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Learning Factory for Changeability

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***Abstract*—**Amongst the consistently fluctuating conditions prevailing today, changeability represents a strategic key factor for a manufacturing company to achieve success on the international markets. In order to cope with turbulences and the increasing level of incalculability, not only the flexible design of production systems but in particular the employee as enabler of change provide the focus here. It is important to enable employees from manufacturing companies to participate actively in change events and in change decisions. To this end, the learning factory has been created, which is intended to serve the development of change-promoting competences and the sensitization of employees for the necessity of changes.
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***Keywords*—**Changeability, human resources, learning factory.

I. Introduction

TURBULENT markets caused by globalization, the quest for competitive advantages and increasing product customization, are the reason for the uncertain requirements systems which are set up today. To meet the unknown market demands over whole production life cycle, flexibility is no longer sufficient, since it only allows changes within the production system to a limited degree [1]. The design of a changeable manufacturing system is needed to master upcoming requirements without avoiding unnecessary investments and delays in the daily workflow. As a consequence, changeability should be specifically adapted to each particular business situation and should be demanded, developed, and implemented on all levels of a production company [2]. During the implementation of changeable structures, frequent problems are experienced for a number of reasons which lead to delays or even to failure of a project [3]. In particular the employees play a major role in the smooth implementation of change measures through their readiness to implement changes. This is because turbulences not only affect the products and their design, but also the manufacturing processes used within the company and, not least, the people working at the company.

A realization of changeable processes in Production is simply not possible unless all employees participate. In particular the readiness to perform and the potential of the employees in realising changeable concepts within the company and instrumenting them successfully are required [4]. The targeted preparation of employees for pending change situations is therefore of major importance for the successful implementation of changeable systems.

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Here the role of management personnel, in particular the shopfloor managers, is of the greatest importance. Their task is to soothe employee fears about changes and to prepare them for dealing with the changes in a targeted manner. Yet management personnel, too, have to adapt to the new conditions and learn how to cope with change situations. For this reason, training of these employees is not only beneficial, but in fact almost essential in order to avoid the failure of planned change processes.

There are a great number of approaches and methods which serve the promotion of changeability; yet these are mainly focussed on technical areas. Humans, with their individual capabilities and competences, remain largely unconsidered [5].

However, available solutions for the development of employee competences have up to now not been orientated towards changeability in terms of all design fields and the possible change drivers. For this reason there is a lack of any suitable methods for the qualification of employees, their flexible deployment within the company or the motivation of employees to participate actively in the company change processes [6]. At this point, approaches must be created in order to prepare organizations and employees for necessary changes.

II. Basic Principles

A. Flexibility and Changeability

As a consequence of the challenges manufacturing companies are facing nowadays, internal and external influences have an effect on a company's requirements on its production system and its system elements. These effects are defined as internal and external change drivers. Influences that affect a company are to be found in the areas of competition, technology, customer and market requirements, general legal frameworks, suppliers and staff, etc. In order to tackle these change drivers, companies need to make their production systems flexible and changeable. Flexibility helps a company to adjust its production system to changing influencing factors to a limited extent, but quickly and with very low financial input [1]. The flexibility of a given system is described by the so-called flexibility corridors. There is a flexibility corridor for each of the possible change dimensions (quantity, quality, time, product, cost structure) (see Figure 1). Changes may be absorbed within these corridors to a certain extent. This has to be determined in advance. However, maintaining or rather creating flexibility mostly ties up resources and requires increased investment. Ideally, investments ought to be made only if needed since in most cases the extent and direction of an upcoming change are unknown beforehand. Based on existing approaches to the definition of changeability [e.g. 7, 8, 9, 10], Nyhuis defines the systemic changeability in the production system as follows: "Changeability as a system characteristic describes the potential to be able to carry out technical, organizational, human and logistical changes outside the maintained flexibility corridors of a production system in a short time, with low investments and considering the interaction of the system elements in case of need. A changeable production system can be adapted in the various dimensions of change, such as quantity, quality, time, product and cost structure [11]. Identifying the right balance between flexibility and changeability is crucial [12]. If the flexibility corridor no longer complies with the change drivers in one or several dimensions, a company may use the existing change corridor to deal with changed requirements if necessary.

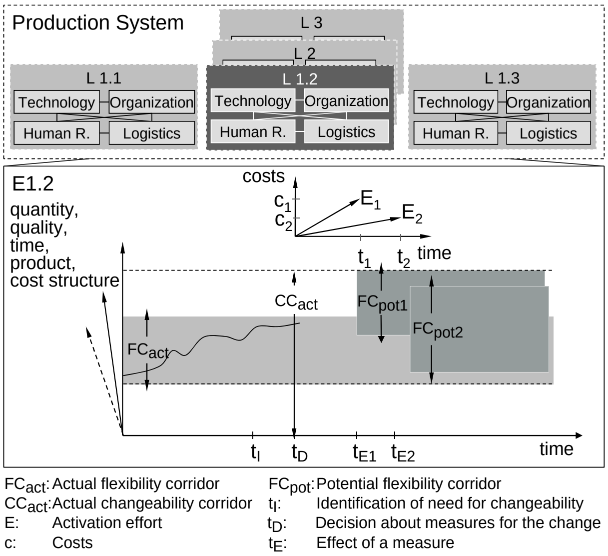

Fig. 1 Systemic changeability in the production system [11]

A change corridor is described by the existing and the potential flexibility corridors (see Figure 1). The recognition of a possible change requirement at a point in time t_I will consequently lead to a decision about the change measures to be determined (time t_D). Both the size of the change corridors and the input needed to install a potential flexibility corridor are decisive for the changeability of a production system. This effort, determined as the activation effort E, is composed of the costs incurred as a result of shifting the flexibility corridor and the time that elapses until a new flexibility corridor is ready for use (time t_E). Different flexibility corridors can be established by selecting the measures. Accordingly, this results in different activation efforts because both the costs and the time required for the implementation of certain measures vary. In summary, the changeability is determined by the size of the change corridor available and the activation effort: the larger the change corridor and the lower the activation effort, the higher the changeability available. Figure 1 focuses on the changeability of a single system element. Since the maximum changeability of the entire production system is always determined by the changeability of the weakest partial link, a systemic approach to changeability is crucial, in addition to the aspects described. Only the adjustment of flexibility and changeability in the entire production system, i.e. also across the various factories and locations of a company network can design the production system in a changeable way. This means that all system elements on all levels, and also their interactions, have to be considered [13]. In this process, the areas of influence technology, logistics organization and human resources are examined for each element. The multi-level control loop of changeability has been developed in the project in order to support the goal-oriented design of changeability [11].

B. Control Loop of Changeability

To be able to make use of the available changeability in the production system, constant searches must be carried out for possible change drivers within a company and the business environment. From this it is possible to derive a need for change, to which the company must react. In this case, the multi-layer control loop provides a kind of instruction so that a decision can be made on the measures required.

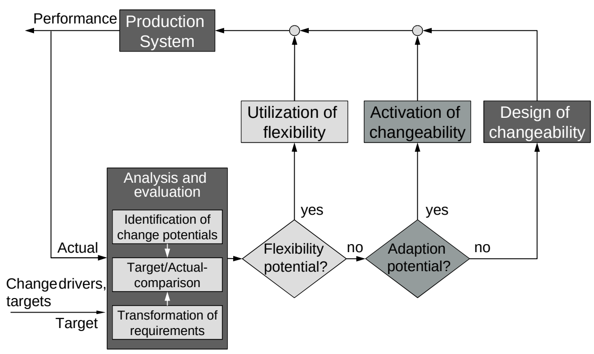

Fig. 2 Control loop of changeability [11]

The control loop (see Figure 2) has been developed by the IFA. The control loop comprises two different fields – the analysis and evaluation tool and the control path. The function of the analysis and evaluation tool is initially to identify possible change drivers, and to define the resulting requirements on the production system. Depending on the target/actual deviations and the available change drivers, various measures will be required for adaptation. Chronological checks are made as to whether the available system flexibility or the inherent changeability are sufficient for dealing with the need for change. If the available change corridor proves insufficient, investments must be made to generate new changeability [11].

C. Evaluation of Systemic Changeability

For the evaluation of systemic changeability, a practice-orientated and holistic method is required which allows the identification of the overall change requirements of a system so that they can be aligned with the existing potentials [17-23]. The following methodology permits an assessment of changeability resulting from the assessment of the change corridor and the activation effort required. A six-stage assessment method makes it possible to make a statement on whether the flexibility potential of the production system can be utilised; whether the inherent changeability can be activated, or whether new changeability has to be designed in the system.

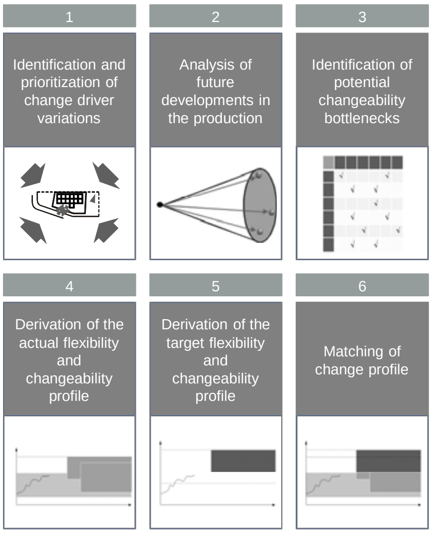

Fig. 3 Procedure for changeability evaluation [16]

The aim of the first step in the assessment system is the identification of the change drivers who will have an effect on the production system under consideration both now and in the future. These change drivers serve to derive needs for change in the relevant dimensions of change in the production system.

The possible future changes produced by the change driver are analysed in the second step. Here the various change dimensions (quantity, quality, time, products and cost structure) as well as time horizons (short, medium and long-term) are considered.

The determination of potential change bottlenecks is contained in the third step. All design modules within the production system are here inspected for compatibility with future requirements in the relevant dimensions for the change.

In the next step, checks are carried out on which flexibility and change potentials are indicated by the system under consideration in the relevant dimensions at the time of the assessment. In particular potential change bottlenecks, but also related design modules are subjected to a detailed inspection in order to detect available change potentials.

In order to meet the future requirements, the fifth step comprises a company-specific determination of the target status of the design modules under consideration with reference to their flexibility and changeability.

In the final step, the current status is aligned with the derived status (target status) of the production system via the determined profiles.

In this way, a necessity for action for the realization of a changeable production system can be derived from possible differences [16].

III. The Human as a Change Enabler

After having described the basic principles of changeability, the next chapter describes which competences are needed to enable shopfloor managers to develop a successful change process. The competences build the basis for didactical models which serve to enable the human for future change.

A. Competences for Changeability

Competence includes the skills, abilities, and knowledge of a person that enable him or her to engage in a professional activity, for instance [25]. Competences may be classified into competence facets. Typically, professional, methodological, personal, and social competences are mentioned [26-28]. Professional competence can be summarized as the knowledge of and the skill in the exercise of practices required for the successful completion of a job or task. Methodological competence describes abilities adaptable in a variety of situations, e.g. to structure problems or to make decisions. The personal competence describes the ability to assess oneself and to create conditions to develop oneself at work. Finally, social competence includes the ability to act in social interaction communicatively and cooperatively as well as to develop goals and plans together successfully [29, 30]. In the available literature, a multitude of competences are mentioned which enable an employee to make changes [31, 32]. Salazar has developed competence profiles for the different hierarchical levels within a company [33].

personal competence	social competence
reflectance design intent responsibility resilience	communication ability teamwork conflict and criticize ability
methodological competence	**professional competence**
ability to change anticipation ability organizational skills problem-solving ability	process optimization business processes change processes economical thinking

Fig. 4 Competences for changeability [33]

In Figure 4 an overview is shown indicating the respective competences which are of particular relevance to shopfloor managers. The aim is to develop these competences through suitable didactic models. The focus should lie on the development of the professional competence "change processes".

B. Developing Competences for Changeability

After it has been explained which competences are required by shopfloor managers to promote changeability, an evaluation is carried out as to which didactic models are particularly suitable for their development.

Often support for competence development is equated with traditional training or qualification measures. This is only partly true; although these measures are essential elements, a complete process cycle is necessary in order to develop and promote competences. This process begins with the internalization of the need for improvement and the development of a corresponding concept. In the following, the employee passes through the stages of knowledge acquisition and its application and the development of appropriate skills to assess the competences acquired. A feedback loop, which enables reflection on the process of competence development, completes the cycle. A very successful approach to competence-based qualification may be learning factories. These are suitable for dealing with the activation of changeability, while increasing motivation at the same time [29]

However, existing learning factories do not yet focus sufficiently on these requirements. One main issue is that change drivers are largely ignored. None of the existing learning factories (e.g. aIE – IFF Stuttgart, Germany; CiP – PTW Darmstadt, Germany; IFA Production Training – IFA Hannover, Germany; Integrated, Scalable Concept of a Learning factory, Vienna, Austria) [29, 34] face increasing product variety, product change or increasing quality requirements.

IV. Approach to a Learning Factory for Changeability

The previous chapters reveal that learning factories are suitable for the preparation of employees for change situations. Accordingly, the IFA in cooperation with Festo Didactic is developing a new learning factory which aims to enable the human for changeability. The learning factory is based on a physical production system for charging units of cordless electric screwdrivers. The learning factory process is organized into production phases and evaluation phases, which are run through in consistent alternation (see Figure 5).

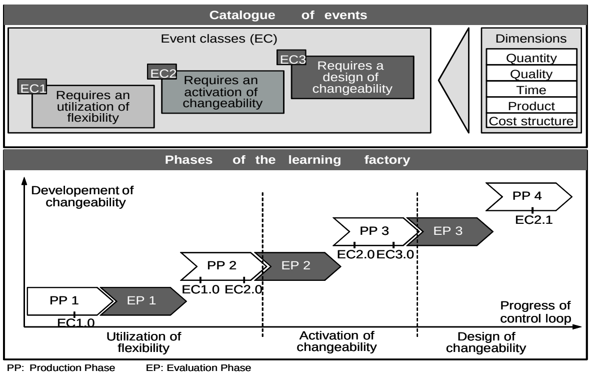

Fig. 5 Concept of a learning factory for changeability [14]

Within the production phases, participants have to face various change events e.g. unpredictable markets or increasing product customization. The events affecting the system are categorized in different event classes (EC) in analogy to the control loop of changeability: Events that allow the participants to utilize the flexibility of the system (EC1), events that exceed the flexibility of the system and require an activation of changeability (EC2) as well as events that exceed the system's changeability and require a design of changeability (EC3). Furthermore, for each event class there are events that affect the different dimensions of change, such as quantity, quality, time, product, and cost structure (see Figure 5). Due to these events, the participants that act as the employees of the production system have to work out solutions together in order to master the challenges and to reach certain production goals.

In the evaluation phases, problems and impressions obtained from the previous production phase are discussed by the participants, and possible approaches for improvement of the prevailing situation are mediated. Step by step, the participants are thus prepared for coping with change situations, with the aim of mastering them under their own responsibility and independently in the manner they think best. In addition, all phases are supported by a coach providing the participants with theoretical input [14].

A. Course of the Learning Factory

The playful handling of change events is carried out within four phases. Each phase consists of a production phase and an evaluation phase as mentioned previously (see Figure 5). During the course of the initial round, event E1 of the event class EC1 occurs, the accomplishment of which is guaranteed due to the flexibility available in the system. The participants have to react to the event instantly. The handling of the spontaneous event is unsystematic and therefore inefficient. In the subsequent evaluation phase, improvements are prepared based on problems arising in the first round. These allow the participants to handle events in event class EC1 more successfully. In production phase two, another event of class one (EC1.0), similar to the first one, appears. This allows the participants to adapt the operational improvement developed in the last evaluation phase and to handle the event more efficiently. Within the same production phase, a further event (EC2.0) occurs. The requirements generated by this event exceed the possibilities of the inherent system flexibility, and the use of changeability is required.

In the following evaluation phase, as a consequence, the participants question if the operational improvement is sufficient in order to handle future changes. As a consequence, the participants learn to implement a continuous change process as described in the following chapter. Selected change events that can be foreseen or derived from known change patterns and that do not exceed the system's changeability corridor can be handled in production phase three. In this production phase, two events tackle the system: One that allows the participants to activate the system's changeability (EC2.0) by using action guidelines, and another that goes beyond the system's changeability (EC3.0) and may even force production to come to a halt. Consequently, based on future change drivers, the participants have to design changeability in the following evaluation phase. Furthermore, they harmonize all different solution elements amongst each other for the areas of influence technology, logistics, organization, and human resources. Finally, the participants

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are able to handle a series of change events within production phase four using a new and expanded changeability corridor (EC2.1). Large figures and tables may span both columns [14].

B. Development of the Professional Competence Changeability Using the Continuous Change Process

Chapter one introduced a general methodology for the evaluation of changeability. This methodology builds the basis for the professional competence "change processes". Nevertheless it has been adapted for the learning factory in order to make it more suitable for the learning factory´s target group. Furthermore it has been extended by the design of changeability. Figure 6 shows the steps of the entire so-called continuous change process. These steps are divided into processes for the upper management and processes for the shop floor management. This division has been conducted since the shop floor management usually does not posses enough data for conducting all steps.

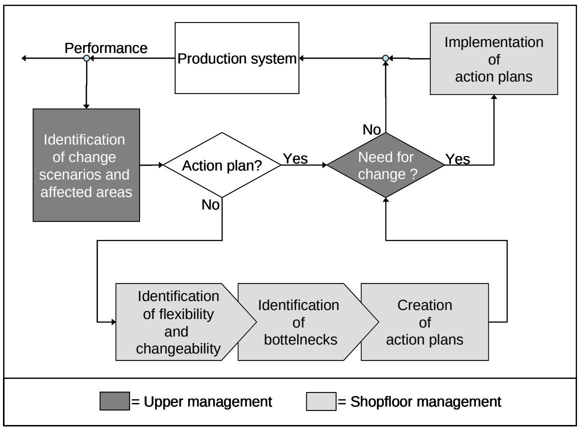

Fig. 6 Continuous change process

First of all, the upper management has to identify possible change scenarios and identify the affected production areas. In the course of the learning factory this information is given by the game leader, who acts as the upper management, to the participants. This information contains the dimension of changes as its value. In the next step the participants have to identify flexibility and changeability corridors. Therefore they have to elaborate the corridor figure for the appropriate production system, as can be seen in figure 7.

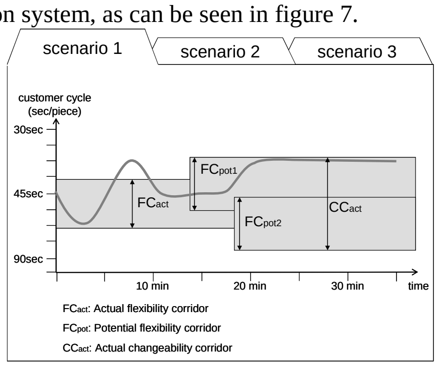

Fig. 7 Corridor figure

Based on the evaluation of the production system, the participants may identify change bottlenecks and elaborate action plans. The creation of action plans includes the identification of solutions for all areas of a production system, as can be seen in figure 8.

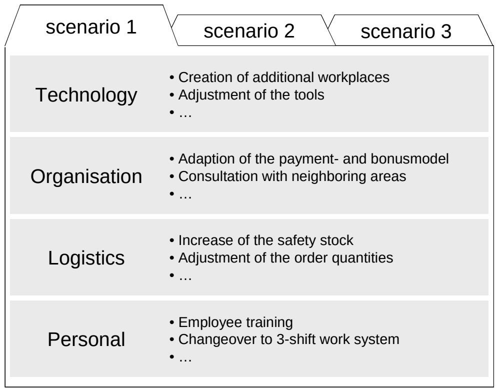

Fig. 8 Changeability action guideline

In the next step, a project plan has to be developed (see figure 9) based on the action guidelines for the appropriate scenario. The action guidelines as well as the project plans may be discussed in close cooperation with the upper management in order to warrant their feasibility and cost effectiveness.

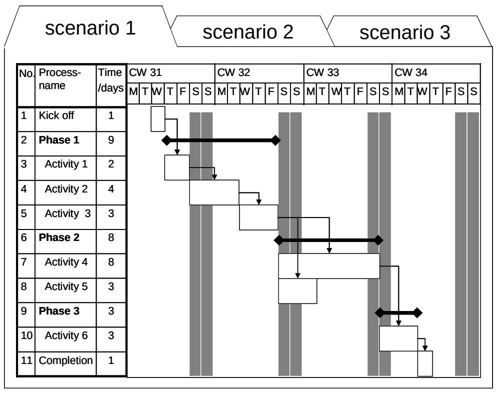

Fig. 9 Changeability project plan

As soon as the management has been notified that an appropriate change event will occur, they may trigger the shopfloor management to implement the according project plan.

V. Evaluation

The learning factory has been tested with industrial partners involved in the WaProTek project at the Institute of Production Systems and Logistics. The physical learning factory can be seen in figure 10.

Fig. 10 Learning factory for changeability

A survey conducted subsequently revealed that the following competences have been developed within the learning factory.

TABLE I
DEVELOPED COMPETENCES

Evaluation of competences	not observable	hardly observable	clearly observable	highly observable
methodological competence				
ability to change				x
anticipation ability		x		
organizational skills				x
problem-solving ability				x
personal competence				
reflectance		x		
design intent				x
willingness to assume responsibility			x	
resilience				x
professional competence				
process optimization			x	
business processes		x		
change processes			x	
economical thinking	x			
social competence				
communication ability				x
teamwork				x
conflict and criticize ability		x		

The results show that the learning factory helped to develop most of the claimed competences and thus may be one important component for companies to enable their employees for future change.

VI. CONCLUSION

Nowadays manufacturing companies have to cope with increasing turbulence in the markets. Individualization of customer demands, the decreasing predictability of sales volumes and any other factors mean that a high level of changeability is becoming a strategic key factor. The participation of the employees in change processes is highly relevant for a successful change. To confront change situations employees should be adequately prepared. Therefore changeability-beneficial competences and methods for handling change situations have to be promoted. One way of preparing employees for change is represented by a learning factory. The requirements for the development of a learning factory, which aims to prepare employees for change projects in their companies, are developed and presented in this paper. This learning factory focuses on the development of different events that generate a demand for change and require its hands-on completion for a production system in the various areas of influence: technology, logistics, organization and human resources. The participants learn to interact in change situations and to implement a continuous change process. In addition to the learned methods and procedures especially the changeability-beneficial competences are helpful at this point. Therefore these essential skills for dealing with change situations are approached and supported particularly as part of the learning factory as the evaluation of the competencies (see Table I) clearly shows. Finally, the preparation of employees for change by means of a learning factory makes them understand the necessity of change processes, and for this reason is one important component for production companies to master the challenges of the future.

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REFERENCES

[1] Abele, E.; Dervisopoulos, M. (2006): Lifecycle Management Concerns Manufacturers and Users Equally (Lebenszyklusmanagement betrifft Hersteller und Anwender gleichermaßen), VDMA Nachrichten.
[2] Kirchner, S.; Winkler, R.; Westkämper E. (2003): Case Study on the Changeability of Companies (Unternehmensstudie zur Wandlungsfähigkeit von Unternehmen), in: wt Werkstattstechnik online, Vol. 93, No. 4, pp. 254-260.
[3] Nyhuis, P.; Klemke, T.; Wagner, C. (2010): Changeability – a Systemic Approach (Wandlungsfähigkeit – ein systemischer Ansatz). In: Nyhuis, P. (Ed.): Wandlungsfähige Produktionssysteme. Hochschulgruppe für die Arbeits- und Betriebsorganisation e. V. (HAB), GITO-Verlag, Berlin, pp. 3-21.
[4] Westkämper, E.: Turbulentes Umfeld von Unternehmen. In: Westkämper, E.; Zahn, E. (Hrsg.): Wandlungsfähige Produktionsunternehmen: Das Stuttgarter Unternehmensmodell. Springer Verlag, Berlin u. a. 2009.
[5] Wagner, C.; Heinen, T.; Regber, H.; Nyhuis, P.: Fit for Change – Der Mensch als Wandlungsbefähiger. In: wt online, Jhg. 100, Heft 9, 2010.
[6] Spath, D.; Hirsch-Kreinsen, H.; Kinkel, S. (Hrsg.): Organisatorische Wandlungsfähigkeit produzierender Unternehmen: Unternehmenserfahrungen, Forschungs- und Transferbedarfe. Stuttgart, Fraunhofer IRB Verlag, 2008
[7] Dashchenko, O. A. (2006): Reconfigurable Manufacturing Systems and Transformable Factories, Springer-Verlag, Berlin, Heidelberg.
[8] Reinhart, G. et al. (2002): Changeable Factory Design (Wandlungsfähige Fabrikgestaltung). In: ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb, Vol. 97, No. 1/2, pp. 18-23.
[9] Wiendahl, H.-P. et al. (2007): Changeable Manufacturing – Classification, Design and Operation, Annals of the CIRP, Vol. 56, No. 2.
[10] Zäh, M. F. et al. (2004): Methodology to Increase the Changeability of Production Systems (Methodik zur Erhoehung der Wandlungsfähigkeit von Produktionssystemen), in: ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb, Vol. 99, No. 4, pp.173-177.

[11] Nyhuis, P.; Klemke, T.; Wagner, C. (2010): Changeability – a Systemic Approach (Wandlungsfähigkeit – ein systemischer Ansatz). In: Nyhuis, P. (Ed.): Wandlungsfähige Produktionssysteme. Hochschulgruppe für die Arbeits- und Betriebsorganisation e. V. (HAB), GITO-Verlag, Berlin, pp. 3-21.
[12] Nyhuis, P.; Reinhart, G.; Abele, E. (2008): Changeable Production Systems. Creating the Industry of Tomorrow, Today (Wandlungsfähige Produktionssysteme. Heute die Industrie von morgen gestalten), PZH Produktionstechnisches Zentrum GmbH, Garbsen.
[13] Klemke, T.; Nyhuis, P. (2010): Transformable and Site-specific Factories in Production Networks on the Basis of Synchronized Location and Factory Planning Processes. In: Proceedings of the International Conference on Asia Pacific Business Innovation and Technology Management, Beijing.
[14] Gossmann, D. et al.: Change-Beneficial Process Architectures and the Human as a Change Enabler International Conference on Changeable, Agile, Reconfigurable and Virtual Production, (CARV 2011). Montreal, 2-5 October 2011.
[15] Wiendahl, H.-P.; Hernández, R. (2001): The Transformable Factory – Strategies, Methods and Examples, Proceedings CIRP 1st International Conference on Agile, Reconfigurable Manufacturing, Michigan, USA, May 2-21 2001, University of Michigan, Ann Arbor MI, USA.
[16] Klemke, T.; Wagner, C.; Nyhuis, P. (2011): Evaluating the systemic changeability of production systems, In: 2011 Global Business & Economics Anthology, January 11-14 2011, St. Thomas, US VI, pp. 87-96.
[17] Heger, C.: Bewertung der Wandlungsfähigkeit von Fabrikobjekten. Diss. Leibniz Universität, PZH Verlag, Garbsen 2007.
[18] Hernández, R.: Systematik der Wandlungsfähigkeit in der Fabrikplanung. Diss. Leibniz Universität Hannover. VDI Verlag GmbH, Düsseldorf 2003.
[19] Möller, N.: Bestimmung der Wirtschaftlichkeit wandlungsfähiger Produktionssysteme. Forschungsberichte iwb. Herbert Utz, München 2008.
[20] Nofen, D.; Klußmann, J. H.; Löllmann, F.: Nutzung wandlungsfähiger Fabrikstrukturen. In: Wiendahl, H.-P.; Nofen, D. (Hrsg.): Planung modularer Fabriken – Vorgehen und Beispiele aus der Praxis. Carl Hanser Verlag, München, Wien 2005.
[21] Schuh, G., et al.: Design for Changeability (DFC) – Das richtige Maß an Wandlungsfähigkeit finden. In: wt Werkstattstechnik online, 94(2004)4, pp. 100-106.
[22] ElMaraghy, H.; Wiendahl, H.-P.: Changeability – An Introduction. In: ElMaraghy, H. (Hrsg.): Changeable and Reconfigurable Manufacturing Systems. Springer Verlag, London 2009.
[23] ElMaraghy, H.: Flexible and reconfigurable manufacturing system paradigms. In: International Journal of Flexible Manufacturing Systems, 17(2005)4, pp. 261-276.
[24] Baldrige National Quality Program (2009-2010): Criteria for Performance Excellence, Gaithersburg, MD.
[25] Kjellberg, T. et al (2007): Taxonomy of terms and definition for competence management. In: Riives. J,Otto, T.: Innovative development of human resources in enterprise and in society, pp. 8-17.
[26] Ley, T.; Albert, D. (2003): Identifying Employee Competencies in Dynamic Work Domains: Methodological Considerations and a Case Study, Journal of Universal Computer Science, Special Issue, 9, 12 (2003), pp. 1500-1518.
[27] Gerst, D. (2007): Human Resources (Humanressourcen). in: D., Arnold; H., Isermann et al.: Handbuch Logistik. Springer Verlag, pp. 343-361, Berlin.
[28] Rosenstiel, L. von (2004): Roles in Organizations from a Psychological View (Rollen in Organisationen aus psychologischer Sicht). In: Rosenstiel, L. von; Pieler, D. et al. (Ed.): Strategisches Kompetenzmanagement. Von der Strategie zur Kompetenzentwicklung in der Praxis. Gabler Verlag, Wiesbaden.
[29] Wagner, C. et al. (2010): Fit for Change – the Human as a Change Enabler (Fit for change – Der Mensch als Wandlungsbefähiger), wt online, Vol. 100, No. 9, pp. 722-727.
[30] Schneider, R. J.; Ackerman, P. L.; Kanfer, R (1996): To act wisely in human relations: Exploring the dimensions of social competence, In: Personality and Individual Differences, Volume 21, Issue 4, pp. 469-481
[31] Erpenbeck, J.; von Rosenstiel, L.: Einführung. In: Erpenbeck, J.; von Rosenstiel, L. (Hrsg.): Handbuch Kompetenzmessung. Schäfer-Poeschel Verlag, Stuttgart 2003.
[32] Heinen, T.: Planung der soziotechnischen Wandlungsfähigkeit in Fabriken. In: Berichte aus dem IFA. PZH-Verlag, Garbsen 2011.
[33] Salazar, Y.; Große-Heitmeyer, V.: Competence Factory – Mitarbeiter zum Wandel befähigen. In: Professional Training Facts 2011 Track 15 Stuttgart, 19. Oktober 2011.
[34] Sihn, W.; Bleicher, F. (2011): Integrated, scaleable concept of a learning factory at the Vienna Univarsity of Technology. In: Abele, E. (Ed.): First conference on Learning Factories, May 19th 2011, pp. 59-73, Darmstadt.

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