Development of a learning factory concept to train participants regarding digital and human centered decision support

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Abstract

Cyber-physical systems lead to an emerging quantity and quality of data that can be collected and processed within the whole production process. [1] This data helps to rationalize and optimize the production planning as well as the operative level. In order to handle this amount of complex information, digital support systems are required. Besides assistant systems, crosslinking of data and machines within a company is one of the central aspects of Industrie 4.0. In a round based training concept the connection between manufacturing execution systems and assistant systems will be explained. Furthermore the changes of work caused by decision support systems as well as the functionalities of assistance systems will be included in the new training concept. Assistant systems can be divided into cognitive and physical assistance. [2] In this article we focus on cognitive assistance. It has perceiving functions and the decision support function because there will be an increasing incidence in the future due to a higher amount of data. To support this theory research results from the project SOPHIE regarding digital and human centered decision support systems will be used. [3] Beside the effects of networking in a company for the employees of production and assembly on the shopfloor the new concept also tries to show the changes on the dispositive level and for employees in the middle management and decision makers.

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1. Introduction

Customers’ requirements are one of the most important topics within a company. One way to satisfy them is a high changeability of the manufacturing systems. With such manufacturing systems customer-specific product solutions can be offered. One way to get to these solutions is to change the education in the engineering and production systems. With such manufacturing systems customer-specific product solutions can be offered. One way to get to these solutions is to change the education in the engineering and production environment as well. This idea is supported by recent studies that say that new teaching curricula are required to enable employees to face new challenges of the industry. [4] Learning factories offer a great surrounding to enable a hands-on learning environment where participants have the space for developing new ideas and concepts [5]. Since the term of learning factories was evolved in the early 1990s, the amount of learning factories world-wide is increasing rapidly. [6]

In 2016 the Chair of Production Systems (LPS) at the Ruhr-Universität Bochum published a roadmap for their learning factory (Fig. 1). The aim was to integrate different researches of the LPS into learning factory trainings. Projects like Adaption, Appsist, DigiLernPro and Sophie should cover topics like maturation models of Industrie 4.0 of a company, assistant and learning systems as well as manufacturing control in companies. [7] At the last Conference of Learning Factories in Darmstadt, the first concept of the expansion of the LPS learning factory was published. [8]

In this case, the assistant system “Appsist” was used in our trainings within the project “Work and Innovation: Strengthening skills, shaping future.” Based on three rounds the participants utilize several variations of the assistant system to experience different stages of assistance while changes on shopfloor-level and their connected processes are focused here. [8]

Often, the industrial participants (works councils, personnel managers) mentioned a lack of knowledge about changes due to the current technological developments in their companies. These concerns have been detected in the production as well as on management level. Though the effects on the management level as well as on the shopfloor-level will be focused in this paper. Moreover there will be a concept of a new created learning factory training at the end. The concept is based on findings from the research project SOPHIE. In this project a human centered multi-agent-system for production planning and control is developed. [3] The developed infrastructure will be used to collect data in round 3 of the new concept.

In chapter 2 there will be a short summary of the current training concept with the assistance system and the addition of the new concept with digital and human-centered decision support. The third chapter will focus three important questions: the target group, timeframe and learning goals of the new concept. In the last chapter there will be a summary and an outlook for the next training concepts that will be implemented in the LPS learning factory.

![Fig. 1. Industrie 4.0 Roadmap of the LPS learning factory [9].](image)
2. Training concept

2.1. Current training concept and potential expansions

One of the current trainings in the learning factory is based on three rounds of a “rigid”, “adaptive” and “networked” assistance system. These three evaluation cycles enable the participants to reflect technological and organizational changes. The current concept focuses on the changes on the shopfloor because the participants are guided through an assembly and maintenance process step by step as an assembly worker or maintainer. [8]

The new training concept with decision support expands the view on the employees of the middle management and decision making level. The new concept consists of three rounds as well to show a similar training structure to the assistance system training. A more detailed structure is shown in Fig. 2.

In a possible training the participants could get the role of a production planner. Their task is to calculate the time of completion of all orders in a production process in the learning factory. Fig. 3 shows the expected changes of the time for each round for data acquisition or calculation or the expected error-proneness of the process.

Round 1 – “rigid” production planning
In the first round the participants have to calculate the time of completion of a production process completely manual. They will use normal lean methods in form of value stream to calculate the production cycle for one product in the learning factory. Here the data acquisition and calculation of the estimated production time is manual. The result of this technique has a very great effort and a non-valid database so that the information value of the planning is low. Failures in the production which can occur cannot be handled very fast.

Round 2 – “simplified” production planning
The methods in the second round change a bit from a manual tool to a supporting tool in Excel. The acquisition of data is still manual but the evaluation is semi-automated. This still has a big effort for the participants but less than in round 1, since planning data like e.g. cycles times are calculated with a program. Again the problem in this round is a non-valid database for the production planning. Still failures cannot be handled immediately since the participants do not have real-time capable data so that the information value of the planning is again relative low.

Round 3 – “interlinked” production planning
The last round is the one where the participants get to know a tool to do interlinked production planning. It includes a digital and human-centered decision support system. As mentioned before the multi-aged-system infrastructure from the project SOPHIE is used to collect the data of the production process. A digital image of all information is created in a visualization of the shopfloor. The data doesn’t have to be collected manually which saves a lot of effort. With real-time capable data the database is also very valid so that the participants have a very good information value of the production planning. Fig. 3 shows that the expected time for data acquisition and calculation in round 3 is
extraordinarily small compared to the other rounds. This high amount of saved time is one of the significances of the development training.

In another exercise the participants in the position of the middle management have to do a shopfloor meeting on a shopfloor board with employees from the production (i.e. other group members). Content of the meeting is a summary of the production status and occurred problems in form of machine failures or production problems and possible solutions. The shopfloor visualization uses data from a tracking and tracing system in the assembly line and the production machines. With this data it is possible to detect problems in the value stream and show the production process in real-time. Inventory, inefficient processes and other information can be analyzed.

A short overview about all three rounds is shown in Fig. 4.

![Fig. 3. Development of time and error-proneness in the three rounds.](image)

![Fig. 4. New training concept.](image)

### 3. Target group, timeframe, learning targets

The target group of many learning factories is limited to students, employees (for example managers) or entrepreneurs. [10] The targeted audiences are various. Depending on the participants' professional background, the focus can be made on the middle management as well as on the shopfloor-level employees. Since the learning factory concept for assistance systems that was created within the project “Arbeit und Innovation” (“work and innovation”) is designed for heterogeneous groups consisting of workers’ representatives as well as representatives of the

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**Fig. 3. Development of time and error-proneness in the three rounds.**

**Fig. 4. New training concept.**
management, our experience shows that a learning factory concept must not be designed exclusively. The projects “Arbeit und Innovation” (“work and innovation”) follow the idea that technological, organizational or social innovations are necessarily embedded into a holistic view of the production processes. Successful innovation processes are a result of a negotiation process between the social partners within a company.

As described in chapter two, the new concept is structured similar to the current concept for assistance systems, which is successfully tested and implemented in Bochum: based on three rounds and combined with an evaluation cycle following each round. The concepts has a duration of 2.5 days. Each round (the practical part, without reflection) takes more or less 1 hour. Thanks to the similar structure and following the idea of a continuous improvement (“rigid” – “adaptive” – “networked” and “rigid” – “simplified” – “interlinked”) both concepts can be easily combined. One option could be to spare the group of participants into a “shopfloor-team” and a “planning-team”. While the “shopfloor-team” follows the tasks of the assistant system concept [2], experiencing the impact of the changes on the shopfloor level, the “planning-team” would follow the tasks as described in chapter 2 focusing on the impact on the dispositive and middle management level. This combination of both concepts simultaneously, underlines the holistic impact on Industry 4.0 on different levels and contributes to a better mutual understanding across departmental and hierarchical boundaries.

Digital decision support systems affect several areas within a company. So there are several possible learning targets that can be identified and focused on. Possible learning goals could be for example:

- benefits of decision support systems
  - economically
  - ergonomically
- possible challenges of implementation (e.g. data quality issues)
- impact on employees (shopfloor and/or middle management)
  - chances
  - risks
- impact on organization of work
  - communication and cooperation
  - hierarchical structure
  - division of labor
- data security and data protection

Digital decision support systems aim to rationalize and objectify decisions concerning the production planning. The general benefits that these systems offer are efficiency improvements, high capacity utilizations, reduction of the lead time, higher changeability and flexibility etc. The participants should get an overview over the central benefits these kind of decision support systems can offer. The degree of detail concerning the technical or economical aspects can be adjusted regarding the participants’ backgrounds. Other important learning goals are linked to the possible impact on the working conditions. As findings from the SOPHIE project show, the tasks and functions e.g. of employees of the middle management might be substituted or changed by using decision support systems. [11] Other impacts of the transparency these kind of systems offer are closely connected to questions about employees` data protection and risks of performance and behavior control. The general learning goal is, that the participants should realize that technological systems, such as digital decision support systems, aren’t neither good nor bad, but they are a result of a negotiation process between the social partners within a company.

The implementation of every technology has to provide a benefit for the company and its employees, otherwise a system won’t be installed. Participants should see improvements by using a decision support system in many regards. They will recognize improvements in the accuracy of decisions and predictions in the production which impacts a higher efficiency in production.
4. Conclusion and outlook

This paper describes a new training concept for decision support systems. This concept will be tested at the beginning of 2018 in an upcoming next training. The results from this training will be evaluated to improve the training to be a fixed component in the trainings of the project “Work and innovation”. Since there will be about 200 participants until the beginning of 2019 the expected evaluation will be very meaningful. Expected results can be a changing area of responsibility for the middle management and decision makers. One of the consequences of using decision support systems can be a minor scope for the employees in their daily work but with more precise predictions in less time than today.

Also the aim to integrate all Industrie 4.0 projects from the LPS into the learning factory is almost reached since another publication for an audit training concept and the project Adaption is already planned. The next tasks will be the integration of DigiLernPro a learning/assistance system and Adaption which contains a capability maturity model of Industrie 4.0 of a company.

As shown in this paper learning factory trainings still have a potential to evolve into new research fields. The aim of the project “Work and innovation” is to integrate all LPS research topics regarding Industrie 4.0 to face as many changes in technology, organization and personal as possible within a company caused by increasing digitalization.

References