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Integration of IT Into a Lean Basic Training: Target Group-Specific Insights and Recommendations

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Abstract

Lean Management and high cost automation are often seen as contradictory. Several studies however have shown that Lean Management and IT can actually match and complement each other. If the overall topic is the evolution of Lean from a simple tool box approach to a Lean 4.0 stage, this paper discusses how IT can be integrated into a Lean Basic Training. The training takes place in a traditional Lean learning factory with a real product and a real value stream. Combining a qualitative and quantitative approach, Lean experts and participants of a Lean Basic Training were asked if they saw any benefit in the use of IT in the training. In addition, they were asked which elements of the Lean training should be supported by IT. By applying inferential statistics, influences of target groups on IT integration were discovered. Among others, integration is significantly influenced by the companies the participants come from, by their level of education, their Lean experience and their IT affinity. Combining these influences of the target groups with insights from literature and the opinion of Lean experts from local companies, selected aspects of IT integration are discussed. Finally, recommendations are given how IT can be integrated into a Lean Basic Training in a traditional Lean learning factory.

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Keywords: lean management; digitalisation; learning factory; training; didactical concepts

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1. Lean and Digital

1.1. Lean and IT

Lean management and high cost automation are often considered as contradicting each other [1]. The same is true for Lean management and IT. Lean advocates argue that IT leads among others to in-transparency of the process flow as job floor employees no longer see the information flow. They cannot react immediately if something unexpected happens, like having to postpone material replenishment due to longer changeover times, as everything is pre-planned and steered centrally by computers in large scale. In that case, IT diminishes the problem-solving ability of a single worker just where continuous improvement is essential to Lean. Companies often move towards Lean management as a response to the complexities and in-transparency brought in by IT. As a result, Lean advocates resist using IT before Lean principles are not implemented manually [2]. On the other hand, Lean has its shortcomings e.g. in forecasting and coping with long ordering lead times. Additionally, it is time-consuming to decompose a complex bill of material or to gather accurate data to get visibility of the current performance without IT support. Similarly, physical Kanban cards can get lost or manual data gathering might be time-consuming. Therefore, Lean and IT can benefit from each other [3] [4] [5] and in reality, this is also what can be seen in most of the companies.

1.2. Learning factories and digitalization

In order to train employees in Lean, learning factories have become very common. They allow an action-oriented approach for the acquisition of competences by a self-controlled and informal learning process [6]. Different forms of learning factories are existing. In order to group them in a standardized way, Abele et al. have developed a description model with several dimensions [7]. Apart from the classical learning factories, more and more so called "Learning factories 4.0" have been established in order to develop the skills future workers require [7]. Some of these "Learning factories 4.0" are completely new others are classical learning factories augmented with IT. For the latter, roadmaps have been developed how an update could look like [8]. Furthermore specific Industry 4.0 solutions for a Lean Lab have been proposed [9]. It was assumed that Industry 4.0 offers additional technological possibilities to enhance work-based learning [10]. As a result, new learning concepts have been developed for teaching 4.0 [11]. For the present paper, the work of Prinz et al. is of special interest. They have developed a training course for deeper understanding and practical use of assistance systems for a learning factory [12].

2. The learning factory "LEAN Lab" at Kufstein University of Applied Sciences

2.1. LEAN Lab

The so-called "LEAN Lab" learning factory at Kufstein University of Applied Sciences consists of a training environment of about 100 m². It was established in 2014 with the aim to create an integrative learning environment for students as well as for employees from regional companies. Several production managers from local industry were involved in the conception. It was also guided by the concepts of already existing learning factories. The setting of the learning factory is based on a production process with seven steps that includes manufacturing as well as assembling processes. The resulting product is a watch in three different product variants. All production processes are kept very simple to be done by the trainees themselves. To handle this, the trainees get a short introduction into the different steps before every training. According to the above-mentioned taxonomy of learning factories, it is considered a "narrow" factory with a physical product and a real value chain.

2.2. Lean Basic Training

Among the many trainings that are being conducted in the LEAN Lab, the "Lean Basic Training" is the most frequent one. Therefore, this training was chosen for scientific evaluation. In this training, participants of an individual company shall obtain a general understanding of Lean management. In addition, the participants shall be able to apply some of the core tool of Lean management to their own working environment. The training is conducted in a co-teaching mode by two trainers. The reason for the co-teaching is, that one of them is an expert from the company who can provide company-relevant business knowledge and the other trainer knows everything about the learning factory. In the simulation, starting from a rather unstructured state, the attendees see a process that is not suitable to fulfil the customer requirements. After the first round of the simulation, the trainees are taught several Lean tools following a general four-phase Lean roadmap: reduce waste, gain stability, reach capability and ensure sustainability. Each time a Lean tool is taught, the attendees have the possibility to apply the learnings directly to the learning factory process. At the end of the 1 ½ days of training and after all the Lean tools were implemented, a second production round is conducted. Now it becomes visible that the process has indeed improved as it is well-organized, balanced and that the product smoothly flows through the company.

3. Research Question & Methodology

The present paper tries to answer the three questions: Do Lean Basic Trainings in a traditional learning factory benefit from IT? Which elements of a Lean Basic Training should be supported by IT? How should IT be integrated into an existing training?

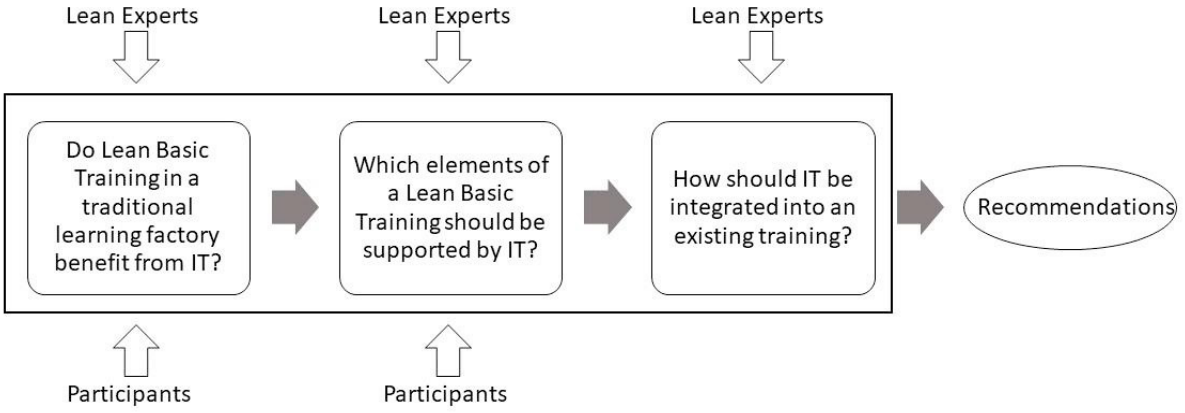

Fig. 1. Overview of research process.

In order to answer the first question, participants have been asked to assess the benefit of an IT support. During the years 2016 – 2018, the data was gathered by a questionnaire at the end of the paper-based simulation training. This questionnaire consisted of open and closed questions. Out of a larger number, a sample of 234 answers was suitable for evaluation. The participants came from three local sites of multinational companies. They are from three different branches of industry: furniture, plastic and automotive. Therefore, the results of the paper are limited to similar industries. The participants were selected by their management according to their involvement in Lean projects. For the second question, the same participants were asked to choose from a predefined list (short list) which of the IT support would be most helpful to be implemented in a next improvement round in the simulation. Their evaluation derived from the experiences they had previously made in the paper-based simulation and their experiences with IT support in their own working environment. The short list of possible IT support was created by a group of 6 Lean experts from regional companies. As it was assumed that a certain group of participants would have different answers than another group of participants, those were stratified according to: company, hierarchy of job,

level of graduation, IT affinity, experience with Lean management and number of trainings completed. For the analysis of the data, inferential statistics was applied. As all of the data are discrete, the chi2 test was applied for hypothesis testing. As a level of significance for falsification of null hypothesis a 5% limit was assumed (p-value < 0,05). This means that if the p-value is lower than 5 % the null hypothesis will be rejected and the underlying assumption be considered as valid for the entire population in focus (significant influence).

To answer the third question, selected aspects of IT integration, such as scope of IT support, moment of integration and type of IT systems, were discussed based on literature and the opinions of three Lean experts. From a list of requirements for a classical Lean training, the experts were asked to choose those aspects relevant for a Lean training with IT support. The results lead to recommendations for IT support in a Lean Basic Training (see figure 1).

4. Results of study

4.1. Benefits of IT in a Lean Basic Training

As it was mentioned in the first part of the paper, the use of IT in the context of Lean management is often discussed controversial in literature. However, looking at industry, most companies use the benefits of both in a pragmatic way. Beside of the trend to enhance traditional Lean learning factories with IT, as mentioned in the first chapter, this was also a reason to ask the participants of the Lean Basic Training at FH Kufstein how they would evaluate the benefit of a possible IT integration into a Lean Basic Training.

The result was surprising. Out of the 234 responses, 65% didn´t see any additional benefit, if they would use IT in order to improve the processes in the simulation game. This result is backed by a series of interviews among six Lean experts. Most of them were reluctant towards IT in the Lean Basic Training. They didn´t want to spend too much or even any additional training time on it. One of the arguments was that they don´t have adequate IT in their own production or a different one. That's why they didn´t see any need to train them in the use of IT. Another argument was, that this might raise desire by the participants that can´t be fulfilled by the company in real life. It was assumed that groups of participants might have different opinions about the benefit of IT in a Lean Basic Training. That´s why this was tested with a questionnaire and inferential statistics. The factors to stratify the participants were mentioned before. Interestingly, no significant influence of the three companies, where the participants came from, was found. Another factor of stratification which was tested, was the hierarchy of jobs. In this case no significant influence was found either. However, looking only at the data set, office employees consider IT more beneficial than job floor members. Maybe this is, because they are more familiar with IT from their daily job. A similar result arose when the influence of the level of graduation was tested: no significant difference. However, looking only at the data set, the participants with apprenticeship saw IT as less valuable. Coming to the next factor, IT affinity, an influence was expeted. This became true. Participants with more IT experience significantly rated the value of IT higher (p = 0,05). No influence on the benefit of IT could be found by the fact that people participated in trainings more or less frequently. Coming back to the discussion at the beginning of the paper about Lean and IT, participants with more Lean management experience should be less interested in IT support. This could not be confirmed in the study. Instead, taking only into account the data set, those with more Lean expertise considered IT more helpful than the others. No significant influence on IT support was found among participants who had encountered challenges in the training (see table 1 column 1-5).

Table 1. Hypotheses and results of target group specific influences on IT benefit and specific IT support.

Null-hypothesis (Ho) Factors	Response	Test	Result (p-value)	Decision about Ho	Response	Result (p-value)	Decision about Ho
The company of the participants has no influence on	benefit of IT	Chi2	0,08	not rejected	Supported elements	0,00	rejected
The hierarchy of the job has no influence	benefit of IT	Chi2	0,47	not	Supported	0,15	not

				rejected	elements		rejected
The level of graduation has no influence	benefit of IT	Chi2	0,34	not rejected	Supported elements	0,00	rejected
The IT affinity of a participant has no influence	benefit of IT	Chi2	0,05	rejected	Supported elements	0,03	rejected
The frequency of participation in trainings of a participant has no influence on	benefit of IT	Chi2	0,76	not rejected	Supported elements	0,10	rejected
The experience with Lean management of a participant has no influence on	benefit of IT	Chi2	0,12	not rejected	Supported elements	0,03	rejected
The challenges of a participant in the Lean Basic Training have no influence	benefit of IT	Chi2	0,90	not rejected	Supported elements	0,15	not rejected

4.2. Elements of a Lean Basic Training that should be supported by IT

Although, as seen in the previous chapter, Lean experts and participants both mainly voted for no IT in a Lean Basic Training, it was further investigated which elements of the training would fit best for an IT support. This is mainly because it was assumed in literature, see before, that Lean expertise moves from simple tool handling to more advanced Lean 4.0 skills. According to them, IT will become a commonly used mean to improve processes. That´s why IT should be part of a Lean training. Nevertheless, the concerns towards IT need to be addressed in the training, which will be discussed further in the chapter "recommendations".

Table 2. IT support in a Lean Basic Training.

Order	Lean expert`s ranking	Participant´s ranking
1.	Working documents (e.g. production order, work instructions)	Status reporting of production order
2.	Performance calculation (e.g. OEE)	Working documents
3.	Status reporting of production order (e.g. amount, time)	Quality documents
4.	Fault reporting	Fault reporting
5.	Production planning	Performance calculation
6.	Quality documents	
	No votes for e.g. Total Production Maintenance, Internal Logistics – Kanban, Kaizen, Idea Management.	No votes for Production Planning

In order to choose adequate areas in a Lean Basic Training where IT could help, a long list was created out of literature [13]. It consisted of elements within the following categories: Value Stream Analysis, Waste Analysis, Total Productive Maintenance, Standard Operation Procedures, Quality at the Source, Performance management, Visual management, Single Minute Exchange of Dies, Production Planning, Production Scheduling, Continuous Flow, Generic Pull System, Continuous Improvement. This list was given to a group of six Lean experts from regional companies in order to choose select (short list) and to put them in a ranked order (table 2). The same task was given to the 234 participants of the Lean Basic Training. Interestingly, the two lists were different. One reason might be that 60% of the participants were workers. As will be shown later, participants with apprenticeship had a significantly different opinion where IT would be helpful. For them, electronic status reporting of the production orders was seen as most important (see table 2). Due to the large amount of data it could also be checked if the differences in the ranking within the participants´ list were of statistical significance. This means that the participants of a similar Lean Basic Training would come to a similar conclusion. This was expressed by the value of the alpha error or p-value from the applied statistical test. We assumed a 5% limit of the p-value as was mentioned before. In our case it turned out that the differences in the ranking of IT support were so large that they can be assumed to be valid for all similar Lean Basic Trainings ($p = 0,00$). It was assumed that groups of participants might have a different opinion which elements of a Lean Basic Training should be supported by IT, This assumption was tested in the following with a questionnaire and inferential statistics. It turned out that participants from different companies had statistically significantly other ideas, where IT might be helpful ($p = 0,001$). Looking at the data, it seemed that participants value IT support higher for those areas, where they already have experience with IT from their own company. This might be explained by the „mere exposure effect": the value rises by the level of exposure. Looking

at the hierarchy of job no significant influence was found. However, only considering the data, workers saw IT support for order tracking and working documents as more important than managers did. In contraty, managers rated the calculation of performance figures higher than workers did. The fact that everybody rated those elements higher, which are closer to his daily work, was also a result from a survey among 80 companies by Adam und Grätz [14]. Taking into account the level of apprenticeship, significant discrepancies could be found between the elements. Those with apprenticeship consider the support for amount / time reporting more important, whereat those with foremanship, the support of working documents ($p = 0,00$). Coming to the influence of IT affinity, participants with more IT experience evaluated certain elements of the list higher than others ($p = 0,03$). The level of Lean expertise had a statistical significant influence, too. Those with more Lean expertise significantly considered performance calculation and working documents as more adequate for digitalisation than other participants ($p = 0,03$). This is understandable as Lean means to have transparency about current performance. Gathering data in order to calculate adequate figures is time consuming. So, IT support in this area might be seen as valuable by those who have done this before only paper-based. No statistical influence was found for the fact if participants encountered challenges in the training. However, looking only at the data set it was obvious that those who had more problems in the simulation game, have preferred IT support on fault reporting. This is understandable as participants want to fulfil their role in the game perfectly and would have liked to report occurring faults rapidly (see table 1, column 1, 6-8).

4.3. IT integration into a Lean Basic Training

The previous sections have shown that neither the interviewed Lean experts nor the participants of the training saw any benefit in the use of IT in a classical Lean Basic Training. Nevertheless, due to the reasons listed in chapter 1, areas were prioritized where IT support is considered as being helpful and target-group-specific influences were discovered. The before-mentioned findings lead to the third research question: How can IT be integrated into a Lean Basic Training? To answer this question, requirements for a Lean Basic Training were gathered from literature. These mostly came from the work of Enke, et. al. [15]. Out of the 70 requirements from Enke et al. the most relevant for the IT topic were chosen. In addition, requirements from Lean theory were added. In order to discuss IT integration, certain aspects were selected: scope of processes, moment of IT integration, type of IT systems, focus and involvement of participants. For each of these aspects the two extreme forms of integration were selected. In the following it was tested which form of IT integration would best fulfil the requirements. Therefore, the three Lean experts were asked. Table 3 shows the result of the evaluation. The rows show the categories of the requirements and the columns show the aspects of IT integration. The numbers indicate the match between requirements and IT integration: If the integration supports the requirement, it is marked “1”. If not, “-1”. If there is no influence, it is marked “0”.

Table 3. Selection of adequate IT integration based on requirements for Lean Basic Training.

Categories	Scope of processes		Moment of IT integration		Type of IT systems		Focus of IT integration		Involvement of participants	
	All company processes	Production process	At the end of the entire lean training	After each lean session	Large, Integrated enterprise solutions	Small, Focused IT solutions	IT is used generally	Applied problem oriented	Applied by a single worker	By a group of worker
Operating model	-1	-2	1	0	-2	0	1	-1	0	0
Purpose of LF	0	2	0	0	2	2	2	1	0	1
Processes	-1	6	0	0	3	2	2	2	1	1
Setting	-1	4	1	0	2	0	2	1	-1	1
Didactic	0	2	1	1	0	2	4	0	1	0
Lean theory	0	6	3	1	-1	3	6	-1	0	4
Digitalisation	-1	1	0	0	1	1	2	0	0	0
Total:	**-6**	**37**	**11**	**4**	**9**	**17**	**33**	**4**	**2**	**13**

In the following, the results of the selection are discussed. Starting with the scope, as the first aspect of IT integration, the result of evaluation is clear. The experts see a large benefit if IT solutions are available for all processes in the Lean Basic Training and not only for production. One reason for this is that interfaces between sales, purchasing and financial processes with production often cause problems in reality. To show how IT can help to overcome this hurdles is considered as a benefit in the simulation training. In the Lean Basic Training, participants start with a broken process which ideally should have improved by the end of the training. Now the question arises when to introduce IT. As the participants are already challenged by the application of Lean tools in a Lean Basic Training [16] it is preferable to introduce IT after the process was leaned out. This would also take the Lean experts´ reservations into account, stating that IT only raises complexity without any benefit. Therefore, only improved processes shall be automated [5]. For the Lean Basic Training this means that first the Lean methods shall be taught and applied to the broken process. Afterwards IT shall be introduced and additional improvement rounds shall conducted using IT [12]. Talking about the third aspect of IT integration, the types of IT systems to be used, the Lean experts were in favour of small, focused IT solutions. The reason for this was mainly because the processes and the layout in the simulation game need to be easily changeable. Contrary to small IT solutions, large enterprise software might be more difficult to adapt quickly. Another argument for small IT solutions is that large enterprise software, such as ERP or MES lead to higher licence costs and specific operating know-how. This raises dependencies from external suppliers and intensive training efforts for the trainers. Outside of the training environment, similar problems with unused functionalities, lengthy change processes and high costs hinder the application of large enterprise software solutions in a Lean environment [14]. Following the Lean principle of simplicity, processes should only be supported by IT where it makes sense. This is not given, if the processes are poor or complexity would rise inadequately by IT [5]. Our Lean experts came to a similar result on the focus of IT integration (table 4). First of all, implementing IT on a large scale without any specific need is not economical. Furthermore, the participants develop better problem solving skills using a problem-oriented IT integration approach. Problem solving skills are considered to be a core competence of future 4.0 workers [12]. The participants only use IT in order to further improve the process if it makes sense to them. As a result, the benefits of IT become more obvious for the participants. This corresponds to the opinion of Prinz et al. They favour an incremental, step-by-step implementation approach in order to reduce the participants´ feeling of overload [12].

5. Recommendations for IT integration and further research

In the following, recommendations based on the findings of the previous chapters are given. One insight was that neither Lean experts nor participants of the Lean Basic Training saw any benefit in IT support. This will lead to additional efforts in the conception of such a training, as the sponsors needs to be convinced of the benefit of IT in a Lean context. Otherwise they will not agree to additional training time for IT. If the support from sponsors and management is missing, the transfer will not be successful in the participants´ daily routines. This is similar to the problems of implementing IT in a Lean production in real life described by Adam and Grätz [14]. Apart from the support of the sponsors, the benefit must also be explained to the participants. When it comes to the second research question, the specific areas of IT support, common knowledge in training design has been confirmed: Know your audience and take them into account. When preparing the training it needs to be considered that participants appreciate IT support more in the areas they know from their own company. Similar IT support as in those companies shall be provided in the training. In addition, the existing IT know-how of the participants shall be found out in advance. The level of graduation of the participants shall also be considered. If the training is intended for participants of apprenticeships, electronic order tracking shall be available. If it is intended for foremen, electronic calculation of performance figures and electronic working documents shall be at hand. If there are many office employees in the training, the administrative processes shall be supported electronically. The third research question was about aspects of IT integration. The result was that IT support shall be available for all processes in the simulation game and that it is better to have small and flexible IT solutions instead of large and complex ones. IT shall be implemented after the process was improved by Lean tools. The IT tools shall be introduced problem–oriented and in a step by step approach. Finally, an outlook for further research is given. In the present study only the

effects of One Factor A Time (OFAT) were tested. Co-variances have not been considered so far. In addition, the results are only valid for a Lean Basic Training as well as participants from three branches. So far it is unclear if the findings are also applicable to other Lean trainings and different branches.

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