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Learning Factory 2.0 – Integrated view of Product Development and Production

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Abstract

Learning factories are the result of a didactical concept used in the engineering education at university. They are set into a realistic production area which is used to teach theoretical methods. Existing learning factories are mainly focusing on one subject. Interdisciplinary approaches integrating different points of view are rather rare. This paper introduces a new concept for an interdisciplinary learning factory that includes the areas of product development and production. This new learning factory is focuses on the improvement of the cooperation between these departments and imparts the theoretical concepts of simultaneous engineering and organisational learning. The learning factory was developed at the Faculty of Mechanical Engineering at Ruhr-Universität Bochum in a cooperation of the Chair for Product Development and the Chair of Production Systems. The new learning factory will be integrated in a superior concept for a student project over a longer time span, which is explained in the second part of this paper. Finally, this contribution describes a prospect on the future extension of the LPS Learning Factory to a learning company and the integration of the learning factory concept into two regional development projects.

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Keywords: Learning Factory; Interdisciplinary Approach; Simultaneous Engineering, Organisational Learning

Nomenclature

FMEA	Failure Mode and Effects Analysis
CoP	Communities of practice

1. Initial situation

In times of competitive and globalized markets, producing companies have to cope with challenging requirements. Products are becoming highly individualized and more sophisticated due to functionality which goes along with an increasing complexity of the product itself as well as the related development processes. Furthermore, the strong pressure for innovation is reflected within the product life cycles. Hence, sustainable business success is directly linked to the effective and efficient transformation of innovative ideas into marketable products. To meet the challenges regarding cost reduction, increased quality and a shortened time to market, research have been proposing the idea of simultaneous engineering for nearly 25 years [1]. Instead of isolated tayloristic separated workflows, product development is organized in temporally overlapping processes (see figure 1). Due to the fact that lifecycle spanning disciplines like production engineering or industrial services are already integrated in the early phases of the development, unnecessary and cost-intensive iterations are prevented. By means of the simultaneous engineering approach it is possible to defuse the so-called "dilemma of product development", which describes the opposing characteristics of the inducement and appearance of failures and costs during the product life cycle [2]. As illustrated in figure 1, the highest potential of influence already occurs during the phase of product planning. In

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contrast, the effects become obvious later on during the manufacturing process or the use phase of the product.

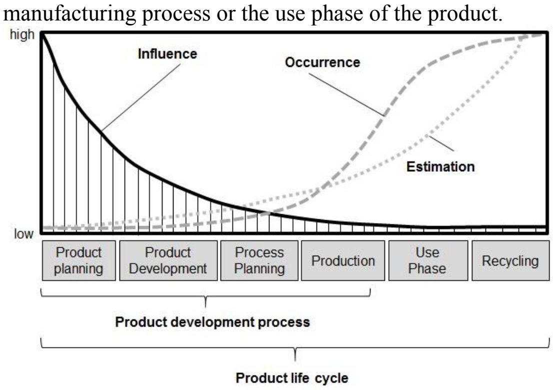

Fig. 1. The dilemma of product development [2]

However, in order to be prepared for the successful application of simultaneous engineering, a company has to lay numerous organisational, technological as well as personal foundations. While organisational and technological approaches (e.g. project teams or IT-support systems) have reached their limits by now, human factors like e.g. attitude, motivation, competences or creativity are increasingly moving to the fore [3]. Following Zink and Eigner, human factors are defined as factors that influence both the performance and the motivation of human beings within working systems and correspond to the following three levels:

- Organisation (Cooperation amongst business processes in terms of the identification and consideration of interests and requirements of diverse departments, strategic orientation, impact of the organisational culture and egoistic behavior of departments)
- Group (Cooperation- and information processes within interdisciplinary project teams, definition of interfaces among group members, motivation and ability to engage in a constructive dialogue with certain disciplines)
- Individual (relationship between the person and the working system due to organisational, technological, personal and economic boundary conditions)

On each of these three levels, different competences can be defined that are key factors to cope with the requirements of successful product development processes. Heyse and Erpenbeck propose a systematic collection of competences within four main categories that can be specified for the focused application [4].

- Personal competences (openness to change, authenticity, holistic thinking)
- Activity and operation competences (decision making capability, goal-oriented behavior, repartee)
- Social and communicative competences (conflict solving ability, problem solving ability, communication skills, integrability)
- Professional and methodological competences (project management, analytical skills, systematical proceeding)

In order to prepare individuals for the demands of the described professional work environments (companies where the product development process is key process within the value chain) higher education needs to focus on developing these competences. In the course of the propagated "shift from teaching to learning" and the associated definition of competence-oriented learning outcomes, student-centric and active learning methods in the context of product development processes are required [5]. Therefore, numerous universities have designed and implemented learning factories as a new active learning method. To support the systematic design process of learning factories, the European Initiative on Learning Factories has created a typology of existing approaches. Herein current learning factories can be mapped and analyzed [6]. Whereas most existing learning factories focus on the field of production (e.g. manufacturing or assembly processes), upstream development processes have remained almost unnoticed until now. This separation is reflected in the education of engineering students at universities. Both fields are taught separately and methods like "Simultaneous Engineering" are only taught theoretically in product development lessons while students specialising in the field of production learn methods for designing the manufacturing process.

Referring to the industrial demand, an integrated approach becomes mandatory that is able to simulate realistic industrial problems (e.g. simultaneous engineering) and thereby to develop students' competences in hands on trainigs. To close this gap, a new learning factory has been developed at Ruhr-Universität Bochum. In cooperation between the Chair for Product Development (LPE) and the Chair of Production Systems (LPS) of Ruhr-Universität Bochum (Germany), the existing concepts have been extended by an interdisciplinary approach aiming for a better cooperation between product development and production. Before the concept of this new learning factory is presented the next following section outlines the current state of the learning factory at the LPS.

2. Current state of apprenticeship

A „learning factory" is a didactical approach used in the education of engineering students at university and of industrial participants. A learning factory enlarges the regular teaching concept by lectures usually held by professors for a whole course combined with small group exercises with a practical learning experience. The students are offered the possibility to practice the previously theoretically learned methods in a real production area. This increases the understanding of the taught methods and the rate of recollection in contrast to the regular teaching concept. The production area consists of both real manufacturing machines and assembly workstations and represents the whole process chain of a gate-to-gate production process for a real product [7,8].

The learning factory at the LPS is not only used for education and research but also for make-to-order production. Before the LPS Learning Factory was implemented, the machines had already been used for manufacturing real customer orders. Thanks to this development the production area represents a particularly realistic image of a manufacturing environment with a heterogeneous machinery.