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Integrated and Modular Didactic and Methodological Concept for a Learning Factory

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Abstract

As today manufacturing is not only subject to a single factory, but a network of globally distributed production sites, the goal-oriented encouragement of professional capacities is the motivation for the Learning Factory on Global Production (LGP). In this context, the design of a competency-based and action-oriented didactic and methodological concept is a prerequisite for sustainable learning results and for the development of self-determined problem solving skills. The presented paper gives an overview to the didactic and methodological design approach of the LGP. The integrated modular concept of e-learning and application in the learning factory environment supports self-directed learning and implemented by structuring the teaching/ learning process according to the model of complete action.

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1. Introduction

Global manufacturing companies are facing increasing competition, the shortening of product life cycles, the increasing number of product variants and the challenges resulting from the development of information technologies. In order to adapt quickly to this fast changing environment, companies need employees which are able to cope with unknown situations and complex problems independently. In this respect, profound technical knowledge alone is not sufficient. The promotion of capacity to act in a professional context is a major measure to ensure competitiveness [1].

Besides that, there is a paradigm change in higher education arising from the Bologna process promoting practical and learner-centered concepts.

Resulting from the interaction of those two trends in global manufacturing and education, the qualification concept of learning factories emerged at a large variety of universities and professional training centers.

2. Learning factories and didactics

Though existing learning factories cover a large variety of engineering-related topics, the issues of global production have not been addressed in any existing learning factory [2]. Despite of different thematic emphases, competence development constitutes a common objective. Tisch et al. [1] perceived a lack in target orientation and missing competence operationalization to be a crucial problem in learning factory design. Hence, effective competence development in learning factories requires a comprehensive didactic methodological concept.

Constructivism and its understanding of learning as an act which cannot be determined but only encouraged and stimulated emerged in the 1990s. Since then learner-centered and action-oriented concepts gained more and more importance [3]. In addition to that, there was a paradigm change in higher education arising from the Bologna process. There is a shift from the content-oriented design of lectures and courses to the strong focus on the learner and the learning process itself [4]. The action-oriented design of teaching/ learning processes tends to have positive effects such as improved transfer and

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retention compared to traditional ex-cathedra teaching methods [5]. Furthermore, one assumes action-oriented teaching/ learning processes to increase learning motivation and foster competence development [6, 7].

For these reasons, teaching/ learning processes in learning factories are preferably designed in a competency-based and action-oriented manner.

2.1. Definition of teaching/ learning objectives in learning factories

Being based on action-oriented principles and mostly aiming at the fostering of capacity to act in a certain professional context, learning factories allow teaching and learning in close-to-reality industrial settings [8]. The promotion of competences in a certain field of engineering is the key objective of many learning factories intending to empower (future) employees to cope better with unknown situations [9].

The common understanding of competence is defined as human disposition to employ, evaluate, extend and connect existing knowledge in order to perform actions independently [10, 11, 12]. In learning factories the concept of competence is interpreted in heterogeneous ways. Wagner et al. distinguishes competence into the four different facets of professional, methodological, social and self-competence [12], whereas Tisch et al. [13] categorize technical and methodological competence, social and communication competence, personal competence and activity and implementation oriented competence. For this reason, a definition of competence categories or facets is required prior to the definition of teaching/ learning objectives. Wagner et al. [12] and Brall [14] define four competence facets:

- Professional competence comprises task-specific knowledge and professional skills such as expertise in a given area, the ability to classify and evaluate expertise as well as the ability to recognize connections.
- Methodological competence comprises (partially independent from a certain professional field) applicable skills to structure and fractionize problems and to find decisions a goal-oriented manner. This also includes the transfer of known procedures and strategies to different contexts.
- Social competence includes the ability for social interaction as well as to act cooperatively in these situations.
- Self-competence includes the ability of self-assessment (reflection), the ability to develop one's own personality as well as personal, motivational and emotional aspects.

According to the model of occupational competence, the development of capacity to act in a professional context is only to be achieved by developing the corresponding competence facets equally [14]. Consequently, all competence facets need to be included as equally as possible into the concept.

2.2. Concept development

In order to achieve previously defined key objectives, the development of a coherent didactic and methodological concept is necessary. Describing relevant features and characteristics, morphologies allow only a first overview of possible design elements also regarding didactics and methodology [9, 15].

The lack of a systematic design approach for the development of learning factories is resolved by Tisch et al. [16] presenting the Learning-Factory-Curriculum-Guide (LFC-Guide), a structured design approach on three design levels. The first didactic transformation aims at developing teaching/ learning objectives formulated as intended competencies from organizational framework conditions. The second didactic transformation aims at designing teaching/ learning processes and the socio-technical learning factory environment supporting the previously defined teaching/ learning objectives.

According to the concept of constructive alignment, sustainable learning success depends on the coordination of teaching/ learning objectives, the teaching/ learning process and assessment [17]. Therefore, if used for intra-curricular training of students, learning factory concepts also need to include the design of assessment approaches.

2.3. Learning Factory on Global Production

At the Institute of Production Science (wbk), the Learning Factory on Global Production (LGP) was launched as an innovative training platform for students and professionals addressing the challenges in global manufacturing. A production network of three globally distributed production sides manufacturing a DC motor with gearbox was chosen as teaching/ learning scenario. Due to their relevance in global production, six topics were identified as modular teaching/ learning units of LGP (Fig. 1) [2].

LGP modules	Topics covered
Site Selection	• Location and process factors • Procedures for site assessment and selection
Location-specific Production	• Material flow planning • Production control
Quality Assurance in Global Production	• Location-specific quality assurance • Quality management in production networks
Sourcing	• Supplier evaluation and selection • Supplier development
Scalable Automation	• Changeability and cost-effectiveness evaluation of production systems • Human-robot collaboration and security technology
Production Network Planning	• Modelling, assessment and comparison of network configurations • Multi-criteria evaluation of production networks

Fig. 1 LGP modules

3. Didactic methodological concept of LGP

The promotion of capacity to act self-determined in a global production environment is the main purpose of the establishment of the LGP. This purpose is to be supported by