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Competence development for the holistic design of collaborative work systems in the Logistics Learning Factory

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Abstract

Shorter product life cycles and emerging technologies in the field of industrial equipment are changing the prerequisites and circumstances under which the design of assembly and logistics systems takes place. Planners have to adapt the production in accordance with the underlying product at a higher pace, oversee a more complex system and – most importantly – find the ideal solution for functional as well as social interaction between humans and machines in a cyber-physical system. Such collaborative work systems consider the individual capabilities and potentials of humans and machines to combine them in a manner that assists the operator during his daily work routine towards more productive, less burdening work. To be able to design work systems which act on that maxim, specific competences such as the ability of integrated process and product planning as well as systems and interface competence are required. The ESB Logistics Learning Factory trains students as well as professionals to gain such qualification by providing a close-to-reality learning environment based on a didactical concept which covers all relevant methods for ergonomic work system design and a state-of-the-art infrastructure composed of an manual assembly system, service robots, visual assistance systems, sensor-based work load monitoring and logistical resources. Group-based, activity oriented scenarios enable the participants to put the learnings into practice within their professional environments. By this, Learning Factories have an indirect impact on the transfer of proven best practices to the industry and thereby on the diffusion of the idea of a human-centric working environment.

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1. Introduction

Manufacturing companies are currently facing socio-technological trends which are expected to influence the general conditions under which value creation takes place [1, 2]. The emergence of new technologies and increasingly shorter product life cycles as technology related trends combined with the social megatrend of an ongoing demographic change in various leading industrial nations will lead to fundamental changes. These upcoming changes are affecting the technical infrastructure of manufacturing facilities as well as the interaction between employees and machines within new, so-called cyber-physical production systems (CPPS). CPPS will result in a global crosslinking of machineries, storage and logistics systems and other means of production. This especially includes a horizontal, real-time optimized integration of value adding networks, the digital consistency of all engineering processes along the complete product lifecycle as well as the corresponding value stream, combined with the vertical integration and up-linking of the involved production systems. Within CPPS, employees, machines and resources will communicate and collaborate like in a social network. In line with the technological changes, the role of employees as well as the requirements and competence profiles of those operating within such systems are going to change vastly [3, 4].

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As a consequence of the demographic change in Europe and many other developed countries, the age structure of employees is going to change by means that the share of young employees is going to decrease and consequently leads to an ageing of the workforce [5, 6]. In line with the growing ratio of older people, work systems have to be adapted to cope with new requirements. As a response to this development and to ensure employability during all phases of the occupational life cycle, innovative technical assistance systems [1] already available today can be deployed to assist the employees and reduce burdening phenomena such as stress and strain. To cope with these changes specific strategies are needed for the competence development of those who are in charge of designing such human-centered, technology-based work systems. Besides activities to sensitize the workforce regarding new available technologies and a fundamental understanding of the core methods of human-centered workplace design, relevant competences needed for an human-centric interaction between employees and machineries - respectively CPS - must be addressed [4, 7]. The outstanding significance of qualified personnel as a key factor for a successful implementation of innovative technologies like CPS and the configuration of state-of-the-art human-machine-interfaces within the factory is proven by several surveys and studies [8, 9]. In this regard, learning factories like the *Logistics Learning Factory* of the ESB Business School, a faculty of Reutlingen University, serve as close-to-reality learning environments, which can be used to inform, sensitize and educate different target groups.

2. The role of humans

Scientists, employer representatives and labor unions consent on the future role model of employees who are designing and/or operating manufacturing systems that are subject to the described socio-technological impacts [10-12]. This will not only affect the machine-to-machine communication, but also the interaction between employees and physical objects in *collaborative* work environments. Consequently, the technological progress will lead to a change of tasks of employees and a shift of the required competences and job specifications [13] which especially will involve the natural capacities of the employees like intelligence, creativity and empathy [14].

A feasible role of employees in a future cyber-physical work environment will be a function in supervision of the superior production strategy, combined with the role of a creative and skilled problem solver who is dealing with occurring issues within the work system ad-hoc. To intervene in the cyber-physical production system (CPPS), the employee will be assisted by various flexible, partly mobile human-machine-interaction solutions and gain a higher level of responsibility [13]. In doing so, the employee will use aggregated real-time information from the CPPS to derive actions or interventions after interpreting the available data. Beyond information purely related to operations, also ergonomic data can be ascertained and considered by those steering and optimizing the socio-technological work systems. At the *ESB Logistics Learning Factory,* learners can slip into that described role: a so-called "stress and strain cockpit" is used to assess stress and strain of employees and to feed the generated ergonomic data back to the digital planning environment, allowing real-time system adaption.

3. Competencies and qualification

Even in the highly technological field of CPPS there will be simple tasks for less qualified employees [12]. The reason is not caused by technological limitations, but rather economic reasons, which militate against automating these processes. For these tasks, innovative technical assistance systems, like collaborative robots, have a high potential to create less burdening work systems to cope with the intensifying demographic change. Nevertheless, the growing penetration of CPPS will cause a higher demand for highly qualified engineers with profound IT and collaborative work system design skills [15].

To parallelize the employee qualification and training processes with the technological and social changes taking place in the industry, specific qualification strategies and concepts have to be developed or existing concepts must be adapted respectively. Amongst others, a basic understanding of how to use the available data sources in an efficient way and specific professional and methodical competences are essential to implement a CPPS [13]. The required qualification measures, covering elements of various engineering disciplines to train the needed competences and system awareness of these production systems, have to be addressed to all employees reaching from skilled workers to engineers [15].

4. Learning Factories

Changing skill requirements lead to a changing use of teaching and learning methods, which can also meet specific training objectives in the fields of planning, implementation and optimization of work and logistics systems. Overall, a growing interest in practical and experiential teaching or learning environments can be determined. As a result, leading universities and colleges react by establishing learning factories [16-19]. These physical, operational factories usually cover the whole creation process of a product selected in accordance with didactical criteria and serve as exemplary and realistic learning environments. The concept of learning factories integrates self-directed and action-oriented learning in heterogeneous groups to encourage implied experiential knowledge, integrated into a formal didactical concept. This enables the trainer to address the intended competences systematically by guiding the learners through the processes necessary to acquire the intended knowledge and professional and/or vocational competencies. This symbiotic combination of teaching professional expertise, methodical and individual competencies as well as soft skills [20, 21] can be achieved by combing traditional, instructor-based teaching methods with hands-on sessions held in teamwork to improve social and group work competencies. The tasks or problems students get confronted with are inspired by issues of high practical relevance and designed openly to avoid predefined solutions