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Systematic learning factory improvement based on maturity level assessment

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Abstract

Continuous improvement is a fundamental way of keeping systems competitive. This is especially true for complex systems such as learning factories, taking into account for example underlying production theories and didactical concepts. Maturity models offer the opportunity to classify an object regarding its maturity level and to identify improvement potentials. Based on current research results, the structure and content for a maturity model assessing learning factories was developed and introduced. The model combines the design dimensions and elements of the learning factory morphology with structural elements of the European Foundation for Quality Management Model (EFQM model). The resulting maturity model is presented in this article. Furthermore, the results of its application are presented. Finally, the conclusions for model revisions will be discussed.

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Keywords: model development; evaluation; validation; EFQM; CMMI

1. Maturity assessment to identify improvement potentials

Maturity models have spread among various fields of application since the introduction of the Capability Maturity Model [1,2]. They are used to assess the development status of an object and derive improvement potentials. Maturity models cover the identification of a current state and the description of development paths from a low level of maturity to a level of full maturity [1]. The use of a maturity model emphasizes the high importance of continuous improvement for organizational design in its field of application [2].

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Learning factories as organizations are also facing the need of continuous improvement, driven by requirements of their stakeholders, new findings from research as well as social and economic challenges [3]. Based on this prerequisite, a maturity model for learning factories was introduced [4], taking into account the well-established design approaches for learning factories, e.g. [5–8]. The following article details an already introduced maturity model [4] regarding development process, structure and content. Furthermore, it describes an evaluation and validation concept.

2. Development of the maturity model for learning factories

For the development of new maturity models, researchers emphasize various steps. For the maturity model of learning factories, the approaches of De Bruin et al. (2005) [9], Knackstedt et al. (2009) [10], Mettler (2009) [11] and Röglinger & Pöppelbuß (2011) [2] as the most common ones are combined. The single process steps are depicted in Fig. 1. The approach covers different feedback loops. Iterations are made especially during the development steps (structure and content) [10] and from the evaluation back to the development steps [10,11].

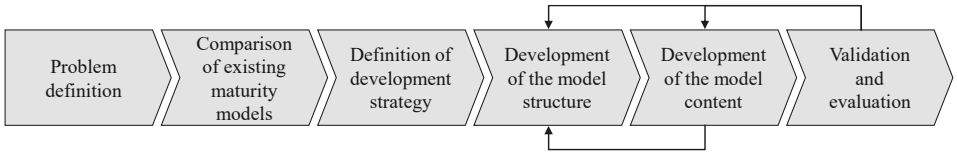

Fig. 1. Approach for the development of the maturity model based on [2,9–11].

The steps *problem definition*, *comparison of existing maturity models* and *definition of development strategy* are already explained in Enke et al. (2016) [4]. The article also addresses parts of the step *development of the model structure*. Nevertheless, the last three steps will be described at this point. The step *development of the model structure* includes the design of the general model architecture [9], the determination and description of maturity levels and the maturation concept [2] as well as the definition of the granularity level regarding maturation [2,10]. De Bruin et al. (2005) call the next step "populate" to describe the d*evelopment of the model content*. This covers the determination of criteria for each maturity and granularity level [2], detailed description of maturity elements [9] and the description of improvement measures [2,9]. Finally, *validation and evaluation* imply the conception of transfer and evaluation [10,11], the validation of the model [11], the execution of the evaluation [9–11] as well as the adjustment of the model structure and content [10,11]. Regarding the last step, Mettler (2009) strongly connects this one to the ongoing application of a maturity model [11]. Furthermore, Röglinger & Pöppelbuß (2011) emphasize a simultaneous documentation of the development process [2], which is continued with this publication.

3. Structure and content of the maturity model

As shown in Enke et al. (2017) the maturity model for learning factories combines different development strategies [4]. Various models are used, and their content and/or structure is transferred to develop a new model. The two main models, which were identified in [4] as the most promising one for a combination in the phase *Comparison of existing maturity models*, are the Capability Maturity Model Integration (CMMI) [12] and the European Foundation for Quality Management (EFQM) model [13]. The CMMI is mainly used to design the structure, the EFQM model to populate the model. Nevertheless, each model provides elements for both purposes.

The CMMI offers two different ways for the measurement and improvement of processes: A representation of one maturity level for the organization at one time and a representation of capability levels for different areas within the organization (different capability levels for different areas at one time). The maturity level is calculated based on the capability levels of the different areas and provides a good overview over the maturation of the whole organization. Thus, it is possible to translate the achieved or measured capability levels in a maturity level and thereby understand how the improvement in individual areas affects the overall maturity of an organization. Each area is rated by its own capability level. This enables an organization to make a much more detailed, more individualized assessment than possible with only the representation of maturity level. Furthermore, it provides a possibility to prepare and compare actual and target profiles. The actual profile is a list that shows the achieved capability levels for the individual areas. Overlaid with the aimed capability levels as part of a development process makes it very easy to visualize problem