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Prof. Dr.-Ing. Lars Ruhbach, Kris Dalm MBA

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ABBREVIATION

VUCA	Volatility – Uncertainty – Complexity – Ambiguity
GPS	Global Positioning System
SME	Small and medium-sized enterprise
TPS	Toyota Production System
LCIA	Low Cost Intelligent Automation
RFID	Radio-Frequency Identification
MES	Manufacturing Execution System
CPS	Cyber-physical System
CIP	Continuous Improvement Process
5S	Sort, Set (in place), Shine, Standardize, and Sustain
SMED	Single Minute Exchange of Die

Lean Philosophy versus Digitization? - An Attempt at Reconciliation.

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Keywords:
Lean Management, Lean Digitization, Digitization, Digitalization, Industry 4.0

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1 INTRODUCTION

Lean philosophy as a term having derived from the Japanese production philosophy of eliminating the waste in either manufacturing or service has not only led to visible improvements in the past few years, but also to a change in mindset that, after intensive efforts, has eventually and with some delay become established in small and medium-size companies. Growing globalization and the associated accelerated need for an increase both in efficiency and flexibility requirements are now forcing manufacturing companies to push for change. The efforts to introduce lean concepts are just beginning to bear fruit, as producers are already being overwhelmed by the digitization wave, which under the pseudo-modern designation Industry 4.0 suggests to the managers that revolutionary change is necessary. It is irrelevant whether Industry 4.0 is actually an industrial revolution or a normal development process that is fast and inevitable due to rapid technological progress. The fact is that production and logistics will increasingly have to adapt to changing requirements and trends in terms of competitiveness. The challenges of the modern world, on which one must orient oneself, can be described by the term VUCA. This acronym is familiar to almost every manager today and refers to the following characteristics [1, p. 4].

V - Volatility
U - Uncertainty
C - Complexity
A – Ambiguity

The integration of the building blocks of digitization in the Lean world and the handling of the associated technologies provide enormous potential for mastering this task, but sometimes contains contradictory views and again requires considerable implementation competence. If one has said goodbye to certain automation elements in the context of introducing Lean Philosophy, for example, a trend towards automation can be recognized again today. Reasons are the changed feasibility limits, which today allow the combination of flexibility and automation. Typical examples are driverless transport systems that were still disinvested a few years ago because they required the complex laying of new lane guidance systems when the route was changed. As layouts must often be changed or adapted to new product variants in the course of continuous improvement, a rigid route does not fit into modern production. Now that today's systems are able to drive around obstacles independently using GPS control [2], driverless transport systems are again being discussed intensively.

2 CHALLENGES OF DIGITIZATION

It is undisputed that companies must follow the path of digitization. The current development offers considerable potential, but also has disadvantages. Figure 1 shows the advantages of the digital world, which can also lead to risks and disadvantages. The changes inevitably result in a change of requirements and burdens as well as new fields of activity. The reaction in real time and the high speed with which complex tasks are solved enable positive effects, but easily lead to a cognitive overload. Working hours can be made more flexible, and this apparently satisfies the desire for a better work-life balance, but this can also mean the loss of sovereignty of time due to constant availability. Bainbridge already pointed out the irony of the automation of monitoring and control processes in industry in 1983 [3]. In critical situations, the operator is not only required to master the tasks but also the background for which the automation was created. Even if responsibility remains with people, the action impulse is often triggered by the technology, which defines the pace and required reaction speed.

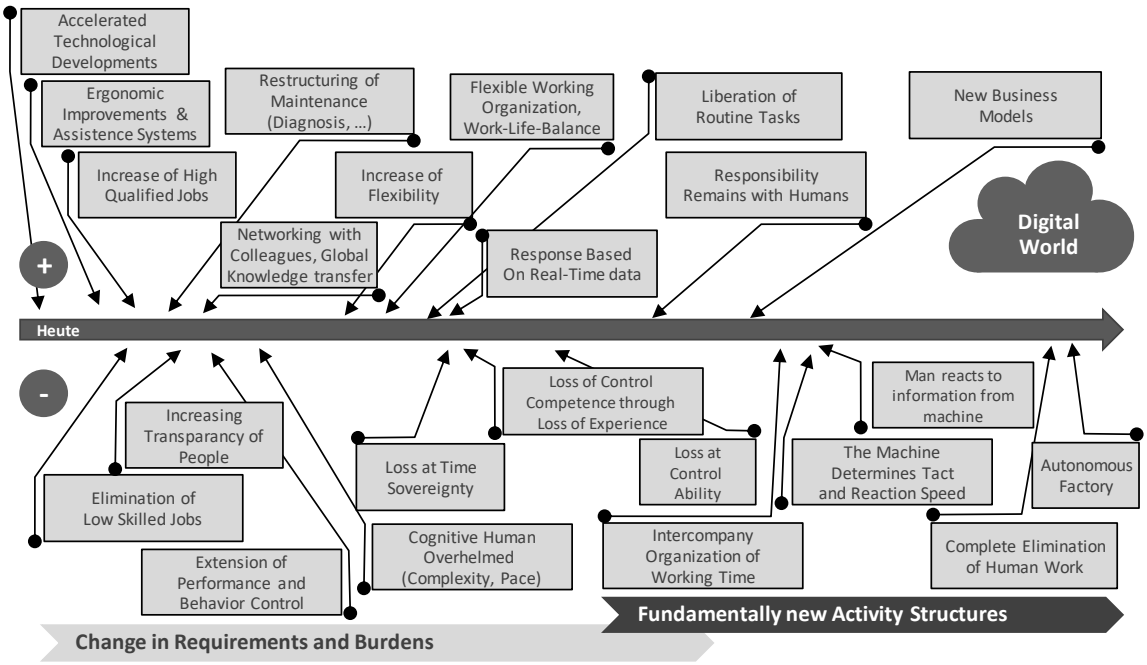

Figure 1: Advantages and disadvantages of the production-focused digitization vision[3]

[3] Own illustration

The basic challenge is to analyze the modules and to adapt them to the specific circumstances while reducing the disadvantages. The question focuses on how the challenges of digitization can be interpreted and mastered in a company-specific manner. Thus, there is both a knowledge problem and an implementation problem.

Knowledge problem

Economically, the development promises great potential. Statistics put a substitutability potential for people in the manufacturing professions through IT solutions in the range of 70% [4, p. 32 ff]. Such values are frightening from a socio-political point of view, but against the background of an increase in productivity they are tempting for the managing director and lead to controversial views and goals that can hardly be implemented within the company. These target conditions often lead to incorrect assessments of actual situations in the company. The problem of knowledge is therefore not an uncertainty about existing possibilities, but an uncertainty about which of them are suitable. Implementation scenarios for digital solutions are already being discussed without having a clear picture for Industry 4.0 or even a digitization strategy in production and logistics [5, p. 33 ff]. Irrespective of a lack of realistic location determination, the contents of this discussion are networking, digitization, interdisciplinarity and automation and their socio-economic effects. Within the department, digitization goals are set without prioritizing them in relation to the overall system. Companies have already had this experience when introducing lean components, so that parallel introduction scenarios can be identified.

Implementation problem

Once the companies have come to understand which steps can and need to be taken, the second barrier is their implementation. Production areas depend on the support of information technology. In this respect, the basic qualifications of the employees are often so divergent that a lack of understanding inevitably leads to implementation problems. In addition to the actual technological tasks, a variety of framework conditions must be considered that can hardly be influenced and therefore make the task difficult, especially for small and medium-sized companies, and make progress unclear. These conditions result partly from the megatrends and partly from sector-specific, regional or global disturbances. However, companies of the size mentioned above are under particular pressure, because on the one hand they are forced by the competition and customer requirements to develop together with them, but on the other hand often have neither the economic nor the structural possibilities. SMEs[4] often lack attractiveness for highly qualified workers who could make improvements with specific or interdisciplinary knowledge.

[4] SME - Small and medium-sized enterprises

Figure 2 shows examples of digitization modules in production, which companies are considering introducing. The discussions are currently based on a high degree of automation, which is a structural challenge for many companies. The implementation is complex and requires the resolution of the historically established hierarchical application structure in favor of an autonomous system capable of making decisions [6, p. 17].

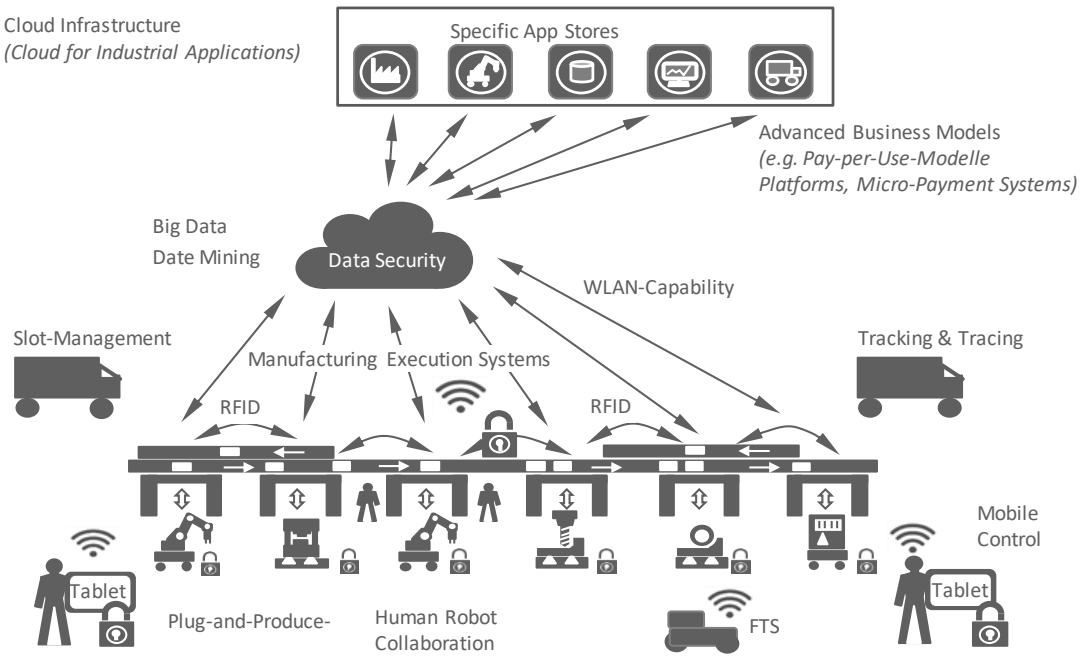

Figure 2: Digitization modules in production[5]

[5] Own illustration

3 LEAN DIGITIZATION OR DIGITAL LEANNESS

Companies are currently faced with the task of having to combine two philosophies that are quite contrary to one another if they are misinterpreted in an ongoing change process. The success of the lean concept is based on the adaptation of principles, methods and tools to the special circumstances and operational difficulties of the company within the framework of a holistic concept. This in turn is based on the basic principles of the Toyota production system. Its Kaizen concept is lived as a philosophy and fundamentally questions complex technologies. The TPS system shown in Figure 3 focuses on continuous improvement. Decisive aspects here are personal responsibility of the teams and the consequent avoidance of waste.

With regard to the new tools, it can be clearly concluded from this that only optimized processes may be included in the digitization considerations if one does not want to create another type of waste or to automate waste by including avoidable and unusable process data [5, p. 50].

These principles of lean philosophy are still valid in the digital world and must be the cornerstones of action when introducing new building blocks. Nevertheless, there are inevitable conflicting goals between the lean philosophy and technology-driven digitization "euphoria".

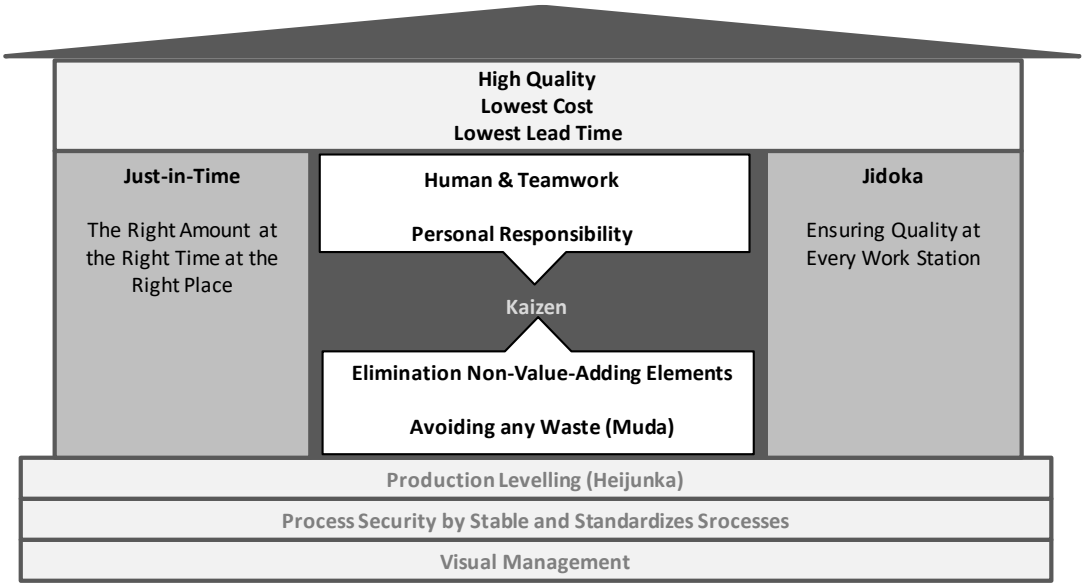

Figure 3: Principles of the TPS (based on [7, p. 65])

While the lean approaches that are successful in production rely on direct communication and on-site presence, networking and IT applications pursue an autonomy that makes on-site communication seem almost superfluous for the worker. Even if this is not the declared goal of the software solutions developed, in practice the effect on the production staff on site is more important than the intention of the software provider.

The companies often struggle with the attempt to delegate responsibility directly to the shop floor and with daily production reviews to motivate the management level installed there again and again to achieve the correct reaction to a deviation from the target by means of target agreement and target achievement. Here, digital options help with the analysis and detection of deviations, but they can help only to a limited extent with sustainable problem solving.

In companies that rely on comprehensive IT solutions in production, data availability is significantly improved, but often there is also a significant decrease in communication. Efficient rounds of kaizen among experts are disappearing more and more, as there are companies in which neither manual notes in production nor flip charts can be found in the meeting rooms.

As a result of the powerful data acquisition, data storage and data processing, knowledge can be derived in an excellent manner, but of course it requires correct interpretation and improvement in a sustainable manner. In such cases, projects might fail both because of ignorance of what is required for improvement and how it can be achieved (knowledge and implementation problem). While the technology of Industry 4.0 development can provide data even more detailed and can thus track down ever more complex problems, the methods of lean management provide support during implementation. Most daily operational problems are not so complex that they cannot be solved with the logic of simple problem-solving techniques and an intelligent selection of relevant data. The technology hype often obscures the eye for obvious and easily usable potential. Data is collected and archived without having to define in advance what the purpose is. Table 1 describes further potential trade-offs between the combination of the lean world and the digital world.

Lean World	Digital World
The employees and their responsibilities are the focus of our actions. The team leader / hancho has a key role and calls for improvements.	The available technology is used and determines the action.
The critical examination of automation leads to transparency and flexibility. Automation is only used as LCIA[6] where it is absolutely necessary.	Automation is an integral part of digitization and necessary for data acquisition at all stations.
Shop floor stocks are dominant and ideally even physically visualized in order to create transparency for those responsible even without IT systems.	All shop floor stocks are scanned and can be called up systemically. Ideally, stocks can be located at any time via RFID[7] and called up in the system.
The focus is on personal communication and the continuous involvement of employees in Kaizen circles at all hierarchical levels.	Digital communication replaces personal communication, the analysis is carried out by algorithms or is significantly supported by them.
Dealing with data is complex and requires discipline and a clear focus on what is necessary. Data acquisition is part of the way to determine the cause.	Amounts of data and storage capacities only play a subordinate role and enable the collection of data without the need to clearly define its use.
Manual shift notes are preferred as a means of increasing motivation in shop floor management. With the data entry the feeling of goal achievement is strengthened.	All data is collected in digital form, making manual documentation unnecessary and / or making it seem annoying.
The path to production (Gemba Walk) is necessary in order to be able to capture important information from production and its background.	IT systems enable real-time access to data and allow diverse and detailed evaluations at any time.
The simple consumption control with manual systems (signal or card Kanban) allows elaborate IT systems to be dispensed with.	The use of real-time IT systems enables efficient control of production (e.g.MES[8]).
The basic principle of the procedure is the striving for standard states in which both the technical facilities and the business processes run.	The mastery of complexity challenges standard states and allows the individualization of singular processes.

Table 1: Comparison of the lean world with the digital world

[6] LCIA – Low Cost Intelligent Automation

[7] RFID - Radio-Frequency Identification

[8] MES – Manufacturing Execution System

4 GENERAL CONDITIONS OF IMPLEMENTATION

Technology

Most of the work is still done in known structures. Production mostly uses the classic architecture model, in which the company orients itself at the planning level on the capabilities of the ERP system and the production processes on the production level are controlled with the support of MES systems, as shown in Figure 4. While the exchange of information in the classic approach is hierarchical and with strictly defined algorithms, other approaches are possible today that often lead to incomprehension and therefore acceptance problems among the responsible managers. In addition to the challenges of plant automation, modern factories are increasingly affecting logistical processes that have not been sufficiently prioritized in the past [8, p. 54]. Cyber-physical systems (CPS) in connection with modern possibilities of data access and methods of data storage offer the possibility to network technical facilities and to make decisions based on algorithms.

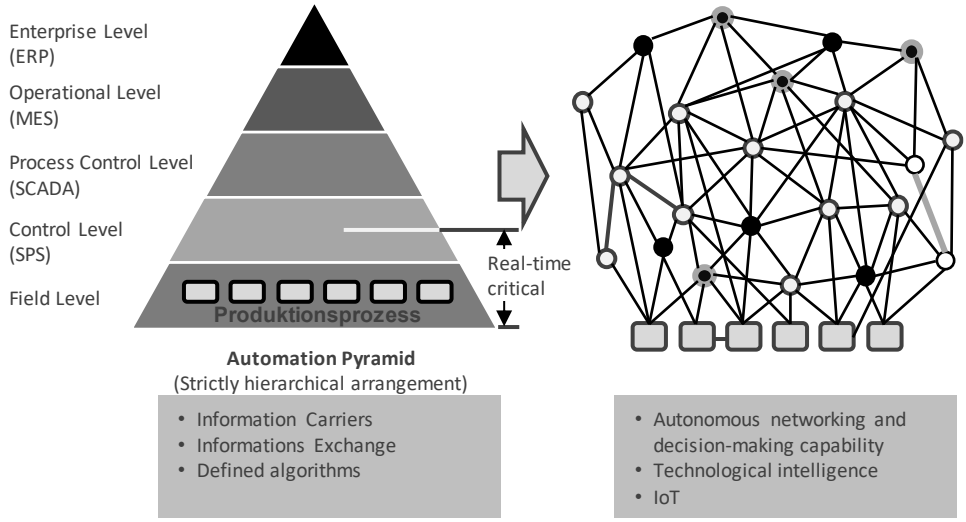

Figure 4: Automation pyramid according to DIN ISO 62264 and automation using CPS[9]

This development demands that those responsible for manufacturing companies fundamentally rethink, questioning paradigms that have been the basis for growth for decades. Problems do not only arise with the extraction of applicable technologies from the portfolio listed in the Gartner Hype Cycle[10]. While the technologies can be made manageable by technical specialists, the development of the social environment,

[9] CPS – Cyber-Physische Systeme – Software network of communication-capable mechanical and electronic components

[10] https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/, retrieved on 2019-12-17

additionally influenced by disturbances of an unpredictable extent, can hardly be assessed. Despite all restraint, situations such as the current corona crisis make clear the advantages but also the limits of digitization. Production systems could work with a guaranteed supply of parts and also produce without people, but the requirements for data networks cannot yet be met nationwide.

The openness to the use of modern tools is decisive for production operations without, however, giving up the logical approaches of previous production systems.

Information technology

When introducing a production system, many companies had to experience how complex it is to introduce supposedly simple processes and ensure their sustainability. The key is to take the employees with you. This task is now repeated with the introduction of digital tools. The level of complexity is higher because the area of information technology is of considerable importance, which many production employees do not yet understand sufficiently. A defining aspect is first of all to be seen in the organization of IT. Since the focus in the past few years has been on streamlining processes without essential IT support, the IT departments in the companies concerned are often underrepresented and at most specialize in ERP applications. Often there is no IT competence in production areas. However, the required IT specialists are currently so in demand that they are almost not available to medium-sized companies, which means that a quick solution to the problem is almost impossible. The current efforts to have the most necessary production and business processes carried out digitally in the Corona crisis show, in addition to this personnel problem, the failures of the past regarding IT equipment and network availability. Strategically, it makes sense to create decentralized IT jobs in production.

Working models

As part of a socio-technical development, the focus is on working time models with flexible components as well as ergonomic considerations. Both aspects provide sensible solutions for the demographic change and the implementation of increasing work-life balance demands of the current and following generation, but undoubtedly cause costs and a considerable change in the mindset of those responsible.

Staff

A particular challenge inevitably arises from the employment of people of different qualifications in workplaces that require sufficient, holistic knowledge at the respective level to be able to understand the problems and act and react appropriately. Employees with this aptitude are hard to find in small and medium-sized companies. This problem area encompasses all employees with responsibility, be it those required to carry out measurements or those who are responsible for production teams on the shop floor.

The lean philosophy is based on the concept of leadership and thus the transfer of responsibility to the shop floor level, but also requires the availability of people who accept this responsibility and do justice to it. Employee turnover, which inevitably arises when there is a regional shortage of workers, is harmful. For many companies, a troubled economy has been the first way to fill personnel gaps for years. The communication that is important on the shop floor is becoming more and more difficult due to the increasing international staff at shop floor level, manual documentation is often not possible or is not precise enough. Without immigration, however, a number of companies with labor-intensive jobs, particularly in assembly, would currently not be able to manufacture their products as needed.

Automated and digitized measurement processes make data writing unnecessary and statistical process control more credible. For the companies concerned, there is therefore an additional need to digitize in order to solve this problem. If the workforce required for the challenge of digitization is not available, the only option remains to empower existing or available employees.

5 CONCLUSION

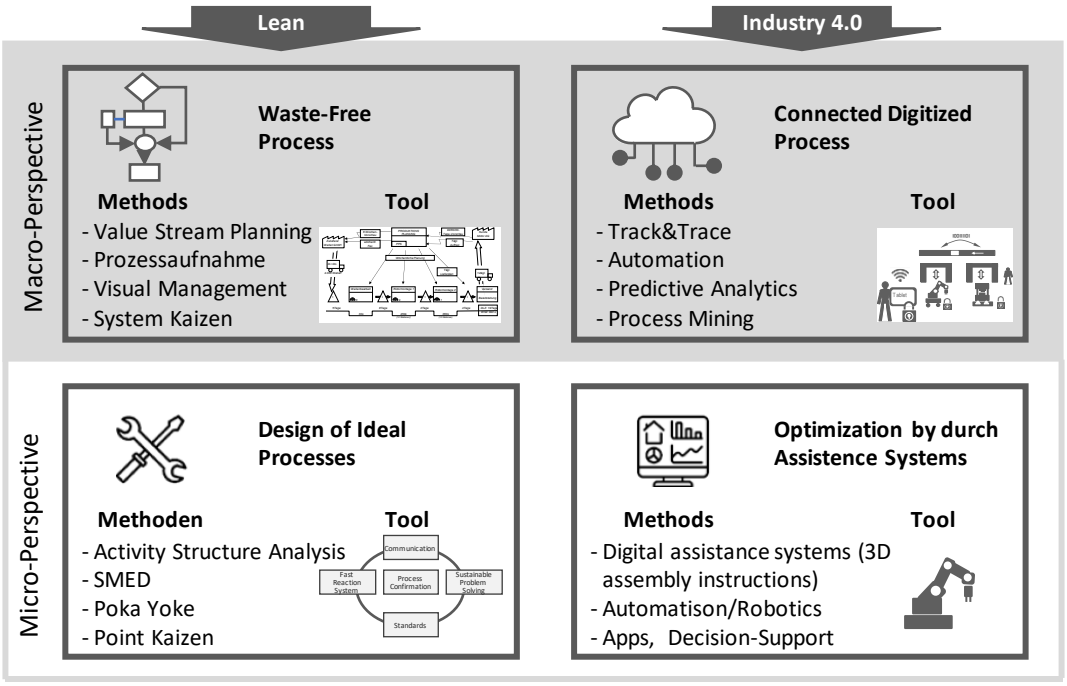

Figure 5: Productivity Methods and Tools, see [9]

Just as in the lean world processes are successfully designed with the help of the well-known lean methods such as CIP11, 5S12 or SMED13 under the objective of waste-free processes, so also in the field of digitization the linking of identified problem areas with suitable solutions from the macro and micro perspectives promises an improvement. Figure 5 shows a productivity kit from the lean world and the digital world [9, p. 410].

However, the explanations make it clear that the success and the interplay of "what" and "how" lies in the combination of both development stages. However, communication between the human protagonists must remain the focus. The trick is to meet the current and future challenges of production through the targeted use of modern means without jeopardizing proven production systems and using them as a basis. This is caused by the lean management philosophy, the sustainable implementation of which is necessary before further steps are introduced. The difficulty lies in adapting this to the general conditions and the structure of the company. If it is possible to achieve the individual optimum between modern digitization and sustainable lean methods, this is a significant step towards competitiveness. Under no circumstances, however, should digitization be an end in itself and a consequence of the ambitious desire to make up for shortfalls as quickly as possible.

[11] CIP – Continuous Improvement Process
[12] 5S – Lean Method (Sort, Set (in place), Shine, Standardize, and Sustain)
[13] SMED – Single Minute Exchange of Die (Method to improve Change Over Processes)

According to the principle “less is more”, the experience of introducing lean has shown that, especially in small companies, concentrating on the necessary components promises a greater contribution to sustainability than the enticing vision of a digital factory. Here too the principle applies that the tool is determined by the problem. The introduction of complete systems should be reserved for companies that have the necessary structures for sustainable implementation.

As with the introduction of the lean building blocks, there is agreement that it is imperative to actively shape the transformation and to take the employees along to counteract concerns [8, p. 4]. Here, too, mere knowledge provides no way. This must be developed by the managers themselves in coordination with the historical conditions and special circumstances in the company and can be supported by external expertise if necessary.

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