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Extending the scope of future learning factories by using synergies through an interconnection of sites and process chains

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Abstract

Learning factories serve as platforms to disseminate research findings into industrial practice and to educate prospective engineers in hands-on courses. The number of competences which can be taught in learning factories is related with the number of available processes and machines. A larger number of machines enables for example comparisons between similar processes, the operation of longer process chains and generally speaking a broader curriculum. However, due to financial or space restrictions the investment in machines is often limited. In order to overcome this issue, the collaboration between learning factories through interconnection of process chains is proposed in this paper. A systematic method, by which possible interlinkages can be found, is presented and a case study of the interlinkage of two learning factories in Bayreuth and Augsburg is given.

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Keywords: Resource efficiency; Learning Factory Networks; Collaboration; CFRP; Additive Manufacturing; Virtual Learning;

1. Introduction

Today's drivers in manufacturing are, amongst others, globalization, changes in demographics, shorter product cycles, greater number of product variants, resource efficiency ambitions and the penetration of internet of things technologies [1]. To cope with these challenges, the competency-level of employees plays a crucial role. In order to improve those competencies, several options for learning exist. Compared to learning through e.g. lectures, students in practical courses of learning factories can gain a greater degree of action substantiating knowledge [2].

Over the past decade several such learning factories have been established by universities, manufacturing companies as well as consulting companies [3]. At the same time, the cooperation between the learning factories was extended during this period. Apart from the annual Conference on Learning Factories, three collaboration networks shall be mentioned here: First, the Network of Innovative Learning Factories was founded in 2013. One of its main goals is to support the mobility of researchers and students to enable dialogues and find joint solutions to common questions. Second, the CIRP Collaborative Working Group on Learning Factories was founded in 2014 in order to "gather knowledge of the global state-of-the-art, and to generate input for further research programs and collaboration models." [4]. Third, the WGP Produktionsakademie was established in 2015 to offer and refine a comprehensive training catalogue for researches and industry customers.

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Those collaboration networks stimulated significant advances concerning the understanding of the term learning factory, the classification of learning factories and guiding methods for developing new concepts [5, 6]. Despite the active exchange between the operators of learning factories, none or very few of the process chains of the learning factories are interlinked according to the authors knowledge. However, such interlinkage might benefit the individual locations greatly, because usually learning factories have tight constraints concerning either the spatial expansion and/or the financial resources, which limit the number of different machines and processes. By connecting the process chains of two or more learning factories, process chains can be extended, similar technologies can be compared and new process steps such as quality controls or analysis tools can be inserted into an existing chain.

In this paper such linking possibilities and its advantages shall be described on a general level and several application examples are given for the potential interlinkage of the Green Factories Bavaria in Bayreuth and Augsburg.

2. Methodology

Learning factories have the goal to generate learning content that is of high relevance for industry practitioners and students. For that purpose a learning environment needs to be set up which is as close to reality as possible, while balancing specificity and generalizability. Therefore today's learning factories outline their learning content along a specific process chain.

However, these environments increasingly strive to meet the changing requirements of their training participants as well as to address new target groups. Consequently, flexibility and adaptability have already become key success factors for existing learning factories. Hence the question arises: How can existing learning factories identify new possibilities to expand and adapt the scope of their existing learning content?

For that purpose, this chapter proposes a concept how to identify and use possible synergies between different learning factory sites. The procedure consists of the five steps abstraction, identification, evaluation, design and implementation (see Fig. 2).

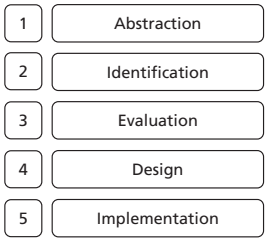

Fig. 2 Procedure model

2.1. Abstraction of learning factory environments

In Fig. 1 a systems analysis approach is chosen in order to abstract factory environments and processes. As a result, the subcategories in learning factories for industrial engineering with a special focus on resource efficiency (LF 1 to LF n) can be identified and generalized. Beside specific process steps (P1.1 to P1.n), cross-sectional technologies (e.g. intralogistics, quality control, analysis tools etc.), auxiliary processes (e.g. compressed air, conditioning of cooling lubricants etc.) and technical building services have been identified. Systems analysis is also useful on the process step level in order to identify flows of energy, material and auxiliaries. Following the procedure model proposed in **Fehler! Verweisquelle konnte nicht gefunden werden.**, abstraction is followed by the identification of possible synergies between existing learning factory environments. For that purpose, four specific options have been identified and are described in more detail in section 2.2. In a consecutive step the visibility of the identified interconnections and synergies is evaluated. This can be done

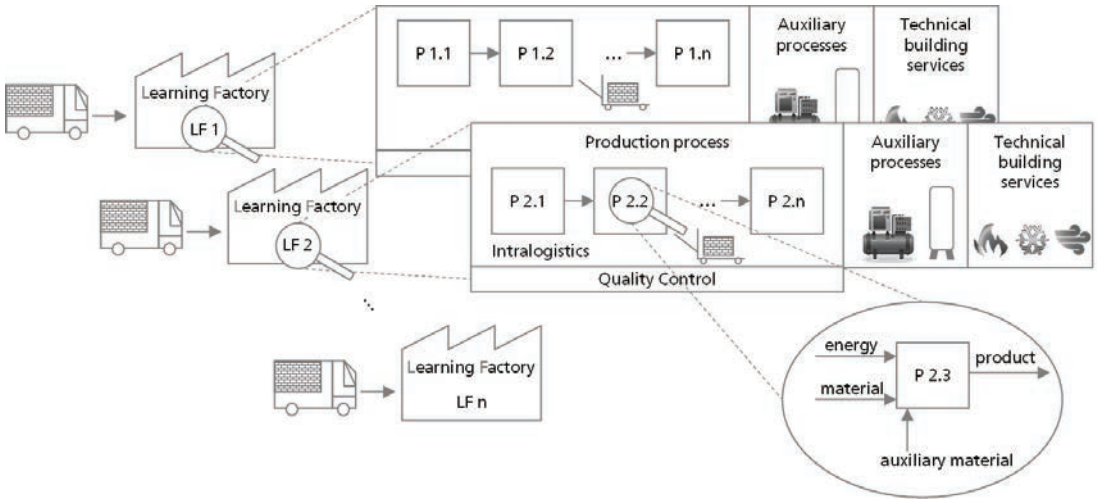

Fig. 1 Abstraction of learning factory environments