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1. Introduction

The subject matter of Industrie 4.0 is generally understood to be "the comprehensive introduction of computer- and communications technicians, and their connection to an Internet network of things, services and data, which makes possible a real-time capability for production," (cf., e.g., Spath et al. 2013, p. 2). This topic is currently the subject of intensive discussions at many national and international businesses. If you input "Industrie 4.0" into the Internet search machine Google, in less than half a second, roughly 15,500,000 search results appear (updated: 08.07.2015). Some people even connect Industrie 4.0 with the fourth industrial revolution, which sums up its comprehensive significance in a straightforward way (e.g., ibid.). The subject of Industrie 4.0 is discussed in companies in its different aspects from different perspectives, with reference to its implications for the organization of the future of the occupational world, both in research and also in direct business practice (cf. e.g. Brödner 2015; Frenz, Heinen & Schlick 2015; Eder in this issue; Gebhardt, Grimm & Neugebauer in this issue; Guo in this issue).

2. Main perspectives for discussion of Industrie 4.0

The fundamental perspectives for discussion of Industrie 4.0, which can be assumed to influence, either directly or indirectly, the design of training and continuing education in the future are especially: (1) the technological perspective, (2) the economic perspective and (3) the occupational-sociological perspective. We must suppose that these perspectives also represent central conditional variables for the design of an Ausbildung 4.0. Below we attempt to outline these three central perspectives on the topic at hand with their core elements in order to build on this by reflecting the implications for an Ausbildung 4.0.

Technological perspective

From the technological perspective, the initial subject is discussed in several domains, such as computer science, electro-technology, mechanical engineering or civil engineering, with different names (e.g. Bauindustrie 4.0, Planen-Bauen 4.0, Handwerk 4.0 or Wirtschaft 4.0 [Construction Industry 4.0, Construction Planning 4.0, Trades 4.0 or Economy 4.0]), in accordance with domain-specific emphasis and priorities. In the sector of industrial production, mechanical- and systems engineering and also in the automotive industry, the subject of Industrie 4.0 is associated with an epoch-making transformation in the technological bases and the technical standards related to these fields. The focus of the technological discussion is on, among other things, cyber-physical systems (CPS), which are described as a complex "network of interacting elements with physical in- and output" (cf.

e.g., Sendler 2013, p. 8). Cyber-physical systems include complex software and hardware components with mechanical or electronic parts, which are equipped with a functional data infrastructure, such as, e.g., the Internet or an Intranet for communication. A cyber-physical system is characterized by its high degree of complexity, and it is composed of a network of imbedded systems and modern actuating and sensing systems, which are connected to each other by wire or wireless communications networks. The main objectives associated with the new Industrie 4.0 technologies are, among others, increasing flexibility requirements of the sales markets, increasing individualization of the products, shortening product life cycles together with increasing complexity of procedures (e.g. Scholz-Reiter et al. 2009; Forschungsunion acatech 2013, Hirsch-Kreinsen 2014). Additional technologies and artifacts considered in the technological discourse are, among others, intelligent machines, machine-to-machine communication (M2M), big data and smart data, Internet of things (for an overview see, e.g., Baum 2013; Kaufmann 2015). The main elements of the technological discussion here are the clarification of specifications for soft- and hardware, data security (cf., e.g., Russwurm 2013), and the potentials of the individual technologies and their interactions with each other (cf., e.g., Baum 2013; Borcherding 2013).

Economic perspective

The economic perspective on the subject Industrie 4.0 addresses especially the functionalities of the new technologies and their implications for an adaptive business strategy together with new or modified business models (cf., e.g., Kaufmann 2015). Thus the business-oriented consideration of the subject treats, among other things, the introduction of decentralized management concepts, *ad hoc* design of production processes and the ability to react quickly and flexibly to customer requirements. Above all the option to industrially manufacture small numbers of pieces or unique copies under comparable conditions with large amounts of identical consumer goods offers new or modified business options for companies. In this field, business model innovations - of the basis of existing company models - the modification of existing business models and the development of new business models are discussed (cf., e.g., ibid., p. 12). A specific, non-representative case study with businesses from the mechanical- and systems- engineering sector, designates the following challenges for businesses as central in the context of Industrie 4.0: individualization of customer requests by decreasing lot sizes, optimization of reaction times, guaranteeing of real-time transparency (i.e., ensuring the possibility of information on the manufacture status of the product ordered), globalization of purchasing, guarantee of high product quality with decreased lot size, implementation of new production procedures and disruptive technologies such as introduction of smart data and optimization of generation of knowledge in the business. The group of authors on the "Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0" ["Recommendations for implementation of the future project Industrie 4.0"] (2013, p. 19ff.) connect the following potentials, in summary, with the introduction of Industrie 4.0: individualization of customer requests, flexibilization, optimization of decision-making, improvement of resource productivity and efficiency, increased potentials for value creation through new services, demography-sensitive employment design, improvement of work-life balance and expansion of competitiveness. In summary, the economic perspective considers the effects of introduction of Industrie 4.0 technologies on future organizational structures, corporate strategies and business processes (for a further overview cf., e.g., Kaufmann 2015).

Occupational-sociological perspective

The occupational-sociological perspective on the topic Industrie 4.0 often considers the relationship of technology and work (for an overview, e.g., Hirsch-Kreinsen 2014; Kuhlmann 2015) taking as a point of departure a socio-technological system (e.g., Ropohl 2009). The main elements of the occupational-sociological perspective are, among others, the clarification of consequences for employment, the direct and indirect effects on the scope of employment and the probability of a possible segmentation of the employment market. In the context of models for work organization that are in transformation as a result of the disruptive nature of the new technologies, possibly modified margins for negotiation, structures for cooperation, and needs for requirements and qualifications are discussed, together with the problems of modified forms of employee participation and participatory processes for system design. Increasing transparency of employees is especially implied by increased digitalization of tasks, which is in turn connected with expanded need for discussion in terms of occupational sociology (ibid., p. 3ff.).

Modified teaching and learning

In addition to the technological, economic and occupational-sociological discussion, the involvement of innovative learning spaces also takes on significance for a comprehensive consideration of possible conditional variables of an Ausbildung 4.0. We can suppose that in the future, modern learning environments in the occupational world will reinforce connections between virtual spaces and physically real spaces. For example, in the context of mixed-reality simulation or augmented-reality (cf., e.g., Guo in this volume). New forms of person-technology interaction could be used to enable the experience of innovative learning environments while at the same time increasing relevance to practice. The use of new options in the field of training and continuing education could provide especial advantages in the future, if it is not introduced as a purely additional element, but rather integrated pedagogically into an actual professional project. In business contexts we can expect advantages if the innovative learning environments are combined with existing networks of business-specific knowledge. In light of the extended expectations for e-learning in general, we may however question whether learning in virtual 3D environments with natural user interfaces in fact entails a better adaptation to the users' needs, better learning performance, higher efficiency of teaching/learning processes (Köhler et al. 2008; Katzky et al. 2013) or greater motivation to learn (e.g., Kerres 2012) in training and continuing education.

In the context of Industrie 4.0, life-long learning becomes a self-evident component of individual professional development. Making life-long learning possible requires, in addition to specialized personnel prepared to provide continuing education, systematic structures for continuing education and innovative learning options that actively support acquisition of knowledge and abilities in relation to learning on demand and cloud learning. In order to be able to use and develop competences in a business in a sensible way in the context of professional education and continuing education, systematic and timely transfer of knowledge within a business plays an essential role. Planning management of knowledge can significantly improve complex business processes that increase production, promote organizational learning, develop new abilities and skills and ensure competitive advantages (cf., e.g., von Krogh 1998; Argote et al. 2000). In this process it is of special importance to design concepts for spatial and temporal flexibilization of transfer of knowledge, in order to sustainably exploit the competences in a business, ensure transfer of practical knowledge and technical innovation within a company and to be able to ensure a high product quality. The better a company manages its knowledge resources and supports its knowledge-bearers in a timely manner in developing competences and convictions relevant to knowledge, the easier it will be for it to react to dynamic changes and initiate innovative processes (Reinmann-Rothmeier 2001).

In this process remote laboratories may constitute a connective innovative element (cf. e.g., Cikic et al. 2009), in order to better connect business and classroom learning with one another. In the case of support of operational knowledge, the focus is not preference for one form of knowledge, but rather the transfer of an elaborated conviction on knowledge and its acquisition, which coherently relates the acquisition of theoretic/systematic specialized knowledge and knowledge based on experience in the context of Industrie 4.0, which conclusively combines them (cf. e.g. Zinn 2015). The theoretic/systematic knowledge acquired mainly in professional schools and the experience-based knowledge acquired mainly in business practice, together with their associated abilities and skills, must not only be compatible, but rather they must support each other mutually. The theoretic/systemic knowledge and the experiential knowledge must as a whole serve as further explanation for each other in a logical and complementary manner.

3. Conditional variables for an Ausbildung 4.0

Even if the above outline of the technological, economic and occupational-sociological perspectives on the initial subject matter together with selected aspects of teaching and learning do not do justice in their extension to the current domain-specific status of the discussion in the context of technologically-oriented environments, it nevertheless becomes clear that these perspectives have direct or indirect implications for the design of future training and continuing education. We may perhaps expect implications in reference to the tailoring of (new) educational professions, modifications in curriculums, profiles of competences or modified use of modern learning environments. Obviously, the innovative technologies and the related economic and sociological discussions result in modifications of needs for qualifications of employees. For example, in light of the cyber-physical systems (CPS) we may suppose that knowledge and abilities in information technologies, competences in management and problem solving will be of increasing importance for future education and continuing education.

In light of the economic discussion on the increasing relevance of the industrial service sector, adaptive personal and social competences (e.g., ability to adopt other perspectives, ability to advise) may increase in relevance for modern education and continuing education (Zinn et al., in this edition). In the context of economic discussion on the modified business models, business processes and organizational structures, we can assume that it is partly a case of modified adaptation in training and continuing education professions in technical and non-technical employment sectors. Central areas such as production, development, logistics, service and controlling, in summary, continue to be the focus of technological and economic changes, which in turn determine restructuring in the occupational world and hence also in training and continuing education.

The occupational-sociological perspective assumes, in part, greatly modified needs for requirements and qualifications, and in this context it demands appropriate possibilities for employee participation. Due to the transformation in the occupational world, we must expect new fields for tasks and employment and new forms of interaction.

The four conditional variables presented in the working model of an Ausbildung 4.0 exist themselves within a direct and indirect complex of causation (see Illustration 1). The functionalities of the new technologies influence, as presented above, the economic decisions and the occupational-sociological discourse. Conversely, we must suppose that the economic decisions cause technological changes. The perspectives and their sub-items in the working model must be understood as subject to further expansion and not conclusive.

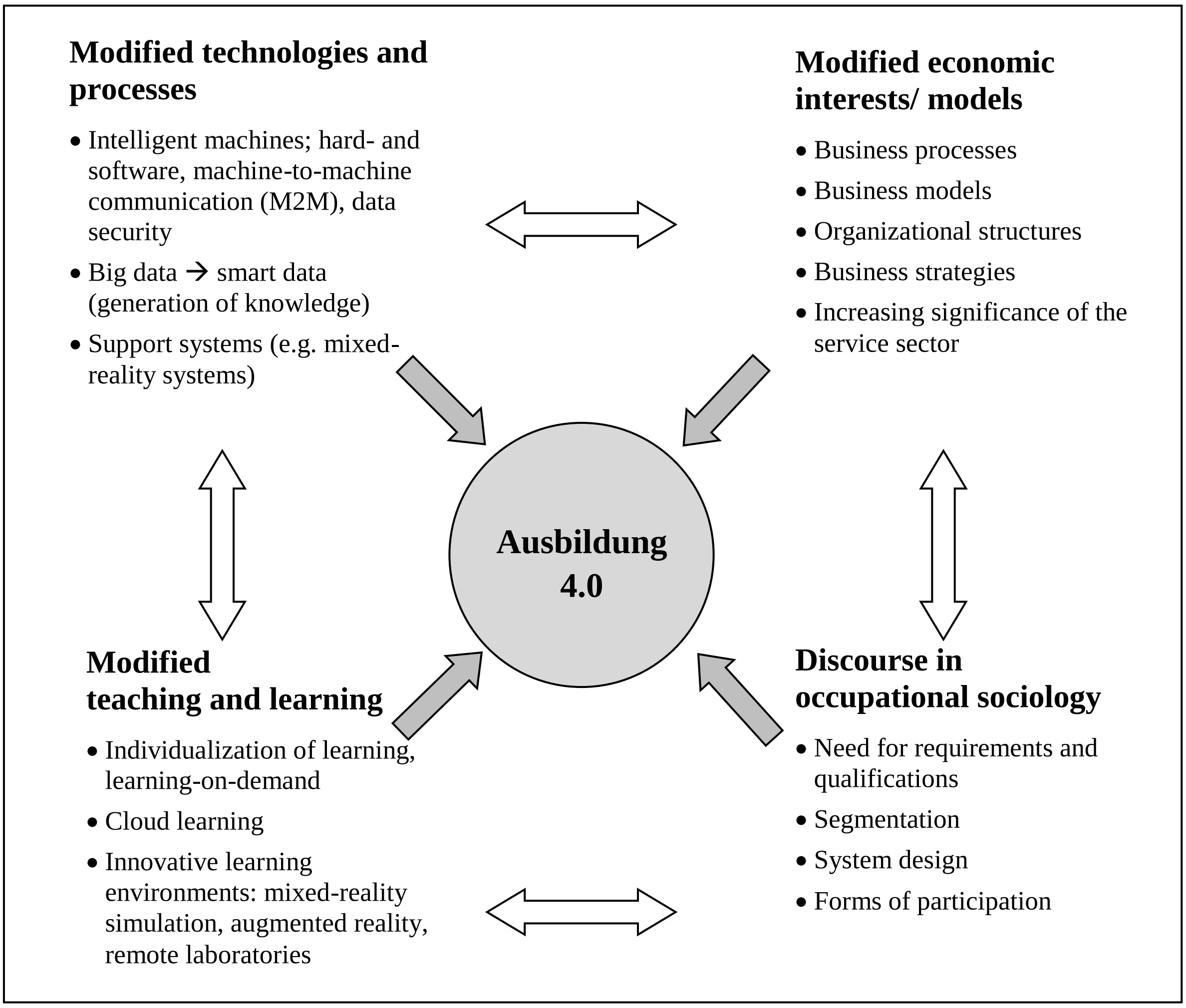

Illustration 1: Model of the conditional variables of an Ausbildung 4.0

From this perspective, the subject of Industrie 4.0 and its implications are the focus of this special edition. The following five contributions in the special edition reflect on this topic by addressing in part very different facets of innovative training and continuing education for the future.

Alexandra Eder (in this edition) treats the acceptance of educational technologies in vocational education in the context of use of digital media at the classroom location. The contribution of Jonas Gebhardt, Axel Grimm and Laura Maria Neugebauer (in this edition) offers a preview of the requirements of the future Arbeit 4.0 and the effect on the training and continuing education of specialized workers. The empirical contribution of Leo van Waveren und Reinhold Nickolaus (in this edition) presents a model of structure and levels of the specialized knowledge among electricians for automation technology. Qi Guo (in this edition) summarizes the current status of mixed-reality systems in the related field of a web-based learning structure, human-object-interaction, gamification and immersion. In the fifth contribution, Bernd Zinn, Emre Güzel, Felix Walker, Reinhold Nickolaus, Duygu Sari and Matthias Hedrich (in this edition) consider an innovative teaching and learning concept (ServiceLernLab) for maintenance technicians in the industrial service sector of mechanical- and systems engineering and the effect of testing of the concept with reference to specialized competences (specialized knowledge and competence for error diagnosis) while also comparing self-assessment, external assessment and objective performance in specialized competences.

The individual contributions to this special edition comprise different research desiderata, thereby demonstrating that up to now there has been only a limited empirical descriptive and explanatory knowledge in the field of the initial subject Industrie 4.0 and its implications for training and continuing education. There is currently a great need for further research, and we would recommend a research program specific to education in the field of training and continuing education in the future (Ausbildung 4.0).

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