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Holistic Approach of Lean Thinking in Learning Factories

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Abstract

Simulation games that employ the "learning by doing" approach are used to transfer complex knowledge from the most diverse fields of economy. Their popularity steadily continues to grow in the framework of seminars and workshops. The Institute of Production Systems and Logistics (IFA) applies this style of haptic learning in order to teach Lean Management contents to students as well as industry specialists and executives. During the interactive training sessions participants are involved in realistic operating situations including actual assembly processes and learn practically relevant research contents. This paper presents a training concept offered within the "IFA Lernfabrik" that incorporates the philosophy and application of Lean Thinking. Particular attention is given to the simultaneous consideration of production and administration. This synchronized approach is based on the fact that presently the administration side offers very high productivity potentials, while the vast majority of improvement activities is performed in production.

To provide a better understanding for this approach, an interactive two-stage training environment was designed to highlight the advantages of Lean Production and Lean Administration methods. The first stage challenges the participants with a situation that is characterized by an inefficient production environment and limited administrative features. The aim is to improve the current situation through the utilization of the lean methods learned during the first stage training session. Within the second stage, the administrative features are being extended, which initially still exhibit wasteful characteristics. It becomes obvious that the advantages of an optimized production are not fully realized due to inefficient administrative processes. This clarifies the principle that productivity improvement activities should always entail an integral optimization of business processes. Therefore, the participants subsequently learn how to transfer and apply the methods of Lean Production in administration as tools to not only optimize their production but the entire organizational structure.

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Keywords: learning factory; Lean Production; Lean Administration; holistic approach

1. Introduction

Practically-oriented learning and teaching methods have established themselves at German universities in recent years. The number of learning factories in academic education facilities, institutes and companies is steadily increasing, with a particular focus on mechanical engineering and economic studies. According to a current study, the content is meanwhile more and more focused on Lean Production [1]. The concept of Lean Thinking has so far been mostly used successfully in production processes to optimize them and to avoid waste. Meanwhile, the administrative side has been neglected for a long time. But now, more and more companies are coming to realize that this leaves optimization potentials unused [2]. The Institute of Production Systems and Logistics (IFA) in Hanover didactically leverages these unused potentials in a new concept which interlinks Lean Production and Lean Administration and shows why this holistic training approach is required.

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2. Use of learning factories for employee development

Aiming to sustainably impart knowledge in realistic production environments and by way of personal experience and action, learning factories are an important element for developing competence in the basic and advanced training of engineers. Further simulation games serve the ability to work in a team, as well as promoting networked thinking. This means that an awareness of the consequences of one's own actions is created. In addition, they also serve the application of knowledge, as well as training decision-making and methods [3]. The effectiveness of simulation games can meanwhile be increased if they are integrated in a seminar concept [4]. The reason for applying simulation games in such seminars is "[…] that a deeper understanding, a eureka moment, will indeed most likely come about through personal experience involving trial and error, i.e. by lived experience, therefore in play in the broadest sense […]" [5]. The portion of learned knowledge to be committed to memory is 10% for hearing, 20% for seeing, 40% for seeing and hearing, and 80% for doing [6]. The benefits of haptic stimuli in simulation games are meanwhile being relied upon in over 50 European learning factories. It is the aim of the learning factory operators to be able to map as many corporate divisions in their facilities as possible. But studies nonetheless show that the teaching proposals are largely focused on the realm of actual production, including the assembly, manufacturing, quality management and internal logistics [1]. On the one hand, this focus can be explained by the basic alignment of learning factories with the problems and interests of industry, which are specifically reflected in the production process. But another way of reasoning would be the theory of growing complexity owed to a stronger integration of additional corporate divisions. The operators of learning factories are therefore currently limiting themselves to their respective core areas.

3. Problem-setting of learning factories concepts

The didactic learning concepts for developing know-how and competence in the learning factories particularly work by linking formal and informal learning and expediting an activity-oriented learning environment [7-9]. The fusion of theoretical and empirical knowledge thus enabled in turn creates a space for exercising decision-making and reflective abilities while ensuring a holistically systematic understanding of the taught interrelationships [10]. However, this holistic understanding also needs to be addressed in terms of the teaching contents.

The value chain concept named after PORTER already points to a difference between supporting and primary activities (Fig. 1) [11]. This market-oriented perspective is meant to highlight how functional activities interact within an enterprise and help to design these in-house processes to the company's advantage [12].

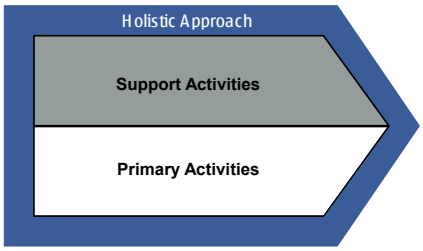

Figure 1: Holistic thinking and approach by Porter [11]

Congruence with this systemic view is still not traceable in the practice-oriented conveyance of knowledge. What can currently be observed in learning factories is a selective orientation of teaching contents towards the manufacturing and assembly processes of a company with a focus on Lean Production. It would be advisable, however, to enable a learning situation that maps the entire production process, in order to heighten the realism in the learning factory as compared to an industrial enterprise. This means that all the operational workflows are included in the learning process, in order to not only be able to mediate the production process, but in particular also its interconnectedness and dependencies. From a didactic, organizational perspective, however, implementing this would essentially require a comprehensively holistic approach and way of thinking [13].

This special challenge calls for the development of new scenarios which generate an initial need for action on the part of the learners that they must 'cope with' in the game. This kind of thought-provoking impulse can be brought to a head in production environments by various extremes to the extent where the current primary processes come up against their limitations and the learner is required to question the entire value chain, or wish to change it [14]. Over the course of recent years, the production-rooted principle of Lean Production has already left its confines as a method by way of generalization and adaption, for example in Lean Administration, and developed into a management philosophy. The next logical step would consequently be a concept for imparting the know-how of this cross-departmental philosophy.

Merging Lean Production and Lean Administration in a simulation game would then serve to transfer the methods known from the direct production area to its indirect environs. The application of lean methods in a physically existent and "tangible" system will furthermore promote the transfer of Lean Thinking to the intangible and partly informal administration processes. This ultimately creates a personally experienced awareness of the interfaces provided in a job execution process and of the interdependencies between production and administration with an impact on the extent in which the holistic improvement potential of an enterprise can be realized.

4. An IFA approach for Lean Competencies

The development of the IFA learning factory as an overall concept pursued the aim of being able to mediate the contents of various specialist disciplines such as Industrial Engineering

and Ergonomics, Factory Planning, Production Engineering, Production Management in a consistent training environment. A particular focus is placed on examining the Production Planning and Production Control, Factory Planning, Work Ergonomics and Lean Management. In the following, an approach to interlink Lean Production and Lean Administration based on the usage of similar methods is presented.

4.1. Parallels between Lean Production and Lean Administration method competence

The combination of Lean Production and Lean Administration contents in a joint training is based on the fact that both approaches show distinct parallels, enabling the use of synergies in mediating competence. This is particularly evident with regard to the methods applied. A great number of Lean Production methods can hence be transferred to Lean Administration and applied there. The main difference between the two areas is meanwhile provided by the object of reflection. While the product takes centre stage in the processes of the direct corporate divisions, the indirect ones are focused on information [15]. What both approaches have in common is the intention to avoid waste and step up the value creation along the process chain. To reach these aims, both approaches are based on the same five basic and interlocking principles of Lean Management. These start off by defining the value from a customer perspective before identifying the value stream per se on this basis. This involves a subdivision of process stages into activities that create value, those that do not, and waste. Once the value stream has been analysed, a third step is dedicated to translating the identified value creation processes into the flow principle, and then into a pull system. The final focus is on a continuous reduction of labour, time, space, costs and errors by striving for perfection [16].

The methods of Lean Production and Lean Administration which are based on these principles can be grouped in three categories: problem solution, process orientation, and process and solution control (Fig. 2).

The problem solution area includes the 5-Ws question-asking technique and the Ishikawa-Diagram, both serving the systematic analysis of causes for a defined problem. Both methods can be applied in the direct areas as well as being transferred to the indirect ones.

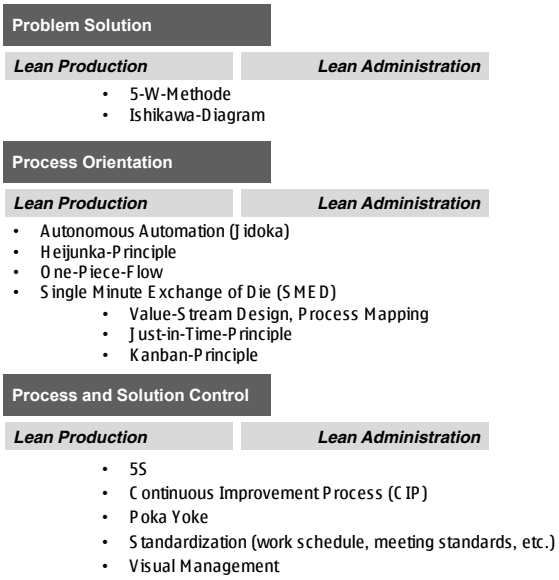

Figure 2: Methods of Lean Production and Lean Administration

The process orientation methods encompass all the process management and process organization methods. The various methods in Lean Production serve to design the production processes. These methods include Autonomation (Jidoka), the Heijunka principle, the Just-in-Time principle, the Kanban principle, the One-Piece-Flow, the Single Minute Exchange of Die and the Value Stream Design [17]. Given that these methods have been specifically designed for the manufacturing process, they are not transferable to the indirect corporate divisions without further ado in most cases. Exceptions in this respect are provided by the Value Stream Design, the Just-in-Time principle and to a certain extent the Kanban principle. The Value Stream Design maps a customer-oriented flow of material and information in a target condition. What this requires is an assessment of the current condition in a value stream analysis. Whether the corporate divisions concerned are direct or indirect is irrelevant in this regard. The essential difference resides in the object of investigation, which either comprises the production processes or the business processes, but hardly makes a difference for the methodical approach in practice [18]. The Kanban principle in Lean Production consists of the two subareas of material Kanban and production Kanban. The production Kanban navigates the flow of material through the individual work systems in a pull principle [19]. This process is exclusively limited to production, whereas the material Kanban, a warehouse control concept for material provision, is part of Lean Production as well as Lean Administration processes. In a production process it can be used to ensure the provision of components required at the work stations, while the application in indirect corporate divisions is focused on the provision of office utensils [20].

The process and solution control methods are basically applicable to both approaches again. To be mentioned as notable methods here are 5S, the Continuous Improvement Process (CIP), Poka Yoke, Standardization, and Visual

Management [17]. The 5S principle engages in the standardization of workplaces, which are tidied up, kept clean and maintained at the same level of cleanliness in five stages. Whether the workplace is located in a production department and the objective resides in the arrangement or standardization of tools, or whether it is an office workplace where the focus is on the standardization of office utensils or folder structures in the EDP system is irrelevant for the application of the method [21]. The CIP, which is based on the Deming cycle, is aimed at a continuous improvement of one's own performance in small steps while including the entire workforce. In this case also, similarly to the problem solution methods, the focus is on a specific problem that is to be eliminated. A CIP in production could for example involve arranging all tools in keeping with the 5S, while the introduction of favourites, enabling faster navigation of folder structures, could be a possible result of a CIP for office workplaces [22]. Poka Yoke is a method for avoiding errors by way of technical precautions ensuring their immediate discovery and prevention. In production processes, this principle is for example found in the asymmetrical alignment of components to be dovetailed so that a faulty attachment becomes impossible. In the indirect areas, one possible application would be the use of forms whose fields require a predefined format in IT [17]. Standardization relates to processes on the one hand and to documents on the other. It is based on the SDCA cycle, which proceeds the Deming cycle in each case [23]. It is also applied in Lean Production in the form of manufacturing processes, as well as in Lean Administration in the form of business processes or documents, for example invoice approvals or the offer document. The last to be examined is the Visual Management. As this method is couched in very general terms, it is also applied in both corporate divisions, be it as an Andon board for showing the current operating condition of a machine in the production department or as a colour coding of folders and files in the administration. [17].

What emerges is that many methods from Lean Production can also be applied in Lean Administration, so that the extra effort required for mediating the teaching contents is small because the method competence is already provided. Whereas the benefits of expanding the teaching contents by the processes of the indirect areas are great. This helps to show that only an optimized interplay of both areas across the entire value chain from order receipt to goods delivery will lead to customer-oriented and efficient processes. Making this fact visible and tangible is subject of the training concept.

4.2. Simulation game structure

The simulation game developed by the IFA combines the two principles of Lean Administration and Lean Production. It is aimed at imparting the fundamental methods of those philosophies and the realization that both areas harbour considerable potentials for improving efficiency, while an optimum can only be reached for the overall system if both areas follow the ideas of Lean Thinking.

The simulation game has four rounds in which the players continually improve the workflows and processes over the course of the game. The roles assumed by the players for this include jobs in production as well as in the indirect corporate divisions.

The game situation provided at the start is characterized by a great number of different forms of waste in the direct as well as indirect areas. The first two game rounds are focused on improving the direct areas, in order to create a clear awareness of the problem for the respective areas. The third and fourth game round then put improving the administrative activities in the foreground. This way of going about things is in particular aimed at reaching two objectives. Interdisciplinary thinking (indirect and direct areas) is to be promoted on the one hand, and the waste in the overall system is to be continually reduced on the other (Fig. 3). Of particular importance for this is the change of perspective from Lean Production to Lean Administration after the second round of the game. What clearly emerges at this juncture is the particular importance of a joint, low-waste and efficient cooperation with regard to the optimization of the overall system "company".

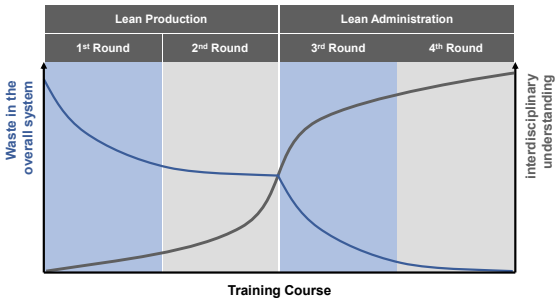

Figure 3: Learning objectives of the simulation game

The first round of the game is aimed at creating an awareness of waste within the process amongst the participants. This is meant to render inefficiencies tangible in order to ultimately assess existing weaknesses of the process in a problem assessment and reflection phase and develop possible improvement measures. This process is kicked off by those taking part in the simulation game and finally supplemented by a theory module in which the essential methods of Lean Production are described (Fig. 4). These include the already mentioned methods 5S, CIP and Visual Management, but also Line Balancing and Kanban.

This is followed by a design phase where a new process is developed, which is ultimately implemented at the real object of the learning factory. This stage is aimed at realizing a process that is as optimal as possible under lean aspects. To this end, consumption-oriented methods of material provision and order clearance need to be introduced as much as an optimized layout for reducing unnecessary movements and Line Balancing of the individual processing operations. The ability to objectivize the effects of process improvements is ensured by tracking various indicators during the rounds of the game.

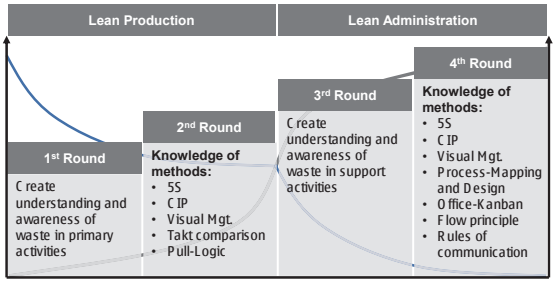

Figure 4: Game round contents

Important Lean Production indicators to measure performance in production include inventories, manufacturing throughput times, reject rates and delivery reliability, amongst others. The order throughput times are of particular importance here. Besides the actual processing of the order, the throughput time also includes the dispositive pre- and post-processing and hence already includes periods that can be allocated to the indirect areas. No separate indicators for quantifying the performance of the indirect areas are initially tracked in the first two rounds of the game.

After the second round, an optimized system is provided with respect to the direct processes. Productivity enhancements by the factor of five are classically measurable in this regard. In addition, the inventories are reduced in the production system and the delivery reliability rises to levels approaching nearly 100%. The development of the corresponding indicators is shown in Table 1. The manufacturing throughput time can no longer be established because of the consumption-related order clearance and is hence left out.

Table 1: Overview of the KPI development in the first two rounds

KPIs	First round	Second round
Output quantity (demand 40)	10 pcs.	34 pcs.
Turnover (32 UV)	€ 288,-	€ 1.280,-
Inventories	€ 167,-	€ 140,-
Delivery reliability	14%	96%
Reject rate	2 units	1 unit
Manufacturing throughput time	16,21 min.	

To highlight the impact of the administration on the process, the perspective is next changed before the third round. The focus is now on the administrative areas. The administrative processes become more comprehensive for this purpose and new jobs such as distribution and procurement are created. The changes in the players' roles between the second and third round are shown in Table 2.

Table 2: Players' roles in the individual rounds of the game

Roles	Lean Production (Round 1 and 2)	Lean Administration (Round 3 and 4)
1	One customer	Several customers
2	Production control	Production control
3	Accounting	Accounting
4	Warehouse/scheduling	Warehouse/scheduling
5	Assembly (five assembly workplaces)	Assembly (three assembly workplaces)
6	Suppliers	Shipping/suppliers
7	In-house transport	In-house transport
8	-	Distribution
9	-	Procurement

Indicators are also tracked here to be able to quantify the performance of the areas under review in these rounds of the game. They are modelled on the production indicators and in particular include the order throughput time at the respective workplaces and the provided inventory. Apart from this also the number of interfaces and the number of documents are recorded. Qualitative indicators are additionally surveyed in order to highlight further changes in the course of the simulation game. These include the perceived workload and the process understanding, amongst others.

In the course of the third round, the players taking part perceive various kinds of waste within the process, analogously to the first round. This helps to create a first awareness of waste while also highlighting the importance of the administration for the job execution process. Although the production system stays the same physically, the performance of the overall system shows a clear reduction which is owed to inefficiencies in the indirect area. This includes a significant reduction of the output quantity, while the delivery reliability to the customer also declines. The reasons for this declining performance are first and foremost a lack of transparency where the ongoing processes are concerned, problems between the interfaces and a great variety of different, unstandardized documents. Eliminating these kinds of waste is the object of a reflection phase, also analogously to the production-related part. Starting from a process assessment with the help of the Makigami method, this stage includes an identification of the problem and search for a solution (Fig. 5). This is ultimately followed by a design process, which is attended by the mediation of essential Lean Administration methods and serves to elaborate the new target process in cooperation with the persons taking part in the simulation game.

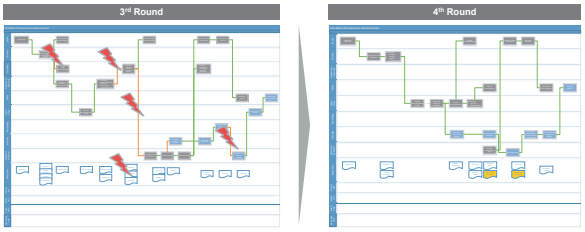

Figure 5: Changes in the job execution process

The newly designed process is characterized by the introduction of standardized documents, transparent

workflows, a reduction in the number of interfaces and information needs, a parallelization of activities and an elimination of unnecessary feedback and approval loops. The consequences of these adjustments include a significant reduction in the order throughput times for the indirect areas and hence also a reduction of the order throughput time.

The optimization of the direct and indirect areas, which are usually considered separately, can ultimately enable the realization of a holistically optimized overall system which is distinguished by the shortest possible throughput times and stable, low-inventory, consumption-controlled and standardized processes.

5. Summary

This paper presents a holistic approach to competence development of Lean Thinking in learning factories. Currently, the didactic concepts in existing learning factories provide a very goal-oriented, but selective knowledge. A holistic understanding, what creates room for cross-functional decision-making and improvement, is imparted by the IFA in Hanover. For that holistic approach Lean Production is suitable due to the fact that this philosophy has already left own limits. Among primary activities the principles of the used methods like 5S or CIP can also be found in support activities of a company and have established the approach of Lean Administration.

The reduction of waste in production is solely relevant, but affecting only a proportion of the total potential for improvement. More than just carrying-over methods and tools of Lean Production into administrative areas, it is very important to also consider the existing interrelationships and interfaces between primary and support activities. The joint training of Lean Administration and Lean Production at the IFA learning factory focuses on the optimization of the entire company. By running through the three steps of problem solution, process orientation as well as process and solution control a continuous improvement of the work flow and the process in production as well as indirect environs is provided.

The main goal is a joint, low-waste, customer-oriented and efficient cooperation. This interdisciplinary understanding is taught within the presented simulation game.

References

[1] Micheau H-J, Kleindienst M. Lernfabrik zur praxisorientierten Wissensvermittlung. Zeitschrift für wirtschaftlichen Fabrikbetrieb (ZWF) 2014; 109. p. 403-407.

[2] Liftin T. Ungenutzte Potentiale entdecken: Administrative Prozesse im Mittelstand, technologie & management (t&m) 2011; p.36-38.

[3] Bergmann J, Carlos J, Gwinner D, Meyer-Lomax D. Einsatz von Logistikplanspielen an deutschen Hochschulen. In: Schwägele S, Zürn B, Trautwein F. Planspiele – Erleben, was kommt. Norderstedt: Books on Demand GmbH; 2014. p.87-101.

[4] Rohn WE. Strategie-Simulationen zur Systemsteuerung und Einsatz von planspielen in der Managementschulung. In: Keim H. Planspiel, Rollenspiel, Fallstudie: Zur Praxis und Theorie lernaktiver Methoden. Köln; 1992. p.336-365.

[5] Vester F. Spielen hilft verstehen. In: Geilhardt T, Mühlbradt T. Planspiele im Personal- und Organisationsmanagement. Göttingen; 1995. p.19-26.

[6] Rohn WE. Simulation – Praxis am Modell erlernen. In: Graf J. Planspiele. Speyer, Bonn: GABAL; 1992. p. 19-28.

[7] Kreimeier D, Prinz C, Morlock F. Lernfabriken in Deutschland – Praktisches Lernen in einer Fertigungsumgebung zur Schulung von Ganzheitlichen Produktionssystemen. Zeitschrift für wirtschaftlichen Fabrikbetrieb (ZWF) 2013; 108. p.724-727.

[8] Dehnbostel P. Berufliche Weiterbildung – Grundlagen aus arbeitnehmerorientierter Sicht. Berlin: Edition sigma; 2008. p.67ff.

[9] Riedl A. Didaktik der beruflichen Bildung. München: Franz Steiner Verlag; 2004.

[10] Lütjens J. Das Konzept einer Lernfabrik. In: Tramm T, Gramlinger F. Lernfirmen. Hamburg: Berufs- und Wirtschaftspädagogik – online 2006; 10.

[11] Porter ME. Competitive Advantage of Nations: Creating and Sustaining Superior Performance. New York: Free Press; 1985. p.36ff.

[12] Porter ME. Wettbewerbsvorteile – Spitzenleistung erreichen und behaupten. Frankfurt, New York: Campus Verlag; 2000. p. 67ff.

[13] Bittmann A, Novak H, Rost H. Lerninseln als Lernorte und systemisches Medium zur Vorbereitung auf neue Formen des Arbeitens. In: Binkelmann p, Braczyk HJ, Seltz R. Entwicklung der Gruppenarbeit in Deutschland. Frankfurt: Campus-Verlag; 1993.

[14] Wagner C, Heinen T, Regber H, Nyhuis P. Fit for Change – Der Mensch als Wandlungsbefähiger. wt Werkstatttechnik online 2010; 100. p.722-727.

[15] Schwickert AC, Fischer K. Der Geschäftsprozess als formaler Prozess. Definition, Eigenschaften und Arten. Mainz: Lehrstuhl für allg. BWL und Wirtschaftsinformatik. Arbeitspapiere WI. Nr. 4/1996.

[16] Womack J, Jones DT. Auf dem Weg zum perfekten Unternehmen. Lean Thinking. Frankfurt / Main: Campus; 1997.

[17] Zollondz HD. Grundlagen Lean Management: Einführung in Geschichte, Begriffe, Systeme, Techniken sowie Gestaltungs- und Implementierungsansätze eines modernen Managementparadigmas. München: Oldenbourg Wissenschaftsverlag GmbH; 2013.

[18] Wiegand B, Nutz K. Lean Administration II: So managen Sie Geschäftsprozesse richtig. Aachen: Lean Management Institut Stiftung; 2007.

[19] Dickmann, P. Schlanker Materialfluss mit Lean Production, Kanban und Innovationen. Berlin Heidelberg: Springer; 2008.

[20] Wiegand B, Franck P. Lean Administration I: So werden Geschäftsprozesse transparent. Aachen: Lean Management Institut Stiftung; 2006.

[21] Klevers T. Wertstrom-Management: Mehr Leistung und Flexibilität für Unternehmen. Frankfurt/Main: Campus; 2013.

[22] Kostka C, Kostka S. Der Kontinuierliche Verbesserungsprozess: Methoden des KVP. München: Carl Hanser; 2008.

[23] Imai M. Gemba Kaizen: Permanente Qualitätsverbesserung, Zeitersparnis und Kostensenkung am Arbeitsplatz. München: Langen Müller / Herbig; 1997.