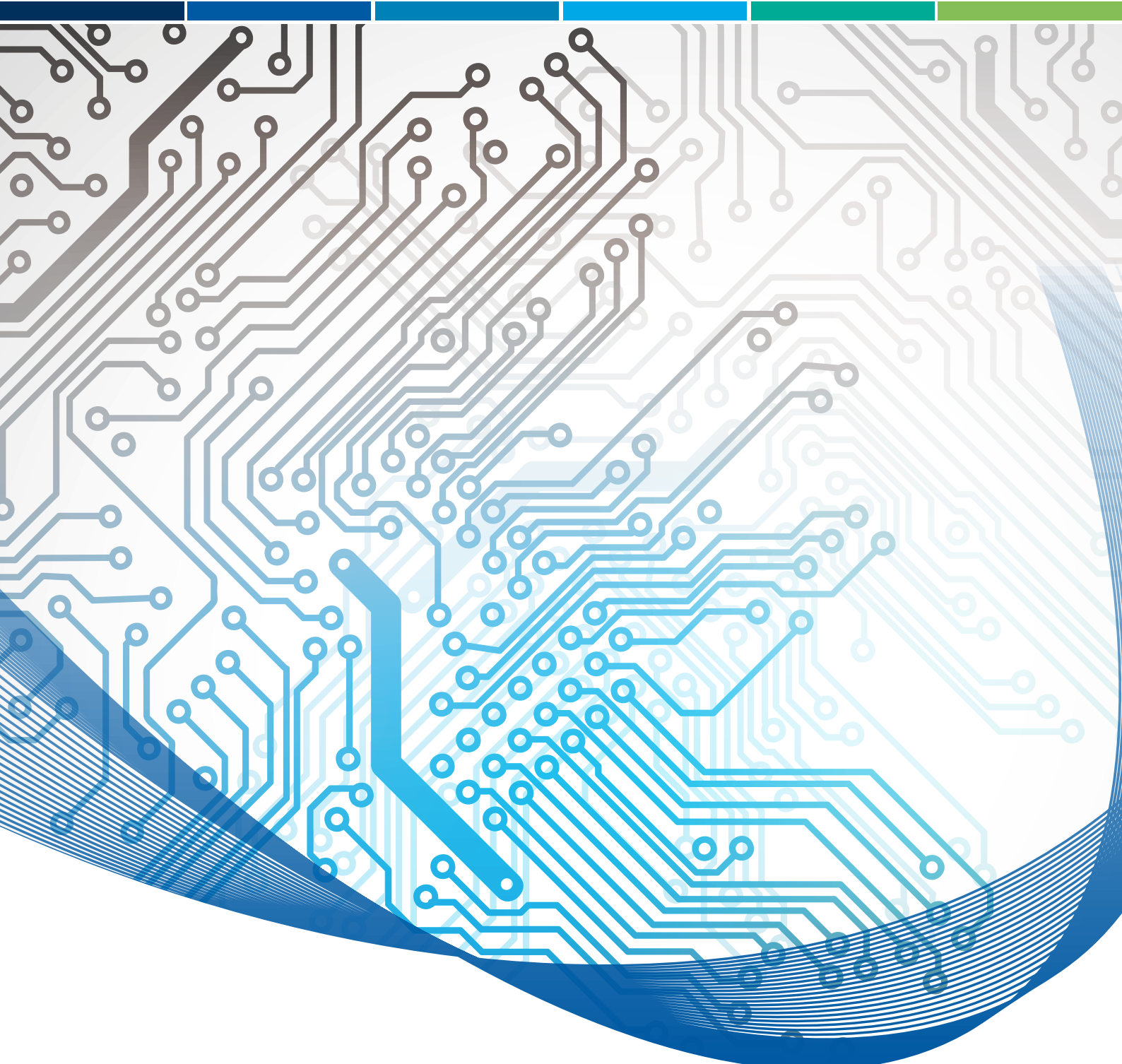




Internationalisation of Vocational Education and Training: Digitalisation

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Greeting

Dear Readers,

Digitalisation is changing our work environment. As a result, the demands being made on initial and further training are also changing. The German dual system, with its combination of schooling and in-company training, is viewed as a successful model. Professional competencies, enhanced by digitalisation, are imparted at both learning venues.

This means that the trainees and training companies, in particular, are the primary bearers of the new, vocational action competencies. The Federal Ministry of Education and Research (BMBF) is meeting the challenge of new forms of teaching and learning by means of digitalisation using the digital strategy "Digital Future: Learning.Research.Knowledge" to ensure that the German dual vocational education and training (VET) system will continue to maintain its exceptional quality in the future.

In accordance with the holistic approach of the digitalisation strategy, we believe that digitalisation will open up new opportunities in the employment market. The goal is to produce responsible and independent apprentices and trainees with digital and media competencies. The curricula will be expanded to include the necessary digital aspects of education. In addition to reading, writing and arithmetic, digital and IT skills are to become the fourth key skill in VET.

Since 2016, the umbrella initiative Vocational Education and Training 4.0 has consolidated the various activities of the BMBF in order to align dual VET with a digitised and networked economy. For example, in cooperation with industry, work places which are affected by digitalisation are analysed with regard to work processes, activities and qualification requirements. In addition, inter-company training centers and competence centers are being funded with the aim of supporting small and medium-sized companies, in particular, in the provision of digital in-company training.

International cooperation in the field of vocational education and training also benefits from this digital expertise in initial and further training that has been created in Germany. For example, partners in the BMBF-funded projects of the "Internationalisation of Vocational Education and Training" (IBB) are developing digitised learning programmes ranging from interactive videos to a virtual reality application.

The current volume of the Internationalisation of Vocational Education and Training series highlights the opportunities as well as the challenges of digitalisation in the field of international cooperation in VET. Best practices are presented in the practical experience-based reports, while the debate and research contributions encourage further discussions. This will contribute further to continuing the exchange between BMBF-funded projects and the interested expert community. I wish all our readers an inspiring read!



Susanne Burger

Director-General "European and International Cooperation in Education and Research"

Federal Ministry of Education and Research

Editorial

Hannes Barske, DLR Project Management Agency

All over the world, national vocational education and training (VET) systems and qualification activities of companies are under considerable pressure to be innovative owing to increased requirements in the employment market. The German dual system of vocational education and training has therefore attracted greater attention in recent years and now represents an important field of activity in international cooperation.

Digital transformation poses a tremendous challenge to VET systems, companies and employees. Thus non-academic occupational profiles have also changed drastically, resulting in new and demanding requirements for the qualification of skilled employees. The megatrend "digitalisation" is changing the way we think about vocational learning. This is true in at least four respects: (1) subject-related, with regard to the vocational skills that are intended to be the result of the learning process, as well as the traditional understanding of the roles of learners and teachers; (2) structural, with regard to the institutional and social embedding of learning processes; (3) methodological-didactic, with regard to the structure of teaching and learning processes, and, (4) economic, with regard to specific business models for the distribution of digital teaching and learning services.

VET is thus implementing a disruptive innovation process that has been in full swing in the work environment for some time. Despite current protectionist counter movements, digitalisation also reinforces another megatrend – globalisation. Digital applications are uncoupling individual links of value chains and supplier-customer relationships from their respective geographical location.

The vocational education and training of skilled employees has therefore acquired both an international and a digital dimension in many professions today. This is where it is important to try out new things and to cross borders not only between countries but also between the analogue and digital spheres. The funding initiative of the Federal Ministry of Education and Research (BMBF) for the internationalisation of VET offers an exciting field of experimentation in this connection.

Many projects show direct or indirect references to the digitalisation megatrend. We have documented these on the following pages. We have also reproduced contributions by the Association of German Chambers of Industry and Commerce (DIHK), the German Confederation of Skilled Crafts (ZDH) and the German Trade Union Confederation (DGB), since economic and social partners are strategic partners of the BMBF in the international VET cooperation. In this connection, we welcome the contribution of the German-Italian Chamber of Commerce (AHK) in Milan, which is being funded within the context of the new funding initiative "WiSoVET" for the integration of economic and social partners in the international VET cooperation. Contributions by "GOVET", the German Office for International Cooperation in Vocational Education and Training at the Federal Institute for Vocational Education and Training (BIBB), the IHK Bildungsakademie Magdeburg and the DLR Project Management Agency regarding the national debate on digitalisation in vocational education and continued training round off the specialist policy framework. We would like to thank all the authors for their time and for the creative, professional potential that has been released through their work!

The current volume is intended as a workshop report that provides a snapshot of a "work in progress". Its special feature lies in the diversity of perspectives, which originate from pedagogy, business economics, methodology and didactics, cultural studies, psychology and other fields of work and research disciplines. This publication is an initial attempt to explore the exciting link between internationalisation and digitalisation in the sphere of VET. This exploratory view has the potential to change our stance on international cooperation in VET and to adapt topics and subjects of cooperation. Whereas we previously acted as mission-conscious, economically powerful advisors and support partners grounded in tradition, we now see an opportunity to learn from others within the meaning of a "VET Cooperation 4.0" and to view the international cooperation and the international project itself as an opportunity to learn.

Contributions from practical experience

Virtually supported learning as a change agent in vocational education and training (VET) systems: Transformation of VET cultures in German-Greek cooperation in vocational education and training

Rüdiger Klatt and Silke Steinberg

Introduction

In dynamic markets, the transformational capacity of vocational learning is an important prerequisite for the success of VET systems at the national and international level. In addition to the necessity of continuously updating teaching and learning content to reflect the latest subject-specific developments, innovation management in the teaching and learning cultures in VET is an equally important aspect. The VET culture must continuously transform itself in keeping with the developmental trends of society as a whole in order to meet the needs of the markets, of apprentices and those undergoing further training, as well as of teachers and trainers. This is often a problem due to the "inertia" of education systems both in partner countries and in Germany. The pilot project "GRÆDUCATION – Research, development and testing of educational services to improve the training of environmental engineering professions in Greece" will be used as an example to show how the trend towards digitalisation can initiate necessary transformations in international VET cultures. It will be shown how common transcultural transformation processes of different national VET systems can be motivated and how they can support the launch of innovation engines in the VET culture and help to pursue common challenges, such as raising climate protection awareness within the context of the project.

In the GRÆDUCATION project, an interdisciplinary Greek-German team is co-creatively generating modernisation impulses for the VET systems in Greece and Germany. On the one hand, existing technical professions are to be expanded with green skills and interdisciplinary training elements with regard to sustainability and modern professionalism. On the other hand, the objective is to develop a conceptual approach to career choice orientation in Greece, with the aim of making green, technical vocational education more attractive, especially for young people. Important steps have already been implemented in both fields of action and developments have been initiated. Greek and German stakeholders

are jointly driving this development forward in working groups, with a view to also closing innovation gaps that exist in both countries in the field of vocational training. In this process, the use of virtual reality (VR) is an approach that can initially solve many implementation problems in the project on a practical level and it has therefore developed into a focal point of the joint discussion. It has also become clear that the use of virtual support tools releases potentials that initiate a process in which the parameters of vocational training can be redefined.

The implementation-related advantages of virtual applications for teaching and learning processes in vocational training have been described many times (Blümel et al. 2010; Goertz 2018a; Fell 2018). Both fields of action in the project already contain concrete scenarios in which VR applications could be integrated into existing didactic concepts in order to optimise the implementation of learning objectives. In order to further exploit the use of new digital tools as a driving force for innovation for Greek-German cooperation in the field of vocational education and training, it is necessary to reflect on how VR influences our perceptual processes, our access to the world, and the structure of social systems.

This article focuses on the transformation potential of VR for teaching and learning cultures, and also for professional cultures. For this purpose, a jointly developed theoretical approach is first of all presented. In a second step, the pragmatic problem-solving approaches in which VR applications can support practical implementation in the project are explained.

VR as a change agent in the culture of vocational education and training

The hypothesis that emerged in the GRÆDUCATION project during the discussion of implementation scenarios is that the use of VR applications, in addition to the

pragmatic, implementation-oriented aspects, can also contribute to the transformation of teaching and learning approaches in which the applications are embedded and to the innovation of VET cultures and systems.

To support this hypothesis, a theoretical approach was developed in the project discourse. The objective was to define how virtual reality relates to analogue reality and then to analyse the added value provided by VR for our cognitive processes and our representation of objects, correlations and situations.

The French philosopher and media theorist Pierre Lévy considers virtualisation to be a process in which the individuals shape themselves and their access to the world.

"Virtualisation... illustrates a contemporary trend, in the sense of a much more general (meaning) of the virtual... In fact, our species... has been formed in and by virtualisation. The contemporary meaning (of virtual reality) can be interpreted as a new outward form of humanity's self-creation." (Lévy 1998, 27, translated by the authors)¹

In this context, Lévy describes the development of languages, the proliferation of technology, as well as the increasing complexity of institutions, as former virtualisations with which the individuals try to continually increase their cognitive abilities and transfer these into new dimensions. Using language as an example, he shows that it is only through verbalisation that we are able to go beyond the present and grasp the past and the future. By means of virtualisation, the individual enables himself to create increasingly complex representations of the world and thereby creates new realities. Digitally generated reality is another virtualisation for this purpose. In this case, virtualisation is not a simple reproduction of *"analogue"* reality, but a mode that goes far beyond it, opening up creative possibilities that enhance the mind of the individual and increase his cognitive abilities. According to Lévy, virtualisation always means an extension of reality. In the virtual, digitally generated reality, things that were previously denied us in the world of analogue experience become possible. Thus, for example, it becomes possible to create three-dimensional drawings in space, things can be viewed simultaneously from the inside, outside and from different perspectives, the human body can

be experienced from the inside, and we can do things that exceed our actual abilities. By means of our actions in virtual reality, the brain, body and virtual environment are brought into a relationship with each other and they determine the cognitive process via an interaction. Virtual reality becomes an instrument that extends our cognitive abilities and transfers them into a new dimension, the *"extended mind"* (Clark and Chalmers 1998).

The perspective of modern cognitive science underlines the aspect that reality is created through cognition. The object of cognition is created by the cognitive process itself. Reality and knowledge are thus always dependent on the instruments of perception and do not exist independently of them. The constructivist embodiment approach of Francisco Varela in particular ascribes this active and creative role to cognition.

"Perception is seen as an active process of hypothesis formation, not as the simple mirroring of a pre-given environment." (Varela et al. 1993, 136)²

In this perspective, knowledge becomes an agile process and a continuous development that is grounded in our ability to understand and is shaped flexibly by the contexts in which it takes place.

".... knower and known, mind and world, stand in relation to each other through mutual specification or dependent coorigination." (ibid., 150)³

For learning and teaching processes, these aspects of cognitive science and the definition of virtuality as an extended or autonomous form of reality give rise to new dimensions and references that have a transformative effect on learning and teaching cultures. Virtual reality as an instrument of our cognition can thus be defined as a change agent in the VET culture.

In this process, VR becomes a fundamental learning venue where professional context is infused in a way that is not possible either at school or in the work place. Students and teachers have new roles and are engaged in a dialogue process with equal rights at this learning venue. They become co-producers of knowledge, develop it further on an equal footing and create content via their

different perspectives, backgrounds and experiences. In this way, contents become agile processes that are constantly renewed and constituted by learners and teachers in the interactive system. This makes it possible to incorporate social, material and technological changes into the professional contexts and environment of the learner. The complexity and volatility of modern markets and work environments are also included.

The learners are trained to develop key skills such as creativity, problem-solving skills, flexibility and innovative ability, in addition to innovative professional skills. The teacher supports this development and both achieve autonomy and behave as equals (see also Große and Steinberg in this publication).

Together, they create innovative content and they constitute and test new methods and learning environments. The virtual experiences are jointly related to the analogous, professional situation and developed further.

On the basis of discussions with Greek and German vocational pedagogues, it became clear that through the extended empirical world in virtual reality in the professional context, problems can be anticipated and co-creative solutions can be jointly constituted and tested. Integrating students into the creative process increases the learning effect and also changes the problem-solving approach. Greek and German lecturers agreed that the co-creative relationship between teaching staff and students in VR can intensify a trend that increases the attractiveness and efficiency of vocational school teaching.

Scenarios for the use of VR applications in the GRÆDUCATION project

Professional activities in the field of renewable energies and sustainable construction, which are a particular focus of the project, require that the skilled employees have technical skills that go far beyond the range of technical skills taught and learnt in traditional job profiles in this field. Innovative technologies that have developed during the last decades have great potential for climate protection. In order to ensure that these technologies can be used optimally, it is important to train skilled employees in these new technologies not only at universities but also in vocational training. There is an enormous need for qualification both at the level of vocational training personnel and at the level of those undergoing initial and continued training. Teaching staff and students must be able to comprehend the complex technological processes that constitute, for example, modern refrigeration systems, air conditioning systems, photovoltaic systems

or IT-supported smart home systems. Modern machines often resemble Black Boxes and offer no insight into how they work. VR applications that simulate such machines so that they can be experienced and accessed from all sides support the learning objective of understanding their processes. The learners can view the machine from the inside, label and colour it and make it their own, as it were. The horizon of their experience is broadened by the virtual version of the machine, enabling them to deepen their understanding of it and improve the way it is used. Different settings and circuits (e.g., with regard to building or plant automation) can be tested virtually without any problems so that optimal solutions can be defined.

Another didactic implementation problem that frequently arises in the area of green skills is training for hazardous situations. Repairing a wind turbine, for example, can pose difficulties for trainees due to the height. It is easy to train virtually for this situation. Even work processes that involve sensomotoric requirements can be learned better with VR-supported training.

In addition, VR offers a potential solution for the problem of lack of infrastructure in schools and companies, which is a recurrent problem that we encounter in GRÆDUCATION. It would be easier for schools in Greece to initially use specific technical infrastructure virtually for training purposes because purchasing the machines and equipment would be too expensive for the schools and also for the local companies which are mostly medium-sized companies. Trainees would thus be given the opportunity to train on the latest technologies. Many machines already have 3D models and CAD files and can therefore be integrated into VR applications at a low cost. This is also an attractive problem-solving approach for German training providers, such as the Education Centre of the Münster Chamber of Crafts, which is the cooperation partner in the GRÆDUCATION project.

In the field of vocational orientation, the *"Unique Selling Points"* (Goertz 2018) of VR applications are even more obvious: Students can experience and gain expertise about professional worlds that would otherwise be inaccessible to them. They can test hazardous situations without risk and explore their technical abilities without the possibility of damaging anything. The immersion aspect offers an intensity of experience that is particularly exciting for young people. Since they are familiar with related technologies from the gaming sector, vocational education becomes more attractive. VR applications in professional orientation offer authentic expertise in worlds of experience that are otherwise difficult to access and attach a *"hip"* attraction to vocational training.

1 "La virtualisation illustre un mouvement contemporain vers le virtuel beaucoup plus general. En effet notre espèce ... s'est constituée dans et par la virtualization. Dès lors la mutation contemporaine peut s'interpréter comme une reprise de l'autocréation de l'humanité."

2 "Perception is seen as an active process of hypothesis formation, not as the simple mirroring of a pre-given environment."

3 ".... knower and known, mind and world, stand in relation to each other through mutual specification or dependent coorigination." (ibid., 150)

Applications that can and should be used in the project have already been developed in recent years, particularly in the area of green skills. A focus on this aspect is planned in the second project phase.

Conclusion

Reflecting on how virtual applications can be integrated into innovative didactic approaches of VET sensitises us to the transformation potential of VR for VET cultures. The exchange between German and Greek vocational pedagogues reveals how old paradigms are already being broken down within this area of reflection and how new areas of development are becoming visible. Moreover, in the area of green skills and climate protection, in particular, there are many conceivable implementation options that support greater sensitisation and commitment to climate protection-related issues in vocational training. The German-Greek cooperation project shows that international cooperation in VET can lead to a joint

approach with regard to climate protection and to a common, sustainability-oriented VET culture.

In this context, digitalisation offers great potential for transnational transformation movements in VET cultures. These movements merge in the course of transformation and break down and redefine existing paradigms within and between the systems (claims of superiority and expectations between teaching staff and students, as well as between the different systems, are abandoned). To achieve this, digital applications, their potential, and their use must be discussed in a targeted manner. The implications of digital innovations for socio-cultural contexts (agile content, knowledge as a process, changes in social systems) must be defined and implemented in our living environments. International cooperation and co-creative discussion on the integration of digital tools show that co-creative networks have the potential to shape sustainable and future-oriented VET cultures and that transformations and innovations are not triggered exclusively by markets. ■

Use of interactive videos to develop the work process orientation in initial and further training – Findings from the KoLeArn project

Tim Weinert, Andreas Janson, Marian Thiel de Gafenco, Ute Urbon, René Wegener and Carsten Mauritz

Introduction

Videos are being used to an increasing extent to impart knowledge and skills. Around 73 percent of young people under the age of 19 in Germany use educational videos on platforms such as YouTube for learning purposes (Rat für kulturelle Bildung 2019, 8). Videos are used as part of formal, non-formal and informal educational processes as well as in vocational education and training. However, educational videos are often not adapted to the context of learners in companies and this can result in the demotivation of employees (Guo et al. 2014, 42). In view of the enormous potential of educational videos, KoLeArn⁴ is geared towards context-sensitive

allocation and development of interactive educational videos. Context-sensitive distribution is particularly important in the target country of China, since in-company qualification processes generally do not take into account the previous experiences and background of personnel (Li et al. 2019, 7).

We follow a four-step procedure to create educational videos in the context of KoLeArn.

In the **first step**, we qualify employees for the creation of educational videos, and vocational education and training personnel (VET personnel) for the designing of educational materials and videos.

In the **second step**, we use intelligent algorithms such as text mining and machine learning approaches which have been developed in the consortium via smarTransfer. The skills and knowledge (SaK) that are necessary for a work process are automatically derived from the documentation available in the company.

In the **third step**, educational videos and other micro-learning videos are developed independently by the employees, based on the SaK necessary for the work process.

In the **fourth step**, educational videos are designed by VET personnel using, for example, the h5p⁵ framework for interactive videos. Figure 1 provides an overview of the process.

⁵ <https://h5p.org/>, last accessed on: 26.06.2019

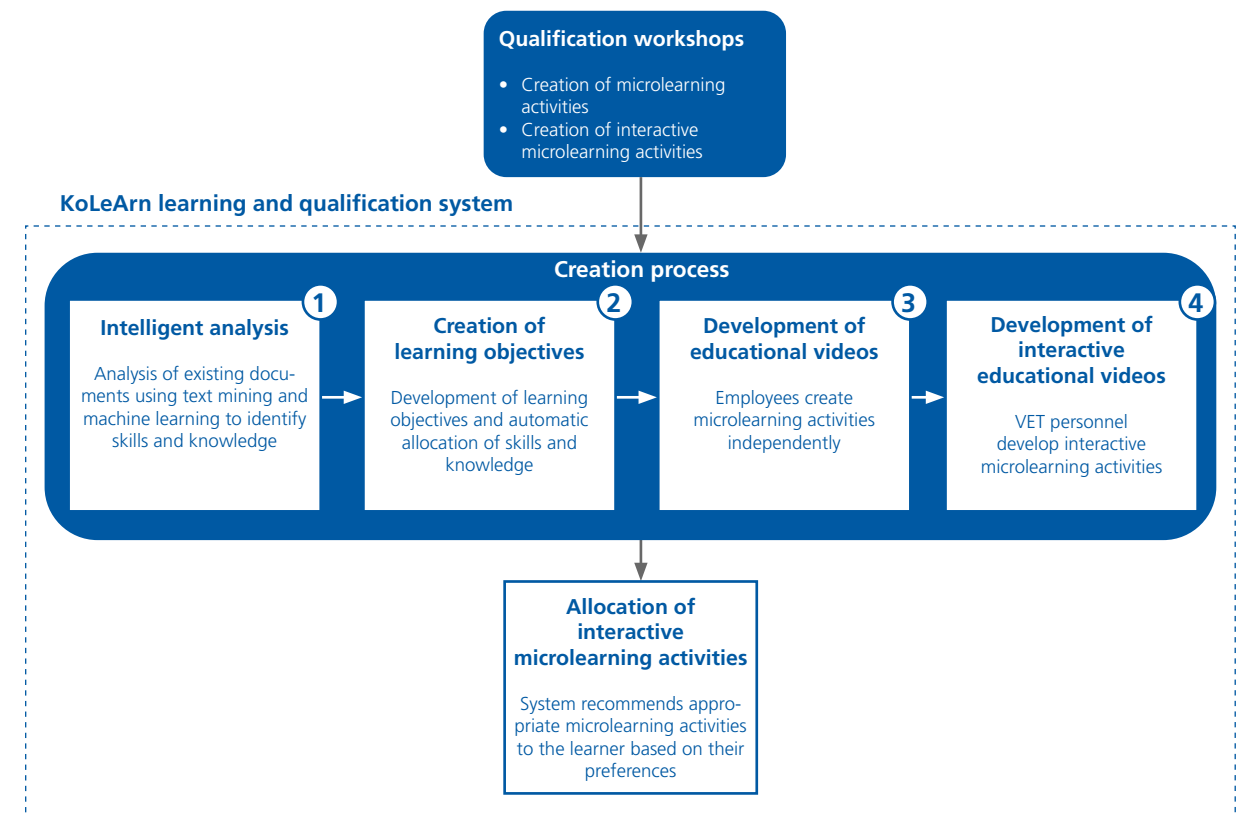


Figure 1: Illustration of the KoLeArn process

⁴ Context-sensitive learning services in the work process of smart industrial manufacturing – Systematic development and pilot phase using China as an example

The KoLeArn process supports the VET personnel in the creation of interactive educational videos that are linked to the different SaK of the learners. Interactive educational videos are created after analysing the learning material, the learning objectives and the SaK of the learners. The intelligent system here supports

the creation process of interactive educational videos on a number of levels.

(a) It identifies the necessary SaK for a work process on the basis of existing documentation (e.g., process descriptions). The system simultaneously analyses

documentation about subsequent users (e.g., CVs) to derive the existing SaK of the users.

(b) It provides feedback during the formulation of learning objectives, since the relevant employees often do not have any didactic education (ibid., 6).

(c) It supports the employees during the creation of educational videos via an introductory tutorial that demonstrates how educational videos should be designed. At the same time, it also provides the VET personnel with a tutorial on how an educational video can be enhanced using interactive elements. The videos are designed on the basis of the collected contextual factors so that the experience of the users can be taken into account. Once the interactive educational videos have been created, the system analyses the employees' current SaK stored in the system and recommends educational videos to them which correspond to their level of knowledge.

The further development of educational videos into interactive educational videos has a great influence on the narrative flow of the learning process. The elements enable learners to influence the course of the learning process (Roth and Koenitz 2019, 249). This allows learners to actively participate in their learning process.

Figure 2 shows an example of a learning process with educational videos, with and without interactive learning elements.

and work processes is important so as to ensure that context-sensitive educational videos are recommended to the learners on the learning platform. Analysis of the documentation also facilitates the subsequent development of interactive learning elements in the video. As shown in Figure 2, a reference to the respective training material or process description can be inserted in the video.

(2) Simultaneously, the learners themselves are also examined more closely during the development of interactive educational videos. Heterogeneous groups with different SaK make it difficult to allocate the educational videos appropriately. For this reason, the previous knowledge of the learners is determined on the underlying learning platform using a two-step process (Tsai and Choum 2002, 157). At the same time, the existing and required SaK of the employees is also identified by means of intelligent analysis of the documentation. In this process, the analysis methods developed for the evaluation of company documentation are used. Thus, on the one hand, we enable more appropriate video recommendations for the learners on the learning platform and, on the other, we enable targeted creation of interactive educational videos for specific groups. The knowledge level of the employees is assigned to one of three knowledge groups (beginner, experienced, expert) based on their SaK.

By using interactive elements, the same educational video can be used for learners with different knowledge levels. This considerably reduces the effort involved in creating videos for different user groups. Figure 3 shows the process for the three user groups mentioned above.

This individual consideration of the learners' prior knowledge can reduce the cognitive load (CL) for the learners when using the interactive educational videos. Here, we use the Cognitive Load Theory as a framework for designing interactive educational videos (van Merriënboer and Sweller 2005, 150). In particular, we use game-based elements to draw attention to important aspects of the learning process (Schöbel and Janson 2018, 1). To design the gamification elements, we use the h5p framework to insert gamification mechanisms such as leaderboards or badges and to make learning processes visible, and also to guide self-directed learning processes automatically using avatars (Schneider et al. 2018).

Contribution and exploitation

By integrating intelligent algorithms for the analysis of existing documentation and by supporting employees in the creation process, the development of interactive

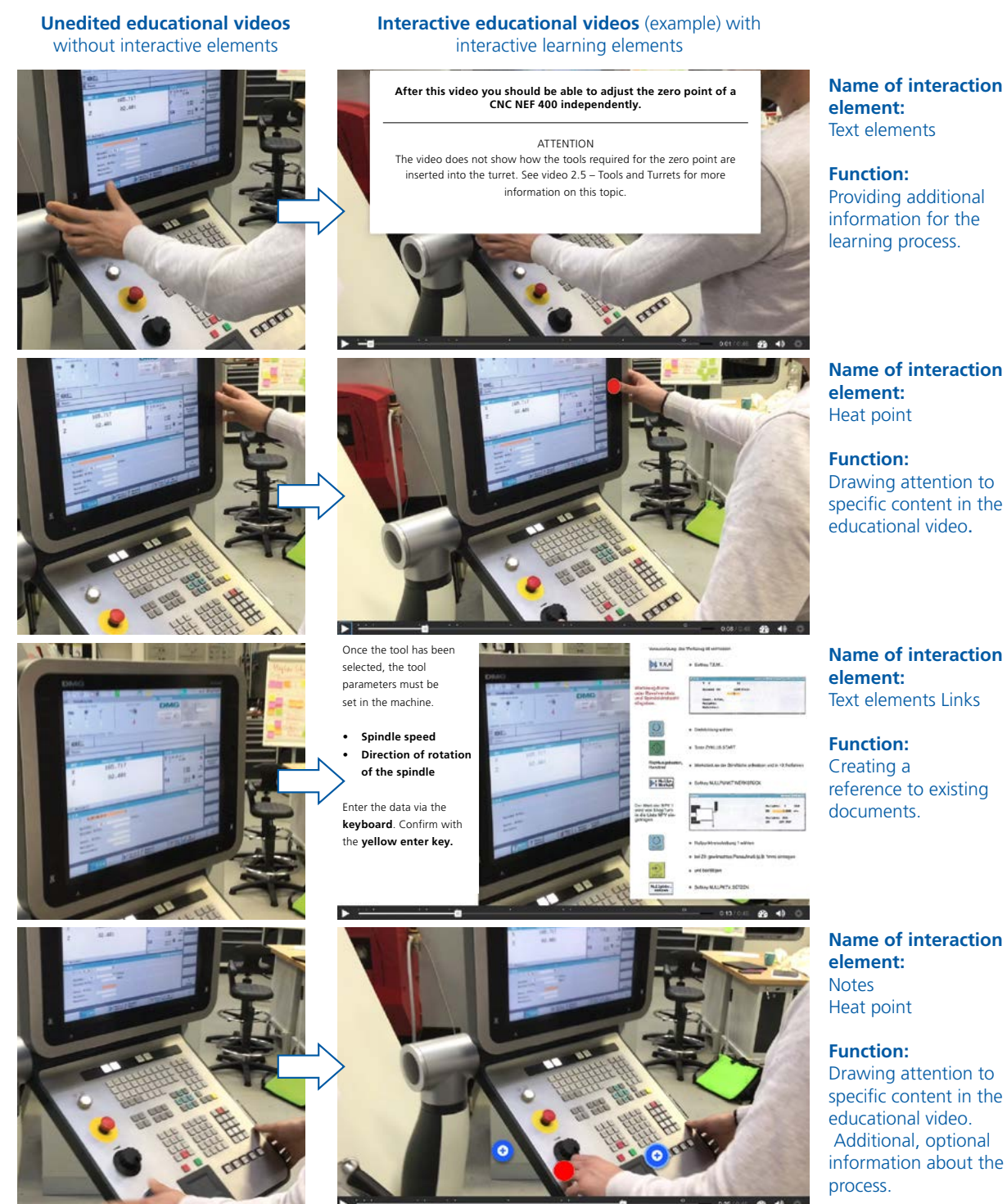


Figure 2: Illustration of the learning process with educational video

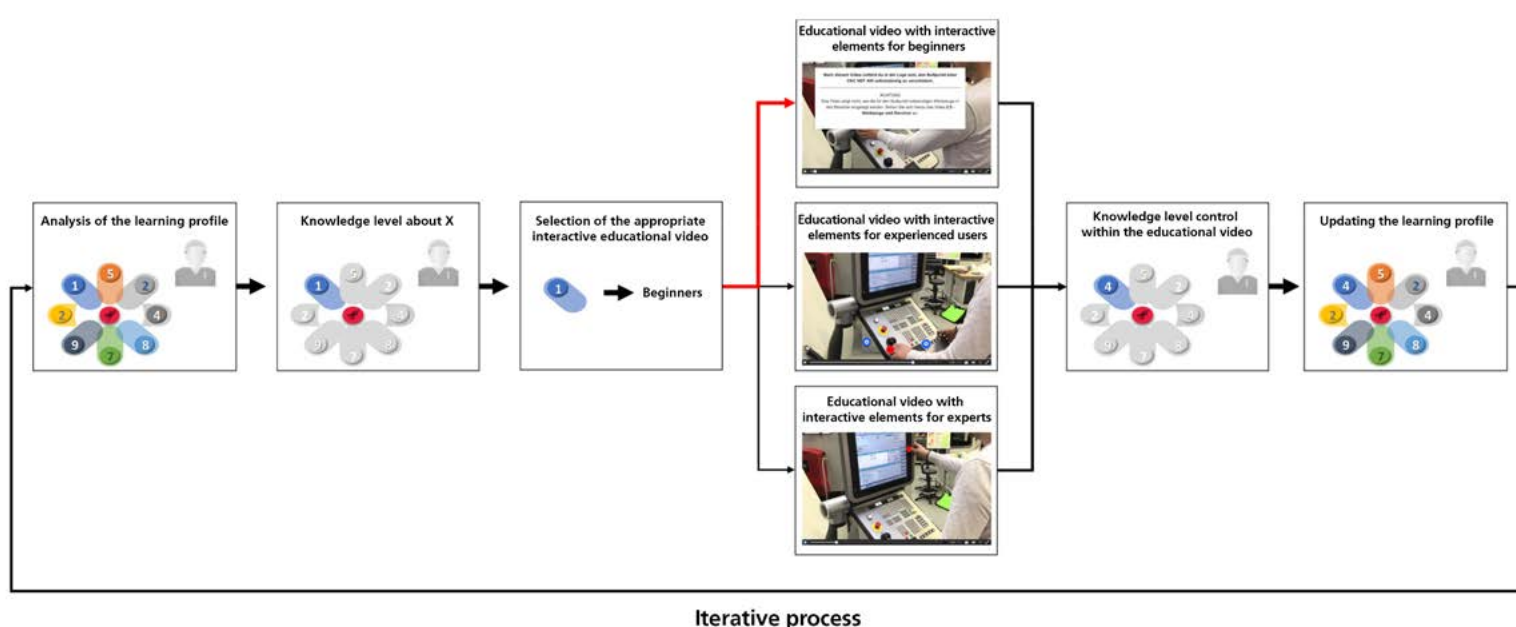


Figure 3: Selection process for interactive educational video

educational videos in education and continued training is significantly simplified. This represents a competitive advantage in the utilization of results for educational service providers who also wish to use educational videos in VET. At the same time, the use of interactive elements allows the educational videos to be adapted to the individual learning level of the employees, which is particularly important in target countries such as China,

so as to meet the rapidly changing requirements of VET in a practical manner. The necessity of filming several educational videos about the same work process for different user groups (beginner/experienced/expert) can be avoided in this way. This is especially advantageous when the educational videos are used in coordinated processes that are difficult to interrupt to film an educational video. ■

From the pressure for industrial innovation to a demand-oriented qualification landscape in Italy

Katrin Helber

In today's global economy, education and knowledge are becoming increasingly critical success factors for economic growth, competitiveness, employability and innovation. Ever-increasing digitalisation and the associated networking of machines, individuals and products, as well as comprehensive data collection and analysis, and applications with artificial intelligence, create new perspectives for employees and also pose numerous challenges in the field of education and further training. The socio-technical link consequently leads to a structural change in the economy, which gives rise to innovative business models and requires new skills from employees. Industry 4.0 is increasingly eliminating traditional

functions in companies and the scope of responsibility of employees is expanding. This means that the expertise of employees alone will no longer be sufficient to manage technological complexity in the future. Instead, new skill profiles that also include interdisciplinary and social skills will become necessary. Current surveys reveal that Italy, in particular, as the second-largest industrial nation in Europe, will be able to fully exploit the potential of digitalisation and withstand international pressure for innovation only if there is rapid development in skilled labour qualification and vocational training (see Destatis 2019b; BMWi [Federal Ministry for Economic Affairs and Energy] 2007; AHK and Ipsos 2019).

The economic ties between the partner countries of Germany and Italy are tightly interwoven. The Federal Ministry of Education and Research (BMBF) is funding the digITALIA project in Italy within the framework of a bilateral cooperation that has existed since 2012 in the field of education. The project aims at providing compatible qualification programmes to counteract the disruptive change brought about by digitalisation. It is being implemented by the German-Italian Chamber of Commerce (AHK Italien).

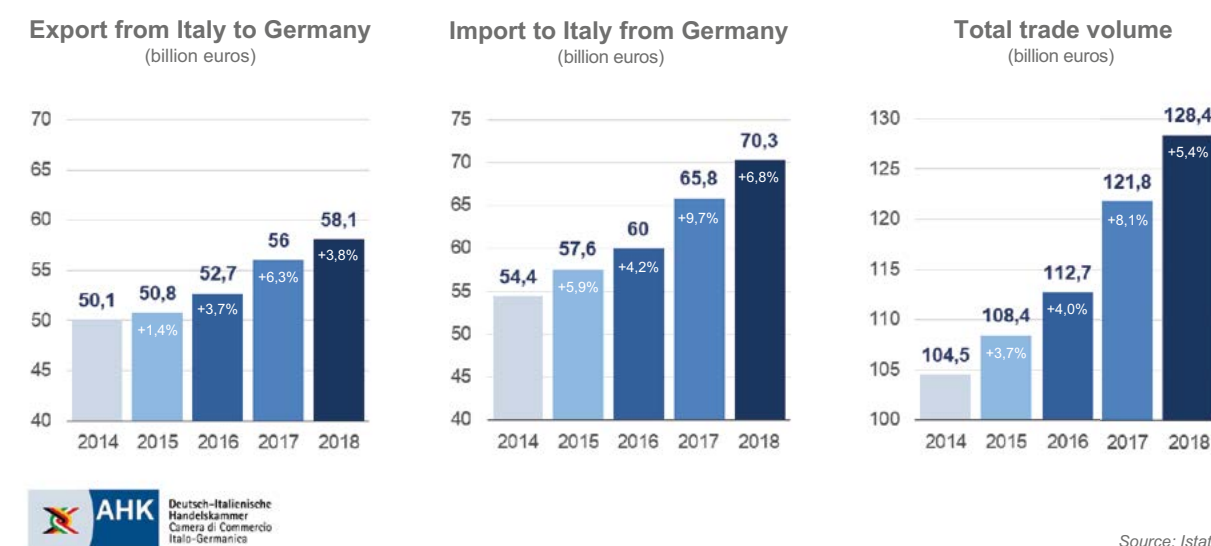
The two-year project was launched in November 2018 and, together with German and Italian partners, aims at developing a demand-oriented qualification landscape for Italy in the key sectors of Industry 4.0, and deflecting transfer options to France. The focus of this project is on the profile "Mechatronics IoT" (Internet of Things),

which will be a bottleneck qualification in the Italian employment market with its predicted shortage of 280,000 skilled employees in the next five years, as determined by Confindustria, Italy's largest employers' association, in its study conducted in 2018 (see Del Frate 2018). But why exactly is Italy's industry under such enormous pressure to innovate and to what extent does digITALIA help to counteract this? To answer this question, it is worth taking a look first and foremost at the German-Italian economic relationship and the education system.

The German-Italian trade partnership is very strong, as was recently demonstrated once again by the historic record achieved in 2018 with a trade volume of over 128.4 billion euros between the two countries, making Italy the fifth most important trading partner for Germany.

Trade record between Italy & Germany

In 2018 the trade record was further extended to over € 128 billion.



The value chains of Germany and Italy are very closely interlinked in the areas of automotive construction, mechanical engineering, chemicals and pharmaceuticals, the electrical industry, as well as metal processing and steel. In 2018, around 52.4 percent of Italian exports to Germany flowed into the five industrial sectors mentioned above, whereas the figure was around 68 percent in the other direction (see Destatis 2019a). This means that Italian and German industries have a high degree of compatibility and, by means of close cooperation and further development in the area of Industry 4.0, (have

the ability to) synergistically advance Europe's economic upswing and jointly shape their industrial future. Due to this strong industrial cooperation between the two countries, it is vitally important for Germany to ensure that Italy has access to a range of education and further training programmes that are geared to the needs of the economy. Well-trained technical specialists will pave the way for the further exports of German goods, facilitate business relations for German and Italian companies and thus secure Europe's competitive edge.

The transition phases in Italy between school and occupation are comparatively longer than average (OECD 2018, 74). This is also reflected in the current youth unemployment rate of 31.4 percent (by comparison, Germany: 5.3 percent; EU: 14.2 percent; see Urmersbach 2019). Despite this high level of youth unemployment, companies are currently unable to find a sufficient number of qualified skilled employees in the employment market, particularly in the technical field (STEM). This situation will be exacerbated in the future due to the demographic change, as the declining birth rate means that the number of skilled employees in Italy will steadily decline (see Del Frate 2018; see Urmersbach 2018). The bipolarity between youth unemployment and a general shortage of skilled employees suggests a clear skills mismatch between the school education system and the requirements of the employment market (see Altagamma 2019, 23-24). The disharmony is also evident in an OECD analysis which shows that 22 per cent of Italian workers are underqualified and 13 per cent overqualified and therefore unable to find suitable jobs (in comparison with Germany: 11 per cent underqualified and 23 per cent overqualified; see OECD 2018). In addition, STEM education and study programmes appear to be less attractive for young people and their parents in Italy. Fewer than a quarter of Italians currently have a degree in the STEM field, which means that Italy's performance is very poor in comparison with other EU countries and it ranks even below the OECD average (see *ibid.*). The

shortage of competent junior staff in the technical field harbours the great danger of crucially impairing the production capacity of companies and thereby creating long-term competitive disadvantages for Italy as a business location, and ultimately for the EU. Dual education models, which are offered via *apprendistato I or III livello* (Italian apprenticeship contract) and, in particular, the programme offered by technical colleges (ITS – *Istituti Tecnici Superiori*) with an application-oriented focus, are significant developments that have already taken place in recent years. Due to the small number of ITS, and the fact that their programmes have not yet been standardised, the positive effects on the employment market have unfortunately been sporadic until now.

This urgency prompted the digITALIA project to set itself the goal of developing a qualification landscape based on existing approaches and oriented to the needs of the industry with a focus on the occupational profile "Mechatronics IoT". At the start of the project, 120 companies in Italy were surveyed on skills and vocational education and training 4.0. The results of the survey, which was carried out by AHK Italien in cooperation with Ipsos and ALDAI-Federmanager in January 2019, were then presented at a symposium on the subject "Pressure for industrial innovation – demand-oriented forms of education and further training", and discussed with representatives from the business and political field. The survey showed that although knowledge about Industry

4.0 is widespread in Italian companies, it appears to be lacking in detail, since only one in ten companies stated that they had in-depth knowledge of the subject. Only 5 out of 10 companies already apply Industry 4.0 within this framework, which indicates some difficulties in its implementation. According to the survey, 46 percent of the companies state a lack of specific skills as the main obstacle to implementation, followed by resistance to change (39 percent), which limits the potential benefits of Industry 4.0.

The majority of the companies also believe that their own employees are not well-prepared to face the challenges of Industry 4.0, which indicates a clear need for specific advanced and further training. In response to the question regarding skills needed to meet the challenges posed by Industry 4.0, the companies listed different specialist skills for different occupational groups, which suggests a very hierarchical structure of the companies. Therefore, soft skills, such as problem solving, creative thinking and client-oriented thinking are the most sought-after skills, but are often exclusively related to management, although, according to the philosophy of Industry 4.0, these skills ought to play an important role in each occupational group in addition to specific professional skills. Younger candidates, in particular, are more likely to possess such skills, but are not always considered due to their lower position in the organisation (see AHK and Ipsos 2019).

Based on the results of this survey and impulses from the symposium, the digITALIA project is now developing a qualification programme aided by intensive dialogue between industry and educational institutions. This qualification programme has a modular structure and covers both initial training as well as advanced and further training (upskilling). Various qualification modules are intended to impart not only technical knowledge and skills to participants but also the soft skills identified in the survey, such as problem-solving skills and creative as well as customer-oriented thinking. These skills are to be imparted in a practice-oriented manner across all areas and levels of the company. The pilot phase of the initial modules is scheduled to start from October 2019 in several regions of Italy. Transferability to other occupational profiles and other countries will also be examined during the further course of the project. In addition to developing a compatible, demand-oriented qualification programme for Italy, the digITALIA project also pursues the goal of providing impulses and recommendations for action for industry-synchronised, international education concepts in order to successfully help shape the pressure for innovation in Europe caused by Industry 4.0, especially in the triad of Germany, Italy and France. ■

Obstacles to the implementation of Industry 4.0



Innovative methods for the transfer of practical knowledge using modern mixed-reality technologies in further vocational training – IHK training formats point the way to the future

Christian Jahr

An important aspect in the area of IHK further vocational training is the practical relevance of the training. The aim is to qualify participants for practical work on the basis of practical experience so that they can achieve maximum competency for professional application. This is especially important in the industrial-technical field, e.g., in the area of further training to become a certified foreman in the metal industry, where proximity to practical formats plays a significant role. In 2018, a completely new form of learning was created with the nationwide integration of Augmented

Reality (AR) (i.e., expanding the real environment with virtual content) in the area of IHK further training qualifications for higher vocational education and training.

For this purpose, the written IHK text volumes were extended by special QR codes, which permit course participants to add virtual and interactive 3D scenarios to the text volumes via all commonly used tablets or smartphones. This allows even extremely complex facts, such as component specifications or even entire process

flows, to be visualised not only in a comprehensible and easily understandable manner, but also to be applied and experienced through the options offered by interactive and independent control.

The advantages of analogue learning media are ideally combined with the benefits of digital content, thereby enabling knowledge to be transferred effectively without media disruption. Participants and lecturers appreciate the digital added value as it increases the attractiveness of the learning process, since this technology now makes it possible to go beyond direct knowledge transfer and enables preparation and follow-up of a topic with a practical orientation. The factual contexts can now be imparted in a much more application-oriented manner in the face-to-face sessions. Finally, thanks to cloud-based integration, the generated digital model of the production plant can be accessed and used anywhere and at any time.

The next phase of practice-oriented further training will involve the development and use of learning tools in the area of Virtual Reality (VR). This offers possibilities of simulating a scenario in which the difference to analogue reality is hardly noticeable. Here, the user is completely immersed in a digitally modelled, virtual environment and is given the possibility of full interactivity, e.g., for training in the handling of hazardous substances, without the risk of any real danger.

The advantage for the direct transfer of knowledge in this process primarily lies in the creation of a virtual, work-appropriate learning environment, which makes

it much easier for the user to acquire knowledge in an application-oriented manner. Here too, the fact that the new forms of learning can be made available anywhere and at any time offers almost unlimited possibilities for use, which is an important aspect for the internationalisation of VET. The German-wide IHK-training standards can be used worldwide with AR and VR. As a result, the same standard of quality that exists in Germany for personnel development can be guaranteed, for example, for German companies with branches abroad.

Individual practical training courses geared to the needs of the company are also possible, in addition to standardised IHK-qualification models. Thanks to the integration of artificial intelligence, the use of trainers is no longer necessary. The acquisition of language skills which would otherwise be necessary for international trainers is now a thing of the past due to these forms of learning, as is the provision of qualified employees. A reduction in the expenditure of time and expenses, accompanied by an increase in the quality of qualification processes, are attractive economic advantages and therefore form ideal framework factors for future-oriented personnel development.

Last but not least, these digitised methods of knowledge transfer also represent an extremely promising approach to effectively accompany the digital transformation of our society and especially of our work environment from the perspective of education and continued training, since the existing fears concerning digital transformation can probably best be countered by a playful experience of the advantages of digitalisation. ■

Desire and reality of digitalisation in the export of VET

Ferdinand Ayen

The NEMID project

NEMID (Nachfrageorientierte Entwicklung und modellhafte Implementierung einer dualen Berufsschule in Serbien) stands for "Demand-oriented development and model implementation of a dual vocational school in Serbia". The school is called "Klett Dual" in Serbia and is anchored in the local education system as a post-secondary educational institution. It is located in Belgrade.

Commercial as well as industrial profiles are planned. A feasibility study and several field studies on site suggested that we should start by establishing different variants for industrial mechatronics engineers. Together with our partner, the ISW Business School Freiburg, we therefore developed three course curricula by mid-2018 (see Table 1).

	Mechatronics ABC	Mechatronic Maintenance	Mechatronic Technician
Character	Continued training as a "taster course"	Continued training as a short course	Training
Duration	1 month	3 months	2 years
Target group	Companies and job-seeking young adults	Companies	Companies and young adults with relevant previous training

Table 1: Course curricula of NEMID

The Serbian Ministry of Education has granted state accreditation for the first two variants as courses of higher vocational training and the third variant is currently being processed.

The thesis: Industry 4.0 will attract widespread response and great demand after relevant training courses

By the end of 2018, Klett Dual had conducted substantiated studies and first-hand discussions with Serbian market participants. It also had a well-equipped learning venue for mechatronics courses, administrative and teaching personnel, a network of companies and institutions, as well as expertise and a modern understanding of didactics and methodology. What was still lacking was a test course with which we could gain our own operational experiences and also allows us to identify the real needs of the market participants, as against the propagated needs. We deliberately chose the ambitious approach of not only teaching the basics of mechatronics in this trial course but also imparting the core of Industry 4.0 in an action-oriented manner.

The underlying thesis was: Industry 4.0 and the overriding megatopic of "digitalisation" is a major concern for all market participants and the demand for educational formats that include the contents of this combination of topics is correspondingly high.

The "Ready for Industry 4.0" course

Against this background, two of our teachers were able to gain twelve graduates from their vocational schools to participate in a 14-day full-time course.⁶ Afterwards, we transferred the course to a larger audience from industry and institutions (chambers and ministries).

At the beginning of the course on February 11, 2019, the students were familiarised with the following introductory scenario: As employees of the "Klett Aircraft Corporation", it was their task to build aircrafts, and there were different ways of doing this. First of all, each student received multi-step folding instructions and a few sheets of paper. They had to work through these instructions and, by the end, had independently folded a paper aircraft. The students therefore functioned as a factory.

Subsequent to this, two groups were formed, and each group member was assigned one or two work steps, and the sheets of paper moved from person to person until the paper aircraft was completely folded again. The second phase of industrialisation with its mass production based on the division of labour was thereby achieved.

The third phase, which was automation by means of machines (Industry 3.0), was simulated by assigning students alternating roles as "automatic units" and "workers", assisting each other.

Finally, a sheet of paper was handed out to each employee, on which only a QR code was visible. Private mobile phones were used to open the underlying web page, on which the individual work steps had been stored. With this, the "Klett Aircraft Corporation" had moved into Industry 4.0, and the students had learned what Industry 4.0 means in an action-oriented and playful manner.

Figure 1: Course "Ready for Industry 4.0" in the classrooms of Klett Dual in Belgrade



⁶ Only male trainees took part in this course.

Seven other learning situations were used to go into greater detail: A Festo MecLab, which is an Industry 3.0 system per se and consists of a stacking magazine, a conveyor belt and a sensor-controlled sorter, was to be upgraded to an Industry 4.0 system. Whereas in the delivery version of the MecLab, the demo workpieces were differentiated and further processed according to their external properties (metallic - non-metallic) by the built-in sensors, the system was now to be upgraded to include an RFID reader and a database in which the properties of the workpieces are digitally stored.

The University of Education, Freiburg (Pädagogische Hochschule Freiburg) was in charge of preparing and implementing the course, and was also able to link the course to various, very relevant, final theses of its master students. In addition, it contributed some of the more complex applications such as database programming.

At the end of this extremely intensive course, it was finally accomplished. To the excitement of all the participating students and teaching staff, the MecLab was successfully converted to an Industry 4.0 system. The learning situations we had designed and implemented around this task covered a wide range of knowledge areas, which included the following: materials processing, industrial automation (including the use of industrial PLCs from Phoenix Contact), the use of electronic switch sensors, CAD/CAM modelling and 3D printing, as well as networking and databases.

The result was presented by a teacher and three learners to around 80 visitors at the premises of the Serbian Chamber of Commerce. The public response was very positive: According to the press review, at least ten Internet news sites, including the Serbian news agency TanJug, two newspapers, and two television stations reported on this event. Numerous business contacts were established or intensified. However, in the aftermath and taking into account all the experience gained in the NEMID project, the picture that emerged was rather more complex and did not quite correspond to "Industry 4.0 is a hit".

The antithesis: It's the mindset that matters, not the buzzword.

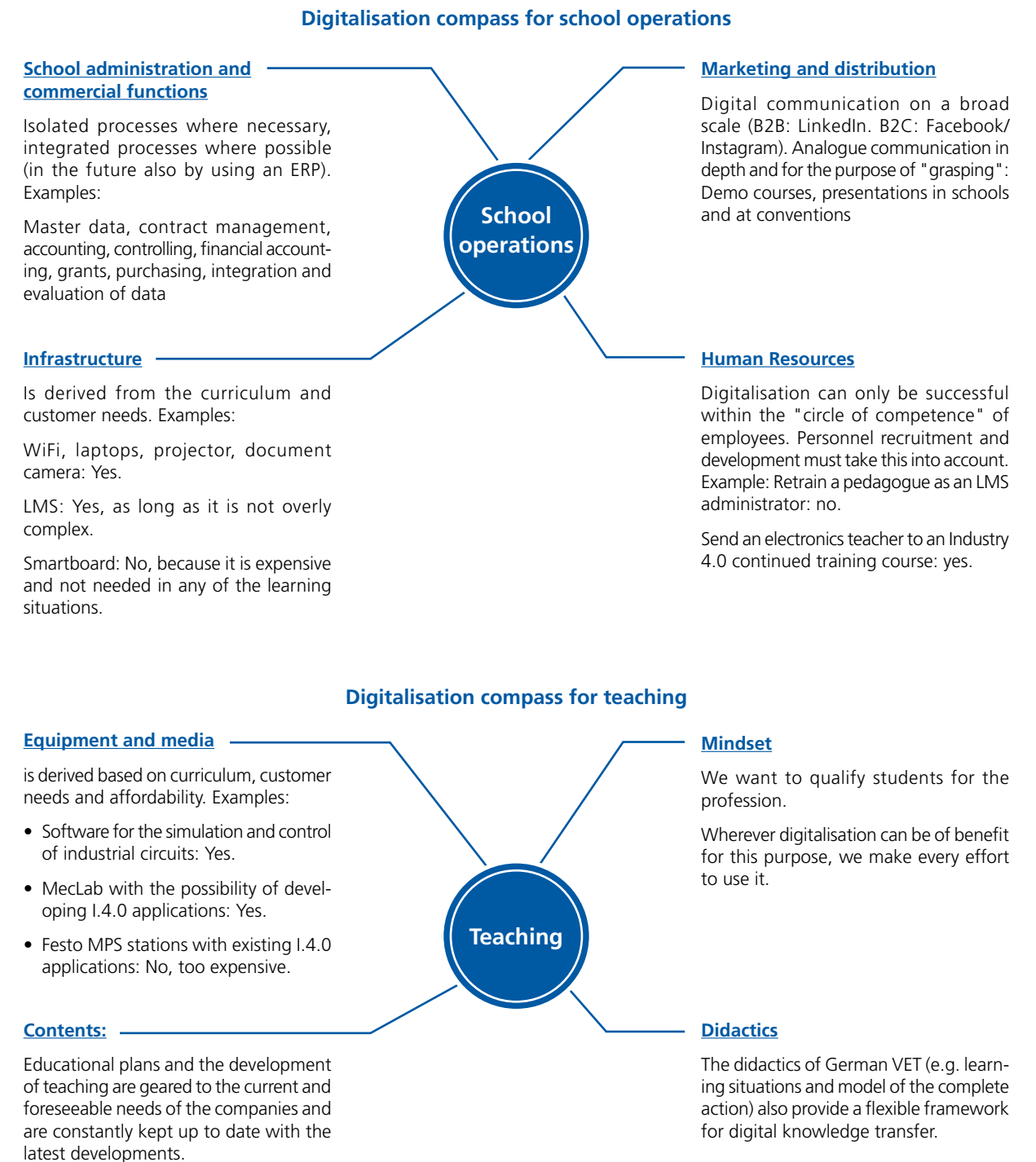
Numerous studies and discussions have been able to convince us that digitalisation has already been a part of everyday life in many local companies for a long time or will be very soon. Some of these companies are ultra-modern, networked production facilities. Nevertheless, not one of our potential customers has been willing to book the "Industry 4.0" course in unchanged form as a variant of the "Mechatronics ABC" course, which was designed earlier.

The reason for this restraint was, to put it bluntly: Companies are not worried that they will soon be digitally outpaced by talking robots or tablet-armed specialists. They have another, far more fundamental problem. There is hardly any practice-oriented education in Serbia. In addition, Serbian companies have to cope with an exodus of young people, which reinforces trends in an ageing society. Finding employees who have some form of digital knowledge is not the main focus. Instead, the focus is on finding personnel who have practical knowledge (which, of course, includes digital knowledge) and who, above all, have a problem-solving and self-reliant attitude. According to this way of thinking, once a company has found such personnel, it will also be able to master future digital challenges.

Our discussion partners were therefore more fascinated by the "how" of our course than by the "what". It was clear that the action-oriented learning, the visible initiative displayed by the students who gave presentations, as well as by the teaching staff, and the joy of problem-solving met a need.

The synthesis: Dimensions of digitalisation and the Klett-Dual digitalisation compass

Despite the reservations of potential customers on site, each educational course is future-oriented. This also applies to the courses that Klett Dual offers in Serbia. Even though the "how" was well received, the "what" must not be neglected in relation to the foreseeable digitalisation.



But what are the dimensions that have to be taken into account when building a vocational school? What is the mindset to be adopted at specific positions within the organisation in order to cope with digitalisation and the associated challenges and opportunities? These questions can be answered in different ways depending on the perspective.

The dual perspective of Klett Dual in Serbia

Experience has shown, especially with regard to the course "Ready for Industry 4.0", that there is not one, but at least two completely different levels at which digitalisation takes place in our commercial context. Unlike in public schools, the school management at Klett Dual is not part of the teaching staff (and the members are therefore not pedagogues). Instead, the management is commercially oriented. As a result, the

levels are already predetermined: On one hand there is the teaching (teachers and students) and, on the other hand, there are the school operations, which have to be sustainable and adequate.

The Klett Dual digitalisation compass

Both levels have a completely different view regarding the question "Where and how does digitalisation take place?" We want to take this into account by equipping both levels with different navigation frameworks. This framework, which we call the "Digitalisation Compass", will serve to provide an overview of the most important dimensions and then independently derive operational measures or principles for action. As a compass, this framework can and should merely provide a direction – the structure and continuous updating should primarily be the responsibility of the participants. ■

Work design that promotes learning for the transformation of the Mexican automotive sector to Industry 4.0

Roman Senderek and Susanne Urhahn

Introduction

The Mexican automotive sector has grown at an immense rate in recent years. A total of USD 60 billion was invested in the automotive industry in Mexico between 2000 and 2017 (Swiss Business Hub Mexico 2019). Nowadays, in addition to production in the classic maquiladoras, an increasing number of branches are also being established in the areas of research and development, especially in the supply industry (Froehler). The country ranks seventh in global car production and fifth in the production of car parts. Forecasts predict that 5 million cars will be manufactured in Mexico by 2020. This enormous growth will thus contribute to an increasingly acute shortage of skilled employees, particularly in regions such as Bajío (Pro México 2017). Mexico is on the verge of becoming the first industrialised country in Latin America (Senderek and Heeg 2017).

Another challenge for the automotive sector is digitalisation. Digital information and communication technologies are constantly changing and opening up new fields of action and activity, which also have an impact

on production and service processes. Restructuring of processes and the emergence of new fields of activity are creating an enormous demand for education and continued training (Senderek 2015). Companies must therefore create new concepts and strategies for their internal qualification and personnel development (Kagermann et al. 2013, 59). The skill requirements for the workforce are constantly changing: Employees must be highly flexible to be able to adapt to circumstances such as frequent product changes or the use of new technologies, and must possess enhanced problem-solving and monitoring skills (Dombrowski et al. 2014).

However, the Mexican automotive sector is growing so rapidly that the existing system for education and continued training is already unable to meet the demand without the effects of digitalisation. New, technology-supported forms of learning can offer advantageous developmental possibilities in this area, as can classic work-related forms of learning (Dehnbostel 2018). Work-related learning presupposes

that work is designed to promote learning. This means that working conditions must be created to enable learning at work (Richter et al. 2016: 88). Work-oriented learning processes and the design of productive and health-promoting work processes can contribute significantly to a positive development of the Mexican automotive sector.

The E-Mas further training programme

Based on the needs of the Mexican education and continued training system described above, work-related learning can contribute to integrating teaching and learning in work processes to a greater extent, primarily in the form of innovative, digitally supported learning concepts. The BMBF-joint project E-Mas is a blended-learning further training programme developed for the Mexican automotive sector in the field of production management. The project has been developed by the FIR at RWTH Aachen University, together with its partners Deutsche MTM-Vereinigung e. V. (DMTMV), the Aachener Werkzeugbau Akademie GmbH (WBA) and the Lean Enterprise Institut GmbH (LEI), in co-operation with the local partner Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM).

Contents and objectives

The objective of the E-Mas programme is to provide high-quality solutions to meet the enormous demand for qualification and thereby support German multinationals and also other multinationals, and, in particular, Mexican companies, in the transformation to Industry 4.0 with targeted further training programmes in the field of production management. The E-Mas programme currently comprises four courses on the topics of Designing of Work and Learning Processes (FIR), Productivity Management (DMTMV), Toolmaking (WBA) and Lean Management Methods for Industrial Change (LEI). These are offered in a blended-learning concept in Spanish, consisting of face-to-face phases in Mexico and e-learning via a learning platform. The further training programme is aimed at skilled employees and operational management personnel at the middle management level.

Another central component of the programme is the E-Mas partner network. In this network, (potential) customers, such as Bosch, Continental and Hella have joined forces with other organisations such as CAMEXA, Ditrats and KITHUB which offer further training extending beyond the E-Mas, as well as with state institutions, such as the Ministries of Economics of the states of Jalisco and Guanajuato, under the leadership of the FIR, to jointly promote further training. The overall concept of E-Mas is to develop and internationalise a comprehensive, cohesive teaching and learning programme on tactical

and operative production management for employees. This topic area was chosen to counteract the shortage of skilled employees in the middle management levels and to enable personnel to successfully assume corresponding tasks and activities that are assigned to this middle management level. The concept focuses on the transformation of companies to Industry 4.0. The overall programme can be titled "Courses on tactical and operative production management for the automotive sector in Mexico on the path to Industry 4.0".

In general, production management comprises all activities related to planning, organising and controlling production in a company. Three different types or levels can be differentiated:

- 1. Strategic production management:**
Cases involving fundamental decisions
- 2. Tactical production management:**
Implementation of decisions and launch
- 3. Operative production management:**
Execution of daily production management

Whereas strategic tasks are usually performed by academically qualified personnel at higher levels of management, tactical and operational tasks are carried out by personnel with a middle level of qualification – precisely the level that is currently experiencing a severe shortage of skilled employees in Mexico. Accordingly, imparting extensive knowledge in the area of tactical and operative production management can contribute significantly to building professional skill in this specific area and reducing the shortage of sufficiently qualified personnel.

These target parameters were covered by the individual thematic modules of the consortium partners. These modules focus on the fields of Learning and Working in Industry 4.0 (FIR), Productivity Management and Industrial Engineering (DMTMV), Toolmaking Management (WBA) and Lean Management Methods for Industry 4.0 (LEI). As a "product", E-Mas has established a comprehensive further training programme with a blended-learning approach for the subject area of tactical and operative production management on the way to Industry 4.0. This further training programme can be purchased in its entirety as an overall programme and can also be tailored to individual customer needs.

The FIR conceived its own further training measure in its sub-project on the topic of work-related learning in Industry 4.0. The aim is to sensitise and enable managers in tactical and operative production management to

implement technology-supported, as well as classic work-related learning solutions. In addition to the target groups mentioned above, the educational programme offered by FIR also addresses the human resources departments of companies. There is a concrete need for the FIR educational programme since the transformation towards Industry 4.0, which can also be expected in Mexico, as well as the lower availability of skilled employees in general in the Mexican automotive sector, requires learning to be even more strongly anchored in the work process than, for example, in Germany. The FIR module assists companies to implement cultures and design structures that promote learning. In this way, the development of the individual skills of employees, as well as organisational learning, is promoted for successful industrial change. The institutionalisation of work-related learning will have a positive effect on the target parameters of productivity and health of the employees, as well as on process innovation.

To be able to adapt the offered course as specifically as possible to the needs of companies in Mexico, an extensive needs assessment was conducted in the target country. In addition to the responsible persons in companies, government representatives at the federal and state level, and those responsible for the respective automotive clusters were interviewed. These interviews also confirmed a high demand for further training in the context of Industry 4.0. During on-site surveys, it also became apparent that differences between the German organisational culture and the local Mexican culture can lead to difficulties. For example, significant cultural differences can be identified in the context of time planning, since planning horizons are considerably shorter in Mexico and appointments are often planned, changed and postponed ad hoc. At the same time, personal contact has much greater significance, as this is the only way in which uncertainties and doubts between potential business partners can be dispelled. The findings regarding cultural differences were accordingly incorporated subsequently into the design of the further training programme.

Blended-learning and learning arrangements

The concept of blended-learning refers to teaching and learning arrangements that combine e-learning and face-to-face learning (De Witt and Czerwionka 2007). A further distinction is made between face-to-face learning with the accompanying use of digital media (ibid.), as well as synchronous e-learning (e.g., webinar, social media) and asynchronous e-learning (e.g., educational videos, online forums, PowerPoint slides) (ibid.; e-teaching.org 2017). In addition to the advantages of e-learning in teach-

ing and learning arrangements (e.g., more self-determined learning, application orientation and flexible design of teaching and learning scenarios, reduction of financial expenditure, better availability of learners at the work place) (Gundermann 2015; acatech 2016; BMAS 2016b; e-teaching.org 2017), the use of media has the added benefit of promoting media competency (digital literacy) in a digitising world of work (EU 2015; BMAS 2016a). The concept of Learning Solutions is understood to mean innovative learning solutions that draw on current pedagogical, psychological (including cultural aspects), didactic, methodological and technological findings (Kerres 2012; Eichler et al. 2013; Seufert and Schuchmann 2013; Gundermann 2015). This includes the user-oriented combination of new technologies, learning formats and processes, learning environments and business models. The aim is to achieve the best possible combination of learning arrangements, against the background of the pedagogical, technical, cultural and economic requirements and framework conditions.

From a pedagogical point of view, the determination of suitable learning contents and components for the possible learning arrangements, as well as the combination of e-learning sessions, and face-to-face sessions is a particularly important aspect. (Baumgartner 2007; Gundermann 2015; e-teaching.org 2017). The learning programme offered in E-Mas can be divided into modules and sections. Concrete learning objectives are defined for each of these sections. Based on these, learning objects (Baumgartner 2007) are determined, which take an integrated view of learning objectives, content, and learning processes. With the help of a learning objective taxonomy, learning objectives are analysed with regard to the dimensions of knowledge and cognitive processes (Anderson and Krathwohl 2001; Baumgartner 2007; Mühlbradt et al. 2015). By grouping a learning objective in a learning taxonomy, it can be ensured that suitable learning arrangements and media are assigned to the learning objects. In the pre-test of the project, the solutions based on this were empirically tested for their function and effect, critically questioned, and, where necessary, modified for the subsequent main implementation of the E-Mas programme.

The Inverted Classroom concept of E-Mas is implemented as follows: First of all, factual knowledge and basic conceptual knowledge about e-learning is imparted. This is followed by face-to-face learning with supervised group work phases in order to acquire in-depth conceptual and procedural knowledge and to provide the opportunity to address detailed questions. Finally, a refresher course is held six months after the face-

to-face course and a digitised performance review is carried out with regard to the concrete application of contents that have been learned and the implementation of the learning objectives.

Conclusion

Due to the enormous growth of the Mexican automotive sector and a relatively young population that does not have adequate specific training, there is an increasing shortage of skilled employees. In addition, companies are facing the challenges posed by the transformation to Industry 4.0. This creates a need for demand-oriented development of education and continued training and, in particular, work-related learning approaches with a focus on more efficient production. Many Mexican non-specialist employees are currently working in the automotive sector. Until now, there have been only a limited number of further training programmes that are able to compensate for the emerging deficits.

This gap can be closed with the E-Mas further training programme, which makes central topics of production management available to the employees. The E-Mas programme effectively combines e-learning

and face-to-face learning in the field of production management, so that preparation and sustainability is assured via e-learning, while the face-to-face phases ensure immediate application and consolidation for the individual corporate context. The E-Mas further training programme provides employees and companies with the tools required to successfully shape industrial transformation.

In particular, the issue of work-related learning and the empowerment of companies was addressed and implemented in the E-Mas further training programme and especially in the FIR course. Employees and companies can thereby be sensitised to integrate learning more strongly into the work process in the future and to thereby continuously pursue further training in the form of lifelong learning.

In addition, it has been shown that a culturally sensitive approach is essential and that cultural differences should also be addressed in the further training programmes. These are the differences that are often decisive for the success or failure of German companies in Mexico and, accordingly, a module to help companies overcome cultural differences was developed within the framework of the FIR course. ■



Contributions from research

Theory-driven and user-centred development of digital learning programmes and services

Andreas Janson, Marian Thiel de Gafenco, Jens Klusmeyer and Jan Marco Leimeister

Introduction

The development, implementation and evaluation of demand-oriented education and continued training services and needs-oriented teaching/learning programmes for the development of vocational skills are a central theme in the internationalisation of VET. To begin with, needs related to the establishment of corresponding business models are analysed. An important component is the value proposition, which is central to the provision of a service, and is increasingly being designed in digital form. Services such as digital learning programmes are becoming scalable, since the fact that (parts of) the service can be provided anywhere and at any time facilitates exportability.

Research shows, however, that there is a lack of concepts for coping with context specificity when using digital learning programmes. New scenarios for learning and working with digital media must be explored and analysed in order to provide demand-oriented and user-oriented services. Hence, on the basis of the 'kuLtig'⁷ and 'KoLeArn'⁸ projects, we present insights into theory-driven and user-centred developments for digital learning programmes in the context of the internationalisation of VET, especially with regard to internationalisation for the target region China.

The method for the theory-driven and user-centred development of digital learning programmes

The starting point for the development of the learning programme presented here is a theory-driven (Briggs 2006) and design-oriented method, which is increasingly used in business informatics (Peppers et al. 2007) and also in vocational and business education (Euler 2014) to address problems in the real world. This method is based on the pragmatic idea that digital learning

programmes should be developed as user-centred services with systematic consideration of the consumers, so that these programmes are actually used and achieve added value (Leimeister 2015) for all stakeholders (e.g., learners and training personnel). Methods from service engineering (Leimeister 2012) are particularly suitable for this purpose. These methods specify how user-centred requirements can be derived for the design process (e.g., through workshops and prototyping methods). The following figure shows the five core aspects of our method in accordance with this basic orientation. These are illustrated with examples in the next section.

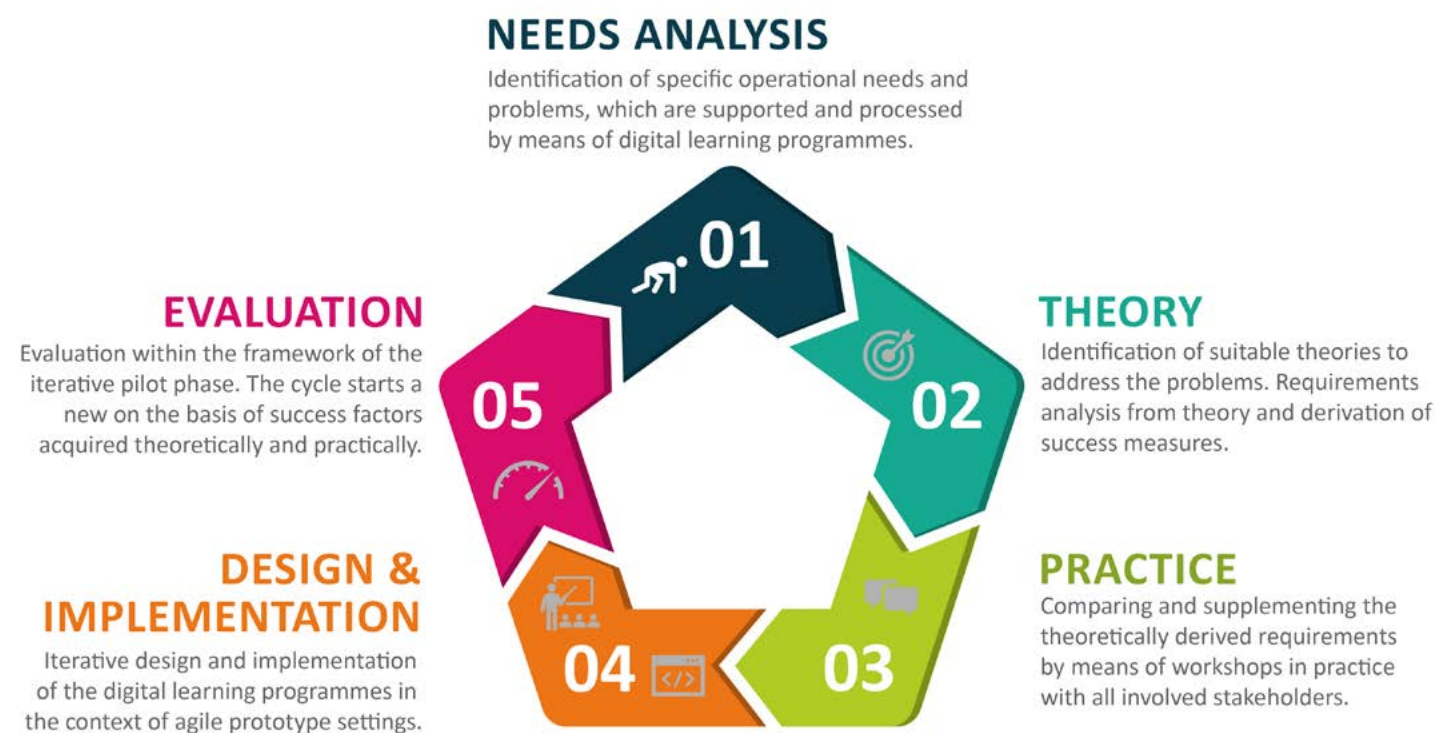
Results and discussion

The development process begins with a needs analysis that addresses the internationalisation of VET for the target country, the People's Republic of China: The growing shortage of skilled employees in the People's Republic of China (Klorer and Stephan 2015) revealed the need for learning programmes in the field of education and continued training. These learning programmes are also intended to secure skilled employees for German companies in China. This assessment was based on preliminary theoretical work, our own surveys in company networks and current developments in education policy. Efforts to reform the vocational education and training system with the aim of improving the quality of (dual) education and achieving higher numbers of graduates are of particular interest in the light of future cooperation, research interests and the export of educational services to China. However, in the medium term, in-company education and continued training measures for employees will retain a prominent role in terms of qualifications.

In order to address the identified need, theoretical points of reference relevant for the development, implementation and evaluation of digital teaching/learning programmes were taken into account from different fields of discourse, especially from interdisciplinary fields. The work on

⁷ "Systematic development and pilot phase of methods and models for the engineering of culturally-sensitive learning services, using China as an example".

⁸ "Context-sensitive learning services in the work processes of smart industrial manufacturing – systematic development and pilot phase using China as an example"



Cognitive Load Theory with a focus on the design of learning materials (Sweller 2019) was found to be central to the research activities in the kuLtig and KoLeArn projects. In addition, cultural differences in the use of digital media were taken into account, especially by discussing IT culture conflict theory (Ernst et al. 2016). The didactic design of the teaching/learning programmes is oriented towards models of work-related learning as a function of the learning venue (Dehnbostel 2007; Berger and Gidion 2010) in order to eliminate the lack of practical skills identified among skilled employees.

Workshops based on the preliminary theoretical work were conducted in the kultig project (see e.g. Ernst et al. 2016) and KoLeArn project (see e.g. Thiel de Gafenco et al. 2018) with subsequent users of the learning programmes or their teachers and superiors. In order to compile the requirements for the design of the learning programmes for the respective fields of application, the requirements were identified, clustered and prioritised and then allocated to the relevant theoretical points of reference. By comparing practical experience, the learning programmes can be developed to fit requirements, and the database of existing research work can be expanded.

Specific design criteria were developed, taking into account the individual, cultural and institutional parameters for successful digital programmes. In this context, a Bring Your Own Device Strategy (BYOD Strategy) with situated and problem-based learning tasks was implemented in a mobile learning application to support teaching in vocational colleges. Work process-oriented

determination of needs and learning content development was initiated within the framework of in-company continued training to enable process-integrated learning in the work place (see also Weinert et al. in this publication).

In both fields of application, the design parameters reflect the contexts of use and promote learning progress and subsequent adherence to the value proposition. Thus, for example, the consideration of cultural characteristics in the context of the development of mobile learning applications has led to a significantly higher rate of success at the level of procedural and skill-based learning (see Ernst et al. 2016 for an experimental comparison between a user-centred and a conventional mobile learning application).

The necessity of needs-oriented and user-oriented development of learning programmes was able to be theoretically supported and proven by the project-specific research activities. Iterative concept development for digital learning programmes and services in international VET is significant against the background of the development of sustainable business models. In particular, early implementation of prototypes in the research process is a basic requirement in many cultures for medium to long-term cooperation. Our results also show that learning outcomes are improved by means of digital learning programmes. The exploitation potential for related business models can thus be strengthened significantly. ■

Virtual reality-supported learning in international VET cooperation: Transformative aspects in learning processes and skill requirements using the example of virtual welding training systems

Romina Große and Silke Steinberg

Introduction

Digital technologies constitute new forms of learning and teaching, create new potentials and challenges for learners and teachers and necessitate new design methods within learning and teaching cultures. A variety of forms for digital learning and teaching have emerged in recent years: Forums, wikis, blended learning, webinars, MOOCs, serious games, simulation games, augmented reality (AR), virtual classrooms and learning in virtual 3D worlds are just a few examples (Goertz 2018, 10). In this context, virtual reality (VR) is a kind of universal tool that is used in different ways.

In order to understand how VR is changing international vocational learning and teaching, and to identify and make use of potentials and challenges, virtual welding training systems will be used as an example to examine the aspects of the virtual learning process that have to be taken into account, in particular, in the conceptual planning of new methodological and didactic approaches in vocational training, and how these can be applied as part of international cooperation in the field of vocational training.

The way we understand vocational learning and teaching has changed considerably in recent decades. Individual activity-based experience is of crucial importance for the development of skills. It is the starting point of cognitive development and a prerequisite for building up activity-based knowledge relevant to the vocational context (Blümel et al. 2009, 96). In this context, the learning process is defined via the interaction between cognition (as an internal factor) and the material or social situation of the learner (as an external factor). This approach has long been implemented in curricula using concepts that describe learning environments and situations, i.e. in curricular elements that embed technical content into concrete application contexts. These application contexts, which also relate to the social teacher-learner system, are culture-, gender- and age-specific and require differentiated consideration.

School-based learning venues are seldom able to reflect the complexity of the working environment and social world. VR is credited with immense potential in this context, but it is not yet used in many education and continued training courses. This is due to the lack of methods and didactics to integrate the changing possibilities offered by new technologies into holistic teaching and learning approaches.

In the welding trade, however, virtual support for education has already been achieved for some time (DVS 2019, 5). One of the reasons for this development is perhaps the universal, context-independent character of welding training. Virtual Welding Training Systems (VWTS) offer a suitable field of action for analysing which aspects of learning are particularly influenced and, when applied to other areas, which aspects place high demands on the implementation of methodological and didactic approaches.

Virtual welding training systems in education and continued training – potentials and didactic challenges

Whereas virtual welding training systems have long been used for education and continued training in the Asian market with great enthusiasm, scepticism in Germany was initially high due to the rather conservative education system. In the meantime, however, experts and users have accepted these systems to a great extent in this country as well and VWTS have become firmly established in practical education and continued training (see Hensel 2013, 20-21).

The image of the welding trade is characterised by physical exertion, pressure to perform and risk of injury (Schulte and Petersen 2017, 110). There is already a great shortage of welding specialists and the need will increase further in the coming years due to the difficulty of recruiting new personnel (MINT 2013, 9; Schulte and Petersen 2017, 110). In order to secure skilled welders,

education and continued training is to be modernised and made fit for the future by means of VWTS (Hensel 2013, 20; DVXS 2019, 8).

Experiences in recent years indicate that the use of VWTS for the learning process has versatile advantages: For example, VWTS can be used effectively for demonstration purposes and for knowledge transfer (Schulte and Petersen 2017, 111). Motor skills are trained during risk-free practice on the welding training system. Direct, continuous feedback (by means of optical and acoustic signals) with regard to the essential parameters of welding (e.g. speed and torch angle) during practice is one of the most important advantages (DVS 2012, 6), and enables learners to correct errors independently (Hensel 2013, 23-24; Schulte and Petersen 2017, 111-112). Error analysis can be carried out subsequently via a replay function, with the assistance of the teaching staff if necessary (DVS n.d., 23; DVS 2019, 8), and enables an objective assessment of performance and quality (DVS n.d., 5). A study conducted by the Schweißtechnische Lehr- und Versuchsanstalt (SLV) Nord shows that the use of VWTS leads to a higher success rate in welding and that training periods can be reduced (DVS n.d., 12-13). Overall, the use of VWTS shows an increase in effectiveness in the practical aspect of welding training (DVS n.d., 12-13; DVS 2019, 6).

A holistic methodological-didactic concept is, however, necessary to make optimum use of the potentials of VWTS in education and continued training (Schulte and Petersen 2017, 109). For this purpose, DVS (Deutscher Verband für Schweißen und verwandte Verfahren e.V. – German Welding Society) has already developed a guideline in 2011 on the possible applications of VWTS in the course of computer-aided welding training (DVS 1108-1), which offers a good orientation for the establishment of virtual welding workshops (see DVS n.d., 4-5). The International Institute of Welding (IIW) recommends that a maximum of 50 percent of the training period should be spent on virtual welding machines (DVS n.d., 4). Experiences show that working on these machines in small teams is particularly effective (Hensel 2013, 23). Learning is also facilitated by computer workstations where the learners can acquire theoretical expertise using e-learning tools (DVS n.d., 6-7). The use of VWTS is considered to be very beneficial for the learning process, especially when integrated intelligent curricula are adapted to individual learning speed and the level of difficulty of the exercises is gradually increased (DVS n. d., 6).

To ensure optimal education and continued training, the advantages of classical education and work process-integrated learning should be combined in a didactic

concept. Schulte and Petersen (2017, 115) recommend a combination of learning venues, i.e. seminar room, computer workstation with access to e-learning materials, VWTS and welding booth, as well as guided face-to-face phases and self-study phases. After the classic theory phase, a training phase should be completed at the VWTS before moving on to real welding. In addition to their specialist and didactic skills, the teaching staff should be confident in handling the VWTS that is being used and should systematically evaluate errors, in dialogue with the learners (see Schulte and Petersen 2017, 115).

The DVS now offers a course on the use of VWTS at educational institutions in order to ensure the effective use of VWTS and to prepare teaching staff to meet the new requirements. This course especially focuses on teaching the necessary media competence and enables teaching staff to conduct educational and training activities using VWTS.

The experiences gained so far and the empirical basis indicate that the use of VWTS has led to an increase in the quality of education and continued training. This appears to be due to parameters such as increased repetition rates, continuous error monitoring and individually adapted learning speeds (Hensel 2013; Schulte and Petersen 2017). In order to maintain the immersive effect of the virtual welding process and its advantages during the learning process with the VWTS, it appears to be particularly important to design the simulations such that they are graphically appealing and as realistic as possible (Schulte and Petersen 2017, 111). The aim must be to depict the welding process so realistically that the learners forget that they are in virtual reality, and can learn using all the senses (Bockholt 2017).

Further research and deliberations on embedding the VWTS into holistic learning and teaching approaches are necessary for the optimal design of education and continued training. These include pragmatic implementation problems, which were addressed, for example, in the context of expert discussions in the joint project "Tecsol – a German-Brazilian cooperation for the development of new vocational qualification structures in the field of welding in Brazil". The experts pointed out that the cognitive capacities and concentration of learners are exhausted much faster using the VWTS than in the real welding booth. Here it is necessary to investigate the maximum period for which concentration can be maintained using the VWTS and how learning periods in the VWTS and in the real welding booth can be combined optimally. It is also necessary to reflect on culture, gender and age-specific research questions arising from the stated advantages of the VWTS.

VR-supported learning concepts in international VET – research questions and future scenarios

VWTS is used specifically for the didactic goal of training motor skills. In the BMBF-funded project "MESA – Use of Media in the Welding Industry" ⁹, applications were designed, for example, in which motion sequences that require precision and routine can be trained without risk of injury (Schulte and Petersen 2017). This allows users to practise the correct hand position during manual welding and formation of the weld seam. As stated above, it is considered very advantageous here when the integrated, intelligent curriculum adapts to the individual learning speed of the learners and gives them the opportunity to analyse and correct their own errors autonomously (DVS n.d., 6).

Learners attain autonomy in the learning process and decide when teaching staff should be involved for objective assessment of performance and quality. Except for a few face-to-face phases, the teacher does not have to be at the same venue during a course; this also facilitates international learning and teaching. Continuous direct and individual feedback from the trainers is possible in a virtual learning situation, which would not be possible in a real teaching situation. As trainers, the teachers enter into a dialogue with the learners on an equal footing. This creates a completely new dynamic in the teacher-student relationship, and demands that teachers not only meet new requirements in the area of media competence but also have interdisciplinary skills to support the students. An intercultural teaching or learning situation requires additional intercultural skills.

This aspect extends beyond the area of virtual welding. In the GRÆDUCATION project, for example, applications are to be developed in which teachers and learners jointly, as avatars, commit to innovative, green technologies and adopt a multi-perspective view. Here, too, the focus is on dialogue-based transcultural exchange and collegial support between teaching staff and learners (see also Steinberg and Klatt in this publication). This requires a new understanding of the teacher-student situation and a new didactic approach to support the training situation, in which the shared activity-based experience is seen as the starting point of the cognitive process that is accompanied and promoted by the trainer. The learning process is controlled by the learning speed of the students and the individual or joint implementation experiences gained from training situations, i.e.

individual learning processes, which do not follow theoretical guidelines, are created. The transformation of the teaching and learning culture is a prerequisite for such a learning process. It takes place according to specific contexts that constitute the situation where it is applied, uses traditional learning and teaching cultures as its starting point, and can be supported by the design and embedding of VR applications. In the international cooperation in vocational education and training, this means that in the different target countries, culture-specific characteristics regarding design and/or embedding of the application have to be taken into account in order to effectively use the advantages of VR-supported approaches.

The necessity of designing and embedding a VR application purposefully within a holistic didactic approach is also evident when we consider the distinction between virtually-generated reality and analogue reality. The use of VWTS has shown that the advantages of immersive learning in welding training can be exploited most effectively if the simulation corresponds to reality as closely as possible (Schulte and Petersen 2017, 111) and the learners no longer differentiate between reality and virtuality. Jean Baudrillard (Baudrillard 1981) has positioned this fusion in the third order of simulacra (stages of representation). Reality and virtuality generate a hyperreality in simulation, in which, structurally speaking, signs and meaning are autonomous (complete separation of signifier and signified). It involves the generation of a realness with no origin in reality, through which things that would not be conceivable without the use of VWTS are made possible in the learning process. By eliminating the difference between staged and authentic experience in the learner's experience, the transfer of learning from virtual activity to analogous activity becomes easy.

In terms of the conception of learning methods and didactics, this means that it is possible to go far beyond the given structures and include imaginary situations and possibilities that are not based on reality. Here, too, it is necessary to design learning and teaching approaches to suit the respective target group and take into account culture, gender and age-specific needs. Only then will the virtual situation be experienced as authentic and allow optimal use of the VR-related advantages. This opens up an interdisciplinary field of research and scope for creative learning and teaching architectures.

⁹ "MESA – Use of Media in the Welding Industry" was funded by the Federal Ministry of Education and Research (BMBF) as part of the "Digital Media in Vocational Education and Training" programme (01.08.2015 to 31.01.2019)

For international VET cooperation, the integration of VR applications offers many practical advantages (improved teacher-learner interaction across national borders), as well as transformation incentives from which vocational education and training cultures can benefit (see also

Steinberg and Klatt in this publication). Concepts in VET must be created and designed for this purpose. Here, VWTS can serve as a best-practice example that provides initial approaches. ■

Potentials of augmented reality in vocational education and further training – development and prototyping of AR app robotics

Uwe Sachse and Frederic Graeb

Introduction

Digitalisation offers opportunities for all learners, as it enables in-depth and individual assistance through digitally supported teaching and learning processes (see inter alia Thomas et al. 2018). Technology-based learning instruments and digital assistance systems are increasingly being used in this context (see Epke et al. 2018, 46-47). Initial experiences show that there is enormous potential available in this area (see Nikodemus 2017; Epke et al. 2018). However, with regard to use in the learning and teaching environment, the requirements placed on the corresponding didactics and methodology must be fundamentally reassessed (see Bacca et al. 2014; BIBB 2018a).

In the following, the development of an augmented reality app for the vocational training of mechatronics will be used as an example to illustrate requirements and potentials in the teaching and learning environment.¹⁰ Microsoft's AR data glasses, the HoloLens, are used in the NEMID project.¹¹ In contrast to virtual reality (VR), the user remains focused on physical reality during the use of augmented reality (AR). Physical reality is however extended and enriched by means of virtual elements and information.

¹⁰ The results presented here are part of the project "NEMID - demand-oriented development and model implementation of a dual vocational school in Serbia" from the funding line "Internationalisation of vocational training" of the Federal Ministry of Education and Research; duration: 01.08.2017 – 31.07.2020. This article describes the development process and prototyping. Integration of augmented reality learning scenarios into the internationalisation process and the business model are future components of the project.

¹¹ Other mobile devices, such as tablets and smartphones, can also be used, in principle. However, the use of such devices greatly limits the scope of performance with regard to usability and user experience.

The development process

The direct involvement from the beginning of the project of all stakeholders at participating institutions, i.e. vocational schools, professional associations and companies, as well as the actual users (trainees), was essential for the development process. Taking this multi-perspective development approach into account, an augmented reality canvas (see Hinrichsen et al. 2016, 6; Apt et al. 2018, 95-96) was used at the beginning to analyse the requirements relating to content, task and didactics from the users' perspective with regard to the application to be developed. The augmented reality canvas (see Figure 1) was used to structure and visualise the results in the workshop.

The following key questions provided an orientation:

1. What are the basic conditions to be considered when developing an augmented reality app for the job profile of mechatronic trainees?
2. Which usability requirements for augmented reality influence its application and user acceptance?

3. How should augmented reality be used in education to increase the success of the learning process?

In the next step, a storyboard was developed, with initial focus on content and sequence, number of chapters, audio/video/text and instructions for direction. The storyboard was developed by a project team at the Albstadt-Sigmaringen University and the company 4smartminds¹² and repeatedly validated and adapted in different design phases with the responsible vocational teachers from the vocational field of mechatronics.

This process resulted in various augmented reality learning scenarios in the subject areas of Industry 4.0/Robotics. The special significance of Industry 4.0 for Germany as an industrial location, requirements such as data goggles for human-machine interaction in the context of interface technologies, and the amendment of the training curriculum framework and the training ordinance for mechatronics engineers (see BIBB 2018b) were decisive for the choice of topics and their structure. A so-called "three-dimensional" vocational field was also selected to demonstrate the potential of virtual, holographic training objects. The results of the app development were again tested and further

¹² 4smartminds, c/Rafael Salgado 19, 28036 Madrid – Spain, info@4smartminds.com

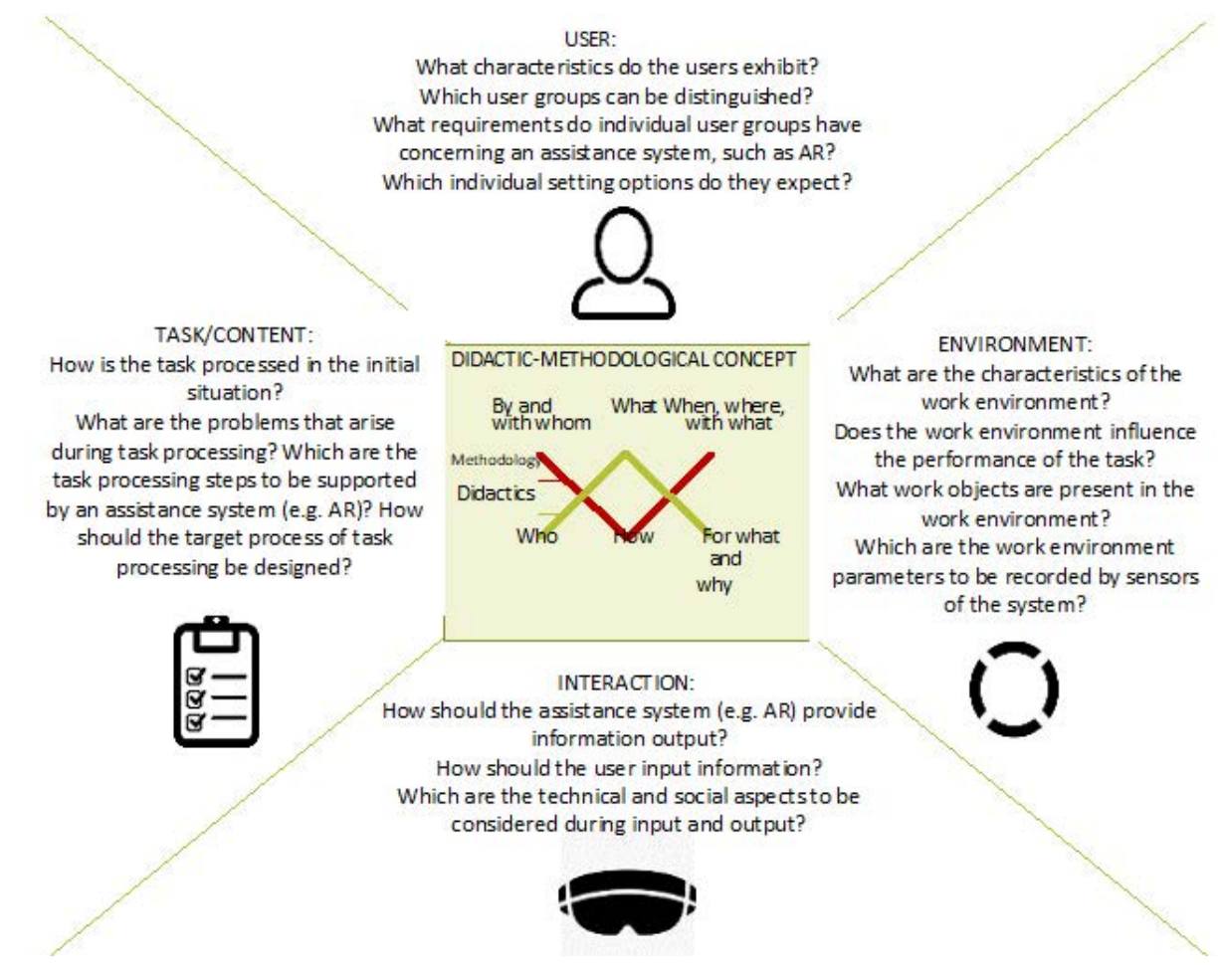


Figure 1: Augmented reality canvas (illustration of the content according to Hinrichsen et al. 2016, 6; Apt et al. 2018, 95-96)

developed with the three partner schools at the various stages of the prototype¹³ (see Figure 2). The aspects of motivation and learning psychology, which have been addressed in a user-centred design process, are essential for the acceptance of this technology (see Pletz and Zinn 2018). Special emphasis was placed on creating a positive user experience and a high degree of usability associated with the use of the HoloLens in the learning process (see Hendrich 2019; Apt et al. 2018, 47).

Augmented reality learning scenarios – AR app robotics

The augmented reality learning scenarios comprise eight chapters: history/background, the significance of robotics, areas of application and use, the most important types and structural shapes, forms of movement, components and assemblies, assembly instructions and an integrated knowledge quiz. The learning period is approx. 60 minutes, depending on learning progress and previous training. The target group is composed of mechatronics engineers in their third and fourth year of training.

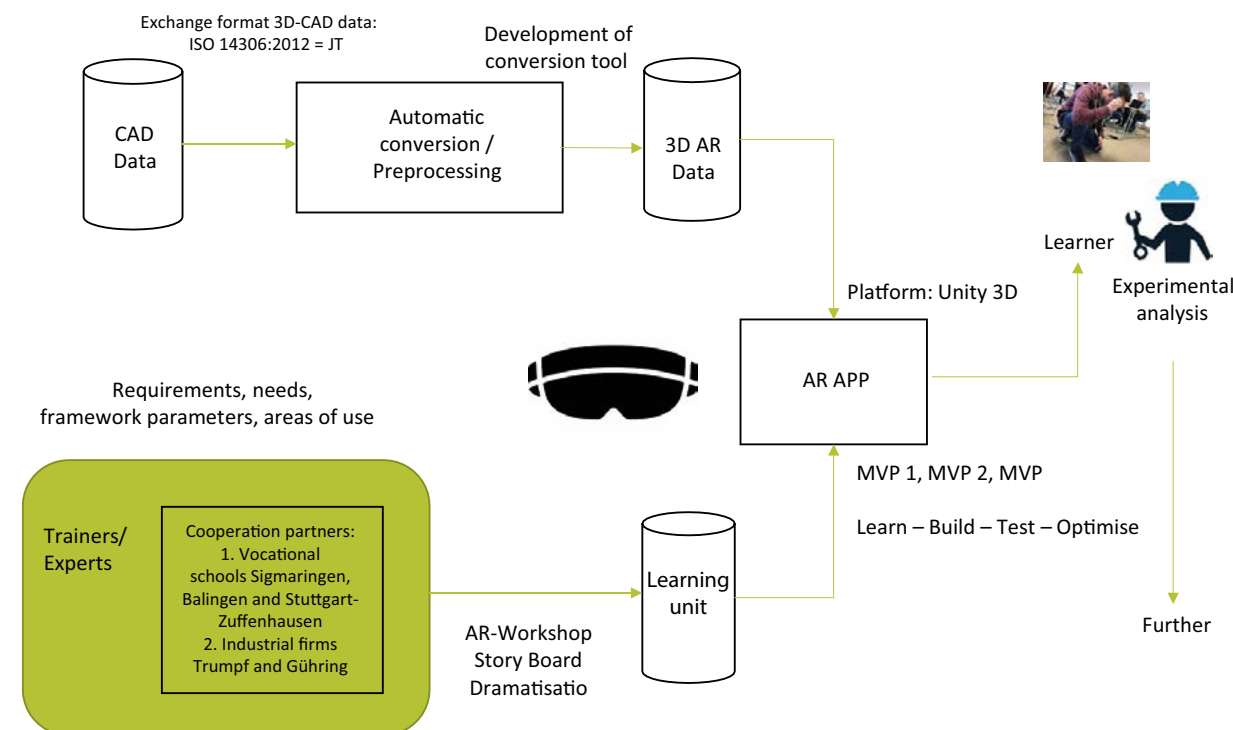


Figure 2: Process for creating the augmented reality learning scenarios – AR robotics app

¹³ Within the prototyping process, the quality of the prototype was developed and tested step by step from low-resolution to high-resolution quality with almost all the equipment and all essential features (MVP = Minimum Viable Product, MVP 1 low resolution, MVP 3 high resolution).

The aim of using the HoloLens is to generate various synergistic effects by optimally combining the technical capabilities of the data glasses (e.g. knowledge transfer via or in future environments that do not exist as yet, training without allocation of expensive and sometimes dangerous real infrastructure by using three-dimensional holographic objects, integration of gamification) with the flexibility, adaptability and responsiveness of learners and teachers.

An important prerequisite for beneficial application is the review and adaptation of the teaching and learning process. To design good didactics, the teaching and learning process must be designed in a way that promotes individual development of skills, the personal learning process and thus the learning experience and successful learning. The experimental analysis of the use of the prototype in the teaching programme at the vocational school therefore focused on the question of how augmented reality learning scenarios must be designed to support teachers, trainers and trainees in the learning process.

Experiment and results

Since the Microsoft HoloLens was only available for developers, it was assumed that the students had little or no experience in handling the hardware. To ensure acceptance among the users, the test persons were allowed to test the HoloLens initially. Simple applications and games were used in this process. Each learning group had one HoloLens. The test persons took turns using the HoloLens and were able to follow the activities of their classmates together on a laptop.

The application was used subsequently (see Figure 3). Five peer groups of four to five learners each were formed for this purpose. An AR coach accompanied the explorative learning of the teams and supported the test persons in using the prototype. To support the learning process further, each student was provided with a worksheet containing the most important content-related generic terms (components of a robot, rotational/translational axes, robot types, movement ranges, task priorities). All participants were able to follow the respective HoloLens View on the group's laptop during the experiment and were thus able to directly participate in the learning experience of the HoloLens wearer.



Figure 3: Agile learning situation – peer-to-peer learning with AR coach¹⁴

Immediately afterwards, a knowledge quiz was conducted and answered individually by the test persons. The prototype and the entire sequence were evaluated in a follow-up survey using a standardised questionnaire with multiple choice questions and supplementary open questions. Finally, all the students discussed their impressions in an open feedback round.

Initial findings from the written surveys and the open discussion round show that the developed AR robotics app has the potential to inspire the students and improve their expertise. The visual presentation of the holograms and the interactive elements of the application were rated positively. Although the results of the knowledge test do not directly show whether learning can be made more successful by the use of augmented reality in education, it became clear that users can process the specific knowledge of the app and are in no way distracted by the experience of augmented reality in the learning process. On the contrary, greater willingness to learn and a positive learning experience could be observed throughout the entire learning process.

¹⁴ Notes: The image shows the group work situation. One student wears the HoloLens, the other four students follow his activity via a live stream on the laptop. The AR coach is in the foreground and accompanies the learning process.



Augmented reality in international VET

There are many possible applications for augmented reality in the context of the internationalisation of vocational training (see Table 1). However, when transferred to international transformational environments, the influence of the respective national culture on learning and acceptance of the technology must be taken into account.

The greater the cultural distance (in terms of learning history, learning methods, learning environment, the learner-teacher relationship, learning media and acceptance of technology, among other things) between the domestic market and the international target market, the greater the need appears to be for specific adaptations to and localisation for the respective market. In addition, the necessary parameters for the use of augmented reality must be met (e.g. infrastructure, i.e. networks and hardware). ■

International potentials of augmented reality in industrial education and further training center

Knowledge transfer: positional knowledge, structural knowledge, behavioural knowledge, procedural knowledge

Learning options in the virtual environment: spatial exploration, conceptual learning, learning of motor skills, procedural learning

Learning concepts: Demonstrating, accompanying, testing

Use of augmented reality: Sequences, process knowledge, risk of damage, use of resources/tools, all variants/all perspectives, introduction of documentation, introduction of simulators, making hidden objects visible, [animated] AR front projections (e.g. concealed installations) on real objects, recording of the current status, remote service personnel can be additionally connected, combining expert knowledge in important projects, checking for collisions (geometric measurement function)

Positive contribution:

- ▶ Presenting critical scenarios without endangering man and machine
- ▶ Training independent of location and time
- ▶ Training in future environments that do not exist as yet
- ▶ Training without allocation of (expensive, dangerous) real infrastructure
- ▶ Reducing the quantity of unavailable skills/qualifications
- ▶ Providing solutions ad-hoc

Table 1: See Runde and Ludwig 2018

Debate contributions



Current developments and trends in the digitalisation of vocational education and continued training in Germany

Charlotte Echterhoff and Andreas P. Müller

Digitalisation of vocational education and continued training in Germany: challenges

Digitalisation of the economy and everyday life has led to a revolutionary change in the way we work. The use of digital technology is omnipresent, especially in an industrialised society such as Germany. Business and production processes are transforming rapidly and there is an increasing interest in digitalisation in the education and employment market policy as well as in society (see Dobischat et al. 2019). The effects on vocational education and continued training are multifaceted. On the one hand, through their work in the company, trainees are already involved in processes in which digital technology is increasingly being used. On the other hand, digitalisation has by no means led only to changes in individual occupational activities. Following the introduction of IT occupations such as IT specialist, more recent studies indicate that other new job profiles may emerge, for example, in the context of robotics, sensor systems and platform technologies (Schwarz 2016, 110). Although there is a danger that a larger number of jobs will be lost (see Bonin et al. 2015), at the same time, the wide variety of new requirements may lead to an even larger number of new jobs being created (Zika et al. 2019, 30-31).

Vocational education and training in Germany is significantly shaped by the model of dual education, in which two equally important learning venues are closely interlinked. It offers the possibility of mapping the digitalisation of work as a continuous development and to integrate it as a future-oriented training opportunity (Schröder 2017). However, digitalisation also has an impact on the form of education because it places entirely new demands on learning and teaching (see Euler and Severin 2019). For example, learning via digital media takes place to a large extent on an informal level. Vocational competencies and the form in which these are acquired at school and in the company are changing (see de Witt 2012).

Current developments and trends in the course of digitalisation in vocational education and continued training show that the transfer from theory to practice plays a key role. Innovations must be made widely usable so

that regions and sectors benefit beyond model projects – strategic partnerships can be a solution here. The education policy must find a way to react agilely to innovations and incorporate these, for example, when revising vocational training curricula. At the same time, it becomes clear that education itself must not be allowed to fade from view behind the label "digitalisation", and that education must be understood holistically. Education and learning function as a social process. If digital media are adopted here, the skilled work of pedagogues is affected first and foremost.

The potential of digitalisation in education will be fully exploited if the digital medium is seen for what it is: an innovative instrument to implement a method from a learning theory. The choice of medium is an individual decision made by the learner. The advantage of the digital medium thus lies in the fact that it increases the number of choices, which means that the needs of internally differentiated learning groups can be met better. It is important to ensure that digitalisation does not act against the social framework of education and that digital learning is not equated with education. Instead, education should always include reflection and the ability to judge what has been learned. In this sense, the intrinsic spatial and temporal flexibility of digital technology could be beneficial in dual vocational training for cooperation between learning venues.

The political framework: strategies and initiatives of different departments

Current developments and trends in the context of vocational training and digitalisation are mainly promoted and supported in Germany by ministries at the federal and state level, by science and business, by social partners, such as professional associations and inter-company vocational training centres, and finally, by education agencies as well. There is certainly something unique in the contextual harmony in Germany between all these educational models and stakeholders that is worth considering in terms of innovation and transfer potential. The federal government's "Digital Agenda 2014-2017"

has already set out the following objectives: to make greater use of digital media in vocational education and continued training, to strengthen digitalisation in inter-company training and to prepare for the challenges of digitalisation in the workplace.

The digitalisation of vocational training is being systematically funded at the federal level. The responsible departments are at the Federal Ministry of Labour and Social Affairs (BMAS), the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry of Education and Research (BMBF). The BMWi's "Digital Strategy 2025" makes it particularly clear that, in the course of the development of innovative and competitive technologies, education and entrepreneurship go hand in hand with regard to digitalisation, for example, on issues such as the sharing economy, renewable energy, IT security and founding of start-ups. The challenges of the employment market and education policy have led to a concerted effort by various departments at the political level, which is reflected, for example, in the "Nationale Weiterbildungsstrategie" (National Strategy for Continued Training) published in June 2019.

Continued training is regarded as the key to lifelong "Learning and Working 4.0", due to the rapid pace of technical progress as well as demographic change. The "Qualification Opportunities Act" (Qualifizierungschancengesetz) is intended to provide the opportunity to undergo continued training, especially for low-skilled workers, and thus ensure their own employability. This is because they are considered to be particularly affected by the changes brought about by digitalisation in the employment market. In this context, small and medium-sized enterprises (SMEs) have a special responsibility to demonstrate ways of providing their employees with continuous and efficient advanced and continued training. Corresponding initiatives are being supported by social partners such as trade unions and professional associations, vocational training centres and agencies, and by non-profit and private institutions (Schmid et al. 2018).

At the BMBF, in addition to programmes for the digitalisation of universities and the recently released "Digital Pact for Schools", vocational training is a central field of action for digitalisation initiatives. The "Digital Media in Vocational Training" funding programme aims to modernise vocational training in the context of the "Educational Campaign for a Digital Knowledge Society" strategy and the "Vocational Education and Training 4.0" initiative, and thus supports Germany's overall competitiveness.

Structural changes in vocational training are to be initiated through the use of modern, digital educational programmes. Since 2012, nine funding initiatives have been launched under the programme. They aim at the media-pedagogical qualification of trainers, at the didactically justified use of AR and VR or at the support of inclusion by means of digital media, for example. In the various funded projects, different levels of digital learning are linked with partners from educational practice, technology, research and even small and medium-sized enterprises, and different sectors are addressed. For example, the project "D.I.A. – Digitalisation.Inclusion.Work" is taking place in the hotel and catering industry, and the project "FeDiNAR – utilising augmented reality to make errors didactically usable" focuses on metal and electrical engineering professions. Consistent orientation towards needs and practical experience enables the learning processes to be directly integrated into the real professional activity.

The "DigiNet" funding guideline differs from the other programmes in that its primary objective is not the new and the innovative. Based on results from previous fundings, it rather aims to increase the impact of good existing approaches. It involves strong networks for digital education: the BMBF is supporting the establishment of sector-specific or regional cooperation structures in the field of vocational training with a focus on digital learning. This enables it to focus on the networking and dissemination of digital learning infrastructures and education solutions, particularly in small and medium-sized enterprises, for example, in the project "LIKA 4.0 – learning on behalf of customers", which aims at the development of a web-based training management system. The funding of cooperation between learning venues, of strategic partnerships and cluster formation is proving to be particularly effective when it involves the transfer of applicable concepts.

The funding of Open Educational Resources (OER) also focuses on cooperation and exchange between stakeholders. Educational materials with open licences herald a systemic change in education, aiming at collaboration and doing away with the previous understanding of learning as an isolated activity. Education as a public good is considered to be a joint task and is to be implemented accordingly. Since digital media are suitable as tools for collaboration and cooperation, they are considered to have great potential for promoting this "contemporary education". Digitalisation is not only focused on technological innovation in this context, but also calls for a change in attitude.

Outlook

The increase in the number of education and continued training programmes devoted to digital subjects, job profiles, requirements, etc., is accompanied by a sharpening of awareness of the challenges involved. For example, it became clear at a relatively early stage that, in addition to education and continued training with digital media, the teaching of media skills and problem-solving skills is indispensable. The focus must not be solely on the characteristics of the learners, but also on the pedagogical staff (trainers, and possibly vocational school teachers) (see Härtel et al. 2019). Media-pedagogical skills must be strengthened in order to facilitate contemporary education and also to exploit the potentials of digital transformation for education (not just the other way around).

The issue of social diversity and inclusion has a special dimension in terms of the employment market and social policy. The qualification goals of education and continued training are changing in parallel with the digitalisation of production technologies, services and teaching/learning scenarios. There is a growing need for comprehensive knowledge, procedural skills, technology impact assessment and a fundamental understanding of how algorithms work. At the same time, society is becoming more diverse and multilingual. It is therefore necessary to meet specific qualification goals with the help of both fundamental and creative-intellectual teaching or learning units – a balancing act that places special demands on curricula and on personnel (see Bylinski and Rützel 2016). ■

Digitalisation in the skilled crafts sector – VET as a driving force

Sven Zoeller and Mirko Wesling

Digitalisation has conquered all areas of life within the span of a few years. This is leading to far-reaching changes in the skilled crafts sector as well (see Theis 2018, 6). Aided by new technological possibilities on the one hand and in response to the resulting change in customer demand on the other, skilled craft businesses are developing new business processes that make use of digital innovations: Roofers use drones to quickly determine the need for repairs to a roof, the automotive mechatronics technician first reads the error memory of the car, 3D scanners support health care professionals (such as audiologists and dental technicians) in measuring the human body. The skilled crafts are also on hand to convert your home into a smart home. Intelligent home technology is installed in such a way that air conditioning, heating, roller shutters, entrance doors, alarm system and lighting are coordinated and work semi-autonomously, as do garden maintenance technology and irrigation, to name but a few. In this way, the skilled crafts bring digital technology to the user in many, diverse areas.

VET promotes digitalisation

The willingness to integrate digital innovations into one's own work processes is growing with the increasing number of digital natives in skilled craft businesses (see Deiniger 2017). But how can the necessary specialist knowledge be acquired in a structured and sustainable manner? A look at the qualifications of employees reveals the following: The vast majority of people working in the skilled crafts (87 percent) have successfully completed vocational training (see Haverkamp and Fredriksen 2018, 49). Consequently, if comprehensive skills for shaping the digital transformation are to be achieved throughout the sector, this can only be accomplished through vocational training. Thanks to its great importance, especially in skilled craft companies, it has the potential to become the driving force for successful digitalisation. The interdisciplinary skills that the skilled crafts have gained additionally at the interfaces between manual and digital processes help to better exploit the possibilities of technology, and this ultimately benefits the private user. Both initial basic training and advanced and continued training are the key to actively shaping the path to digitalisation.



The skilled crafts are seeking to adapt education and continued training regulations during their revision such that, on the one hand, the need for digital skills arising from professional practice is taken into account and, on the other, vocational skills are described in a manner that allows the concrete teaching and learning content in companies, inter-company training centres and vocational schools to be continually adapted to future digital progress. This open-structured formulation is a key factor in the success of vocational training in Germany.

Specific advanced and continued training programmes (e.g. Smart Home System Integration) play an essential role due to the rapid pace of new developments and the large number of potential skills required in very different areas of application. Thanks to these programmes, it is possible to react to new requirements selectively and rapidly according to specific needs.

Advantages for other countries as well

What sets Germany apart when compared to other countries is its high-quality dual vocational training system, the high proportion of added value generated by the skilled crafts in the country (see ZDH 2019a) and the high

reputation of the skilled crafts sector. These factors have a strong appeal abroad and generate growing demand for Germany's International VET Cooperation (IBZ) (see BiBB 2019). With the edge in experience gained from the implementation of digital content in a potential total of 130 German skilled crafts, the amended education and continued training regulations can be adapted to the respective requirements of the partner country within the framework of International VET Cooperation. This can be achieved, in particular, with the help of the SCIVET strategy kit (see ZDH 2019b).

Conclusion

An advanced vocational education and training system is a key driver of digitalisation. It also ensures widespread participation in technological progress. If organised well, it can support the future viability of professions and form the basis for successful digitalisation in companies. When supplemented by existing professional experience-based knowledge, a solid basis is created for customised orientation to market requirements. Experiences gained from implementation in German vocational education and training is also highly relevant for international VET cooperation. ■

Innovation potentials of VET 4.0 in international trade union cooperation

Hans Ulrich Nordhaus, Martin Roggenkamp and Monika Stricker

Placing the focus on people also means involving them fully in the design of their work. Good working conditions cannot be achieved without workers' participation. This applies in particular to the development and use of new technologies and the associated changes in work organisation and processes. Workers' and workers representatives' participation at an early stage of planning and development can help to prevent subsequent undesirable developments.

The digital transformation is therefore a great challenge for trade unions. Further development of initial and continuing vocational education and training plays a decisive role in shaping this change in a socially acceptable form. The digital transformation goes hand in hand with a fundamental change in employment structure and company job profiles. There are two hypotheses on the development trends (among others, Hirsch-Kreinsen and ten Hompel 2015): (1) A general upgrading of qualifications is taking place. On the one hand, simple routine activities are being reduced to a large extent, and, at the same time, there is an increase in activities that focus on the processing and handling of a large variety of information about ongoing processes, characterised by a high degree of structural openness, limited division of labour and high flexibility. (2) This contrasts with the forecast of a polarisation between the demand for, highly-qualified activities on one hand and, on the other, activities that are simple but cannot be automated. This leads to an erosion at the middle qualification level, namely at the level of skilled workers.

Against this background, the development of employees' skills is a central resource for shaping digital change and preventing the de-qualification of skilled work. Scientific and political discussions (see inter alia the recommendations for action from the "Digital Workplace" platform for continued vocational training) have revealed that the changing skill requirements can be differentiated on the one hand into IT skills and the use of digital media in the respective technical field and, on the other hand, into the growing importance of process knowledge, problem-solving skills and key competences to enable self-directed and cooperative communicative action, as well as competences to cope with change at the individual level.

In order to promote vocational training 4.0, which corresponds to these skill requirements, the following approaches are of primary importance from the perspective of trade unions.

The modernisation of occupational profiles has a dynamic tradition in Germany and is based on a proven procedure involving the participation of social partners, ensuring that the requirements of the workplace are directly taken into account. This was most recently demonstrated by the partial revision of the curricula of the occupations in the metal-working and electrical trades which considered the new requirements of digitalisation. In addition, the training regulations are formulated in a manner that is structurally and technologically open-ended, to ensure that technological innovations can be integrated into practical in-company training.

The qualification of the training staff is another key element for VET 4.0. Instructors must not only be qualified and supported in integrating the new skill requirements in the vocational training, but also in dealing with digitalised learning/teaching concepts that require a change in the role of the training staff from knowledge mediators to coaches and learning process facilitators and necessitate media-didactic skills, knowledge and experience in dealing with new technologies.

Finally, VET 4.0 requires an integrated education strategy that ensures permeability between vocational and academic education and between different specialist disciplines within the framework of lifelong learning.

Digital transformation is a global process, which means that trade unions in different countries are being confronted with similar challenges. Technological change is taking place primarily in specific sectors. As a result, cross-border value chains are more decisive for the nature of the challenges than the national context. Transnational cooperation between trade unions and the exchange of ideas, proven procedures and good practices at the international level can hence make an important contribution to the structuring of VET 4.0.

German trade unions can provide significant contributions with regard to reorganisation procedures based on social partnerships and the qualification of the training staff, whereas they can learn about permeable educational pathways. The new digitalised teaching/learning concepts can be an important medium for international trade union

cooperation because they enable knowledge transfer that is location and context-independent, allow better networking and continuous exchange, and thus promote mutual learning between trade unions from different countries. They also promote better access to education in countries with a weaker education infrastructure. ■

Economy 4.0 and vocational education and training: Which reform stimuli for innovative qualification formats can be identified in the German Chambers of Commerce Abroad (AHK)?

Three continents – three perspectives

Bonny Brandenburger

The digital transformation and an increasing use of industry 4.0 technologies, such as the 3D printer, have led to a change throughout work and production processes. In particular, this results in individuals being faced with new qualification requirements, as clearly shown by a qualitative survey conducted by Service GmbH of the Association of German Chambers of Industry and Commerce (DIHK) in June 2019. The surveyed Chambers of Commerce Abroad (AHK), namely, the Delegation of German Industry & Commerce Shanghai/China (hereinafter AHK Shanghai), AHK Italien and AHK Mexiko, all agree unanimously: one of the central challenges in the course of digitalisation is the appropriate qualification of employees. The head of the VET department of AHK Shanghai reports that there exist so-called "smart factories", some of which have very modern equipment. However, there is a lack of corresponding personnel to control and maintain the machines. The survey also revealed that there is not only need for specialist knowledge, especially in industrial automation. In addition, various key competencies are increasingly in demand. Depending on the occupational group and hierarchical level, there is a lack of skills such as networked thinking, creativity, problem-solving skills and methodological knowledge among personnel.

Innovative qualification programmes from the AHK community

In order to meet the increased demand from the business sector for appropriate qualification models, the interviewed AHKs are already working on different formats. AHK Shanghai, for example, wants to offer the apprenticeship as a mechatronics technician with specialisation "Robotics" in the future. New content will be integrated into the existing education curriculum for this purpose. The AHKs are also working on new additional qualifications, e.g., AHK Italien as part of "DigITALIA" project. In this project, a company survey was conducted to determine the skills and abilities needed in future workplaces. Based on this, suitable formats are now being developed to impart the required skills. AHK Italien, as well as their counterparts in China and Mexico, are using existing DIHK-Bildungs-GmbH programmes, such as the certificate courses "Skilled Labour for Industry 4.0 (IHK)" and "Agile Mindsetter (IHK)", as a basis for this.

Hybrid education formats – a new area of business?

A further important step in modernising vocational training involves closer networking of the vocational and academic education system. The three AHKs that were surveyed report that both trainees and companies are

increasingly interested in hybrid education formats and that the aspect of lifelong learning is becoming more and more important. In this context, work is already under way on corresponding advanced and continued training programmes in cooperation with universities and companies. AHK Mexiko is currently developing a masters programme in engineering in cooperation with BMW, IHK Munich and a domestic university. This programme is designed to prepare prospective graduates for jobs at the middle management level and to facilitate access to university education.

AHK Italien is planning to introduce an inter-company trainee programme for university graduates who find it difficult to enter the employment market. Not every company can offer its own trainee programme as an entry opportunity. The AHK therefore wants to bundle resources and prepare university graduates for the employment market in a demand-oriented manner with the help of targeted skills management. For example,

university graduates with a commercial background can use the programme to acquire the technical expertise needed for a job in the area of sales engineering.

There is general agreement that hybrid education formats represent a potential new business field for the AHKs. In addition, according to the surveyed AHKs, the required skills must first be identified specifically, and suitable formats for education and continued training must then be determined. This requires so-called "change agents" in the companies, who can develop a systemic view of the company processes, link different hierarchical levels with each other and thus create a common understanding of continued training needs. However, according to the interviewed AHKs, some companies and organisations need not only good ideas but also a cultural transformation in order to drive forward further stimulus to reform. In particular, a change in thinking from the classic, top-down approach to a network-like approach is required. ■

Areas of action in vocational training during the digital transformation

Ralf Hermann and Hannelore Kress

The digitalisation of the workplace is predominantly perceived as a "designable challenge" (Esser 2019, 3), which first and foremost offers new opportunities. These consist of potentials for new business models and economic growth, facilitation of work processes, diversified working and learning environments and incentives to make vocational education and training more attractive. However, "the future of digitalisation" must be designed "by human beings" and "with a human dimension" (Popp 2019, 24). The required normative framework is set by democratic negotiation, regarding which educational goals – and thus which humane and social development goals – should be served by technical innovation, and how its opportunities should be structured, its risks limited and its consequences managed.¹⁵ In this context, education – and especially

vocational education – has more than just a technically determined implementation function that reacts to practical constraints. On the contrary, it can play an "active-constructive role" by producing knowledge, skills and reflective abilities that are among the prerequisites for innovative technology development (Lee and Pfeiffer 2019, 161). The accelerated change in technologies and work requirements also confronts the VET system with expectations of rapid, frequent and small-scale adaptations. Systemic educational goals, however, remain focused on "professionalism" as the normative principle of good work and high-quality, sustainable education.¹⁶ This corresponds to the fact that even under conditions of highly dynamic innovation, standards are created on the basis of negotiation of interests and social partnership-oriented consensus.

¹⁵ The challenges for "good work" in the future include, for example, the risks of a digital divide, the casualisation of independent work, the discrepancy between added value and income, the erosion of work-related social ties, the dissolution of collective bargaining agreements and the removal of boundaries in terms of work time and work space.

¹⁶ Whether these system constituents will be able to withstand the impact of digitalisation is an "open question for the future. A radical departure from the principle of regulated occupation would, however, be accompanied by serious implications for qualification and 'education'" (Dobischat et al. 2019, 10).

In addition to normative issues, VET-related discourses on digitalisation address other dimensions as well: trainees/learners, companies, regulatory policy and pedagogy (see Euler and Severing 2019). A number of initiatives have been launched to anticipate the future demand for skilled employees in companies, to implement technical and organisational adaptations to learning venues according to requirements, to describe and strive for skill profiles and development opportunities in education and continued training, and to promote innovation and development of skills among the trainers.¹⁷

A fundamental discourse is being conducted on employment forecasts and the derivation of requirements for VET management and practice. Polarisation of work structures – between iterative routine and self-organised, innovative key activities, and more generally between low-skilled, low-wage employment on the one hand and high-skilled, high-wage employment on the other – is not expected for Germany (Helmrich et al. 2016, 66), in contrast to the USA, for example (Frey and Osborne 2013). According to these forecasts, the German employment system gains stability through its mid-level segment, i.e. the segment of well-qualified skilled employees. Accordingly, corporate employment systems in Germany tend to be "more concerned with upgrading qualifications" (ibid., 69), in particular of vocationally trained workers on the intermediate skills level, towards academic qualifications.

In Germany, the number of job losses is expected to be much lower initially.¹⁸ In their most recent digitalisation scenario, the qualification and employment projections (The QuBe project – Qualifications and Professions in the Future, being conducted under the joint leadership of the Federal Institute for Vocational Education and Training (BIBB) and the Institute for Employment Research (IAB) in collaboration with the Institute of Economic Structures Research (GWS), assume that the number of newly created jobs will exceed the number of vanishing ones until around 2030, with an acceleration in the pace of change. For Germany, a net loss is only expected in about 15 years (Wolter et al. 2018; BIBB 2019, 419; see also Figure 1). This certainly implies immense regroupings within the qualification and employment system, with massively changed job

profiles, sector-specific differences and a "trend toward broad-based higher qualification" (BIBB 2019, 422, see also Kruppe et al. 2019, 14).

A high percentage of narrowly defined activities is already potentially replaceable during the digital transformation, particularly where the qualification base is low. The percentage of employees in occupations with high substitution potential (>70 percent) has risen from 15 percent to 25 percent between 2013 and 2016 (Dengler and Matthes 2018, 7). However, this does not directly mean the loss of jobs or "extinction" of occupations. Occupations that have a broad definition of "competency" offer opportunities for adaptation to changing requirements and are themselves subject to far-reaching adaptations in the digital context.

The screening of occupations and sectors as part of the BMBF/BIBB project "VET 4.0" analyses qualified trades, continued training needs and sectors, with regard to digitalisation requirements and consequences. It documents significantly different degrees of digitalisation in different sectors. Recent regulatory procedures in the industrial metal-working and electrical occupations and in the creation of a new occupation in the field of e-commerce have been a reaction to the high level of modernisation required in specific sectors. Procedures have been accelerated, new occupational profiles related to the digitalisation of work, data protection and IT security have been integrated, and additional qualifications in the area of process integration and IT-supported applications, among others, have been introduced in the respective occupational groups.¹⁹ The training regulations are being formulated to ensure openness to new technologies. Despite uneven development in the different sectors, it is obvious that in the medium term, a large number of existing qualified trades will have to undergo comprehensive revision (see Spöttl 2018, 8).

The skill requirements analysed by the BIBB Qualification Panel provide orientation for the further development of VET. In addition to IT and occupation-specific professional skills (e.g. mastery of cyber physical systems), generic skills such as learning aptitude, understanding of processes and systems, and flexibility and creativity in solving new, non-routine problems are gaining in

¹⁷ Of particular note are the BMBF's funding announcement "InnoVET" (www.bmbf.de/innovet) and the BMBF/BIBB initiative VET 4.0 – (<https://www.bibb.de/de/49603.php>).

¹⁸ Bonin 2015 predicts a risk of job loss for 12 percent of employees, particularly among the low-skilled and low-paid.

¹⁹ Electronics for building and infrastructure systems, operating technology, automation technology, information and systems technology, mechatronics (www.bibb.de/de/84066.php), clerks in e-commerce (www.bibb.de/de/berufeinfo.php/profile/apprenticeship/261016), system mechanics, industrial mechanics, construction mechanics, tool mechanics, cutting mechanics (www.bibb.de/de/berufeinfo.php/profile/apprenticeship/121214); URL accesses: 23/08/2019.

Chart C2.2-2: Number of jobs that will be created and those that will disappear between 2018 and 2035 (in millions)

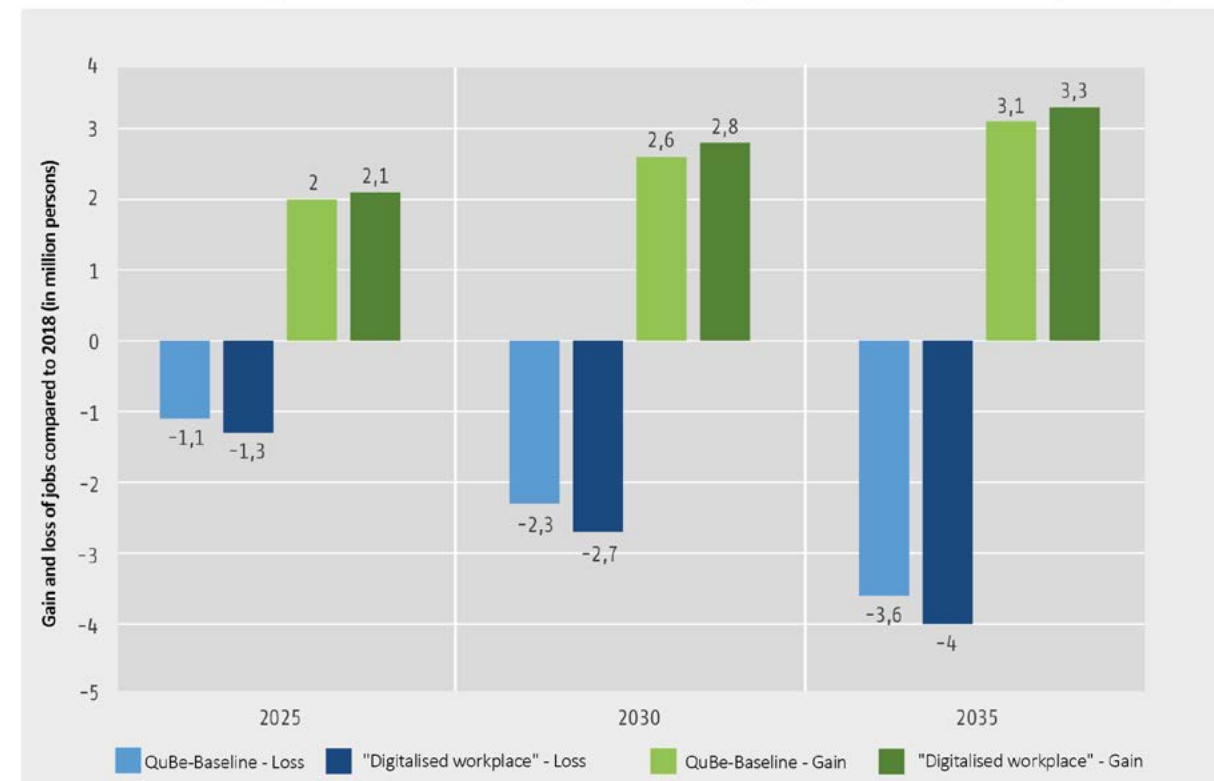


Figure 1: Number of jobs that will be created and those that will disappear between 2018 and 2035 (in millions) (BIBB 2019, 425)

importance for VET 4.0 (BIBB 2019, 449; see also Zinke 2018). Accordingly, system-oriented, deductive didactic approaches are coming to the fore (BIBB 2019, 454).

Digitalisation increases the demands on the education system to adapt in terms of greater permeability between vocational training and academic education. At the subject level, this includes opportunities for educational pathways to become more socially and professionally permeable (Kaßbaum and Ressel 2019).

Changes in the range of tasks, rising expectations with regard to qualifications and faster innovation cycles result in the growing importance of continued training – from an individual, corporate and systemic perspective. This involves, for example, regulatory frameworks and education policy concepts for continued training 4.0, the development of perspectives through "career trajectories", and inclusive participation in continued training. New learning media are being developed and didactically prepared as open educational resources for education and continued training.²⁰

Digitalisation also requires new forms of learning and a redefinition of the skills and roles of learners and teachers. Trainees and learners are learning autonomously to an increasing extent, and accordingly, the role of company-based and school teaching staff is changing to that of learning facilitators. In addition to the teaching of technical digital media competence, the support requirements and measures are primarily directed towards the pedagogic-didactic expansion of competence of trainers with regard to the creation of materials and the structuring of teaching/learning arrangements. One requirement in this context is the strengthening and support of the trainers through corporate organisational and personnel development (Dietrich 2018, 29-31). In cooperation with the BMBF, the BIBB is planning a nationwide teaching programme in 2019 in the use of digital media for training personnel (BIBB 2019, 487).

Companies exhibit very different degrees of digitalisation. Larger companies make greater use of digital technologies. Clearly differentiated degrees of digitalisation can also be seen when individual occupations are considered (see

²⁰ For the BMBF initiative regarding the status of the development of OERs in vocational training, see Grimm/Rödel 2018.

Padur and Zinke 2019).²¹ Overall, companies with a high degree of digitalisation also show a greater willingness to provide education and continued training (BIBB 2019).

In order to make it easier for interested small and medium-sized enterprises to digitalise production and service processes and to facilitate their first steps, the BMBF is supporting inter-company education and continued training centres with approximately 120 million euros until 2023. The funds can be used for the purchase of equipment, machines, systems, software, and for innovative learning/teaching environments and qualification. This special programme has already made it possible to provide over 26,000 digital devices and equipment to around 200 inter-company vocational education and training centres since the start of funding (see online at: www.bibb.de/de/77627.php#module98948).

BIBB is conducting the research and transfer initiative "ASCOT – technology-based assessment of skills in VET" (2011-2015) and "ASCOT +" (2019-2022) on behalf of the BMBF in order to be able to assess and verify the acquisition of digital skills. Digital instruments for trainee learning and assessment are being developed and tested in this context in the vocational fields of health care, technical industrial and commercial occupations (see online at: www.ascot-vet.net).

International cooperation and digitalisation

The opportunities and challenges of digitalisation are global in nature. Technological opportunities are opening up everywhere, teaching and learning environments are changing, and education systems are being transformed. In all parts of the world, the new workplace is also imposing fluid qualification requirements on education and continued training. The transition to the world of education 4.0 is taking place simultaneously and experimentally in a kind of global laboratory, without any fixed expectations and with a wide range of innovations in the most diverse locations. Given that one of the objectives of international VET cooperation is to gain impetus for the further development of VET in Germany, the field of digitalisation offers particularly good opportunities. International partners are showing great interest in the adaptations described above regarding the German VET system. Conversely, as a location for education and innovation, it is in Germany's interest to gain access to process solutions and technological solutions abroad and to jointly test the integration of these solutions into vocational training.

All instruments of cooperation should be used in this process. Dialogues at the educational policy level and practical level must treat digitalisation as a key issue – on an ongoing basis and in all cooperation between countries. Dialogue and exchange of experiences serve to identify concrete needs, which are then used as a basis for country-specific action concepts and measures. At the same time, they are intended to identify examples of good practice or create them in a cooperative manner. Pilot projects should hence test technological and process innovations within corporate and school education, develop materials and learning environments, and strengthen pedagogical capabilities for teaching digital media competence. Companies abroad and their cooperation partners in local and regional value chains have a key role to play in testing digital educational innovations. Providing support for German companies in the development of skilled employees 4.0, by means of good and fair education, strengthens the competitiveness of these companies. At the same time, the companies themselves are competent stakeholders in the implementation of VET innovations. There is also great potential in the services provided by the German education sector for education and continued training with a view to future skills, which are in demand in numerous countries and which are supported, for example, by the BMBF initiative "iMOVE – Training Made in Germany" or by the instruments of project funding.

The entire range of topics in VET 4.0 is suitable for international cooperation. Research, for example, on the change in qualification requirements, on the introduction and substitution of technology, on effects on companies, institutions and education management, has long been carried out with a mostly international perspective. The results of international research enable "evidence-based" adaptation of VET management and practice in Germany as well. Potential for practical cooperation lies, for example, in the continuing joint development of teaching and learning (personalisation of learning processes, access to resources for lifelong learning, multi-channel learning, practical simulations, location-independent and international learning groups, and pedagogical continued training). In many countries, including Germany, improving the attractiveness of vocational training is an urgent task. Digital media development, pedagogic-didactic development of skills and active participation of the "digital natives" in educational design can make a valuable contribution to this and should be a core subject of international cooperation.

²¹ In the exemplary study of 12 professions, media designers, agricultural and construction machinery mechatronics engineers, and industrial clerks showed the highest degree of digitalisation.

Improving access to education through digitalisation is another topic that is gaining in importance both in Germany and in cooperating countries (e.g. in the EU, Russia, Israel and elsewhere). The inclusion of groups that are excluded from participation in education for a wide variety of reasons is beneficial for individuals as well as for national economies and social cohesion.

When considering country-specific and regional perspectives, the European level can only be considered to a limited extent here. Digital change is a central task for shaping VET in Europe (see ACVT 2018) and is currently the focus of the "Education and Training" working group (ET 2020). It is increasingly becoming the subject of institutional and project cooperation among European partners who take the initiative in shaping digital change (e.g. France, Italy, Latvia). The latest trends in the training of skilled employees for the electromobility and automation technology sector are being discussed with Slovakia. Exchange with countries with dual education models (Austria, Switzerland and Denmark) has been established for many years. Digitalisation is a self-evident and stimulating part of further cooperation for Germany in this context.

Outside Europe, global "innovation leaders" are driving the digital transformation. VET – with its good reputation on the German side – should be integrated into innovation dialogues with the relevant countries in Asia and North America. Intensive exchange already exists in the "German-Israeli Programme for Cooperation in VET", in which digitalisation is a priority. Innovations in digital media and learning environments as well as the continued training of pedagogical staff are part of the cooperation portfolio. Israel has set the course in dealing with globally-oriented educational platforms by participating in EdX with a national platform (IsraelX), thus creating access to teaching and learning resources. The global programmes offered by education platforms and MOOCs (massive open online courses) also have an impact on Germany and require general positioning on how VET systems and institutions should respond to the opportunities offered by these, and their global market power.²²

Although the priorities in developing countries differ from those of OECD countries, the former are also faced with the pressure to act and the opportunities provided by digital change. E-learning and m-learning can redefine

access to educational content in these cases in terms of broader participation, as long as it is offered in a socially inclusive way. Some East African countries are already making innovative use of digital technologies (e.g. Kenya, Rwanda: financial services). Potentials for VET cooperation should be examined more closely and developed jointly. In many African countries, however, infrastructure problems remain a serious obstacle to sustainable education reforms even in the mobile-digital age. Rapid substantial progress is therefore scarcely realistic without joining forces with financial cooperation stakeholders. In all countries, and particularly in developing countries, close coordination between German government stakeholders internally and with non-governmental stakeholders is also necessary in order to pool cooperative activities and structure them effectively. This is taken into account in the country-specific strategies that are developed for selected cooperating countries in accordance with the federal government's strategy.

In the cooperation BMBF portfolio, VET 4.0 is already on the agenda for several countries, some of which have digitalisation strategies and are also driving forward the change in VET. In Russia, teaching/learning materials are being analysed with a view to digital possibilities and new platforms are being created with a focus on quality assurance for education. The "Future Skills" programme is taking a disruptive approach in confronting vocational fields with formal and informal models and recombining these via a navigator platform. A dialogue forum "Innovation in VET" was established with China in 2019. The key questions are: How can the rapid marketability of cutting-edge technologies be achieved, what qualifications are needed for this and what forms of training measures are available for the teaching staff and trainees?

During didacta 2018, the BMBF and the German Office for International Cooperation in Vocational Education and Training (GOVET) invited the cooperating non-European countries (which at the time were USA, Russia, China, Mexico and India) to exchange experiences on digitalisation and VET. The exchange is to be systematically continued and intensified in cooperation with these countries. In addition, digitalisation offers the opportunity to open up multilateral exchange formats and to cooperate with interested partners on specific topics even beyond the framework of bilateral formats. ■

²² This raises questions about the relationship between supply and demand orientation of (continued) education and commercial educational content in relation to management, standards and curricula; about the recognition of informally acquired skills; about learning support and orientation towards education biography; and about the social inclusivity/exclusivity of marketed content. At the same time, institutions have to measure themselves against high quality standards if they wish to survive in global competition with programmes of their own.

Change paralysed instead of accelerated – virtual reality in vocational education and training: what Germany can learn from Switzerland

Axel Koch

They look like they're from another planet. They wear opaque, black masks on their faces similar to diving goggles, have a kind of gear stick in each hand and they move strangely around the room. These are young people who practise nursing activities with virtual reality goggles and controllers in their hands. In their goggles, they see a lifelike room in a hospital with a patient in a bed. Their task is to recognise and correct the errors that are built into the depicted situation. For example, the glass of water may be placed too far away from the bed. In real life, the patient would not be able to reach the glass to drink from it.

Virtual reality (VR) is gaining ground in education. This is because the required technology is now powerful enough (2016). One of the pioneers in the use of VR in nursing education is the Bern Nursing Education Centre, which, according to its own statistics, is the largest nursing education provider in Switzerland with 1,200 students (Fell 2018). For prospective nursing professionals, the virtual world offers completely new learning experiences. They can fully immerse themselves in the everyday life of nursing, move around in the room and interact with everything that happens in the virtual world. Immersive learning is the new German term for this; the term describes "immersion" in the learning environment involving as many senses as possible.

In the following interview with Christian Steiner, who implemented the VR project at the Bern Nursing Education Centre with his company Senselab.io, we look at the question of what Germany can learn from Switzerland when using virtual reality in vocational training.

"The idea for the virtual patient room was born about two years ago," says Christian Steiner, co-founder of Senselab.io, the company that implemented the project. It was not the technology itself that was the driving force behind the project, but capacity bottlenecks in training. Prospective nurses usually practise nursing activities in real rooms with actors as patients. Virtual Reality appeared to be the ideal solution to avoid having to maintain a large number of furnished rooms or even operating theatres,

and having actors and actresses on hand. In order to ensure that as many nursing students as possible would benefit from the new technology, the first step was the above-mentioned virtual patient room.

Virtual reality is fascinating. Everything is so tangible. You can immerse yourself in the action and it feels so realistic. This is quite different from solving tasks on the computer by clicking on answers. Those who immerse themselves in VR quickly lose their sense of the real world around them. VR enables the user to deal with a learning object directly and intensively. The content is made available as a 360-degree video and can therefore be experienced in all directions by the viewer, just as if they were in the middle of the action. This virtual spatial experience becomes even more intense when data gloves or gesture control are added (2016). The more strongly the perception is integrated, the greater the learning effect. Learners not only hear and see the content, but also perform actions and thus immerse themselves fully in the simulated learning environment (Haidar 2019). This was also shown, for example, in a comparative study of 99 students. They were able to concentrate longer on the learning material by using VR and could retain it better than by reading a text or watching a video (Allcoat and von Mühlenen 2018).

This is also confirmed by initial experiences in the Bern Nursing Education Centre. Instead of learning lists of classic sources of error in nursing like learning vocabulary, the nursing students learn by actively doing things in the virtual patient room. They move through the room, bend down, have to pick up a bottle from the floor, change a full urine bag or put a remote control that has fallen to the floor back on the bed. As a result, they are later able to recall the things they have learned much more easily.

But despite all the enthusiasm and effectiveness – it is time-consuming to depict training content in virtual reality. Financial limits are quickly reached, as Christian Steiner knows, having founded an agency specialising in virtual reality with his business partner Claus Divossen four years ago. It takes about three months of development time for a first prototype such as the virtual patient

room and costs a five-figure sum. In view of these costs, the Bern Nursing Education Centre still has a long list of unfulfilled wishes. After it became clear that a single provider alone could not cope with the investment, the Swiss have now taken a new approach. "We are setting up a nursing consortium in order to bring together several nursing companies around one table," reports Steiner. The first step is to define the requirements for the VR application in more detail and to assess what shared financing might look like.

The Senselab.io co-founder is convinced that this is a good approach for the future of vocational training. Basically, the providers of various vocational training courses should get together and consider which VR applications offer sufficient added value for their sector, thus making it worthwhile to invest in the development and actualisation of the applications. It would involve cooperation, concentration and joining forces.

However, Steiner knows from his experience in other German-speaking countries that German vocational training is still a long way off from such ideas. One reason for this is that the willingness to invest in the new technology is significantly higher in Switzerland, for example, than in Germany. Another difference is the attitude towards the development of VR applications. "German customers actually want a finished application all at once and do not understand that such emerging technologies can actually only be created iteratively. In other words, that you might have to go through two or three development loops to find out what the benefit factor is and where it helps you personally."

And finally, training structures present another obstacle. On the one hand, there are rigid training regulations that are almost impossible to change. On the other hand, there is also a lack of easy access to digital media. Whereas in Switzerland the freedom to use media already exists in school teaching, Germany gets entangled in licensing, legal issues and, according to Steiner, "idiotic fees".

Switzerland follows the principle that everything that is freely available may also be used in school teaching. "In Germany this is just pure hell. On the other hand, in Switzerland, for example, schools can access everything that is on television free of charge, via a complete database. Be it news, numerous documentaries, or even the smallest snippet of editorial content." And this is not the case in this country. The teaching staff would be forced to urge their students to watch specific content in their free time. Overall, in Steiner's experience, there is unfortunately hardly any momentum in Germany with regard to the digitalisation of schools and education.

In Switzerland, he said, there are many more resources that are invested in the training of young people. This leads to the availability of much better learning materials and also much better learning structures. "Just imagine this nursing centre. It is a huge building and on the top floor a complete hospital has been recreated, where they can do whatever they want in a teaching context. It's really rare to find something like that here in Germany."

In addition to digitalisation, Steiner sees another trend that should not be overlooked in education: "I was born in 1985, so I turned 34 this year, and would describe myself to a small extent as belonging to a generation where state education is actually completely overrated. And this is even more the case with the generation that is now coming of age. I believe that more than half of the occupations that interest young people today are not recognised by the state."

So it's high time to rethink the education system and to accelerate the tempo of change in Germany, says Steiner. Above all, smart financing models and cooperation are needed to enable better and more resource-efficient training with the new technologies in the long term. Virtual reality, for example, makes it possible to practise training content more realistically, to make learning more effective, and also to promote fun in training. Switzerland is a model for the future. ■

Further information

Website "Immersive Learning News". Operator: Torsten Fell: <http://www.immersivelearning.news/> (last accessed on: 02/08/2019)

DIVR Award website of the German Institute for Virtual Reality <https://www.divr.de> (last accessed on: 02/08/2019)

Website eLearning Journal with awards: <https://www.elearning-journal.com/award-uebersicht-2019/> (last accessed on: 02/08/2019)

Digital business models for VET cooperation 4.0?

Léna Krichewsky-Wegener

Vocational education and training (VET) projects funded within the framework of the funding guideline for the "Internationalisation of Vocational Education and Training" (IBB), are called upon to make a "contribution to the sustainable development of business models for German providers of education and continued training services" while "taking into account the innovative use of digital media" (BMBF 2016, 2).

A business model "describes the basic principle by which an organisation creates, communicates and records values" (Osterwalder and Pigneur 2011, 18). A business model is digital if digital technologies have induced a fundamental change in business activities and value generation (Veit et al. 2014, 48). For VET providers, digital technologies have the potential to bring about change in at least three respects.

- ▶ Digital technologies are changing the workplace and thus affect qualifications requirements and learning needs (content).
- ▶ Digital technologies create new opportunities for designing teaching and learning processes (form).
- ▶ Digital technologies open up new possibilities to design the business processes for VET provision process).

Based on an analysis of the demands on employees in the workplace 4.0, Sauter (2017) emphasises the need for a paradigm shift in VET. Pure knowledge transfer, which he describes as "instructional didactics", is not suitable for preparing people to solve problems, which are as yet unforeseeable, in complex systems in a creative and self-organised way. Instead, he said, VET needs to focus on competence, understood in a holistic way as including cognitive, behavioural and affective dimensions. Within the framework of "enabling didactics", informal, collaborative and self-organised learning as well as learning from real challenges and in networks are particularly in demand (ibid.).

The IBB projects focus, without exception, on sectors that are strongly affected by technological change, such as logistics and the automotive industry.²³ This is reflected in the value proposition of the projects, which aim at training learners according to the latest international standards. Around half of the projects use e-learning modules or webinars to supplement face-to-face events and thus support self-directed learning. However, only a few projects make the paradigmatic leap towards the "enabling didactics" described by Sauter (2017). A noteworthy exception is provided by a project, whose value proposition is described as innovation through work-integrated learning with the support of self-organised learning using digital media.

In the business processes of the IBB projects, digital technologies have, at most, a complementary or supporting function. Most of the services are developed in close dialogue with the customer, and in a few cases, they are also explicitly customer-integrated. Digital media is also used for communication. A third of the projects use social media to acquire customers and individual projects have also set up a website or developed an app. However, in comparison to the possibilities of digitalisation pointed out by Seufert et al. (2017) for the business models of German VET providers, the majority of IBB projects remain rather conservative. For example, the other elements of the business model, such as cost structures, sources of revenue, key partnerships and resources do not indicate innovative, technology-based approaches.

Overall, the business models of the projects in the IBB funding guideline take into account the possibilities of digital media, especially in their service portfolio. With a few exceptions, however, no radical business model innovations based on digital solutions can be identified as yet. This largely corresponds to the situation in the German market for VET, where "digitalisation is on the upswing, but still at a relatively early stage" (Kirchgeorg et al. 2018, 2). Although competition from international education start-ups is less pronounced in the



VET sector than in the university sector, it is important to identify design potential that is as yet untapped in this context for the development of trend-setting and sustainable business models (Stifterverband für die Deutsche Wissenschaft e.V. and McKinsey & Company 2019). Digital solutions appear promising, particularly in view of the special challenges posed by activities

abroad,²⁴ such as the effort involved in coordination and communication, high costs of travel, protection of intellectual property and the often poor image of vocational education and training abroad. ■

²³ The following statements are based on a survey by the Business Model Canvas of twelve funded projects in May 2019.

²⁴ The following challenges of internationalisation mentioned in the text were the most frequently mentioned in a survey of the projects of the IBB funding guideline in September 2018.

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