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Editorial: Teaching and learning between virtuality and reality

ABSTRACT: Discussions about the digitisation of the professional and working world assume that virtual teaching and learning will increasingly merge with real teaching and learning which will result in new, innovative technology-based teaching and learning approaches. Against this background, this article addresses technology-based realms of experience and considers the challenges associated with the use of virtual teaching and learning environments in vocational education and training.

Keywords: Virtual reality, professionalisation, teacher training, digitalisation

Lehren und Lernen zwischen Virtualität und Realität

ZUSAMMENFASSUNG: In der Diskussion zur Digitalisierung der Berufs- und Arbeitswelt wird davon ausgegangen, dass virtuelle Lehr- und Lernwelten zunehmend mit realen Lehr- und Lernwelten verschmelzen und neue innovative technologiebasierte Lehr- und Lernarrangements prägen. Im Kontext dessen, beschäftigt sich der vorliegende Beitrag mit technologiebasierten Erfahrungswelten und wirft dabei einen Blick auf die Herausforderungen, die mit der Nutzung von virtuellen Lehr- und Lernumgebungen in der beruflichen Bildung verbunden sind.

Schlüsselwörter: Virtuelle Realität, Professionalisierung, Lehrerbildung Digitalisierung

1 Introduction

Technology in contemporary societies is omnipresent and has a multi-faceted character. Not only have cars, aeroplanes and trains contributed to a general improvement in mobility, but also to a variety of socio-economic, socio-ecological, institutional and individual changes. Our private and professional lifestyles are shaped by information technologies (IT) such as the Internet and mobile devices including laptops, tablets and smartphones (see, for example, Dolata & Werle 2008).

The introduction of new technologies always goes hand-in-hand with opportunities, risks and challenges (see *ibid*.). As the following example will show, the increasing digitalisation in the education sector must also take account of the Janus-faced nature of technology . The Bring your Own Device (BYOD) approach, in which private mobile terminals are integrated into educational institutional networks, combines various economic and ecological potentials for the institutions in question, but also entails risks and challenges such as ensuring educational justice and data protection in addition to many unanswered questions concerning the actual educational benefits for students. The use of tablets and smartphones in classrooms also presents basic challenges for teaching and learning. According to recent surveys (Calmbach et al. 2016), the smartphone is the most important technical device for young people, but this does not automatically mean that using a smartphone in the classroom will contribute to more positive cognitive, motivational and affective learning outcomes. In the OECD study "Students, Computers and Learning", Bos states that, by international comparison, those countries that have invested a lot of money in IT equipment for schools in the past have not succeeded in significantly improving the student’s performance in reading literacy, mathematics and science (Bos et al. 2015). According to Bos: "The increased use of digital media does not seem to result in better student performance *per se*. It's the teacher who counts". (Bos 2015, p. 8) Expressed in more simple terms and to put it bluntly, the use of IT in schools does not automatically result in higher educational success rates.

Whilst (dynamic) technological change has always played a significant role in the vocational education sector and presents challenges in terms of the process of vocational education and training (e.g., the obsolescence problem, forecasting deficit), the current discussion on the digitisation of the employment and vocational arena and the relevant new technologies is associated with far-reaching changes in teaching and learning (*cf*. Bonz, Schanz & Seifried 2017). The fact has been established that teaching and learning in all domains are currently subject to numerous changes connected with the possibilities of spatially and temporally delimited learning, adaptive and individualised learning, problem- and action-oriented learning as well as cognitively activating learning, and are increasingly taking place in cooperative and collaborative digital learning settings (*cf*. Scheiter 2017). This raises the question of which technologies are or will be important for teaching and learning in the vocational education and training sector going forward.

The Gartner hype cycle (2018) gives a general overview of the technologies currently under discussion in the professional and working environment[1] Albeit transferring the forecasts on "expectations of new technologies" to the (vocational) education sector is only possible to a limited extent, it is interesting, from the perspective of the current subject and in the context of the link between vocational education and training to current or future production and work processes, to consider the expectation-related classification of technology-based realms of experience.

The 2018 hype cycle shows virtual assistant technology at the "peak of inflated expectations" and mixed and augmented reality in the "trough of disillusionment". According to current

[1] The Gartner hype cycle evaluates new technologies in terms of public attention or the expectations associated with them (Fig. 1). The X-axis plots the time since the technology in question was first announced whilst the Y-axis shows the attention paid to it by the public (Gartner 2018). IT consultants use the corresponding analyses of the expectations placed on a given technology to evaluate the introduction of new technologies in companies.

forecasts, digital twin technology which depicts a tangible or intangible object and supports real-time data exchanges, is at the "peak of inflated expectations". The digital twin is referred to as the "real" (virtual) counterpart and is associated with fundamentally progressive effects, particularly for production technology (Gartner 2018).

Overall, it remains to be seen which innovations will actually become established within the focused technology-based realms of experience. In addition to the technologies, which are the focus of this article, the 2018 hype cycle (Fig. 1) lists other interesting technologies in which virtual components play a significant role, such as the Smart Workspace (e.g. Sharma et al. 2019) and Brain-Computer Interface (e.g. Coogan & He 2018), which may take on a central role in the context of Extended Reality (XR) in the future (Gartner 2018).

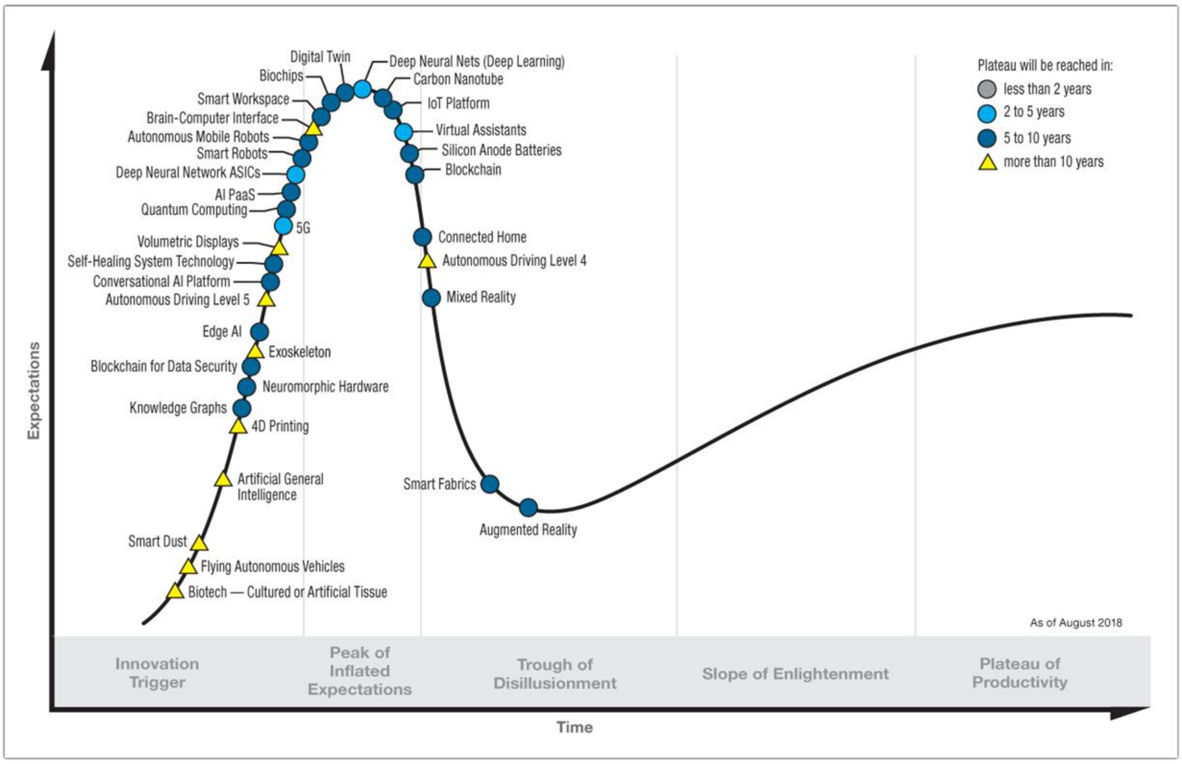

Fig. 1: The 2018 Gartner hype cycle (Gartner 2018)

Publications on the topic of “industry 4.0” tend to assume that virtual and real teaching and learning locations are increasingly merging across domains (*cf*. Spath et al. 2013). Virtual and augmented reality combine multiple potentials for improving teaching and learning as well as realising novel teaching and learning concepts (Zinn 2017). The Conference of Education Ministers (CEM) strategy paper "Education in the digital world” states that: "The meaningful integration of digital learning environments will require a new teaching and learning process configuration. Not only does this change teaching and learning, but also the range of teaching options. Digitalisation has resulted in the development of a new cultural technology - the competent use of digital media - which in turn complements and changes the traditional cultural accoutrements of reading, writing and arithmetic" (KMK 2016, 7f.) Therefore, both teachers at general and vocational schools and lecturers at corporate and university teaching centres need to have the relevant knowledge and skills to use new digital media in a professional manner to design teaching and learning processes.

In the section entitled "When virtual becomes reality” in the OECD’s "Trends Shaping Education 2019" (OECD 2019)" study it is stated that "The Internet has become an integral part of our lives. Many common activities that formerly required physical contact or social interaction, such as talking to family and friends or consulting a doctor, are now being carried out online. However, the digital environment is no virtual "second life", but is instead increasingly becoming an integral part of our physical reality. Whether it concerns a job, a room for the night, or the love of your life, online activities often translate into offline outcomes. This presents a challenge to the education system, which must take advantage of the tools and strengths of new technologies whilst at the same time addressing potential misuse issues such as cyberbullying, loss of privacy or the illegal trade in goods." (OECD 2019, P. 98)

This statement gives rise to two key questions: (1.) How can education help students to develop the digital skills required to create and produce digital content and help them express themselves and learn with a sense of ease? (2.) Do schools have the partnerships they need (e.g. with technology experts, entrepreneurs and others) to help their students develop the skills needed to negotiate dynamic online marketplaces? (OECD 2019, p. 99). The digitalisation of education has numerous ramifications for teachers and students as well as for educational institutions and society as a whole. Questions arise concerning the media and digitisation-related skills of teachers. The professionalisation of teachers, technology acceptance (Zinn & Pletz 2019) and the material framework conditions surrounding responsibility in schools, companies and society are all are key areas for development (*cf*. Eickelmann & Gerick 2017; van Ackeren et al. 2019; Zinn 2017).

Against this background, this article considers a selection of specific aspects of teaching and learning with and within technology-based (computer-generated) realms of experience in addition to the question of which technology-specific knowledge and skills teachers need to have in the field of teaching and learning between virtuality and reality. Section Two provides an overview of the specific technology-based realms of experience in focus. Theoretical approaches to teaching and learning as well as modelling digital competencies are considered in Section Three in the context of the professionalisation of teachers. Section Four addresses the relationship between "virtuality and reality” before Section Five concludes the article with a summary and prognosis.

2 Technology-based realms of experience

Throughout the article, Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and Cross Reality (XR) are referred to as technology-based realms of experience (*cf*. Zinn 2020). In technical terms, VR is generally understood to refer to computer-generated real-time representations of real or fictitious environments into which people can enter in virtual form and with which they can interact via artificial and natural user interfaces. VR is focused on the users’ experience of finding themselves in a strange (virtual) setting (*cf*. Rheingold 1992). According to Dörner *et al*., VR is a metaphor based on the analogy of reality (*cf*. Dörner et al. 2014). VR involves the transmission of a person’s sensory impressions via artificial and natural user interfaces. Natural user interfaces for visualisation can enable realistic navigation and interactions, thus facilitating an authentic user experience. In addition to the visual impression, which is rendered in 3D through stereoscopic display technology, VR can also provide auditory feedback and create a spatial scenario that gives one the impression of being in a digital world that exists in complete isolation from the real external world (*cf*. Dörner et al. 2014).

VR-supported teaching and learning can be delivered through various kinds of VR systems, including the following three variants: (1.) Non-immersive VR, which includes a desktop-based environment and a 2D environment on a standard screen, which the user can perceive from an egocentric and/or allocentric perspective. (2.) Partially immersive VR, which supports 3D (spatial) perception with the aid of VR goggles (e.g., head-mounted display, or cardboard spectacles). (3.) Immersive VR, which facilitates complex motion sequences and requires special sensors and/or cameras in addition to mostly natural user interfaces. Users can receive immediate feedback in response to their own actions via real-time visualisations and system responses. Various sensors track the user's head and body movements and give users the feeling of moving within and interacting with the virtual world (*cf.* Zinn et al. 2020).

MR applications with integrated AR technology are increasingly being used in addition to pure VR systems. "AR, i.e., the enrichment of 3D environments with data (also known as blended reality), can be used to create a new experience of the world by extending access to information and creating new learning opportunities. [...] The responsive interactivity of AR enables learners to develop a broader understanding of a subject or a concept by handling virtual objects." (Johnson et al. 2016, p. 40; Olshannikova et al. 2015). AR is generally understood to refer to technology-supported adjuncts to the real-physical world, whereby the "augmented" information can address various human sensory modalities. The computer-generated information can include visual representations, such as images, videos, and text or auditory information in the form of a spoken text (with avatar) or music (*cf*. Preim & Dachselt 2015).

Milgram and Kishino (1994) define MR as a continuum between the real and artificial worlds. The hybrid use of VR and AR as well as the enrichment of the technology-based realms of experience through additional technological add-ons is also referred to generically as Cross Reality (XR) or Extended Reality. Coleman defines cross-reality (also known as x-reality) as "an informational or media exchange between real- and virtual world systems" (Coleman 2009, p. 16). Interested readers may refer elsewhere to more detailed and even more extensive definitions of the technology-based realms of experience: differentiated definitions and descriptions of these specific technologies can be found, for example, in Brill 2009; Dörner et al. 2014 for VR and AR; in Milgram and Kishino 1994; Coleman 2009 for MR and for XR in Mann et al. 2018.

Empirical studies of VR have shown that the users of VR applications can fully immerse themselves in the media and react to it as if the virtually perceived object is very real, despite the fact that it does not even exist "in reality" (*cf*. Draper *et al*. 1999; Slater 2003; Heeter 1992; Wirth *et al*. 2007; Vorderer *et al*. 2004). In the mediatised world people can feel spatially present rather than being bound to the respective physical places of reception such as the desktop workspace. Although there is no uniform definition of the term "presence", one definition frequently used in the context of virtual environments is "the subjective experience of being in one place or environment, even when one is physically situated in another" (Wittmer & Singer 1998, p. 225). According to Wirth and Hofer, spatial presence is the basic condition for other variants of presence, such as social presence, whereby social presence encompasses the feeling of togetherness and of communicative exchange with other (visually represented) persons or avatars (*ibid*.). The term co-presence is used to describe the coincidence of spatial and social presence (ibid.). Social factors, such as the reactions of other stakeholders to the user, reinforce those impressions that make the user aware of his or her presence in the virtual space and favour immersion and a "flow experience" (Zinn, Guo & Sari 2016).

3 Points of reference for teaching and learning within and with technology-based realms of experience

Pedagogic approaches and concepts

Based on the current state of the relevant research, several theoretical pedagogic approaches and concepts are essentially applicable to teaching and learning with technology-based realms of experience. In particular, the embodied cognition approach, experiential learning, situational learning, constructivism and social constructivism, presence theory, flow theory and cognitive load theory are considered relevant for teaching and learning in virtual environments (Loke 2015; Weibel & Wissmath 2011; Zinn, Guo & Sari 2016; Schuster et al. 2016; for an overview see Zinn & Ariali 2020). Selected approaches and concepts are examined in more detail below with regard to their specific significance for teaching and learning within and with technology-based realms of experience.

Sensory functions and complex interaction with the environment (e.g. learning a sequence of actions) play a crucial role in cognitive processes according to the *embodied cognition* approach (*cf.* Kaltner 2015). According to the principles of embodied cognition, information on a particular process is stored in various sensory modality memories as a multimodal experience. Remembering a particular category (e.g. smell, mechanical resistance) reactivates multimodal representations and mentally simulates the perceptions and actions related to the experience. Teacher knowledge and skills seem relevant in terms of being able to design a virtual learning and working space in a competent and didactically-relevant, subject-specific manner to enable as diverse an auditory, visual and sensorimotor experiential space as possible in a (virtual) teaching and learning process. Virtual environments could provide methodological relief, given the fact that the implementation and integration of complex professional situations in the vocational school learning venues is often associated with a number of problems (e.g. high acquisition costs and system complexity, risk factors in the working environment). Assuming that they represent comparable situations that trigger the same behaviour and thinking in learners as a real situation, virtual environments could also be used to support *situational learning* at the vocational training site (*cf.* Loke 2015), . According to Dewey (1938), learning is only effective if it is linked to specific experiences for the individual concerned. Relevant experiential spaces can be created by users interacting with their working environment via natural user interfaces in a realistic manner in technology-based realms of experience (*cf.* Haase et al. 2015).

Learning and working in virtual environments is risk free, causes no material wear and tear and avoids damage to machinery. The possibility to change the practical design of or modify training situations is a fundamental feature of technology-based realms of experience (*cf.* Katzky et al. 2013). Popular contemporary virtual environments provide a variety of tools that support *collaborative learning* and working. According to the theory of social constructivism (Vygotsky 1978), social interaction, among other things, are crucial to learning. Collaborative learning, in the course of which group members coordinate and work together synchronously is a special form of learning in the (virtual) group. Groups with a collaborative orientation differ from individually oriented groups in that the group members work together rather than side by side. Barron (2000) was able to demonstrate a positive correlation between the quality of interaction in virtual environments and the effectiveness of collaborative group work. Older studies on virtual teamwork suggest that virtual collaboration can result in lower performance (Baltes, Dickson, Sherman, Bauer & LaGanke 2002) and satisfaction (Warkentin, Sayeed & Hightower, 1997) as well as reducing trust and cooperative behaviour among team members (Bos, Olsen, Gergle, Olson & Wright, 2002). If one accepts the paradigm of social constructivism and transfers it to technology-based realms of experience, the use of collaborative tools and the facilitation of diverse verbal and non-verbal interactions between users, even in the form of avatars, appears interesting and logical. Virtual forms of collaboration can enable dispersed teams to learn in a flexible and cost effective manner, independent of their spatial and temporal availability. Despite these heterogeneous findings, more research into this subject is still required. Wittmer and Singer carried out research into the *presence experience* and identified positive correlations between work performance and perceived presence in the virtual environment(Wittmer & Singer 1998). Lombard and Ditton (1997) have demonstrated that there are certain tasks for the execution of which perceived presence can be an obstacle because the presence experience is influenced by various factors (e.g., the use of an avatar, multiple sensors). Therefore, it is recommended that learners be given opportunities to control the degree of presence in the respective virtual environment themselves. There is a correlation between the presence experience in virtual environments and the flow experience (*cf.* Weibel & Wissmath 2011; Zinn, Guo & Sari 2016). The basic assumption in *flow theory* is that a person can experience an activity as being pleasurable and as a uniform flow, and make no, or hardly any, differentiation between his or her self and the activity in question (*cf.* Csikszentmihalyi 1997). Flow experiences can occur when the person carrying out the activity is neither under- nor overworked. Therefore, the best possible relationship between the skills of the users and the specific (virtual) learning requirements should be sought when designing a (virtual) learning environment. Pedagogic psychologists describe the flow experience as a performance-relevant component of the motivation to learn (*cf.* Engeser et al. 2005) and as having a positive motivational effect (*cf.* Sherry 2004; Voiskounsky et al. 2004).

As an interim conclusion, one can note the fact that various teaching approaches and concepts as well as pedagogic theories can be applied when teaching and learning in technology-based realms of experience. Although theoretical pedagogic approaches and concepts often have no direct practical relevance for decisions pertaining to didactic design, they nevertheless provide teachers with a broad range of relevant information (*cf.* Reinmann, Ebner & Schön 2013) and therefore also have indirect practical significance for the design of technology-based teaching and learning scenarios.

Modelling digital competencies

A broad consensus has emerged across the board and independent of the technology in question that simply increasing the understanding of the relevant technology is insufficient in terms of modelling digital competencies. Instead, a teaching framework is required that (to the greatest extent possible) addresses all areas of teaching and learning relevant to the respective technology. But which specific skills are important for technology-oriented teacher training and which special features are of particular relevance for the technology-based realms of experience that are the focus of this article?

The "European digital Competence Framework for Citizens - DigCompEdu", which represents a general frame of reference for the promotion of digitisation in education, highlights several relevant areas of competence (author group DigCompEdu 2018), whereby the following six areas of competence are listed as being worthy of note: "professional engagement", "digital resources", "teaching and learning", "evaluation", "learner orientation" and "promoting the digital literacy of learners". The reference framework addresses the professional environment in which teachers operate, the pedagogical and didactic competencies of teachers and the specific skills of learners. DigCompEdu sets out 22 competencies spread over six different competence levels ranging from "beginners" (A1) to "advanced" (C2) and focuses on teachers at general or vocational schools, universities and universities of applied science as well as teachers in the field of adult education (*ibid*.).

The KMK model identifies comparable areas of competence in relation to the strategy of the Conference of Ministers of Education and Cultural Affairs "Education in the Digital World", albeit with different names : "searching, processing and saving data", "communication and collaboration", "production and presentation", "protection and staying safe", "problem solving and taking action" and "analysis and reflection" (KMK 2016).

Technological Pedagogical Content Knowledge (TPACK) is an international framework model (Koehler & Mishra 2009) which will be presented in more detail below due to its relevance to teacher training (*cf*. Koehler & Mishra 2009; Mahler & Arnold 2018; Baran et al. 2019) particularly in the context of technology-based realms of experiences. The TPACK model was developed by Koehler and Mishra (Koehler & Mishra 2008; Mishra & Koehler 2006) on the basis of pedagogical content knowledge (PCK), which was essentially shaped by Shulman (1987) and forms a central aspect of the professional knowledge of teachers (Baumert & Kunter 2011).

The model assumes that a meaningful integration of technology in teaching-learning arrangements requires specific knowledge on the part of the teacher, which includes content-related, pedagogical and technological components that interrelate in a complex manner (*ibid*.). TPACK comprises the three main competencies of Technology Knowledge (TK), Content Knowledge (CK) and Pedagogical Knowledge (PK) as well as the three overlapping areas, which are Pedagogical Content Knowledge (PCK), Technology-specific Content Knowledge (TCK) and Technological Pedagogic Knowledge (TPK) as well as the overarching Technological Pedagogic Content Knowledge (TPACK)[2].

Content knowledge (CK) is at the core of the professional competence of teachers across all models, and includes subject-related knowledge, subject-content concepts, theories and models, as well as pedagogical knowledge (PK), which includes, among other things, a conceptual basic knowledge of pedagogy, a general understanding of didactic concepts and planning, and a knowledge of teaching implementation and the orchestration of learning opportunities (*cf*. Baumert & Kunter 2011). Pedagogical content knowledge (PCK) is another key aspect of the professional competence of teachers, which essentially comprises an understanding of the didactic and diagnostic potential, the cognitive demands and implicit knowledge prerequisites of specific tasks, an understanding of student perceptions and of multiple presentation and explanation possibilities (*ibid*.). Technological knowledge (TC) also includes an understanding of (digital) technologies that are of relevance to education. It also includes technology-specific knowledge that enables teachers to adapt the purpose of a given technology (e.g. VR environment) to produce an adaptive, goal-oriented learning environment. Transferred to professionalisation in the field of technology-based realms of experience, teachers require a specific declarative knowledge of possible areas of application for AR, VR, MR and XR as well as a practical knowledge of the use of computer-simulated teaching and learning environments. Technological content knowledge (TCK) includes ways in which different technologies can be used and the basic possibilities these technologies offer for teaching and learning. With reference to technology-based realms of experience, teachers

[2] In respect of TPACK as an overarching knowledge component, Koehler and Mishra state that: „TPACK is an emergent form of knowledge that goes beyond all three “core” components (content, pedagogy, and technology). Technological pedagogical content knowledge is an understanding that emerges from interactions among content, pedagogy, and technology knowledge. Underlying truly meaningful and deeply skilled teaching with technology, TPACK is different from knowledge of all three concepts individually. Instead, TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones.“ (Koehler & Mishra 2009, p. 66).

need a declarative and practice-oriented knowledge of how AR and VR environments, including the various technological variants (see above), can be used in teaching-learning scenarios. They need to know that virtual environments can be used to create learning conditions that would be too dangerous or too expensive under real world conditions, or to open up areas that would be inaccessible in reality. There are possibilities to simulate control, production or work processes as well as to illustrate them true to image or simplified. VR environments can be used specifically to support pupils with learning difficulties (*cf*. Ariali & Zinn 2018; Hamdani et al. 2018; Zinn et al., 2020).

Prospective teachers need to be made aware of the fact that technology-based environments can be used to generate sensory data that humans in the real world would not normally be able to experience. Ultrasound or magnetic electrostatic fields, for example, can be visualised in virtual environments to present complex and abstract facts in the classroom (*cf*. Guo, Ditton & Zinn 2019). The properties and principles of complex systems, for example, can be viewed in a comprehensible manner by integrating technology-based realms of experience into real-life teaching environments. At the same time, learners can be given more opportunities to steer the processes of knowledge acquisition through supplementary information (*cf*. Schuster et al. 2016). Technological-pedagogical knowledge (TPK) is about understanding the methodical use and boundary conditions of technology. Teachers need to know which AR apps are available and can be used, for example, to provide pupils with individualised support. AR applications can promote differentiated teaching by individualising the learning content or supporting collaborative learning, for example in the context of online courses.

Interim conclusion: According to the TPACK model, teachers need a comprehensive understanding of the manifold potential interactions between content, pedagogical and technological knowledge. They also need the knowledge and skills to constructively use VR, AR and MR to support teaching and learning processes whilst taking into account the complexity of the diverse relationships and individual needs of students. Fig. 2 below provides an overview of the content aspects considered to be relevant for technology-related experiences.

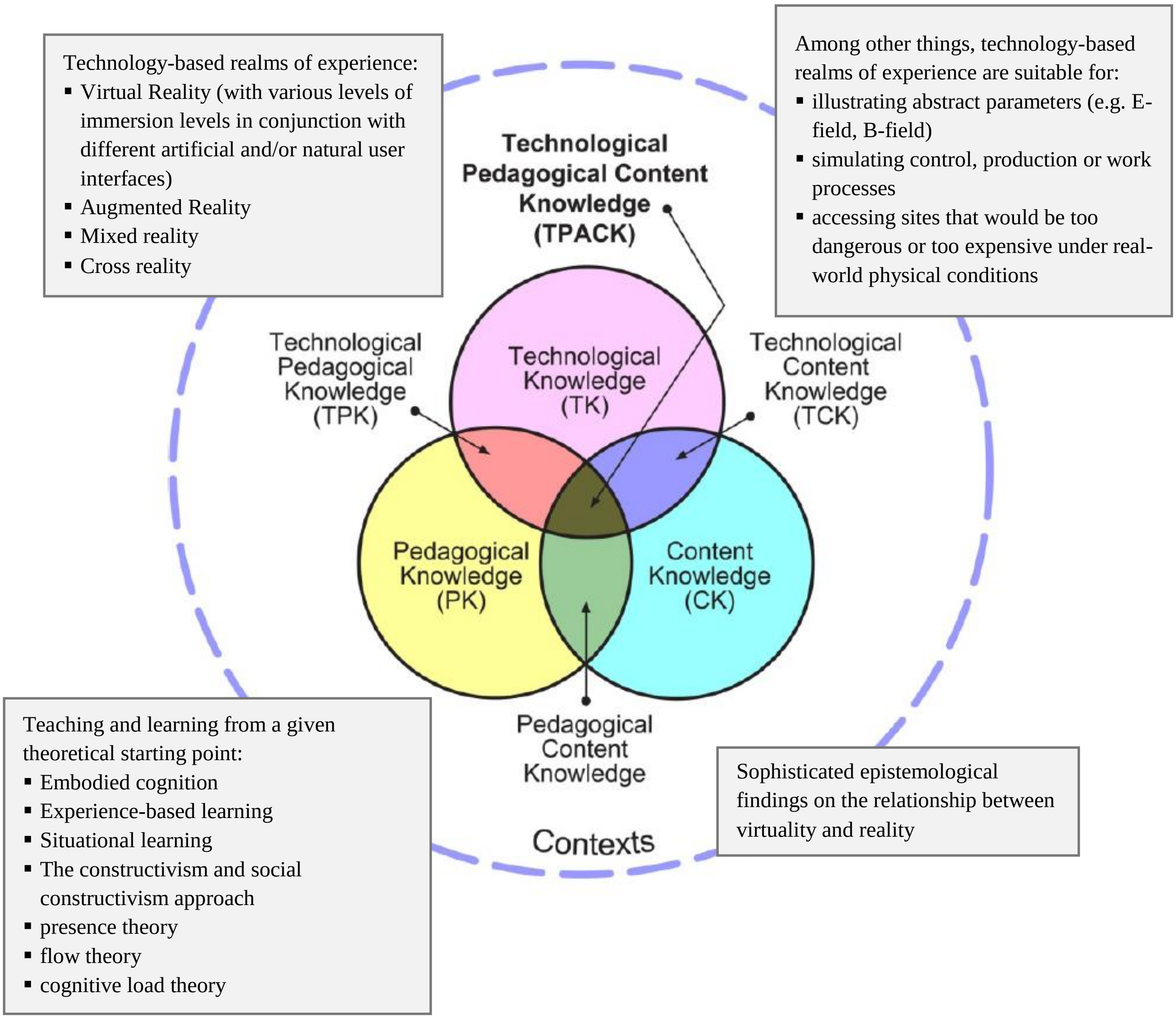

Fig. 2: TPACK framework model including knowledge components (Koehler & Mishra 2009, p. 63) with my own additions relating to technology-related realms of experience

4 Virtuality versus Reality

As described above, there is a basic assumption that virtuality and reality are increasingly merging (*cf.* Scpath et al. 2013), yet the fusion of virtual and real environments is also creating a fundamental problem. On the one hand, virtual learning environments enable new "realistic" teaching and learning possibilities, but on the other, teachers and learners can be (consciously or unconsciously) deceived by virtual environments about the nature of reality and the sensual "real" realm of experience of the users can be permanently restricted or manipulated. This is one technology-specific aspect that is of particular importance from a scientific-theoretical perspective and will be briefly touched upon in the following paragraphs.

In general, discussions about "virtuality" refer to the quality of an object (or a person, process, etc.) that does not exist in the form in which it is presented, but seems to resemble the actual object in terms of its effect and essence (see Section 2). In other words, virtuality refers to an imaginary entity that projects the essence, functionality and effect of the real-life object. Whilst (real) realities can feed into an epistemological logic of abduction, deduction and induction and their structure, reliability and coherence can be verified on the basis of existing scientific paradigms, corresponding analyses of virtual realities are restricted. Virtual realities can take on structures that are independent of reality; they do not have to comply with the laws of nature and represent reality in a "real” manner. In most cases, the intention for a virtual reality is to represent the real world with all its peculiarities and make it vividly tangible.

So separating the virtual and real worlds becomes a fundamental challenge for teachers and learners alike. Thus, technology-based realms of experience also have a bearing on basic epistemological questions. Both teachers and learners need to have sophisticated epistemological convictions to be able to use technology-based realms of experience in teaching and learning scenarios in a profession-oriented manner and in a reflexive and critical way.

5 Summary and prognosis

There is an urgent need for technology-specific professionalisation to ensure that the technology-based realms of experience considered in this editorial are used in a professional manner by vocational school teachers and corporate training personnel for vocational education and training purposes, particularly in view of the dynamic process of digitisation in the employment sector which includes the increasing use of VR and AR in work, production and business processes.
This article is based on the assumption that the new forms of human-technology interaction can make specific learning environments tangible and that they generally have a wide range of potential applications. The use of technology-based realms of experience such as VR, AR and MR is considered to be particularly beneficial in the field of vocational education and training provided that they are not introduced as a pure adjunct, but are also integrated into real vocational projects in a didactic and methodological manner. For example, specific corporate scenarios and practical references could be integrated into initial and continuing vocational education and training via technology-based realms of experience, and corporate processes and procedures could be taught in a "safe" teaching and learning environment. The explanations presented in Section Three suggest that several teaching and learning theoretical approaches and concepts that are generally regarded to be important and can easily be integrated into the conceptual design of teaching and learning scenarios involving technology-based realms of experience. In my opinion, the DigCompEdu and TPACK framework models (see Section 3) represent logical ways forward for the professionalisation of teachers in the context of digitisation.

As described at the start, digital media can be broadly understood as a new cultural technology with the aid of which cultural and technical problem-solving concepts for different real-life scenarios can be formulated (KMK 2016). This definition draws attention to the special significance of digital media for many areas of society, but also points out the complex interactions between technology as an object and its overall design and the framework conditions for its use. Whilst the use of media in teaching has always been an essential component of vocational teacher training and didactics in the broader sense, new digital media, such as VR, AR, XR and the associated educational potential, play a significant role in the professionalisation of corporate technical teachers.

Precisely how complex virtual realms of experience actually do merge with real environments in the professional and working world remains an open question. However, despite this, there is a consensus that digital media are now indispensable at corporate and vocational school teaching centres. Prospective vocational school teachers and corporate trainers must develop specific IT skills to be able to use digital media in a professional manner.

Given the demand for evidence-based (digital) teacher training, this desideratum goes hand in hand with the need for more research on focused technologies and the aforementioned fields of action including the adaptation of educational plans, the further development of teaching methods, the training and further education of teachers, infrastructure and equipment, educational media, e-government and the relevant legal and functional frameworks (KMK 2016). This also raises the fundamental research question as to the extent to which virtual experiences are or must actually be comparable with real experiences and the impact they will have on vocation teaching and learning scenarios and the development of vocational skill sets. Overall, the empirical findings on technology-based realms of experience in relation to teaching and learning are still unsatisfactory, both in relation to initial and continuing vocational education and training and in terms of research into learner and teacher training in the field of vocational training. Despite the fact that various empirical studies have been conducted in this field (see above), further research and a domain-specific approach appear desirable, particularly in the narrower context of vocational training processes.

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