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When digital lean tools need continuous improvement

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Abstract. Lean practitioners have traditionally been reluctant to automate and digitalize production. Over the last years the combination of lean and digitalization has been actualized in academic publications, but still there are unanswered questions. In this paper, we address the relationship in a qualitative case study of a performance management system in a lean production context in a department of a Norwegian light-metal production company. We find synergies between lean and digitalization, as the digital system supports visualization of performance, problem analysis and continuous improvement through employee involvement. Nonetheless, we also find that digital solutions might be a barrier for motivation and further production improvement when IT systems are not developed aligned with the continuous improvement on the shop floor. We encourage organizations to find alternative ways of organizing the relationship between distributed continuous improvement and centralized IT development to strengthen the synergy of digitalization and lean.

Keywords: Digital Lean, Continuous Improvement, Organization Design.

1 Introduction

It is wrong to automate something just because we can – Taiichi Ohno [1], p 93.

The wise sayings of Taiichi Ohno and other Toyota senseis have led many lean enthusiasts to be reluctant to automate and digitalize production [2]. Improving work processes prior to automation, and keeping things simple, “low-tech” and flexible have been, and still remain, the ideal for many lean practitioners.

In recent years however, both academics and practitioner are pointing to the attractiveness of combining lean management with information technology, digitalization and automation, often referred to as Industry 4.0. Pinho and Mendes [3] reviewed publications, showing evidence that lean and IT were both complementary and mediators, but also rivals in practice, calling for further empirical studies. In a later review, Lorenz et al. [4] argued for synergy: 1) digital solutions support lean and 2) lean supports dig-

italization. As examples of the first point, IT-systems have been shown to improve supply-chain efficiency [5], reduce costs and waste regarding time [6], and control, error detection and correction [7]. Regarding the second point, recent publications [8][9] state that lean fosters benefits of digitalization and emergent technologies, even that without lean thinking, firms risk to “digitalize waste” [4], an echo of Ohno’s advice.

This paper addresses the relationship between lean and digitalization through a case study of a performance measurement system, which was designed and used to support continuous improvement at the shop floor. Our findings support the synergy view, with one important reservation: Unless the development of the IT-systems can keep up with the developments at the shop floor, they likely become barriers to further performance improvement. The way IT development is typically organized makes this issue an important practical problem. We encourage organizations to explore new ways of organizing the relationship between distributed continuous improvement and centralized IT development.

2 Methods

Our case study analyses the use of a digital tool for performance measurement, called Team Performance (TP), in a department of a Norwegian electrochemical plant, here called Department. Department has around 240 employees, divided into five shifts with seven teams on each shift producing liquid light-metal in large batches during continuous 24-hours production. This department was chosen due to being a pioneer in using TP to support continuous improvement.

Qualitative data was collected during a two-day visit to the plant in October 2020 where we collected field notes through 7 observations on the factory floor, 7 observations of meetings and 15 recorded interviews. Subsequently, we conducted 10 additional interviews by video conference. In total, the informants represent all organizational levels: operators, employee representatives, middle managers (shift managers and process managers), division manager, and divisional support staff including head of organization development and the project manager with responsibility for design and training of the overall performance measurement system. In addition, we have secondary data from collaborating with the case organizations over several years, including visits to other plants, participation in workshops and other activities.

The themes in this paper emerged inductively from the data collection and analysis process [10]. Field notes and transcribed interviews were coded thematically [11] by two of the researchers and discussed to develop common interpretations. The overall analysis was fed back in a presentation and discussed with the company for informant validation. The data were categorized in several steps where the structure in the findings section represent the top-level categories with excerpts from the underlying coded material.

3 Case description and analysis

In 2007, the case company developed its own «company-specific production system» [12], which was implemented at the different plants and departments in the following years. The production system combines conventional lean principles for process control and continuous improvement with ideas of self-managing teams and less-hierarchical organizing. While repetitive task should be standardized, operators should also be skilled and empowered to respond to deviations in the chemical processes, see [13] for a similar case.

A small corporate staff is responsible for documenting and updating the content of the production system and producing teaching material. They also conduct training and support improvement initiatives at the plants, along with local lean-coordinators, typically one or two at each plant. In practice the different plants, and even different departments, are free to emphasize different tools and principles, depending on the nature of production and short-term priorities. A structure of parallel teams is set up to aid knowledge transfer (“best practices”) between plants regarding the main technical processes.

In 2016 Department was chosen as a pilot unit for implementation of TP. In short, TP is a performance measurement system that collects and displays data from several machines and other systems, presented as selected performance indicators (PIs). The teams can monitor their own performance or analyze their development over time. They can also compare their performance to other teams. Furthermore, TP is used in Department’s various meetings, for quality control, feedback, problem analysis and learning. Hence, TP supports local improvement and learning, and also the company’s overall lean approach as explained by the head of the corporate staff:

TP supports execution of standard operational procedures, (...), it gives important input to our improvement meetings (...), it has an impact on the optimization of flow (...), it is important for the team and individual competence development (...), [and] it helps managers focus and pay attention to tasks in a good dialogue with the teams.

3.1 TP supports and motivates performance and improvement

TP has been well received and utilized in Department. Although our informants report variation in enthusiasm, TP was generally described as a highly effective tool for quality control and improvement. Our observations confirm that TP was evident in the working routines and regular meetings. The performance measures were also discussed informally during breaks.

TP seemed to motivate workers to perform and take part in improvement activities. Both managers and operators confirmed that TP enhanced the workers' motivation to perform and learn as they could see their own results and analyze the causes and effects directly. One union representative said:

What we have achieved is a system that shows us that changed effort leads to improvement, more efficiency and improved profit. And at least, I should mention, TP is an opportunity to participate, which means a lot to people. Having a chance to improve your workplace.

The high level of utilization can be explained by TP being tailor-made for certain teams and processes in Department. As one of the process managers told us: *I would claim that the standard dashboards are tailored to the needs we had back then.* On the other hand, work-groups in Department which had been less involved in the design of TP found it relatively harder to relate and employ TP.

3.2 TP needs to keep up with development to support the processes

Department had a 13-year history of systematic continuous improvement at the time of our visit. We found the learning-and-development mindset integrated in the informants' reflections, also towards a performance measurement system like TP, as illustrated by one of the managers:

Ideas have to grow from the organization. Understanding what to measure is a learning process, this is not initially apparent. (...) There will appear suggestions from the organization on what to measure to improve along the process.

TP had been designed and implemented at one point in time, and the risk of the system lagging behind the developed needs for digital support of process improvement was apparent in the interviews. We will highlight three aspects here:

Firstly, concerning **adjustment of standard threshold values**: TP has a traffic-light function showing red, yellow and green depending on deviation from defined target values of the PIs. After improving their accuracy for years, the teams' actual targets had become more nuanced, leading to the demand of a more detailed palette. One of the process managers had programmed an excel spreadsheet supporting different shades of green and yellow, but she did not have access to change the standard threshold value settings in the TP system. Another manager explained the situation to us:

The challenge now is that some teams perform so well on the existing measures that they may get demotivated. They need something new to strive for, more than to make the green numbers even greener.

Secondly, **development in what to measure**. Standard PIs were seen useful for the managerial teams at the corporate level as they were able to benchmark results and spread best practice within the company. Nonetheless, managers and operators at Department had a different view here. While they had moved forward in their learning process, Department called for different PIs as their problem areas had shifted. Furthermore, various teams had different needs for improvement and control. This was a concern of the union representative:

We have talked about finding new things to measure. Being stuck in the mud is less interesting for operators.

An update in PIs in TP would nevertheless be unsatisfactory as the expressed need at Department was constantly improving and changing PIs to support the development areas for production. One of the managers stated:

Managers have reported that we need dynamic PIs, a dynamic portal with relevant PIs. Presently TP is static, at risk of being stranded. The energy drains out and we need to get the [central] tech team onboard.

Thirdly, our informants did not only call for moving threshold values or focus areas, but to **expand the whole TP system** to provide more detailed information and further support for statistical analysis. One of the process managers acknowledged that TP is not yet complete:

We have significant operations to which TP does not give feedback, operations that are important for the overall process stability. We acknowledge that we have lost some things on the way; issues become degraded as they are invisible on the dashboard.

3.3 Access to fix and improve digital solutions

Successful digitalization is about more than software. This was clearly exemplified at the time of our visit at the plant. The head of Department told us:

We used to have screens like iPads, but when you have 50 operators and 2 devices for each team you hardly have time to log on during a 15 minutes brake. Thus, we bought the large touch screens on the walls in the team rooms.

At the time we visited the plant, the screens were out of order to the operators' frustration:

Some teams struggle with the motivation. Normally we have touch screens in all the team rooms where they can check and discuss their performance during breaks. These screens have been broken for a while now, and then it's hard to keep the good spirit.

However, fixing hardware was within the Department manager's power of action, and at the time we presented our findings for the case organization for validation, this problem was solved. Software changes in the TP system seemed more arduous having a long decision-making chain from a local operator to his manager, coordinated at Department and then to the central software team if the suggestion reached up on the corporate list of priorities. One shift manager explained the gap in time and space:

Well, then we have to address problems during daytime and they [central unit] need to agree upon our requests. We do not even always agree on changed measures across shifts. It is a cumbersome process, as for everything we want to change. It is time consuming.

Even the coordinating manager at Department found this path frustrating:

I'm in charge of the digital part. If they want changes in the dashboard, I handle it. Not technically, but I report it further. (...) I struggle to get through and get help from those on digital (central unit) (...) They do not have the capacity to prioritize our needs. (...) When they are not engaged it is hard to get the operators on board.

4 Discussion and conclusion

Our findings on the relationship between lean and digitalization is paradoxical. On one hand, TP visualizes the production process and results in a way that supports performance management and problem solving. Hence our findings show that digital tools can support lean production [4][14]. On the other hand, our findings demonstrate that the digital systems can appear as barriers to performance and process improvement if they cannot keep up with the pace of improvement at the shop floor.

Previous research has addressed a concern about digitalization as "technology push" where processes are modified to fit new technology rather than the opposite that is central in lean [1][15]. Further, one has argued that digitalization often enhances complexity whereas lean stands for reducing complexity [4]. Our findings show that lean and process improvement can push the need for new and more complex digital solutions whereas existing digital solutions can lag behind.

Ashrafian et al. [16] considered organizational aspects to explain both synergies and challenges between the logics and practices of lean and digitalization. The lean work organization, characterized by shop-floor empowerment, might be counteracted by digitalization. As we have seen in this case, digitalization is often driven by IT-experts organized in central units, creating or configuring solutions based on corporate or marked standards. Increased digitalization can lead to a redistribution of power in the organization. As continuous improvement becomes more data-driven and the complexity of problem analysis increases, responsibility and influence move from the operators

to experts on statistics and technology at central staff divisions. Central IT-experts are challenged to deliver updated solutions to several different production units and are simultaneously striving for standardization for cost efficiency and data integration. When diverse units improve their practices and experience different IT needs, organizations might experience an increased time-space-gap [17] between central developers of digital solutions and various local users of digital solutions.

Solutions to keep the speed of process and technology development in balance could be found in designing a digitalized lean organization. Local lean activities should be coordinated by managers on all levels in the organization to increase the effects [18], whereas digitalization teams and experts should be organized in ways that close the distance in time and space to the local users on the shop-floor level. We call for more research on how to align strategies and organizational structures for lean and digital solutions in production development, however suggest that digitalization and lean should be handled less as two opposing concepts in organizational practice.

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