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Exploring the effect of digitalizing shop floor management

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Abstract

Shop floor management is an essential tool for manufacturing firms wanting to create a lean culture. Traditionally, shop floor management is operationalized through periodical meetings with the team on the shop floor in front of a visual management board (i.e., whiteboard). Some traditional lean researchers argue using such an analogue board improves employee engagement. However, others claim that digitalization offers new possibilities to lift shop floor management to the next level. To shed light on this discussion and provide empirical evidence, this paper explores the effects of digitalizing shop floor management in a multiple case study within a single firm.

Keywords: Digitalization, Lean, Shop floor management, Continuous Improvement

Introduction

Today’s manufacturing operations are complex processes with an increasing number of product variants. To ensure performance, operations managers need to motivate employees to strive for excellence. A popular tool to facilitate such a culture of continuous improvement is shop floor management (Hertle et al., 2015). This leadership approach stems from lean manufacturing and emphasizes continuous improvement (kaizen) among employees (Lanza et al., 2018). As there is no consensus about the definition of shop floor management (SFM), in this study we adopt the view of Hertle et al. (2015), who present SFM as an “integrated managerial system that facilitates the communication, control of performance, and implementation of lean methods on the shop floor”. Within the last decade, many manufacturing companies have been adopting some form of SFM to improve their processes (Lanza et al., 2018). Firms typically operationalize SFM by holding frequent meetings in front of visual management boards on the shop floor, where teams discuss current operational performance information and improvement suggestions. However, little research has been conducted on the success factors of SFM (Kurpjuweit et al., 2018). One reason for this is that the focus of SFM is the involvement of the employees (Hertle et al., 2015): therefore, cause and effects relationships are not easy to observe and successful practices not agreed upon.
On the one hand, the traditional lean literature often suggests the use of physical, analogue material (i.e., pen and paper) when it comes to information acquisition in problem-solving and improvement activities (Enke et al., 2018). They argue that digital technologies increase the complexity on the shop floor and thereby detach the operator from the problem-solving process (Parry and Turner, 2006).

On the other hand, advocates of digitalization and many consultancy firms favor the digitalization of as many operations as possible, including management activities. As digital possibilities increase, the shop floor must face the impending digitalization frontier, both embracing digital transformation and making use of the new opportunities it presents.

As the two streams differ in their perspective, the literature does not offer a clear guidance on whether or not to, or indeed when and how to, digitalize SFM. This research aims to enable improved understanding of how digitalization may affect SFM. Furthermore, it shall therefore shed light on the advantages and disadvantages of switching towards digital SFM.

RQ: How does the transition from an analogue to a digital form of shop floor management affect its performance?

Theoretical background
This chapter reveals an overview about the existing literature on digital shop floor management. To understand the rationale of shop floor management, this chapter first introduces its origins in the lean and the continuous improvement process literature. The paper continues with a brief review about the current trends in digitalization. Finally, it combines the two areas of shop floor management and digitalization by providing an insight on the current discussion about their synergies.

Lean management and CI
The history of lean management traces back to the research conducted by Krafcik (1988) on the International Motor Vehicle Program. This research has yielded in many following studies and contributions, in which The Machine that Changed the World and Lean Thinking were among the most popular ones (Womack et al., 1991; Womack and Jones, 1996). The aim of lean is to eliminate waste thus deliver more with less, encouraging firms to strive towards perfection. Womack and Jones (1996) define five principles to achieve this. Specify customer value aims to ensure that only products that address a customer need are designed and produced. Identify the value stream intends to identify and eliminate non-value adding activities in the entire value stream. Flow production enables short cycle times, low WIP inventory and high flexibility to produce a variety of products. According to the pull principle, products are pulled through the value chain based on actual customer demand. Overproduction is prevented as products are only released in the process if the downstream processes step requires replenishment. Finally, strive for perfection demands the critical scrutiny and continuous improvement (CI) of the status quo based on active involvement of qualified and empowered employees.

The latter principle is reflected in the continuous improvement process (CIP) and has received research not only from the stream of lean literature but also from total quality management (Lam et al., 2015). The CIP helps to constantly develop processes further towards an overarching goal or next target condition (Rother, 2010). The Japanese term kaizen is often seen as a synonym for the CIP. Kaizen was first introduced by Imai (1986). He differentiated the concept of kaizen into three different hierarchical areas of participation: management, group, and individual. On these different levels, kaizen aims
Digitalization of the shop floor management

In recent years, the digitalization of manufacturing has received a high attention from both researchers (cf. Kusiak, 2018) and policy-makers (Prinz et al., 2018). It thereby constitutes one of the most significant trends in industry and society alike (Hagberg et al., 2016). Even though many of the digital technologies are not new, the rate at which they are recently finding their applications in manufacturing is increasing (Yoo et al., 2012; Brynjolfsson and McAfee, 2016). The potential of digitalization are able to increase revenue and productivity as well as innovation alike (Matt et al., 2015). This can be achieved by the successful implementation of existing and emerging digital technologies. Among other implications, these technologies allow for a horizontal and vertical connection of data within the production (Kagermann, 2014). This leads to an increased transparency over the processes within production.

With the technological possibilities of connectivity (e.g., manufacturing execution systems or cloud computing) and visualization (e.g. interactive screens and data analytics) organizations consider reducing the amount of paper within production by digitalizing such tasks instead. This often means that the traditional whiteboards used for SFM are considered as potential targets for digitalization. Several scholars have been discussing and studying the possibility and the effect of a digital SFM (Hertle et al., 2015; Lanza et al., 2018; Sven-Vegard Buer et al; Müller and Müller, 2018; Hambach et al., 2017).

Digitalization of SFM is related to the transfer of otherwise analogue tasks of data collection and / or visualization to automated digital solutions. Examples for data collection are obtaining daily production levels or the reoccurrences of certain failures. Even though this data might be collected digitally (e.g., through an ERP or MES), they can still be visualized analogue. For instance, when a shift leader prints retrieves the data,
prints it, and puts it on a white board. This analogue process is still widely happening within industry (Lanza et al., 2018).

Transitioning to digital SFM not only changes both, the collection and visualization of data, but also the analysis during the meeting (Hambach et al., 2017). Expected benefits from digitalizing the SFM tasks include increased transparency, quicker reactions on deviations, and improved decision making through data (Lanza et al., 2018). Hambach et al. (2017) also see potential in reducing time-consuming activities and further elaborate on visualizing the strategic alignment with company-wide goals as well as deviation management through real-time data.

Method
To investigate the effect of the digitalization of SFM we used a multiple case study within a single firm (Eisenhardt, 1989; Yin, 2013). The firm produces technological products for the maritime industry and is headquartered in Norway. At the site of the case study the firm has been implementing lean and shop floor management (SFM) since 2015 on teams at the shop floor and in 2017 scaled up to include the senior management team. It recently transitioned its SFM from analogue to digital throughout the organization, migrating its kaizen platform from whiteboards with paper cards to a digital, online solution. To increase the generalization, we conduct research at team level and investigate multiple teams. Thereby, we differentiate between different types of teams. In total, we investigate the CI activities of four teams, described in Table 1. The first two teams work on the shop floor at the headquarters in Norway. We choose two teams that differ in size (number of employees). The first team consists of a large number of employees whereas the second is a small team. The divisional management team forms the third team, representing possible differences from the hierarchical levels. We also choose a fourth team from a subsidiary in Germany.

Table 1 – The analyzed teams in the study

<table>
<thead>
<tr>
<th>Team ID</th>
<th>Area</th>
<th>Employees</th>
<th>Year of CI introduction</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shop floor</td>
<td>24</td>
<td>2015</td>
<td>Norway</td>
</tr>
<tr>
<td>2</td>
<td>Shop floor</td>
<td>5</td>
<td>2015</td>
<td>Norway</td>
</tr>
<tr>
<td>3</td>
<td>Management</td>
<td>10</td>
<td>2017</td>
<td>Norway</td>
</tr>
<tr>
<td>4</td>
<td>Shop floor</td>
<td>16</td>
<td>2015</td>
<td>Germany</td>
</tr>
</tbody>
</table>

We first quantitatively investigate the effect of digitalization on the CI performance. For constructing a relevant performance measure for the CI we use the number of completed (implemented) improvement suggestions from the employees per year. To compare the performance, we gathered data on the number of suggestions before and after the implementation.

In the qualitative part of the research, we conduct semi-structured interviews with the teams. We lead further interviews with other teams and employees of the company to obtain an external perspective and receive a holistic view. This enriches the quantitative analysis and helps to identify the antecedents for the changes. The interview guide can be found in Appendix A. We visit several shop floor management meetings and observe the meetings. This helps us in triangulating the data and ensures that what the interviewees answer can be found in the reality.
Table 2 – Description of the interviewees

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Area</th>
<th>Team</th>
<th>Function</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shop floor</td>
<td>Other</td>
<td>Change Agent</td>
<td>40min</td>
</tr>
<tr>
<td>2</td>
<td>Shop floor</td>
<td>Other</td>
<td>SC Lean Champions</td>
<td>45min</td>
</tr>
<tr>
<td>3</td>
<td>Shop floor</td>
<td>1</td>
<td>Change Agent</td>
<td>30min</td>
</tr>
<tr>
<td>4</td>
<td>Shop floor</td>
<td>2</td>
<td>Change Agent</td>
<td>30min</td>
</tr>
<tr>
<td>5</td>
<td>Management</td>
<td>3</td>
<td>QC Manager</td>
<td>40min</td>
</tr>
<tr>
<td>6</td>
<td>Shop floor</td>
<td>Other</td>
<td>Group Leader</td>
<td>45min</td>
</tr>
<tr>
<td>7</td>
<td>Shop floor</td>
<td>Other</td>
<td>Team Leader</td>
<td>40min</td>
</tr>
<tr>
<td>8</td>
<td>Management</td>
<td>Other</td>
<td>Production Manager</td>
<td>45min</td>
</tr>
<tr>
<td>9</td>
<td>Management</td>
<td>Other</td>
<td>Finance Manager</td>
<td>30min</td>
</tr>
<tr>
<td>10</td>
<td>Shop floor</td>
<td>Other</td>
<td>Planner</td>
<td>45min</td>
</tr>
<tr>
<td>11</td>
<td>Management</td>
<td>Other</td>
<td>Lean Program manager</td>
<td>30min</td>
</tr>
</tbody>
</table>

Analysis
Currently, the company has two types of shop floor management meetings. In the first one, called Kanban meetings, the teams meet every morning to define what they are working on today. The second meeting, called Kaizen meetings, takes place once every week and discusses the status of new and current improvement suggestions from the team. It is the kaizen process that has recently been digitalized – the firm currently maintains an analogue system for Kanban. The transition from before to after the digitalization is illustrated in Figure 1.

As such, the results of the quantitative analysis are illustrated in Figure 2. The digitalization of SFM (kaizen platform) seems to negatively affect the large team, resulting in a small reduction in improvement activity. We suggest that this may be due to a phenomenon we shall call out of sight, out of mind, which implies that the drop in performance of the larger team may be due to the fact that the larger the team, the easier it is for members to “disappear” into the digital world – with less perception of
accountability for not presenting / realizing improvement suggestions. For the other three teams, however, we find a (significant) increase in improvements. The ongoing qualitative analysis shall help to investigate the causes for the different patterns.

![Figure 2](image)

**Figure 2 – Number of improvement suggestions per year and team (before and after digitalization)**

**Discussion**

The analysis shows that there are multiple fields of improvement with the digitalization of the shop floor management. In the following section we present propositions that have been derived from our analysis of the case study.

**P1: Digital CI systems can improve horizontal collaboration.**

First, the digitalization of SFM allows for greater horizontal collaboration. Improvements that are suggested by the employees do not always only affect the team from which it stems from. Sometimes other teams are affected or do not support in the problem-solving process. Before the digitalization this would mean that the team manually transfers the improvement suggestion to the other department in which it is taken care of. By transferring the card, the team also lost track of it. It was not clear whether or not the improvement was realized and which actions were initiated in order to do so. As one interviewee stated “[…] we did not know what happened to the suggestion when we were giving it to the other team”. After the implementation the team could digitally assign the improvement suggestion to another team without losing track on the progress of the card.

**P2: Digital CI systems can improve the vertical escalation.**

While some suggestions can be solved at the team level on the shop floor, some others might require the involvement of higher-level management. Such decisions might be related to higher investments or affect the strategic position and therefore need approval. An interviewee mentions this speed of escalation: “We get a quicker decision on whether the improvement can be implemented”. As for the horizontal connection a digital shop floor
management system also allows for vertical escalation towards higher-level management. Suggestions can be tagged and forwarded to the management board meetings. This increases the speed of decision-making and transparency for the employee that identified the improvement suggestion.

**P3: Digital CI systems can optimize workflows by reducing administrative time.**

In line with Lanza *et al.* (2018) the case reveals the benefit of reduced preparation time through digitalization. Data collection and visualization (i.e., printing, posting, etc.) can take time of the team leader. As one team leader states: “... before it took me around half an hour to prepare the meeting and assign tasks.” Having the data in real-time, digitally, allows the team leader to focus on other important activities that add value to the team’s performance. Follow up time

**P4: Digitalization of shop floor management does not have to reduce employee engagement.**

One of the central criticisms against the digitalization of shop floor management is the loss of engagement of the employee who cannot relate to the digital board in the same way as to the analogue. However, we did not find this in our interviews. The engagement was not affected by implementing the digital solution, neither negatively nor positively. As one interviewee puts it: “I don’t care whether I write it manually or on the screen. This doesn’t affect my suggestions.” The quantitative data supports this assumption. In contrast to the criticism, the amount of improvement suggestions went up after implementing the digital solution in most cases.

**P5: Digitalization provides possibility for analyzing data on historical CI activities.**

Even though some solutions promise benefits from analyzing historical CI data, none of the teams used that data. Potential benefits would include learning or suggestion prediction. Having the improvement suggestion written on paper restricts an automated inquiry. However, the digitalization allows for filtering and searching for specific historical suggestions. These previous suggestions could be used for revealing recommendations for current problems.

**P6: Technological experience of the employees affect the transition.**

Finally, the potential benefits are also influenced by the technological experience of the team. Being used to digital systems in private life helps to adopt to digital technologies at work as well. The case study revealed positive reactions of the employees on the digitalization of the shop floor management. However, this might have been different in other companies, especially in less technological developed countries. An interviewee confirms this by stating: “For people that are not used to digital technologies, the effect may be different and they might be less confident with the system”. But at the same time, it is important for the company to make use of the employees capabilities to use digital tools. If they are able to use them in their personal life to make it easier and more efficient, why should they refuse to do so at work?
Conclusion
This research contributes to the discussion between lean traditionalists and digital advocates about the digitalization of shop floor management. It helps in exploring the changes and their underlying antecedents that occur when an organization decides to implement digital SFM. Building up on the existing discussion in the literature the study derives several potential benefits and challenges when digitalizing shop floor management. To validate these, we empirically investigated the transition of a company from analogue to digital shop floor management. Thereby, the study suggests six propositions for the suitability of digital shop floor management. For practitioners this research supports deciding whether a digitalization of their SFM should be undertaken and what to expect from it.

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Preprint accepted by the EurOMA conference 2019 in Helsinki


Sven-Vegard Buer, Giuseppe Ismael Fragapane and Jan Ola Strandhagen, “The Data-Driven Process Improvement Cycle: Using Digitalization for Continuous Improvement”.


Appendix A – Semi-structured interview guide

I Introduction
Characteristics of interviewee
1. Please briefly introduce yourself and your current position
   a. Position
   b. Career background
   c. Years of employment
2. What do you understand under the term SFM (meetings)? Which functions do you include under SFM.
3. How many of such SFM meetings do you attend in a working week?

II Application of digital shop floor management
General questions about SFM
4. How often do you perform SFM meetings? And who is involved? Does the SFM cascade?
5. Which topics do you address in SFM?
6. Why do you use SFM? What do you think would happen if you would stop doing it?
7. How do you measure the performance of your SFM itself?

Transition to digital SFM
8. Did you digitize parts of the SFM functions? If so, which ones?
9. What were the reasons for implementing digital functions into your SFM?
10. How did you digitize the SFM? Did you develop your own solution or bought an existing one?
11. How did the implementation work?
12. How is the data for the SFM collected? How do you visualize it?
13. Which KPIs do you track? How are they aligned with organizational goals (e.g., Hoshin Kanri)?
14. How do you feel has the SFM changed after the digitalization?
15. In your opinion, what are the benefits of the digital SFM in comparison to the analog?
16. What disadvantages do you see?
17. How did it affect the continuous improvement process?
18. How did the role of the employee change after the digitalization?

III Conclusion
19. Do you think the digitization of the SFM improved the SFM?
20. Do you want to add something?