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Digitalisation, Artificial Intelligence and Vocational Occupations and Skills: What are the needs for training Teachers and Trainers?

Attwell, Graham
Pontydysgu, graham10@mac.com

Deitmer, Ludger
University of Bremen, Institute Technology and Education, deitmer@uni-bremen.de

Tūtlys, Vidmantas
Vytautas Magnus University, vidmantas.tutlys@vdu.lt

Roppertz, Sophia
University of Bremen, Institute Technology and Education, sophia.roppertz@uni-bremen.de

Perini, Marco
University of Verona, Department of Human Sciences, marco.perini@univr.it

Abstract

The paper seeks to explore the impact AI and automation have on vocational occupations and skills and to examine what that means for teachers and trainers in VET. It looks at how AI can be used to shape learning and teaching processes, through for example, digital assistants which support teachers. It also focuses on the transformative power of AI that promises profound changes in employment and work tasks. The paper is based on research being undertaken through the EU Erasmus+ Taccle AI project. It presents the results of an extensive literature review and of interviews with VET managers, teachers and AI experts in five countries. It asks whether machines will complement or replace humans in the workplace before going to look at developments in using AI for teaching and learning in VET. Finally, it proposes extensions to the EU DigiCompEdu Framework for training teachers and trainers in using technology.

Keywords

AI; occupations; tasks; teacher education; VET

1 Introduction

Artificial Intelligence (AI) can be defined as a system that has been designed to interact with the world in ways we think of as human and intelligent. Ample data, cheap computing and AI algorithms mean technology can learn very quickly. The transformative power of AI cuts across all economic and social sectors, including education (UNESCO, 2019). A European Joint Research Council policy foresight report (Tuomi, 2018) suggests that "in the next years, AI will change learning, teaching, and education. The speed of technological change will be very fast, and it will create high pressure to transform educational practices, institutions, and policies." They say it is therefore important to understand the potential impact of AI on learning, teaching, and education, as well as on policy development.

The questions that arise in this context are: *What impact does AI have on vocational occupations and skills? And what does that mean for the teachers and trainers in VET?* These questions are addressed by project partners from five European countries in the Taccle AI project. The answers to these questions should help in identifying which competences and skills teachers and trainers need to have in order to prepare (young) people for an AI-based working environment.

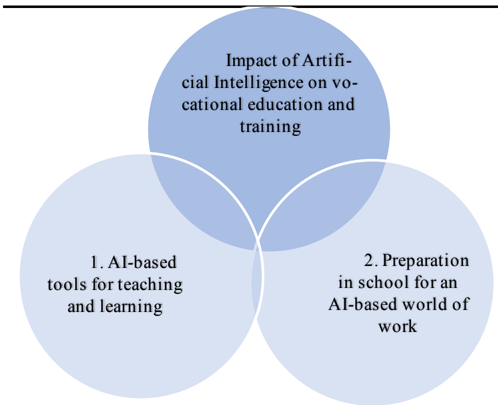
The following section outlines the potential influence AI can have on Vocational Education and Training and thus forms the basic framework of this paper. The third section describes the methodological approach used to answer the research questions. In the following sections the results are presented. Sections four and five are mainly the result of the literature research. With these findings and the interviews, the European DigiCompEdu framework was extended in section six.

2 The potential impact of ai on vocational education and training

There are basically two dimensions of how AI can affect vocational education and training. AI can be used to shape the learning and teaching process, through for example, digital assistants which support the teacher in teaching in the classroom. AI can undertake administrative tasks, freeing teachers for more time supporting learners. In the school context, there could also be AI-based learning data analysis (Learning Analytics), AI-based individualised learning offers (Adaptive Learning) or AI-based assessment systems (mmb Institut, 2020). Regardless of their specific design, these applications would change learning and teaching.

Another impact for vocational education and training is that the transformative power of AI promises profound changes in employment and work tasks. For VET the greatest implications of AI lies in the changing tasks and roles within jobs, which require changes in initial and continuing training for those in work as well as those seeking employment.

Figure 1
Potential impact of Artificial Intelligence on Vocational Education and Training



Artificial intelligence can, therefore, enter vocational education and training in two fundamental ways (Figure 1). Firstly, **AI-based tools for teaching and learning** can be used in the classroom. On the other hand, AI can be addressed as a consequence of the increased use of technology in business and industry in the classroom. AI technologies are discussed in schools in a practical or theoretical way to **prepare young people for an AI-based working environment**.

3 Methodology

Based on the potential impact of AI on VET a thematic mapping was developed along which the literature research took place. The two possibilities of how AI can influence vocational training were investigated more deeply in the literature research, taking keywords into account. The guiding question for the literature research was what impact AI has on VET. More specifically, we asked: What impact has AI on Vocational Occupations and Skills? Which AI-based tools could be useful to support teaching and learning processes? Which are their characteristics? How could VET schools/centres training-offers and activities be updated in view of a world of work based on artificial intelligence? The string "*Artificial Intelligence OR AI*" was combined using the Boolean AND with the following keywords which are related to the aim of the study: "*Vocational Education and Training*", "*New World of Work*", "*Smart Factory*", "*Skills*", "*Competences*", "*Teaching and Learning*", "*Learning Analytics*", "*Digital Assessment*", "*Intelligent Tutoring Systems*", "*Adaptive Learning*", "*Pedagogical Agents*, *School Management Systems*", "*Smart Learning Environments*"; "*Adaptive Learning*", "*Employment and Labour Market*", "*Ethics*", "*Learning Management Systems*". The project partners have basically limited themselves to literature published in the last ten years. However, if there was relevant literature outside this time window, it was included. Due to the explorative nature of the review, the research was not restricted to the most significant databases for searching relevant papers regarding educational research (i.e., Scopus, ERIC, Web of Science, Emerald, Springer, Taylor & Francis Online, Oxford University Press). The research was also expanded to institutional and European projects reports (e.g. Erasmus + projects), and grey literature. In order to ensure quality, peer-reviewed papers and journal papers were preferred. As mentioned before, since there are relatively fast changes and technological innovations in the field of AI, non-peer reviewed reports, internet articles or other sources were used to include current perspectives. In conclusion, while this overview is not exhaustive, a concerted effort has been made to identify and include peer-reviewed and grey literature, policy reports, and expert research reports that would be of interest to teachers or trainers on the subject. Contributions which did not address the research questions (e.g. history of AI, technological details of AI, etc.) were excluded from the review.

Parallel to the literature research, the project partners conducted explorative country case-studies (Luo, 2015) through semi-structured expert interviews to explore the perspectives and experiences of the respondents in AI and VET. According to Meuser and Nagel, experts are those persons who are themselves part of a field of action. The status "expert" is always relational to the research topic and is awarded by the researchers (Meuser & Nagel, 2009). Two groups were interviewed. One group consisted of vocational school teachers, trainers or other persons who practice in vocational education and training. The other group consisted of people from the field of artificial intelligence and development. The semi-structured interview method made it possible to discuss topics within the framework of AI and VET which were not included in the interview guidelines. The interviews were analysed in order to highlight best practices implemented by interviewees in AI in VET.

4 Artificial intelligence and employment, the labour market and society

This section will explore the implications of AI for the changes of employment, labour market and work by focusing on the changes of skills and competencies.

4.1 Will machines complement or replace humans in the workplace?

Literature on the implications of AI for work and employment distinguish between the replacement of human workers and the use of AI to assist human performance.

Schwab and Nadelia (2018) claim that there is a lack of information on how machine learning algorithms are functioning and how they reflect existing social changes. AI will transform work tasks but will not make human activity completely obsolete. With a few exceptions, only parts of jobs can be completely automated. Susskind and Susskind (2015) criticize such "optimistic" thinking about limitations of AI in automating jobs based on the belief about the inability of AI to replicate human brains and consciousness (AI fallacy). They claim that "increasingly capable machines (whether using AI, Big Data techniques or techniques not yet invented) will arrive at conclusions and offer guidance that in human beings we would regard as creative or innovative." In discussing the potential of technologies and AI to replace human activities (including education), they focus on three main questions:

1. What is the new quantity of tasks that have to be carried out?
2. What is the nature of these tasks?
3. Who has the advantage in carrying out these tasks?

Tuomi (2018) differentiates the implications of AI for work by distinguishing between the level of operations, the level of actions and the level of activities. At the level of *operations*, the AI augments and complements them by increasing the efficiency and effectiveness of current ways of doing things. At the level of *actions*, AI replaces, substitutes, and automates actions that were previously undertaken by humans, whereas at the level of *activity*, AI transforms the motivation of persons to perform certain activities, making current activities and specializations redundant and obsolete. The McKinsey report (2018) indicates that by 2030 there can be expected to be significant transitions accompanying automation and AI adoption – changing the mix of occupations, skill and educational requirements. Around 3 percent of the global workforce will need to change occupations by 2030. Occupations made up of physical activities in highly structured environments or in data processing or collection will see declines. Growing occupations will include those with difficult to automate activities such as managers, and those in unpredictable physical environments such as plumbers. Occupations that will see increasing demand for work include teachers, nursing aides, and technical and other professionals. Research literature indicates that current ICT systems show increasing ability in language, vision, movement and even reasoning. "IT capabilities that have been demonstrated in research settings could provide the reasoning, vision and movement skills required in most current jobs, only for language skill does the analysis suggest that a substantial number of current jobs have skill requirements that clearly outstrip the IT capabilities demonstrated in research literature. (…) Occupations representing 82 percent of current employment will be potentially vulnerable to displacement by IT over the next few decades" (Elliott, 2017, p. 604–624). Demand for physical and manual skills and for basic data input and processing will decline, while growth will be strong in demand for interpersonal skills, creativity, and empathy. Advanced IT skills and programming alongside complex information processing skills will also see a surge in demand. In highly automated plants, the software is the interface for all technical solutions. In this case, all tasks, especially service, maintenance and repair, have been structured around software tasks. Highly qualified technicians are necessary to maintain this software, while programming is left to the engineers (Spöttl et al., 2016).

Digital Taylorism allows lower skilled workers to execute "automated" complex tasks, which previously required higher skills. In the McKinsey survey, 40 percent of companies describing themselves as extensive adopters of automation and AI expect to shift tasks currently performed by high-skilled to lower-skilled workers. This is also related to the emergence of new middle-skilled, "new-collar" jobs. For example, registered nurses and physician assistants now do some of the tasks that primary care physicians once carried out, such as administering vaccinations and examining patients with routine illnesses.

There is also seen to be a "liberating effect" of AI in different work processes, for example, AI driven educational systems complement teachers, so teachers with the help of AI can focus on the teaching and mentoring that cannot be automated through AI. Hirsch-Kreinsen and

Ittermann (2017) claim that automation and the increasing flexibility of production (where AI contributes) help to optimize value chains and to develop business models based on the highly intensive involvement of customers. It can lead to an improvement of the quality of work and better opportunities for human-oriented shaping of work organisation, as well as a better fit between work and private life.

4.2 The skills and competences needed in the age of artificial intelligence

Research literature identifies a range of implications of AI for skills needs (McKinsey, 2018):

1. Demand for advanced technological skills such as programming will grow rapidly. There is also a lack of sufficient understanding of technologies to lead the organization through the adoption of automation and AI.
2. Increasing demand for key skills and competencies: social, emotional, and higher cognitive skills, such as creativity, critical thinking, and complex information processing, basic digital skills.
3. Demand for physical and manual skills will decline but it still will remain the single largest category of workforce skills in 2030 in many countries.
4. There are expected declines in the need for basic cognitive skills, particularly the basic data input and processing skills used by data entry clerks and typists and in a range of back-office functions.

The application and development of AI based technologies challenges the traditional boundaries of disciplines, knowledge and competence areas. For example, the application of sensors and the networking of cybernetic-physical systems (CPS) increase productivity but at the same time require interdisciplinary individual and collective competences that integrate knowledge and skills from the fields of machinery production, electronics and information and communication technologies (Gorldt et al., 2017). Such erosion of the disciplinary and occupational boundaries of competence is also enhanced by changing industrial production, including virtualisation, individualisation and flexible production processes as well as the integration of digital, virtual and real dimensions of production processes and the increasing transparency of the production processes (Gorldt et al., 2017).

Decentralized intelligence linked to Industry 4.0 provides skilled workers with increased volume of data needed for the performance and management of different work processes. Maintenance still requires traditional manual skills as well as the mastering of SPS, robotics, pneumatics, hydraulics, etc. These, however, are no longer sufficient. Simply amending occupational profiles will not be enough. The authors of the Bayme VBM study (Spöttl et al., 2016) call instead for a systemic shift to work process orientation in the design of occupational profiles. Maintenance processes will be based on informatization. Occupational and advanced training profiles must focus on these central developments. The Bayme study (Spöttl et al., 2016) claims that if the future development of production technologies will focus on assistance/support systems and if skilled workers at the shop-floor level are given the chance for co-shaping, Industry 4.0 can be used as an "assistance system", where skilled workers and technological applications would thus control and influence one another, whilst decision making power remains in human hands. At the same time, skilled workers have to deal with increasing demands in terms of interpreting system data. Analytic capability and thinking in networks are prerequisites in order to deal with abstract information and to gain a swift overview of the production process.

AI cannot replace skilled workers in the automated control of production plants, where skilled workers execute such tasks as troubleshooting, assessing damage and analysing causes of faults. Skilled workers remain important decision makers, controllers, maintenance operators, co-shapers and experts in many work processes, such as maintenance of production systems and equipment.

5 Vocational education and training in the age of artificial intelligence

The development and deployment of Artificial Intelligence has profound implications for vocational education at a number of different levels including the organisation of VET, the curriculum for VET subjects and occupations, teaching and learning in VET and the role of VET teachers and trainers.

According to Susskind and Susskind (2015), AI helps to transform the education process by making it more flexible and individualized. In the following section, examples are given of how AI technologies can be used in the VET learning contexts. Afterwards, the influence of AI on the VET curricula is discussed.

5.1 Using AI in provision of vocational education and training

An **Intelligent Tutoring System** (ITS) is defined as an IT tool capable of helping a student in the same way (or almost) as a human tutor. Specifically, the functions it should perform are the following:

- presenting learning contents;
- evaluating the efficacy of student learning process (what and if the learner is learning);
- promoting learner motivation;
- helping learners to cope with difficulties, to bridge learning gaps by getting examples and extra explanations.

An excellent ITS can interact with the learner through instant feedback, on-demand, corresponding to the requests, appropriately to the situation. To answer students' questions, it is also able to store, represent and retrieve information (Jia, 2015).

ITS were being used by the 1970s, a period in which the potential offered by AI was small compared to today. The development that AI has seen in recent years has fostered its use for particular purposes in the context of ITS. In particular, it has been used for generating adaptive feedback, hints or recommendation, defining, classifying and updating the student diagnosis model, for student evaluation, for presenting adaptive learning material or content; and for adapting navigations of learning pathways (Mousavinasab et al., 2018).

ITS, in general, has been recognized as an effective method by several studies. In particular, a meta-analysis conducted in 2016 of 50 studies revealed an effect size of 0.66 (Kulik & Fletcher, 2016). According to the literature, ITS are widely used in schools and universities (especially for STEM and for the medical sector) but empirical research on ITS effectiveness in VET were not found.

A **smart classroom** is a physical learning room equipped with sensor technology. The data collected via sensors, e.g. with microphones or cameras, are used by humans or AI systems to provide learning assistants, tools or strategies for the learners (Southgate et al. 2019). A smart classroom should support the teacher in teaching in order to make learning more effective for the students.

The special thing about a smart classroom is that the learning environment is context-specific. This means that the learner's environment is recorded (for example, using sensors) (Southgate et al., 2019). Individual support can be offered to the learners based on the data collected. It is also possible to adapt the way information is presented to personal learning preferences. Smart classrooms are therefore ideally context-specific, adaptable and personalisable (Hwang, 2014). In Germany, the Technical University of Kaiserslautern and the German Research Center for Artificial Intelligence are working together on a smart textbook for tablets.

With the help of the smart textbook "HyperMind"[1], individual learning should be made possible. For example, an eye-tracker is installed under the display. This enables the eye movements of the students to be recorded and identifies where reading is slower or something is repeated. This activity detection can be used as an indication that a student could use help or additional information at this point. The student can then be provided with individual content. The smart textbook is also intended to help teachers to shape the learning process. For example, the data collected from the students can be used to train an AI. In this way, learning behaviour can be analysed (Learning Analytics). In China, smart classrooms are already more widespread. In 2018, a Chinese school made the headlines by filming students in class and using AI to evaluate whether they followed the lessons[2]. If facial recognition detected that a student was mentally absent, the teacher received a push notification on his or her mobile phone. Whether the focus here was on the learning success of the students and not on monitoring was much discussed in the media. So, in the case of smart classrooms, as with all applications, dual-use must be discussed and it must be determined whether the positive effects of use outweigh the negative and how these can be promoted in contrast to negative consequences. This example suggests the need to update the five ethical key issues highlighted by James (2009) in "Young people, ethics, and the new digital media": identity, privacy, ownership and authorship, credibility and participation.

Learning Analytics (LA) has been defined as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (SOLAR, 2011). It can assist in promoting personalized learning and enable adaptive pedagogies and practices (Johnson et al, 2014). There are a number of research and development projects around recommender systems and adaptive learning environments. LA is seen as having strong relations to recommender systems (Adomavicius & Tuzhilin, 2005), adaptive learning environments and intelligent tutoring systems (Brusilovsky & Peylo, 2003), which are increasingly being adapted for vocational education and training. Apart from the idea of using LA for automated customisation and adaptation, feeding back LA results to learners and teachers to foster reflection on learning can support self-regulated learning (Zimmerman, 2002). In the workplace sphere LA can be used to support the reflective practice of both trainers and learners “taking into account aspects like sentiment, affect, or motivation in LA, for example by exploiting novel multimodal approaches may provide a deeper understanding of learning experiences and the possibility to provide educational interventions in emotionally supportive ways” Bahreini et al., 2014).

The use of Artificial Intelligence (AI) within assessment tools supports assessment and evaluation through automated grading and feedback, including a range of student-facing tools, such as intelligent agents that provide students with prompts or guidance when they are confused or stalled in their work. Such tools are increasingly being embedded in popular online learning applications like DuoLingo. The development of Natural Language Processing (NLP) allows the digital assessment of open questions and texts, as well as other forms of questions like sentence completion or filling in missing words which research suggests are more effective forms of assessing learning (Jacoby, 1978). Digital Assessment is not only important for providing formative feedback to students but allows teachers an evaluation of student understanding and engagement, helping them to focus teaching on supporting learners with things they may not easily understand.

1 https://www.uni-kl.de/uedu/arbeitsfelder/unterrichtskonzepte-af1/hypermind/

2 https://www.telegraph.co.uk/news/2018/05/17/chinese-school-uses-facial-recognition-monitor-student-attention/

5.2 Integration of AI into the design of work-oriented curricula

The current re-design of a curriculum is a complex educational and training oriented activity. In some European Countries also VET teachers and trainers are also involved in this process and take an active role. It has to cover the professional work and learning tasks of an occupation in all its dimensions: work process knowledge covered in practical work skills from the work process in the company but also more explanatory in depth and/or reflexive knowledge which could be addressed more clearly in a VET school or special course

For actual, advanced and timely curricula, work process changes are the basic impulse to form new vocational learning programmes which include work and learning tasks (WLT). Curricula are a key framework to say what kind of technical and organisational skills are to be followed and which of the learning tasks get priority and in which order they can be grouped and systemised. The skills spectrum starts from beginners' tasks, advanced beginners' tasks, advanced tasks and very advanced expert tasks (Rauner & Haasler, 2009). In principle, several curriculum structures can be distinguished (Arnold, Lipsmeier & Ott, 1998). The so-called learning arena curriculum is one possible option under different curriculum designs to deal with AI in VET, while it prepares well for more student cantered learning and project orientation (Boreham & Fischer 2009). The developments in the world of work in the AI era can thus also be found in the facets of the learning field concept as an advanced option for a work process re-orientation of the curriculum, through:

- the multidimensional project topics,
- by addressing of professional, organizational and social skills,
- the direction towards operational work processes, company work task and business orientation,
- the orientation towards systematic, holistic training processes by by real problem-oriented settings for team building and forms of stronger cooperation and communication (Deitmer & Heinemann, 2010; Deitmer, 2019).

The design criteria for such a curriculum can be summarized as follows:

- Work Practise based curriculum are a good option in the context of AI system applications because disruptive change will have a massive effect on the design and content of different technical, social and business occupations.
- Curriculum changes occur from the industrial labour market which will threaten low skilled jobs but on the same side will enhance existing non-routine job tasks such as to be found in different occupations, for example industrial electronic and mechatronic occupations.
- The curricula can cover all learning places: company, training centre, vocational education school.
- Curricula follow an open content approach which is demonstrated by a continuous openness to new knowledge like new AI tools; system elements and methods.
- The Curriculum supports the integration of different kinds of knowledge domains, practical experience and theoretical knowledge gained by implementation of AI devices into real production facilities.
- The framework of the curriculum gives direction for trainers and teachers in delivering them more freedom to organise high quality work and learning processes at different levels for apprentices, trainees or students.

6 The preparation of teachers for AI-based vocational education

In order to be able to use AI tools in VET schools or to carry out AI projects, teachers must be trained and need knowledge about AI. Based on the literature and the interviews conducted, four new competence categories for teachers and trainers were developed:

- Category 1: Awareness of the implications of AI for work and society
- Category 2: VET curriculum design and development
- Category 3: School-based and work-based vocational training
- Category 4: Competence development of VET teachers and trainers

These categories are to be understood as a supplement to the European Framework for the Digital Competences of Educators (DigiCompEdu) (Redecker & Punie, 2017). The existing DigiCompEdu Framework is directed at teachers at all levels of education and is intended to support them in the use of digital media in educational programmes.

The DigCompEdu Framework aims to capture and describe educator-specific digital competences by proposing 22 elementary competences organised in 6 areas. The competences are divided into further levels (A1, A2, B1, B2, C1, C2) so that teachers can determine their level of competence[3]. Area 1 is directed at the broader professional environment, i.e. educators' use of digital technologies in professional interactions with colleagues, learners, parents and other interested parties, for their own individual professional development and for the collective good of the organisation. Area 2 looks at the competences needed to effectively and responsibly use, create and share digital resources for learning. Area 3 is dedicated to managing and orchestrating the use of digital technologies in teaching and learning. Area 4 addresses the use of digital strategies to enhance assessment. Area 5 focuses on the potential of digital technologies for learner-centred teaching and learning strategies. Areas 6 details the specific pedagogic competences required to facilitate students' digital competence. In sum, the DigiCompEdu Framework is designed to be used in all sectors of education.

Nevertheless, VET is special. This is mainly due to the fact that technologies play a particularly important and dual role for VET teachers. On the one hand technology forms the subject of much vocational education and training in its use in different occupational areas. On the other hand, technology is a means of delivering VET. The acquisition of digital competences is certainly an important first step towards being able to deal with new technologies and to use them in a targeted and pedagogically valuable way. On this basis we suggest the following competences are adopted for the use of AI for teaching and the application of AI-based tools in vocational education and training (Table 1 – Table 4):

Table 1
Awareness of the implications of AI for work and society

No.	Category 1: Competences
1.1	To identify the main changes in work processes due to the use of AI.
1.2	To identify and discuss the implications of AI for skills and knowledge needs in the work processes.
1.3	To explain the implications of AI for the vocational education and training systems and their reform and development.
1.4	To explain the implications of AI for the design, provision and award of qualifications within all occupational profiles within important domains such as technical production, construction, health, trade, social and agriculture.

3 DigiCompEdu Check-In https://ec.europa.eu/eusurvey/runner/DigCompEdu

Table 2
VET curriculum design and development

No.	Category 2: Competences
2.1	To facilitate open content in the VET curricula and the inter-disciplinary integration of vocational knowledge fields related to the implementation of AI technologies.
2.2	To design VET modules and curricula for the attainment of competencies needed to work and learn with AI-based technologies.
2.3	To adjust school-based and work-based training for the skills required for using AI technologies and solutions in work processes.
2.4	To apply AI solutions (e.g., learning analytics) for the design and implementation of VET curricula or modules.

Table 3
School-based and work-based vocational training

No.	Category 3: Competences
3.1	To prepare AI enhanced workplaces for the work-based learning; to install and /or adjust the AI augmented workplaces for learning purposes; to install and maintain smart classrooms for VET.
3.2	To use AI-based tutoring systems in the training process; to apply "just-in-time" learning solutions enhanced by the AI in the work-based learning; to use Learning Analytics in the contexts of work-based learning and informal training.
3.3	To use the AI applications for the engagement, recruitment and support of VET students and apprentices: e.g. to design and evaluate chatbot applications, smart tutoring systems.
3.4	To support independent learning and competence development of students/apprentices in the field of AI applications in the work process by design and initiation of smart factory projects.
3.5	To use AI enhanced technological solutions for the effective communication between VET teachers and company trainers in new work-based learning activities.
3.6	To use AI for development of multimedia learning materials and Open Educational Resources for VET; to apply AI powered MOOC's for vocational learning.
3.7	To apply AI-enhanced solutions for the formative and summative assessment of work-based learning.

Table 4
Competence development of VET teachers and trainers

No.	Category 4: Competences
4.1	To identify the competencies needed for the teaching and training of trainers and teachers on how they can enhance their capacity to apply AI in the work processes.
4.2	To design and apply different kind of initial and formative training courses for teachers and trainers in order to deal with human centered AI solutions in their professional role.
4.3	To apply AI solutions for the development of professional and pedagogical competencies including course designs in different formats and arrangements: internal, MOOC, online etc.

This framework aims to serve as a basis for further discussions between experts and researchers on the implications of the digitalization and AI for the work, careers and competence development of VET teachers and trainers. It also provides initial guidance for the wider discussions about the new competence requirements of VET teachers and trainers, as well as new approaches to their competence development.

Conclusion and Outlook

AI is one of central factors in the technological and organizational transformations of work and learning. The changes in the work processes caused by the digitalization and AI significantly transform the VET curriculum design by strongly imposing work process orientation, learner centredness, interdisciplinarity and project logics. The same changes transform the learning and teaching processes in VET by bringing in different enhancing and supporting measures, such as Learning Analytics, Moocs and others. These transformations, in turn, create new requirements for the skills and competence of VET teachers and trainers for involving the AI related knowledge and skills in the curricula, using AI in the training and assessment practices, or using AI in developing the know-how and skills of teachers and trainers.

References

Adomavicius, G., & Tuzhilin, A. (2005). Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions. *IEEE Transactions on Knowledge and Data Engineering*, *17*, 734–749. http://dx.doi.org/10.1109/TKDE.2005.99

Attwell, G., Deitmer, L., Heinemann, L., & Kämäräinen, P. (2013). *Developing PLEs to support work practise based learning*. e learning papers 35.

Arnold, R., Lipsmeier, A., & Ott, B. (1998). *Berufspädagogik kompakt; Prüfungsvorbereitung auf den Punkt gebracht.* Cornelsen.

Bahreini, K., Nadolski, R., & Westera, W. (2016). Towards multimodal emotion recognition in e-learning environments, *Interactive Learning Environments, 24*(3), 590–605. https://doi.org/10.1080/10494820.2014.908927

Boreham, N., & Fischer. M. (2009). The mutual shaping of work, vocational competence and work-process knowledge. In R. Maclean & D. N. Wilson (Eds.), *International handbook of education for the changing world of work* (pp. 1593-1609). Springer.

Brusilovsky, P., & Peylo, C. (2003). Adaptive and intelligent Web-based educational systems. *International Journal of Artificial Intelligence in Education, 13* (2-4), 159–172.

Deitmer, L. (2018). Innovation Skills in Apprentice Training. In S. McGrath, M. Mulder, J. Papier, & R. Suart *(Eds.), Handbook of vocational education and training: Developments in the changing world of work* (pp. 1-17). Springer.

Deitmer, L., & Heinemann, L., (2010). *Innovation through evaluation and quality development of in-company training and workplace learning*. Conference Proceedings on Second International Online Conference on Innovation in Training Practice, www.trainersineurope.org

Eliott, S. W. (2017). *Computers and the future of skill demand. Educational research and innovation series*. OECD Publishing, Paris.

Gorldt, C., Wiesner, S., Westphal I., & Thoben K. D. (2017). Product-Service Systems im Zeitalter von Industrie 4.0 in Produktion und Logistik – Auf dem Weg zu Cyber-Physischen Product-Service Systemen. In M. Bruhn & K. Hadwich (Eds.), *Dienstleistungen 4.0* (pp. 363–378). Springer Gabler.

Hirsch-Kreinsen, H., & Itterman, P. (2017). Drei Thesen zu Arbeit und Qualifikation in Industrie 4.0. In G. Spöttl & L. Windelband (Eds.), *Industrie 4.0 – Risiken und Chancen für die Berufsbildung* (pp. 131–152). W. Bertelsmann Verlag.

Hwang, G.-J. (2014). Definition, framework and research issues of smart learning environments - a context-aware ubiquitous learning perspective. *Smart Learning Environments, 1* (1), 1–14.

James, C. (2009). *Young people, ethics, and the new digital media: A synthesis from the GoodPlay Project*. The MIT Press.

Jacoby, L. L. (1978). On interpreting the effects of repetition: Solving a problem versus remembering a solution. *Journal of Verbal Learning and Verbal Behavior*, *17*(6), 649–667.

Jia, J. (2015). Intelligent tutoring systems. In M. Spector (Ed.), *The SAGE encyclopedia of educational technology* (pp. 411–413). Sage Publications.

Johnson, L. Adams Becker, S., Estrada, V., & Freeman, A. (2014). *NMC Horizon Report: 2014 Higher Education Edition.* The New Media Consortium.
Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of intelligent tutoring systems: a meta-analytic review. *Review of educational research*, *86*(1), 42–78.
Luo, H. (2015). Case Study Research in Educational Technology. In J. M. Spector (Ed.), *The SAGE encyclopedia of educational technology* (pp. 85–88). https://doi.org/http://dx.doi.org /10.4135/9781483346397.n44
McKinsey (2018). *AI, automation, and the future of work: Ten things to solve for. Briefing note for the Techn4Good Summit, organised by the French Presidency*.
Meuser, M., & Nagel, U. (2009). The expert interview and changes in knowledge production. In A. Bogner, B. Littig, & W. Menz (Eds.), *Interviewing experts* (pp. 17–42). Palgrave Macmillan.
mmb Institut. (2020). *KI@Ed noch nicht in der Fläche angekommen. Ergebnisse der 14. Trendstudie „mmb Learning Delphi".* https://www.mmb-institut.de/wp-content/uploads/mmb-Trendmonitor_2019-2020.pdf
Mousavinasab, E., Zarifsanaiey, N., R. Niakan Kalhori, S., Rakhshan, M., Keikha, L., & Ghazi Saeedi, M. (2018). Intelligent tutoring systems: a systematic review of characteristics, applications, and evaluation methods. *Interactive Learning Environments*, 1-22.
Rauner, F., & Haasler, B. (2009). *Lernen im Betrieb. Eine Handreichung für Ausbilder und Personalentwickler.* Christiani Verlag.
Redecker, C., & Punie, Y. (2017). *European framework for the digital competences of educators DigiCompEdu*. Publications Office of the European Union.
Schwab, K. (2018). *Shaping the fourth industrial revolution*. Penguin Books.
SoLAR (2011). *Open learning analytics: An integrated & modularized platform. White paper.* Society for Learning Analytics Research. http://solaresearch.org/OpenLearningAnalytics.pdf
Southgate, E., Blackmore, K., Pieschl, S., Grimes, S., Mcguire, J., & Smithers, K. (2019). *Artificial intelligence and emerging technologies in schools*. University of Newcastle, Australia.
Spöttl, G., Gorldt, C., Windelband, L., Grantz, T., & Richter, T. (2016). *Industrie 4.0 – Auswirkungen auf Aus- und Weiterbildung in der M+E Industrie. Study of the Bavarian Metal and Electrical Industry.* www.baymevbm.de/industrie4.0
Susskind R., & Susskind, D. (2015). *The future of professions. How technology will transform the work of human experts.* Oxford University Press.
Tuomi, I. (2018). *The impact of artificial intelligence on learning, teaching, and education.* Publications Office of the European Union.
UNESCO (2019). *How can artificial intelligence enhance education?* https://en.unesco.org/news/how-can-artificial-intelligence-enhance-education
Zimmerman, B. J, (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, *41*(2), 64–70.

Biographical notes

Graham Attwell is director of Pontydysgu, a research SME based in Wales and in Valencia Spain. His research interests include developments in the labour market, the uses of technology for knowledge sharing, teaching and training. Currently he is developing a Chatbot for information about jobs and careers for adults.

Dr **Ludger Deitmer** works as a senior researcher at the University of Bremen, Germany, at the Institute Technology and Education (ITB). His research interest focuses on workplace based learning approaches, in company training and learning approaches, evaluating the quality of apprenticeship, Local and regional governance of VET systems, and enhancing incremental innovation.

Dr **Vidmantas Tūtlys** is a researcher and professor at the Academy of Education Science of Vytautas Magnus University in Kaunas (Lithuania) and a member of the VETNET – European Research Network of Vocational Education and Training. His research interests include the methodology and policy of the initial vocational education and training, development of qualifications and their systems, development of continuing vocational training and human resource development. Vidmantas Tūtlys has participated in a range of European research and development projects in the fields of the VET policy, qualifications, VET curriculum design, development of apprenticeship and work-based training, implications of the Industry 4.0 for curriculum design and qualifications.

Sophia Roppertz is a research associate at the University of Bremen, Germany, at the Institute Technology and Education (ITB). Her research work focuses on changing competence developments in maritime economy and adult education as well as on learning with digital media.

Dr **Marco Perini** is a PostDoc at the Department of Human Sciences of the University of Verona, at the Centre for Action Research on Vocational Education and Training (CARVET). His main area of research includes Vocational Education and Training, educational technologies, work-based learning and teacher education.