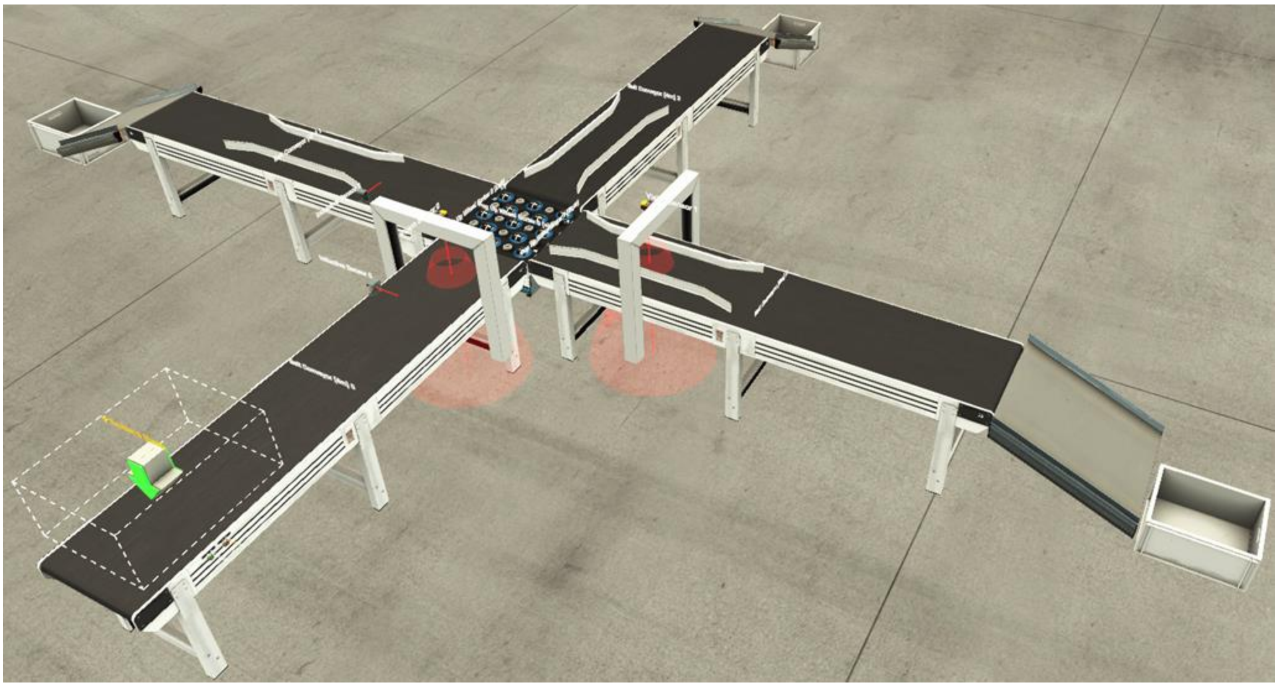


- Metal Raw Material is selected as the Part to Emit.
- A minimum time of 30 seconds and a maximum time of 40 seconds are determined. Within this time window, the emitter randomly provides the raw material.
- "Up to 0" means that the emitter delivers raw material without any piece limitation.

Sample solution for the PLC in Function Block Language:

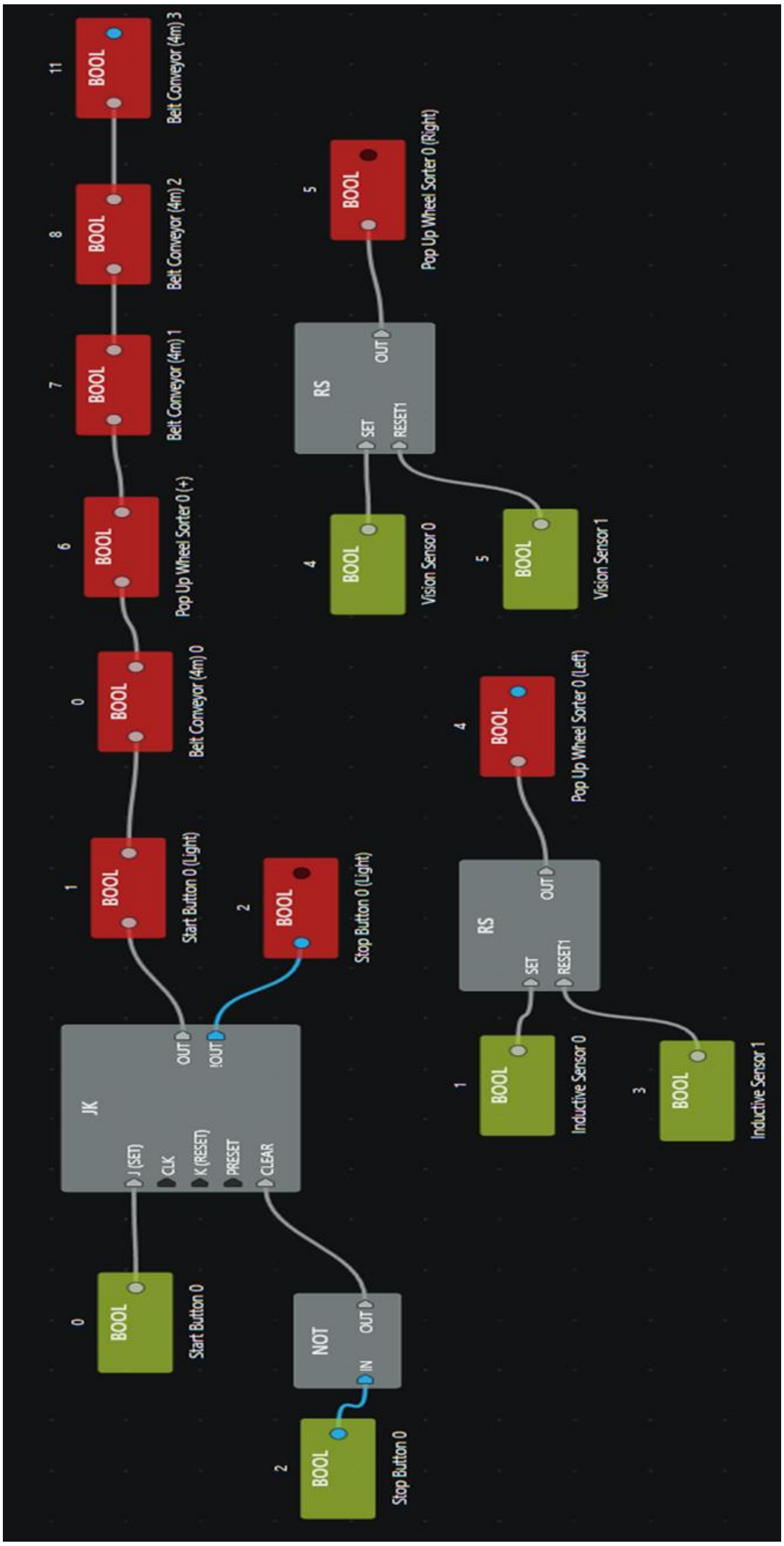


4. Final task assignment for the conducted workshop



The emitter randomly provides blue plastic finished products as well as green plastic and metal raw parts. These parts are to be fed into three different bins in the sorting system.

Sample solution for the PLC in Function Block Language:



Useful links:

Download: https://factoryio.com/download-archive/
Manual: https://docs.factoryio.com/

4.3. What opportunities does a digital twin offer in modern industrial production 4.0 and in projects at vocational and technical schools?

The digital twin - a key technology for Industry 4.0

As already explained, Industry 4.0, the next industrial revolution, is being utilized in different contexts and discussed in various fields. The concept of the digital twin was initially defined by NASA in 2010 as a simulation of a vehicle or system that uses the best available physical models to closely replicate the behavior of the real object.

Over time, "digital twin" has become a popular marketing term applied to a variety of simulation tools for machine or plant simulation. A powerful marketing campaign by Siemens gave the term a second interpretation, referring to a dynamic 3D model, such as a production facility, machine, or car, including its associated simulation. The new focus was on the simulated and visible 3D model. This interpretation is currently considered state-of-the-art and is shared by a wide industrial audience, from vendors to users. However, technically, the implementation remains an Industry 3.0 technology that is useful for many use cases but cannot be defined as "Industry 4.0".

The concept of the digital twin (see Image 7) is based on modeling assets with all their geometric data, kinematic functions, and logical behavior using digital tools. The digital twin directly relates to the physical asset and enables its simulation, control, and improvement. According to Gartner, "less than 1 percent of the physical machines and components in use today are modeled in a way that captures and mimics the behavior."

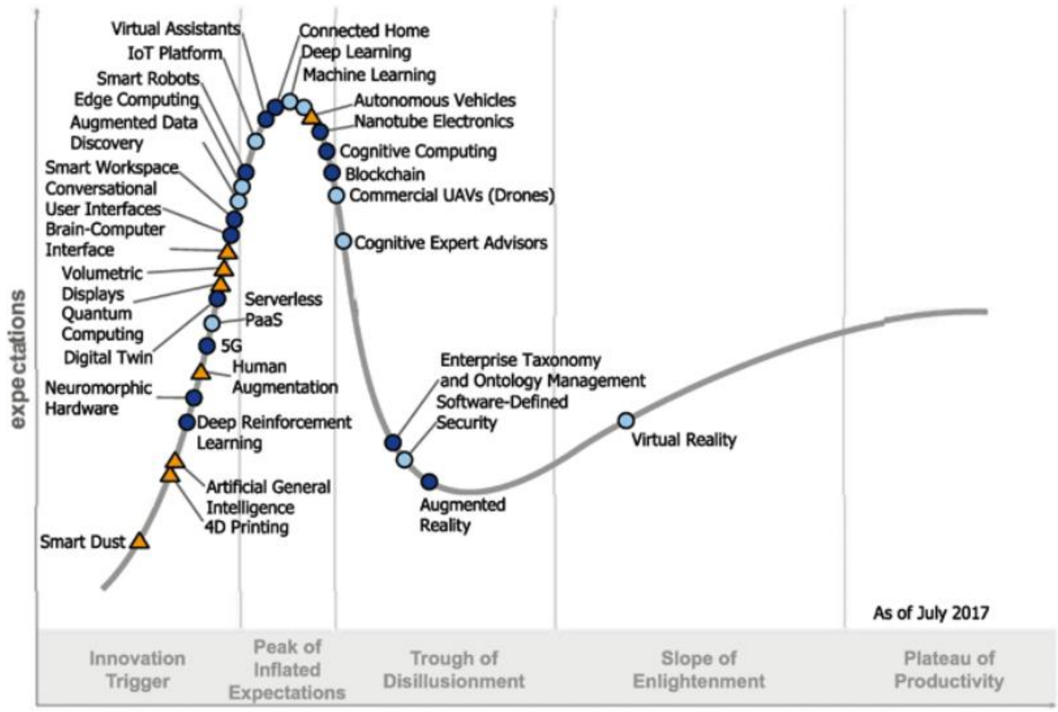


Image 8: Gartner Hype Cycle for Emerging Technologies 2017

The digital twin concept holds significant potential in modern industrial manufacturing, as it allows for real-time monitoring, predictive maintenance, performance optimization, and virtual testing of different scenarios. By creating a virtual replica of physical assets, students and professionals can gain insights into the behavior, performance, and interaction of these assets in a safe and controlled environment. This enhances learning, problem-solving abilities, and innovation in the field of Industry 4.0.

Currently, digital twins are being discussed in Industry 4.0 working groups within the context of Asset Administration Shells or Industry 4.0 components. Digital twins are not individual objects or monolithic data models but consist of various aspects of digital representation, functions, models, interfaces, and more. From the perspective of manufacturing and technical development, it is apparent that digital twins require and cover different aspects, such as:

- Self-description using unique attributes and parameters that describe configuration data, for example, for automatic identification to easily connect machines and components with MES and other Industrial IoT solutions.
- Models of the correct runtime behavior of a machine, a line, or an entire production operation based on learned data from machine learning.
- An extensive range of offline and online simulations, such as finite element simulations, virtual commissioning, or physics simulations where manufactured goods interact with machine kinematics. Ideally, the different simulation models should be able to interact with each other to generate an integrated simulation model.
- A digital factory that describes machines and other manufacturing resources, buildings, and utility facilities. A Building Information Model (BIM) could also be part of a digital twin as long as it contains relevant information, such as topology. The concept of digital factories already has a long history and is described by well-known standards like VDI 4499.
- IT security, access rights, certificate handling, version management, and compatibility checking of different versions of digital twins.

Digital twins are crucial for Industry 4.0 and the digitalization of manufacturing. Their content is of great importance during all phases of the lifecycle and in various types of applications. In summary, a digital twin offers many opportunities in modern industrial manufacturing 4.0. Firstly, it can help optimize the production process and increase efficiency. Through the digital twin, problems can be identified and resolved in advance before they occur in real production.

Another advantage is the ability to map and monitor the entire product lifecycle. With the digital twin, for example, the manufacturer can monitor the condition of the product throughout its lifespan and plan maintenance work before failures occur.

Furthermore, the digital twin can also contribute to the development and testing of new products. Through simulations and modeling, the manufacturer can explore various scenarios and bring new products to the market faster and more cost-effectively.

4.3.1. Implementation of learning situations in the context of Industry 4.0 using a digital twin in vocational education and training at the Gewerbliche Schulen Dillenburg

A digital twin offers many opportunities to enhance and optimize manufacturing in Industry 4.0. What benefits does this bring to vocational schools, and how can digital twins be implemented in vocational education and training? These questions will be addressed in this section, along with examples of their application in the everyday school life at Gewerbliche Schulen Dillenburg.

In vocational and technical school projects, a digital twin can be of great value. Students can gain practical experience in working with modern technologies and develop their skills in the field of Industry 4.0. Furthermore, the use of a digital twin can help illustrate complex relationships and processes, leading to a deeper understanding.

At Gewerbliche Schulen Dillenburg, digital twins are implemented in vocational education and training in various ways to support students' learning process. Here are some general examples of their application in the classroom:

- Virtual exercises: By using a digital twin, students can engage in virtual exercises to improve their skills and prepare for real-life scenarios. They can simulate various aspects of production or maintenance without the need for real machines or equipment.
- Troubleshooting: A digital twin can also be used to assist students in troubleshooting. They can learn to identify and resolve issues by examining virtual machines or equipment and experimenting with different scenarios.
- Design and planning: Through the use of a digital twin, students can learn how to design and plan machines or equipment. They can test and simulate different designs to find the optimal solution.
- Collaboration: A digital twin can enhance collaboration between students and teachers. They can collaborate virtually to solve problems, exchange ideas, and develop projects together.

The benefits of working with a digital twin in vocational education and training are diverse. Here are some examples:

- Cost savings: The use of a digital twin can save costs as students do not require real machines or equipment to improve their skills.
- Safety: Working with a digital twin is safer than working with real machines or equipment. Students can learn how to troubleshoot or solve complex problems without compromising their safety or that of others.
- Efficiency: The use of a digital twin can improve efficiency. Students can virtually explore different scenarios to find the optimal solution and save time.
- Flexibility: A digital twin also offers more flexibility. Students can access virtual machines or equipment from anywhere and learn without being tied to a specific location.

The competencies developed through the use of digital twins in the classroom are highly versatile. Here are some examples:

- Technical competence: Working with a digital twin allows students to acquire technical skills, such as operating CAD software or programming robots.

- Problem-solving competence: Digital twins often require solving complex technical challenges, allowing students to learn how to systematically analyze problems and develop creative solutions.
- Teamwork and communication: Working with digital twins often involves teamwork. Students can learn to communicate effectively, take responsibility, and achieve goals together.
- Analytical competence: By analyzing data generated by digital twins, students can learn to interpret data and draw conclusions.

To ensure that the acquired competencies of students have been fostered and consolidated, an assessment should be conducted following each project or completed learning situation. Various methods can be used for this purpose. Here are some examples:

- Evaluation of work products: Teachers can assess the work products created by students, determining whether they meet the requirements and which competencies have been demonstrated.
- Reflection: Students can be guided to reflect on their own work and evaluate the competencies they have acquired and areas for improvement.
- Peer feedback: Students can provide feedback to each other, enhancing the quality of their work results and competencies.
- Presentations: Students can showcase their work results through presentations, demonstrating their competencies.

In summary, a digital twin in vocational education and training offers numerous benefits that can enhance students' learning process. They can improve their skills, solve problems, collaborate, and prepare for real-life scenarios without the need for real machines or equipment.

Next, practical examples of the application of Industry 4.0 and the use of digital twins in the everyday school life at Gewerbliche Schulen Dillenburg will be presented.

5. Application examples of Industry 4.0 and digital twins in the everyday classroom at Gewerbliche Schulen Dillenburg

First example: " Development of a digital for a production process "

Target Audience: Students of the further education or training or apprentices in the field of technology. Learners from different occupational fields can also work together on this project. The project has previously been implemented with students from the occupations of industrial mechanic, mechatronics technician, and IT apprentice (see Appendix 1.1).

Duration: 6 weeks (approximately 30 class hours)

Learning Objectives:

- Understanding the concepts of Industry 4.0 and the digital twin in the context of smart factory
- Ability to create a digital twin for a production process (CAD knowledge is required)

- Development of problem-solving and teamwork skills
- Improvement of presentation skills

Task Description:

In teams of 4-5 members, the learners are tasked with creating a digital twin for a production process of their choice. They will use the in-house ETS facility as a model, which can depict various process flows. In creating the production process, they should utilize various technologies such as sensors, IoT platforms, and cloud services to model the process flows. The learners should follow these steps:

- Identify the production process to be modeled and analyze the current state (as-is)
- Design a concept for the digital twin and select the necessary technologies
- Implement the concept and create the digital twin
- Test the digital twin and analyze the results
- Present the project and discuss the outcomes

The learners are expected to collaborate within their teams to carry out the project. They should document their results and present them in a final presentation. The presentation should also highlight the benefits and challenges of using a digital twin in industrial manufacturing.

Competencies:

- Problem-solving skills: Students must be able to identify and solve problems during the creation of the digital twin.
- Teamwork: Students should work in teams to execute the project, effectively divide tasks, and collaborate to achieve the goal.
- Technical competencies: Students must be able to utilize various technologies such as sensors, IoT platforms, and cloud services to create the digital twin.
- Presentation skills: Students must be able to present their results in a clear and persuasive manner.

Assessment:

Competencies can be assessed through various means:

- The quality of the created digital twin can be evaluated based on test results, such as the accuracy of the modeled process, functionality of the digital twin, and its adherence to the chosen technologies.
- The learners can submit their documentation, including the process analysis, concept design, implementation details, and analysis of the results, for evaluation. The documentation should demonstrate their understanding of the concepts of Industry 4.0, the digital twin, and the application of relevant technologies.
- The presentation of the project should showcase the learners' ability to effectively communicate their findings, demonstrate the functionality of the digital twin, and articulate the benefits and challenges of using a digital twin in industrial manufacturing. The presentation should be clear, well-structured, and engaging.
- Peer review can be employed to assess the collaboration and teamwork within the teams. Each team member can provide feedback on their peers' contributions, problem-solving

approaches, and teamwork skills. This feedback can contribute to the evaluation of individual and team performance.
- The teacher can also conduct individual feedback conversations to assess the learning progress and the development of competencies for each learner. These conversations can provide an opportunity to address any challenges faced by the learners and offer guidance for improvement.

By employing a combination of these assessment methods, the learners' understanding of the concepts, their ability to create a digital twin, their problem-solving and teamwork skills, as well as their presentation abilities can be effectively evaluated. This assessment process ensures that the learning objectives are met and provides valuable feedback for further improvement.

Second example: Introduction into the cyber physical factory

Target Audience: Students of the further education and training and professionals involved in the integration of cyber-physical systems in manufacturing.

Duration: The duration of a training program on "CP-Factory" depends on various factors such as the extent of knowledge imparted, participants' prior knowledge, and the teaching methodology. Typically, such a training program can range from a few days to several weeks.

Learning Objectives:

- Learners should understand the concepts and technologies of CP-Factory.
- Learners should be familiar with the requirements for professionals working with this new technology.
- Participants should be able to plan and implement the integration of CP systems in manufacturing.

Content:

- Introduction to the concept of CP-Factory.
- Overview of the technologies and systems used in a CP-Factory.
- Requirements for professionals in a CP-Factory.
- Planning and implementation of CP systems in manufacturing.
- Examples of successful integration of CP systems in manufacturing.

Many learners have completed their education several years ago and have had little to no experience with CPS until the training. The skills and abilities they acquired during and after their vocational training are often insufficient to handle the new technologies. Therefore, there are new requirements that learners need to understand, deepen, or consolidate as an extension of their expertise:

- Understanding system architecture: Professionals need to understand how the various components of CPS work together to form the overall system.
- Programming skills: CPS are programmable systems that require specific logic and behavior. Professionals need to be able to write or understand code to ensure the functionality of the CPS.
- Knowledge of data analysis: CPS generate large amounts of data that need to be evaluated and analyzed to optimize system performance.

- Integration capability: CPS are often integrated into existing systems. Professionals need to be able to seamlessly integrate the CPS into the existing system and ensure smooth operation with other components of the system.
- Knowledge of security: CPS are often connected to networks and other systems, which brings potential security risks. Professionals need to be able to identify and address security vulnerabilities to ensure system security.
- Teamwork: Working with CPS often requires collaboration with other professionals and departments. Professionals need to be able to work effectively in teams and exchange information.

Methods for working with CPS:

- Lectures and discussions.
- Practical exercises and case studies.
- Group work and presentations.

Competencies:

- Understanding of the concepts and technologies of the Cyber-Physical Factory.
- Planning and implementation of cyber-physical systems in manufacturing.
- Analysis of requirements and risks related to cyber-physical systems.
- Teamwork and presentation skills.

Assessment of Competencies:

- Practical exercises and case studies that allow participants to apply what they have learned.
- Group presentations where participants can demonstrate their planning and implementation skills.
- Feedback and reflection at the end of the training program.

Different target groups learn about working with the CP Factory in various training and further education programs at the Further education and training s. In the appendix, an article on the implementation of these educational offerings at the GSD can be found (see Appendix 1.2).

6. Concluding theses on the didactics of digitalization and the implementation of digital twins in vocational education and training

The implementation and use of digital twins in vocational schools are of great importance and should be strongly recommended. This technology offers numerous advantages and opens up new possibilities for effective and practical vocational education.

One main reason why digital twins should be used in vocational schools lies in their ability to simulate real and complex work environments in a virtual form. By using digital twins, students can acquire practical knowledge and skills without relying on real machines and equipment. They can simulate various scenarios, experiment, and analyze errors, leading to a deeper understanding and more efficient training.

Furthermore, digital twins provide the opportunity to create realistic situations that may not be easily accessible or safe in the real world. For example, students can simulate dangerous or costly work environments without actually being physically present. This increases safety and reduces potential risks in the training process.

Another crucial advantage of digital twins in vocational education is their ability to enable a high level of interaction and independence for learners. By being able to independently explore and manipulate virtual environments, learners can determine their own learning pace and deepen their understanding. They can make mistakes, experiment, and develop problem-solving strategies without experiencing real-life consequences. This promotes learning motivation and the development of problem-solving and creativity skills.

However, the integration of digital twins in vocational education is not just an option but an urgent requirement. The ongoing digitalization has already led to significant changes in the workplace, especially with Industry 4.0. Companies are increasingly relying on automated processes, intelligent machines, and connected systems. Without knowledge and skills in dealing with digital technologies and an understanding of their practical application, graduates of vocational schools are inadequately qualified for the job market.

Vocational education without digitalization is no longer up to date and cannot meet the demands of the modern workplace. The increasing interconnectivity of machines and the introduction of digital technologies require a new set of competencies that align with industry needs. Working with digital twins enables learners to develop these competencies and prepare for the requirements of the digitized work environment.

Overall, the integration of digital twins in vocational school instruction offers a multitude of benefits that should not be ignored. By using digital twins, vocational schools can prepare learners for the demands of the modern industry and ensure they have the necessary skills and knowledge to succeed in a digitized work environment.

However, a successful integration of digital twins in education requires careful planning and implementation. It is important for schools to have the necessary infrastructure and resources to effectively use digital twins. This includes access to powerful hardware and software, training of teachers in digital technologies, and creating a learning environment that promotes creativity, collaboration, and independent learning.

To assess the effectiveness of working with digital twins and evaluate the acquired competencies of learners, various methods can be employed. For example, practical projects and tasks can be conducted where students use digital twins to solve specific problems or simulate complex scenarios. The results can be evaluated based on predefined criteria and performance measurements.

Furthermore, oral presentations, group discussions, or portfolios can also be utilized to assess the understanding and application of acquired competencies. Peer feedback and self-reflection are also valuable tools for assessing learning progress and promoting awareness of one's strengths and areas for improvement.

In summary, it can be said that working with digital twins in vocational schools is of great importance to meet the demands of the digitized work environment. By using this technology, learners can gain practical experiences, develop their competencies, and be prepared for the job market. It is essential for vocational schools to recognize the potential of digital twins and integrate them into their curricula and teaching methods to ensure contemporary and future-oriented vocational education.

7. Ethical aspects - Learning concepts for learning location cooperation 4.0 in the context of Industry 4.0

Socrates: "Don't fight the old, create the new"

The article deals with a seemingly small aspect in the extensive discussion about Industry 4.0, the contents of which are generally not mentioned or are only mentioned in passing. At the same time, the new challenges, and burdens with consequences for people and, as a result, for society, demand answers and confrontations with the topic. With the increased use of collaborative robots (cobots), man and machine are moving closer together in a "collegial" manner. At this point at the latest, the question of ethical aspects arises when "sentient robots" reach out to humans and give them a helping hand.

How many feelings and affections does the person have towards the "new" colleague or does the person want or should the person have feelings towards him? Or does the increased use of robots lead to mechanized feelings in humans? There are currently no conclusive answers to these pressing questions with "right" and "wrong". We are only at the very beginning of the development. Nevertheless, timely discussion or targeted planning for learning situations is already necessary.

7.1. Learning environment

Quote from the 2020 project application round:
"The digitalization of the world of work, especially in the context of Industry 4.0 and a new digital learning culture, requires expanded skills among learners. In addition to specific professional core competencies, skilled workers must also have broad, interdisciplinary competencies in order to successfully meet the changes in industrial production and society. This implies correspondingly professional teachers who prepare young people for the professional requirements in the best possible way within the framework of education and training."

1. The Corona pandemic has accelerated the digitization of the world of work: there are more video conferences, more home office and more mobile work. Advancing digitalization is putting a strain on more and more employees in their jobs, according to a sobering finding by DGB boss Yasmin Fahimi after a survey at the beginning of December 2022.
2. After the French composer Maurice Ravel (1928) with the long "Bolero" as a ballet piece, which begins quietly and imperceptibly, increasing increasingly into the perceptible and culminating in an unmistakable finale, the comparison culminates: **Such a bolero is currently moving towards the world of work** (Welf Schröter, 2016, FST BW)
3. **Objectives of the "Forum for Social Technology Design (FST)"** The development and strengthening of design competence on the part of trade unions, works and staff councils, shop stewards and employees has been the core task of the "Forum for Social Technology Design" network at the DGB Baden-Württemberg for 30 years. (Lead: Welf Schröter)
4. "Shaping the future humanely" was the demand in 2019 (Prof. Dr. Ulrike Buchmann, University of Siegen, on the occasion of the 20th University Days in Germany) "The contribution of vocational education and training lies in making the complex interrelationships, which are often summarized in simplified terms under the term

digitization, understandable and thus shapeable - in all courses of vocational education and training and across all technical and content-related priorities."

5. "The transformation processes around digitization require a high degree of technical, personal and social competence, communication, action and decision-making skills, abstraction, creativity and frustration tolerance. In this respect, vocational education and training has a comprehensive educational mandate in a historically unprecedented form," Prof. Buchmann continued.

7.2. Cooperation as a place of learning 4.0 in the changing world of work

Intelligent networking of machines and processes in industry, based on modern information and communication technology, form the basis for so-called cyber physical systems (CPS) in the field of Industry 4.0.

- Employees are experiencing a fundamental change in their working conditions
- What role do people play in the digital transformation?
- How does education respond to this? How should education respond to this? This challenge is not a question of technology alone or controllable through financial means
- Any splinter of thoughts could have an extensive discussion as a basis
- The task in the project will have to be to focus on the central points and to bring them to implementation according to the project idea
- The current inventory of the technical possibilities on the ground is one thing; the parallel discussion of possible solutions is the other

Ten examples of the impact of Industry 4.0 on factory workplaces
In the future, employees will need completely different skills and qualifications.

SOURCE: BOSTON CONSULTING GROUP, MAN AND MACHINE IN INDUSTRY 4.0

- **Big data-driven quality control**
  algorithms identify quality problems from recorded data and thus reduce product defects
- **Robot-assisted production**
  Flexible humanoid robots take over tasks such as manufacturing and packaging
- **Self-driving vehicles in logistics**
  Intelligent, fully automated transport systems navigate within the factory (see Rittal, Haiger)
- **Production line simulation**
  New software enables simulation and optimization of the assembly process
- **Smart Supply Network**
  Smart networking of production inventories and suppliers enables better purchasing decisions
- **Predictable maintenance and servicing**
  Remote monitoring of all machines and equipment enables repairs to be carried out even before breakdowns occur

- **Machines "as a Service"**
  Manufacturers no longer sell machines, but provide them as a service, including maintenance and servicing.
- **Self-organizing production**
  Machines communicate and coordinate with each other, thus optimizing their use and output
- **Additive production of complex components**
  3D printers create complex components in a single step and make assembly line work superfluous
- **Augmented Work, Maintenance and Service**
  Virtual reality glasses and robots will simplify the operation, remote control and maintenance of the digital factory (HTL St. Pölten, ESF)

In the world of work, two dynamics of automation overlap (Welf Schröter):

1. *Automation of physical machines* with the help of state-of-the-art control software (in the tradition of "lean production")
2. *Automation of the virtual work and business space* with the help of modern delegation techniques and autonomous software systems

7.3. Evaluation of requirements (level of requirements, future significance, educational aspects, societal aspects)

1. Reference: Rittal a partner in Haiger as a place of learning; dual training in schools and companies

2. Work tasks on and with cyber-physical systems (CPS) are becoming more complex than on "old" existing plants and systems of production (training workshop near the production facility according to Industry 4.0 standards at Rittal in Haiger)

3. "Thinking along the value chain" is important as a key qualification (Rittal philosophy).

4. High willingness to learn and change, flexibility and creativity of the employees as a prerequisite

5. Intensive interaction between all stakeholders (superiors, colleagues and customers) is required

6. The hard and soft skills mentioned above will become increasingly important. This results in new demands on the educational staff of the dual education and training system.

7. Training and study content must be adapted and new learning content must be included in the training curricula.

8. Taking into account the principle of complete action, new learning situations must be designed or existing learning situations can be worked through and adapted to the new prerequisites and conditions.

Soft Skills

1. *Methodological skills:* comprehension, self-management, discipline, frustration tolerance, problem solving

2. *Social skills:* ability to work in a team, empathy

3. *Personal competence:* self-reflection, curiosity, passion, self-confidence, goal orientation, willingness to learn, flexibility and creativity

Hard Skills

1. Professional Competence

2. Professional qualifications

3. Experiences

4. Language skills

Knowledge of IT structures on shop floor

1. Which systems work together on the shop floor and how can they be influenced?

2. Feedback and storage location structure on the shop floor

3. Ongoing control, data collection and processing, data protection, feedback and adaptation of detailed plans as well as actual data management

4. Workforce planning

Planning and control components

1. Creation and evaluation of production programs

2. Application and evaluation of the various planning and scheduling methods, material and capacity planning

3. Setting planning parameters in the leading planning and MES system

Process Thinking

1. What are processes?

2. What are the dependencies and influencing factors?

3. Linking sub-processes to overall processes

4. Methods for process modeling, evaluation of processes and their capability

5. Measuring process performance

Analysis of conditions for success for sustainable cooperation between learning venues

1.Good organization to combine practical and theoretical learning content

2. Placement in operational personnel development = sustainability

3. Open and honest dealings with each other

4. Assistance and mutual assistance5. Continuous training and qualification of educational staff in schools and companies

Welf Schröter (FST):

1. The concept of "Industry 4.0" is not a new generation of technology, not a corset, not an "off-the-shelf costume" for the company.
2. Rather, it is a different combination (flexible integration) of existing techniques from the customer's perspective "in batch size one".
3. These include: digitization, virtualization, cloud computing, fast networks, Internet of Things (RFID, CPS Cyber-Physical Systems), organic electronics, humanoid robotics) and others

7.4. Understanding and shaping the digitalization of tomorrow

The use of data analysis methods and so-called "artificial intelligence" (AI) in business, but also in public administration, is **steadily increasing**. This **simplifies workload**, as the use of these systems can accelerate procedures and processes. At the same time, however, the increased **use of self-changing systems** also poses **enormous challenges**. The new technology will fundamentally revolutionize processes and procedures in companies and public authorities and thus bring **profound changes for employees and citizens**. If **machines increasingly take over the work of humans and make their own decisions,** then co-determination by humans will also dwindle. The result would be non-transparent decisions and processes without a say. In addition, the **processual experience of employees** is lost. The positive tone of the public debate about the advantages of "AI" usually ignores these consequences. Previous approaches **to integrating the systems into everyday work focus almost exclusively on strengthening the technical skills** of employees so that they **can master the new technology**.

This **approach is correct, but it does not go far enough,** as the use of "AI" brings about a much more profound change than previous digitization. What is needed are **new concepts and approaches** to discuss consequences today that will only affect employees in the future. How can companies or authorities start this process? **What needs to be considered in order to make this process successful?** Why do the processes of co-determination themselves need to be reconsidered? (Source: unknown)

"First we design our tools, then they shape us," warns media critic and technology consultant John Culkin. Industry 4.0 is also seen as society's largest social experiment and education must prepare people for this.

Welf Schröter: "the promises of freedom of the digital revolution have not been fulfilled" and "no machine will become self-confident".

Robots leave their cages and work together with the specialists on site as a "colleague" (collaborative robot cobots). They work together with humans and are not separated from them by protective devices in the production process. They reach out to people. At this point at the latest, ethical aspects are affected.

Forum „Social technology design“

The effect of humans on technology or the effect of technology on humans is primarily based on findings from empirical research. Nikolas H. Müller in "Mensch und Technik in der angewandten Forschung" Springer Verlag 2022

7.5. Ethical aspects of the use of technology

The development of Industry 4.0 in extension to Work 4.0 up to Living Environment 4.0 (IAL 4.0) -Manfred Becker in: Personalmagazin 12/15- forms the basis of the aspects of ethical aspects. "For example, it has not yet been clarified what demands digitization places on employees and what contribution the education system and personnel development must make to ensure that people accept the new challenges without fear and motivation." (Becker)

Ethics sees itself as a branch of philosophy in which methodological consideration is given to the requirements for moral action (Misselhorn 2018). Ethics can be both descriptive and normative. With regard to AI, the subfield of machine ethics has emerged, which carries facets of descriptive and normative ethics. On the one hand, the focus is on the question of whether it is even possible to equip a machine with moral capabilities. On the other hand, it is to be discussed whether machines are to be evaluated as morally acting actors at all (Misselhorn 2018). Ultimately, this leads to the question of whether an AI system is allowed to make decisions autonomously.

An important lever lies in the design of a machine-compatible ethics that is both oriented towards the nature of AI and takes into account the interaction between "man and machine". The freedom must be created so that intelligent machines can develop their potential for the benefit of society. At the same time, however, areas must also be defined that are reserved only for humans because of the potential danger. (N.H. Müller Springer 2022)

So far, only technical aspects have been addressed. The use of new techniques, tools and software would be addressed. Man acts as a conductor and organizer of the processes, believing that he has thus fulfilled the challenges. The effect of permanent adaptation strategies on humans urgently needs further aspects. The new challenges also have to do with different working conditions, the question must be asked "what does this do to people?"

Definition of ethics as opposed to morality: Ethics is regarded as a philosophical discipline that establishes the principles, values and prerequisites for a validor bad action and the resulting motives and consequences. It is designed to help people make the right decisions.

Both terms are related to the crucial difference:

Ethics means the general scientific examination of "right" and "wrong".

Morality refers to the respective values and norms of a group.

7.6. Ethical aspects in the context of Industry 4.0

1. **<u>Exploring Terrain 4.0</u>**

The target concept is primarily aimed at complex production and value-added networks related to industrial production.

The "digital actors" are the state, business and trade unions with different mission statements and humanization ambitions.

There are new "production concepts" in which systematic access to labor power seeks to open up previously untapped power reserves. Production without people and concepts with astonishing belief in technology are certainly present in the current debate.

2. **<u>Trade union view</u>**

From a trade union point of view, the technology-centred and market-oriented strategies should be countered by the labour perspective. Digital technologies are not aimed at substituting living work, but at "enhancing intelligence". It combines human reflection and adaptability with machine precision and speed. (Brödner 2015)

3. **<u>"Good", digital work:</u>** The BDA (Association of Employers) wants to use digitization to prevent any regulation. To this end, attempts are being made to discredit design approaches and the adaptation of the rules of the game and protective mechanisms for employees to new developments as bureaucracy in general. Digitization is an interest-driven process. Characteristics: acceleration of globalization, changed market structures and the facilitation of new forms of work. Flexibility and efficiency (networking through CPS, hybrid division of labor between "man and machine", mobile work), result orientation (on demand economy) and new independence (crowdworking).

4. **<u>Good work in the digitized world:</u>** Annelie Buntenbach, former DGB Federal Executive Board, asks what new digital possibilities mean for people's work. This question must not be at the end, but at the beginning of innovation processes. "We don't want people to be turned into an appendage of smart machines and systems." The approach is a socio-technical work design in order to secure existing employment and develop new perspectives. Above all, in addition to the participation of employees, there is a need to expand co-determination rights.

5. **<u>The working world of the future - between the "digital assembly line" and the new humanization</u>**

(Boes, Kämpf et al. 2015)

"Workplace of the Future – Unculture of Permanent Availability or New Time Sovereignty?" Digitization is changing the traditional space-time structure of work. With the Internet and mobile devices, it is possible to work from any place and at any time. The strict separation of work and life, but also the importance of the company as a central place of production, is eroding. (see IAL 4.0)

6. **<u>Workplace of the future:</u>**

"Liquefaction of the boundary between work and private life with an extension of work into the private sphere."

What is initially seen as a gain in flexibility for employees (working from home, interrupting work for two hours for private purposes, gaining a piece of sovereignty to adapt work to the needs of private life) is seen differently by employees.

Employees report that work is taking up more space in their lives, both through an extension of working hours and through greater engagement with work and new performance requirements in the context of digitalisation.
The need for a good work-life balance is increasing. It is becoming increasingly difficult for employees to switch off; they are expected to be there for the work in the first person and with full commitment (Boes/Kämpf 2015).
Empirical observations show that new office concepts, home office and mobile working do not automatically lead to an improvement in the work-life balance. Here, the course must be set in a sustainable direction through the design.

7. <u>Social Relationships and Culture - Where is the human being in the working world of the future?</u>

Ultimately, the crucial question is: what role should people play in the working world of the future? Following the guiding principle of the "responsible employee" a) become an essential actor in shaping it or b) should the design of the working world of tomorrow be enforced against people?
Empirical results show that a lack of employee participation very soon at least provokes their passive resistance. In view of the increasing complexity, companies are increasingly dependent on employees who are highly motivated and act independently and "in first person".

8. **<u>Plea for a new humanization of work</u>**

Companies are at a crossroads; a negative scenario is a digital assembly line that standardizes and devalues highly qualified work. If the design is to be central to setting the course in the companies, a positive guiding orientation is required. For this reason, there is a plea for a new humanization of work that builds on the opportunities of the information space and places people with their collective expertise and creative intelligence at the center of the upheaval.
Digitization needs people and their participation (Boes /Kämpf 2015).

9. <u>Vocational Education and training 4.0</u>

In the world of work, which is characterized by digitalization, education and qualification play a key role. The new quality of vocational education and training in the logic of Industry 4.0 is called "Vocational Education and Training 4.0" (IG Metall Kaßebaum/Ressel)
In this sense, "Vocational Education and Training 4.0" is even more of a programme than a finished concept.
In human-machine interaction, it leads to new requirements in interaction and cooperation, but also to new qualification requirements for the workforce.
The qualification requirements in the digitized world of work consist of the increasing importance of interdisciplinary competencies and work content such as active problem solving, IT skills, working in networked systems, mastery of complex work content, control of communication and the coordination of processes. In terms of education policy, the temptation to conclude from digitization that real production experiences are losing importance must be resisted.
With regard to the interdisciplinary qualifications considered necessary, such as the ability to work in a team, willingness to cooperate, reliability, mobility and willingness to learn, it can be stated that they are already "an integral part of metal and electrical professions (Ahrens/ Spöttl 2015).

7.7. Vocational Education and Training 4.0 as a compass for a future education concept

1. The relationship between experiential and scientific knowledge

As a result of digitalization, the relationship between experience and science orientation in professional action must be redefined. What is needed are scientific and professional skills. With science in the background, the duality of practice-oriented theory and reflected practice must be taken into account in training. (IG Metall) This approach plays a fundamental role, especially when it comes to integrating ethical aspects into technical knowledge transfer.

2. The importance of work and business process-oriented learning

A broad range of expertise, a high degree of social skills and a high degree of flexibility in dealing with work requirements describe the requirements for qualified work in the digital world of work. Vocational learning includes technical and social knowledge, the acquisition of the ability to act and the practical experience made possible in the learning process. Therefore, the learning situation along the value chain must be process- and problem-oriented.

3. Vocational learning aims at reflection and the design of work

In the real process, the digitization of the world of work will take place in many small and large steps. Employees are part of these processes. Therefore, the development of their design competence in various dimensions must be part of the professional learning processes beforehand. There must be no separation or an additive approach to reconcile technology and ethical aspects both in the learning location cooperation with the companies and in school learning situations.

4. Vocational learning is education

The discussion about possible and meaningful forms of work and employment in the digitalized world of work is overshadowed by far-reaching processes of economization of education, work and society. Vocational qualification is often reduced to adaptation qualification. Theconcept of vocationality always includes personal development. Vocational learning is social learning, it promotes and develops professional and social identity. What is needed are "holistic" educational processes that also enable reflection on professional, social, economic and societal experience. (IG Metall "Good Work" 2016)

The ethical aspects, which have been lacking so far, must be given much more prominence here, which includes more than the market-conforming concept of "employability". They must be an integral part of technology lessons and must not be seen as "appendages" in general education subjects. Team teaching of teachers of technology and general education (politics, social sciences) would be an organizational solution model.

7.8. Outlook, Conclusion

Christian Morgenstern (German poet, died 1914): " He who knows nothing of the goal will not find the way"

A plea for the consideration of **more people in the world of I 4.0**
The relationship between "man and machine" will be reshaped in "hybrid" systems, in which technology itself becomes an "actor" in areas. Whether digitized industrial work will drive the polarization of qualification requirements or whether it will become the basis of cooperative work depends crucially on how the organization of work and the interface between "man and machine system" are designed. Good work in a digitalized world of work can only mean that employees are capable of acting as planners and decision-makers of digital technologies and not as their appendages. The changes in the context of the advancing digitalization of work make work-oriented work more important than ever. Maintaining or enabling professional action in a digitalized world of work requires a broad education based on the principles of vocationality. Learning in the work process, interdisciplinary and critical thinking are becoming more important than ever in the course of increasingly complex work requirements. (IG Metall "Good Work 2016")
The impact on private life and society must not be ignored here. The future skilled workers must already be prepared for this during their training. However, exclusively technology-oriented teaching does not provide these necessities. In plain language: ethical aspects cannot be an appendage of "technology", but must be placed at the centre of all future education and training measures.
"The further development of a concept for vocational education and training 4.0 is an indispensable requirement." (IG Metall "Good Work")
If no ready-made concepts can be offered at present, sensitization of learners must be promoted as a minimum approach in future cooperation between learning venues. The examination of ethical aspects must become an integral part of technology lessons.
The evaluation of the key questions confirms the fears that ethical aspects have played no role at all so far.

<u>Key questions for group work (broken down by participating countries)</u>
1. Industry 4.0 is primarily related to technology. The emphasis on ethical aspects could initially obscure the view of technology. What do you think?
2. Are ethical aspects already dealt with in this context in the classroom at your school?
3. What experience do you have?
4. What has been a hindrance so far?
5. What would the lessons have to look like in order to adequately take ethical aspects into account?

<u>Evaluation of the key questions</u>

Unfortunately, the feedback so far has been modest or there has been no concreten. However, there were declarations of intent that these important aspects would have to be taken into account in future planning.

Trend results:

The emphasis on ethical aspects does not affect the view of technology. The technology must be understood, as it can be used to identify the ethical aspects. There is no concrete experience. However, there are ethics classes whose curriculum is largely unknown. Ethical aspects are dealt with in general education (geography, history and civic education), but not specifically with regard to I 4.0 or AI. There are no obstacles per se. There was no feedback on what a concrete lesson could look like. There were general answers such as "ethical aspects should/could be taken into account in some subjects in the curriculum (e. g. automation technology) In other technical subjects it makes no sense (e. g. in basic subjects, practical lessons).

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Appendix 1: Homepage GSD

App. 1.1: Project fair of the students of the further vocational education at the GSD

App. 1.2: Project fair of the vocational school. Awarding of the Rudolf-Loh prize

App. 1.3: Implemented learning site cooperation in the field of Industry 4.0

App. 1.1: Project fair of the students of the further vocational education at the GSD

Project fair of the students of the further vocational education at the GSD

The final semesters of the Electrical Engineering and General Mechanical Engineering departments at the further education and training have successfully completed their final projects. The annual project work forms an important component of the last phase of the advanced training program for state-certified technicians.

Over a period of eight months, the students have extensively engaged with specific technical problems. The collaboration with local companies has been a valuable experience for them as they can apply their acquired knowledge in practice and gain insight into the working environment of these companies. In turn, the companies benefit from the innovative ideas and solutions provided by the students.

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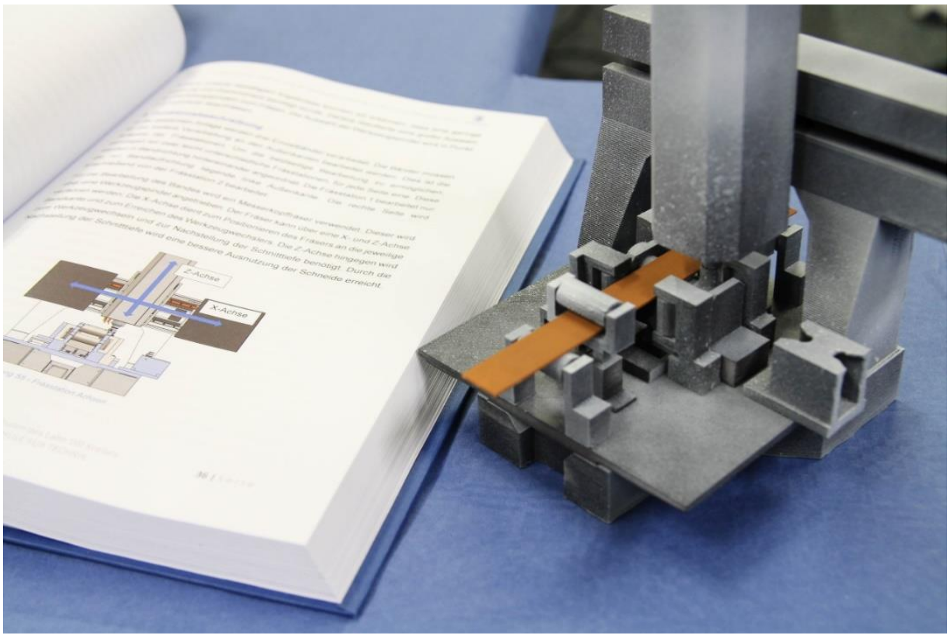
The graduates apply the competencies they have acquired in the further education and training and establish a vital link between theory and practice. Therefore, the motto of the project work is: "Away from the school desk and into practice!" The project work encompasses many activities that future technicians will encounter in their professional lives, which in turn greatly motivates the young technicians. Throughout the project phase, the students receive support and guidance from the respective companies as well as the teachers at the further education and training. Department head Burkhard Meuser and Deputy School Principal Burkhard Schneider expressed their gratitude to the aspiring technicians for their dedicated work and outstanding results in their welcome speeches. Behind the showcased 10 projects are 10 companies that have made these challenging tasks possible. The school administration extends its gratitude to the local companies as "this cooperation is very important for our school," according to Burkhard Schneider.

During the event, the industry was further represented by the jury of the Rudolf-Loh Prize. Led by Sebastian Loh, owner of Hailo, the jury's task was to identify a project that best meets the criteria for the award. The winning team will be recognized and honored during the Further education and training 's graduation ceremony.

The project topics this year were diverse and covered a wide range of themes. For instance, one team optimized the edge processing of a welding system for Isabellenhütte in Dillenburg, while another team designed a height-adjustable faucet for use in an aircraft kitchen on behalf of Safran in Herborn. Linde+Wiemann's challenge was to develop a testing device for T-Roc crash tubes for Volkswagen AG. Furthermore, a production model for the training workshop of Rittal was completely redesigned. The extension and automation of a test rig for vertical units of metal ultrasonic welding systems was a project assignment from Schunk, and Stahlo in Dillenburg tasked a team with modernizing and optimizing a packaging process. Two additional project themes involved bringing existing systems up to current technical standards. For Jung & Debus, a team focused on an edge processing machine, while Oculus in Wetzlar was concerned with a polishing compound system. Bretthauer Kunststofftechnik commissioned a group to design and build a special machine for inserting roller bearings, and Meyer GmbH benefited from the development of a semi-automated threading and countersinking machine. The expertise of the graduates was impressively demonstrated through the results achieved by the teams. The projects were challenging and required a high level of technical knowledge, creativity, and commitment. The aspiring technicians showed themselves to be true team players, putting their skills in service of project success.

The project fair held at the premises of the further education and training was a great success. In addition to many interested visitors from the participating companies and other semesters of the further education and training, many former graduates of the school also took the opportunity to view the projects of this year's final semesters. Throughout the event, numerous technical discussions and exchanges took place between students and visitors.

Future graduates of the further education and training in Dillenburg can trust that they will always be trained with the latest knowledge, thus maximizing their opportunities in the job market. This year's project fair was once again an impressive demonstration of the extensive diversity and high level of expertise at the further education and training at the Gewerbliche Schulen Dillenburg. If you need further information about the further education and training, Burkhard Meuser, as the responsible department head, and all the teaching staff are available to assist you.



App. 1.2: Project fair of the vocational school. Awarding of the Rudolf-Loh prize

Awarding of the Rudolf Loh Prize 2023

A special Industry 4.0 school project - Vocational school students at the Gewerbliche Schulen Dillenburg (GSD) develop and implement a sorting system

On November 11, 2022, an ambitious vocational school project was launched, which has now successfully concluded during the school's project fair. The jury of the Rudolf Loh Prize, consisting of representatives from the industry and teachers from the school, was present on this day to review the project work results. The Rudolf Loh Prize has been awarded to vocational school students and students from the Further education and training at the Gewerbliche Schulen for several years, rewarding their commitment to generating creative and technically competent solutions for technical tasks.

Students from the apprenticeships of IT specialists, industrial mechanics, and mechatronics were given the task by their teachers Benjamin Krau, Torsten Reh, and Stefan Göbel to develop and manufacture a sorting system for various materials. With a focus on the diverse tasks in the field of Industry 4.0, the project aimed in particular to promote targeted collaborative work in interdisciplinary teams. To achieve this, the project assignment was designed in such a way that the group members from different occupational fields relied on each other, and successful project implementation was only possible through close coordination. The teams met for project meetings during vocational school days or used digital exchanges. They quickly realized that active communication and leveraging the various competencies were essential for their collective success. The task was solved in line with the teachers' and industry's expectations. Therefore, Sebastian Loh, owner of Hailo, and the other members of the jury, training manager Matthias Hecker (Rittal), and Martin Gaubatz (Hailo), as well as Andreas Franz (GSD), praised the approach to successfully master the challenges posed by Industry 4.0.

The apprentices in the field of metal technology were responsible for designing and manufacturing brackets and fastening options for various system components such as sensors and pneumatic components. They also ensured a logical system layout and optimized the process flow by developing and producing suitable singulation and feeding elements. The apprentices in the mechatronics field planned and implemented the automated operation of the system, including selecting appropriate electronic components such as the system's sensors. The apprentices in the IT field took on the task of recording the production data generated by the system, such as the number of sorted parts, and visualizing it in a processed form.

The jury, along with the many visitors to the fair, including numerous representatives from training companies, were very impressed and honored the winning group by awarding them the Rudolf Loh Prize. The students were rightly proud of their work and delighted with this special recognition.

The vocational school project not only provided valuable experiences in their respective fields for the apprentices but also demonstrated the importance of jointly tackling tasks in interdisciplinary teams for successful work in the future world of work.

Getting the Rudolf-Loh-Prize from Sebastian Loh (center): Timo Cestonaro, Joel-Maximilian Ferber, Tim-Lukas Gahn, Samuel Jung, Adrian-Alexander Reszka, Justus-Jonas Schmidt, Finn-Niklas Schneider.
In the picture from the left: Jonas Dormagen (Headmaster GSD), Martin Gaubatz, Andreas Franz (GSD), Matthias Hecker 3rd from the right and on the right Burkhard Schneider (debuty headmaster GSD)

App. 1.3: Implemented learning site cooperation in the field of Industry 4.0

Teachers from Gewerbliche Schulen Dillenburg and employees of Friedhelm Loh Group engage in joint professional development

For the past year, the Cyber-Physical Factory, also known as the Learning Factory 4.0, has been in operation at Gewerbliche Schulen Dillenburg (GSD). GSD is currently the only vocational school in Hesse, Germany, equipped with such innovative facilities. The installation of the facility was made possible through financial support from Friedhelm Loh Group, Lahn-Dill-Kreis, and the association supporting the vocational schools in Dillenburg. Apprentices and students from the further education and training learn the basics of digital manufacturing and Industry 4.0 principles through programming exercises on the facility.

In the previous school year, GSD teachers became familiar with the facility and effectively integrated it into their teaching. However, specific questions arose regarding the utilization of the facility in instructional applications, highlighting the need for a training program to deepen their understanding. Mr. Norbert Szabo, an employee of Festo Didactic, had previously conducted the commissioning and training for the teachers a year ago and was once again engaged as a trainer for this purpose.

The training program was attended by Andreas Franz, Torsten Reh, Meinolf Tegethoff, and Benjamin Krau from the Industry 4.0 team at the school, as well as Robin Nadler, Production Team

Leader, Marc Weitzel, Trainer, and Kevin Grahn, System Maintenance Technician and dual-degree student, from Friedhelm Loh Group.

In collaboration with Friedhelm Loh Group and Loh Academy, the complex topic of Industry 4.0 will be taught using the Learning Factory 4.0, providing skilled workers and middle-level managers with the opportunity to acquire the Industry 4.0 competencies demanded by companies. With the same objective in mind, the school and the IHK-Lahn-Dill will offer further training modules for skilled workers in the fields of metal technology and electrical engineering.

Udo Bretthauer, Chairman of the association supporting the vocational schools, Ina Lecher, HR Developer, Matthias Hecker, Training Manager (both from Friedhelm Loh Group), and Udo Wiesner, Technical Consultant for Learning Systems at Festo Didactic, visited the training session alongside Burkhard Schneider, Head of the Industry 4.0 Department at GSD, to assess the progress of the teachers and industry employees. Mr. Bretthauer emphasized the importance of cooperation between companies and vocational schools in order to jointly tackle the challenges of digitalization and Industry 4.0. He highlighted that this training program serves as a great example of lived collaboration between educational institutions and industry.

Image 9: Teachers from Gewerbliche Schulen and employees of Friedhelm Loh Group engage in joint professional development at the Learning Factory.