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Introducing competency models as a tool for holistic competency development in learning factories: Challenges, example and future application

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Abstract

Learning factories, which foster practically oriented teaching-concepts, offer excellent opportunities to develop students' competencies in self-controlled learning processes based on competency models. To evaluate these competencies, the aim of this paper was to establish a competency model for students working with a learning factory. Semi-structured interviews were conducted with lecturers and students who had experiences working with the learning factory. The recorded interviews were analyzed using qualitative content analyses with MAXQDA to identify the crucial competencies students develop when working with the learning factory. The applied coding scheme was built deductively based on literature of learning factories and competencies. Overall, twelve competencies were identified (e.g. Applying Knowledge) which can further be assigned to the three main clusters professional/methodological, social and personal competencies. The distribution of competencies in professional/methodological and social and personal competencies was even. These results support the opportunities learning factories offer for higher education competency development of professional as well as social skills. Furthermore, results provide the opportunity to establish and adapt competency-based teaching concepts in higher education and organizations.

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1. Introduction

With the rise of Industry 4.0, technological innovations in producing companies are continually growing and changing fast. In line with technological innovations, companies worldwide have to adjust their operational procedures as well as work routines [1]. As a result, the demands for employees are constantly changing. Employees need to be prepared to repeatedly adjust their knowledge and competencies to the developing digital work environment around them [2, 3]. To support their employees, companies need to provide learning environments which foster autonomous, competency-oriented learning. Learning factories offer great potential to combine both of these aspects [4, 5]. A learning factory is an innovative learning environment to teach practical competencies and focus on the application of knowledge across all engineering disciplines. Currently, learning factories have primarily found their way into engineering education in higher education systems. As well as organizations, higher education systems have to prepare their students for the job market by offering teaching concepts that lead to a systematic and tailored development of individual competencies. This responsibility can best be fulfilled by applying competency models to higher education [6] and derive adequate didactic concepts. The aim of this paper is to introduce a specific competency model used at the Technische Universität Braunschweig to illustrate the methodological approach and the potential and opportunities the use of a competency model has for higher education.

1.1. Competency models in higher education

Competencies can be defined as the sum of all knowledge, abilities, skills and proficiencies a person can apply when faced with a new or unexpected situation [7]. They are situation-dependent behaviors which are visual in action and social contexts and are therefore observable [7]. Most important, competencies are modifiable and can actively be fostered using new and complex tasks, e.g. within a didactic concept in higher education systems [c.f. 8, 9]. In everyday (work) life competencies are needed to autonomously find solutions in unprecedented situations. Job-related competencies can be subdivided into four main categories: professional competencies (e.g. knowledge about processes), methodological competencies (e.g. techniques to structure yourself), social competencies (e.g. socially appropriate behavior in interactions) and personal competencies (e.g. strategies to handle yourself, e.g. self-reflection) [8]. In organizations, competency models are well-established for goal-oriented personnel development [10]. Competency models are constructed for specific positions within an organization to develop employees accordingly [11]. Typically, a competency model includes a finite number of competencies organized under the four above mentioned main categories. Actions in personnel development (e.g. trainings) can be designed based on the competencies identified in the competency model [12]. In line with the use in organizations, competency models can be applied to higher education. They can serve as a basis for the adequate design of didactic concepts, document the status quo and may be used to assess the individual's as well as the group's development over time [13]. Furthermore, the adequacy of didactic concepts used to develop the defined competencies can be evaluated (cf. [12]).

1.2. Competency management in learning factories

As already mentioned, the learning factory offers an innovative learning environment for systematic competency development in engineering education. Within this learning environment, lecturers can focus on the application of previously acquired theoretical knowledge to teach practical competencies. A learning factory can be designed for various practical contexts (see www.DieLernfabrik.de). At the Technische Universität Braunschweig, the learning factory focuses on energy and resource efficient manufacturing. The model-scaled system makes it possible to replicate system dynamic effects of the real-sized system without jeopardizing the learner (for example, by high forces or high voltages) [14]. The part of the learning factory used for the competency model in this paper is the "experience-lab" - a physically scaled model of a real factory process chain, realized by so-called modular production systems (for