Towards Competence Development for Industry 4.0

Milos Kravcik(✉), Xia Wang, Carsten Ullrich, and Christoph Igel

Educational Technology Laboratory, DFKI GmbH,
Alt-Moabit 91c, 10559 Berlin, Germany
Milos.Kravcik@dfki.de

Abstract. Technological changes always bring new opportunities and risks that can modify the existing marketplace. This is also valid for the Industry 4.0 trend, which raises hopes on one side and fears on the other. Especially small and medium-sized enterprises (SMEs) cannot ignore this challenge, if they want to prosper in the future. They certainly need technological support that can assist them in planning, steering, and monitoring the transition process as well as in up-skilling their employees. Design and development of such a system is the aim of the ADAPTION project. In this article we report on this ongoing work, especially on the tool using the newly created progress and maturity models, but also on the related competence development approach. These efforts should enhance the palette of novel methodologies and facilities that are needed to efficiently support workplace learning and training under new circumstances.

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Keywords: Competence development · Workplace learning · Industry 4.0

1 Introduction

Intelligent tools (exploiting big data) transform work processes and it is difficult to predict related changes and their consequences [1]. The trend opens new opportunities and business executives should consider complementarities of humans and computers, to be successful in the marketplace. Another challenge is to establish organizational strategies for upskilling employees, focusing on competences that cannot be replaced by machines. The technological developments reform manufacturing and supply chains, where the competitive advantage in small and medium-sized enterprises (SMEs) depends on skilled labour and specialization. The *Industry 4.0* paradigm shift from resource-oriented planning to product-oriented planning is based on networking of intelligent machines and products, called *Cyber Physical Production Systems* (CPPS). With changing customer demands, the product will be able to request the necessary production resources autonomously. Consequently, the industrial workforce has to develop new competences in an efficient way, which requires novel education paradigms. The challenge is to develop new learning settings and measures for this purpose. To manage the related change process, it is crucial to win the support of employees. However, it is not quite clear how to successfully implement the organisational change, as the available theories and approaches are often lacking empirical evidence [2]. Critical success factors as well as methods for measuring the success of organisational change management are needed.

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2 Related Work

In the past, there were various efforts to support professional learning. Building a technical and organizational infrastructure for lifelong competence development was already the aim of the TENCompetence project 10 years ago. Their demand-driven approach [3] was based on the qualification matrix, mapping the relevant tasks on the required competence profiles. Such a competence map was used by the staff for self-assessment. The resulting competence gap was analysed, in order to prioritise competence development needs. For the required competences, expert facilitators were identified, and competence networks were established. To support this methodology, the *Personal Competence Manager* was implemented [4], which at the individual level enabled goal setting (specification of the target competence profiles), self-assessment (to identify the knowledge gap), activity advise (selection of personal development plans), and progress monitoring (to support awareness and reflection).

As a major requirement is to develop new competences in the industrial workforce quickly and efficiently, breakthrough paradigms for continuous training of employees are needed. Previously, different approaches have been investigated. The ROLE project developed a flexible one based on the responsive and open learning environments [5], which was later customized for SMEs in the BOOST project [6]. The APPsist project implemented an advanced architecture with intelligent assistance and knowledge services at the shop floor [7]. The Learning Layers project aimed at the scalability issue, using mobile devices with collaboratively created and shared multimedia artefacts, e.g. adaptive video based on semantic annotations [8]. Affordances of augmented reality and wearable technology for capturing the expert's performance in order to support its re-enactment and expertise development are investigated in the WEKIT project [9].

A study on competence requirements in the digitized world of work [10] identifies the insufficient qualifications of employees as a major problem for the transition to Industry 4.0. Four main competence types were distinguished: Professional, Data and IT, Social, and Personal competences. The last two of them represent the soft skills, which are crucial and should be continuously developed. There is a big challenge to realize new forms of individualized and informal learning integrated in various settings (including workplace) and cultivating meta-cognitive skills (e.g. motivation and self-regulation). Key for Industry 4.0 are combinations of professional (especially production process and systemic knowledge) and IT competences (mainly data analysis, IT security and protection) with social (including cooperation, communication abilities) and personal (like lifelong and self-regulated learning, analytical ability, interdisciplinary thinking, problem solving) skills. Moreover, several dozens of other important competences were identified in this study, which need to be cultivated.

Business intelligence and analytics became an important area of study, which reflects the impact of data-related problems to be solved in contemporary business organizations [14]. In the age of big data, the emphasis in industry has shifted to data analysis and rapid business decision making based on huge amounts of information. Development of such competences requires trial-and-error and experimentation.

3 ADAPTION System

The ADAPTION project [11] aims at the individual support of SMEs in their transition towards Industry 4.0. Its approach is based on the progress and maturity models [12], taking into account the technical, organizational and personal aspects. The consortium put a lot of effort into the development of these models, when production system and workplace learning experts used their aggregated knowledge to formalize requirements for transition of companies to Industry 4.0. Moreover, the outcomes were intensively consulted with real SMEs regarding their appropriateness and usability. Currently, a software system is being developed, which facilitates the description of the current and target states of the company (Fig. 1), as well as the specification of actions that should be taken to overcome the identified gap (Fig. 2) and their evaluation. In larger companies it may not be easy to describe the current status consistently, as there can be differences between its various departments. Nevertheless, in all cases it is reasonable to focus on a suitable part of the company, which can be presented and assessed consistently. For similar reasons it is recommended to also consider a suitable time frame for the target status achievement (e.g. 6 months). The idea is to stay focused as well as to plan and monitor the progress properly.

Fig. 1. Identification of the current and target status for one of 42 categories.

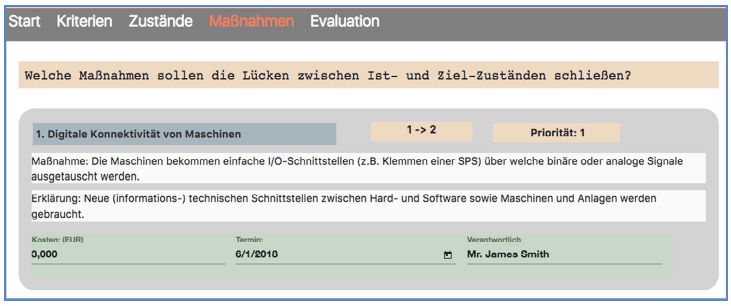

Fig. 2. Specification of operations that have to be performed to fill the existing gap between the current and target status for relevant categories.

4 ADAPTION Competence Development Concept

The operations specified to fill in the identified gap may include qualification and upskilling of employees. This should be concretely assigned to individual persons. In these cases, target competence profiles will be specified, suitable candidates, who can set up their goals and assess their current status of the required competences, in order to identify their personal competence gap, will be selected. They will then create their personal development plans (as a collection of learning resources) with the assistance of the system. Following the plan, they record their achievements and reflect on the progress, in comparison with the selected learning and training objectives.

As mentioned earlier, the related research includes an overview of the relevant competences for the Industry 4.0 area [10]. Based on the individual qualification goal the system will *advise resources* to acquire the relevant competences and *monitor progress*, supporting awareness and reflection of individual users. This means that the system will include both recommenders as well as learning analytics facilities. A good source of relevant learning resources is the MOOC *Hands on Industrie 4.0* (in German) presented by renowned experts from science and industry [15].

Following [13], we consider a service architecture with 4 layers: 1. *Data* – multimodal sensory fusion (e.g. physical environment, attention, affect), 2. *Basic Services* – data analysis (e.g. domain, user, context, pedagogical, adaptation model), 3. *Smart Services* – intelligent multimodal assistance (in work) and knowledge (in training) services (e.g. guidance and recommendations, awareness and reflection). 4. *User Interface* – personalized and adaptive learning and training (e.g. with wearables and augmented reality), including soft and motor skill training as well as immersive procedural training (like capturing and re-enactment of expert performance). In order to gain the trust of the user, it is necessary to keep clear privacy rules as well as to provide explainable machine decisions. Later on, the system will be evaluated, using the Technology Acceptance Model.

5 Conclusion

Industry 4.0 changes the manufacturing world dramatically and especially SMEs need and deserve special support in order to be able to benefit from the new conditions. Such a transition includes change management at the technical, organizational as well as personal level. The ADAPTION project deals with design and development of a software system that can help identify the current and target status of the company, plan the necessary operations to overcome the existing gap as well as monitor and evaluate the progress. A crucial part of these changes represents the human factor with upskilling of the workforce and development of required competences. This work is in progress and in this paper we report on the current status of the software tool and the principles of the competence development approach.

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