

The next generation shop floor management – how to continuously develop competencies in manufacturing environments

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Abstract

Manufacturing companies have to cope with a rising number of product variants as well as ageing personnel due to the demographic change. These challenges require companies to develop their employees' competencies – problem solving competencies in particular – especially on the shop floor. In order to support a value-driven material flow, shop floor management systems have been introduced in many manufacturing environments. The integration of a competency management system that continuously develops problem solving competencies through shop floor management seems to be a promising approach. In this paper, today's understanding of shop floor management as well as its connections and differentiations to other managerial systems are developed in order to fully grasp its potential for competency development. To use shop floor management as a facilitator for competency development in production environments the problem resolution cycle known from lean production is picked up and thoroughly analyzed regarding the integration of competency development. An outlook is given on a current research project which aims at concretizing these means of competency development through shop floor management.

Keywords: shop floor management; competency development; lean production.

1. Introduction

Future manufacturing systems will be challenged by a rising number of product variants, shorter product life cycles and the need to address the demographic change of involved employees [1]. Together with the trend for a knowledge society the competency development of employees is important for these future manufacturing systems [2]. Especially, the competencies needed for systematic problem solving and continuous improvement are crucial [3]. However, competency development (internal and external) is time and cost expensive and releasing shop floor employees for dedicated training is not always possible – especially for small and medium-sized enterprises [1]. Thus, an integrated competency development system on the shop floor of manufacturing environments needs to be developed.

To integrate such a competency development system through the shop floor management method seems to be a promising approach. A study on German manufacturing companies shows that lean production oriented KPI (key performance indicator) tracking is relevant in about 80 % of the surveyed companies [4]. So the basic concept of shop floor management is present in most companies and could be enhanced for systematic competency development.

Funded by the German Federal Ministry of Education and Research the project “ZielKom” aims at establishing such a competency development system through shop floor management. The Technische Universität Darmstadt undertakes this project together with three German manufacturing companies as well as the Technology Consulting of the German Confederation of Trade Unions.

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2. Shop floor management as a system of methods to manage manufacturing

The term “shop floor management” is not new to academic research but nevertheless there is little consensus about its specifics [5–7]. Even the denomination of lean leadership is used to describe shop floor management but since it focusses only on the leadership component this notation will not be used in the following paper [8,9]. The topic of shop floor management came on the agenda of lean literature with the release of Womacks “The machine that changed the world” [10]. Although it was not mentioned directly in the first version of the Toyota house [11], other researchers linked shop floor management to some of its parts. Several constituents can be seen as part of the block “People and Teamwork” while the base is “Visual management”. In some of Likers 14 principles of lean production [12], connections to shop floor management can be detected.

2.1. Objectives of shop floor management

Neither the origin of shop floor management is not consistently defined, nor are its specific objectives. The pursued goals are associated with the use of lean principles in wide fields of manufacturing industries. Since one of the objectives of lean production is the efficient design of value creation, also communication channels are shortened in order to enable fast information flows [13]. By the reduction of hierarchy depth the shop floor personnel receive wider responsibility both in functional and disciplinary questions [14]. As the foremen have to execute more and more planning and organizational work, less time of managerial staff is spent on the shop floor. Even if some managers can’t afford to spend their whole day on the shop floor, they have to assist their workforce in a methodical way. Consequently one of the objectives of shop floor management is the *development of shop floor supervisors to methodical coaches* for their co-workers.

Another aspect of lean production is the growing expectations on the shop floor worker himself. With the need for techniques like source inspection or working in small teams, new competences have to be developed [15]. As workers in person have the best overview over their field of work, they should be empowered to collect and also interpret relevant KPIs in their working area [16]. Hence, the task oriented development of the workers’ skills and the *utilization of their complete potential* is another objective pursued by shop floor management, which will be investigated throughout this paper.

A main criticism on the introduction of lean methods is that they might have a positive short term effect, which, however, is decreasing over time [17–19]. The often mentioned reason is the lack of a cultural change in the companies, which has to come along with the development from classic production systems to lean production [16]. This cultural change, which also accompanies the emergence of advanced skills, has to be guided by managers and leading personnel. Hence, the two aforementioned objectives of shop floor management also help to *make other lean methods more sustainable* and act as an enabler for their long term success [18].

Table 1. Objectives of shop floor management in the literature.

	Drew et al. [19]	Grundig/ Meitinger [18]	Heinen [17]	Hölzl [13]	Illing [20]	Illing [21]	Kudermatsch [16]	Lowe [14]	Peters [6]	Riegger [5]	Standard/ Davis [15]	Suzuki [22]
Development of leading personnel to methodical coaches				●				●	●			●
Utilization of workers’ complete potential							●			●	●	●
Sustainable support of other lean principles	●	●	●				●		●			
Optimization of KPIs			●		●	●		●	●	●		

Apart from supporting other lean principles, shop floor management also aims at improving operational figures directly. Therefore, a more quantitative goal of shop floor management is the systematic control and *improvement of operational figures or KPIs* [6]. Examples of increases in quality, efficiency, and reliability of order fulfilment due to the introduction of shop floor management are reported [5,17,20,21].

Concluding, four major objectives of shop floor management can be detected (see Table 1) from which two aim at developing skills of a company's employees. Besides optimization of operational figures and supporting the implementation of other lean principles, shop floor management seeks to improve the skill level from both the shop floor workers as well as from their supervisors.

2.2. Constituents of shop floor management

The objectives of shop floor management outlined above are reached by the employment of different constituents of the shop floor management system. As there is no commonly accepted definition of shop floor management, also its components are not specified consistently. Nevertheless, some components can be identified, which are mentioned by the majority of authors (see table 1). Shop floor management focusses on Genba, which is the Japanese word for shop floor. This is the place where value is created [22]. As a consequence of the growing responsibility areas of managers, they tend to spend less time on the shop floor. This should be compensated for by a new structure of the daily routines of managers and the introduction of shift meetings [5,18,23], which take place on the shop floor and not in closed meeting rooms [6,24,25]. By those strategies the leading personnel should be recognized at the shop floor, which enhances motivation of the workforce and facilitates the problem solving process [8,19,23,26].

Since presence of managers at the shop floor is the basis, another component of successful shop floor management is the dedication to their employees. They should be recognized as the company's most important resource and as a driver for changing processes within the production area [27]. Therefore, the potentials of employees have to be utilized and further developed [18,28–31], so that the 8th type of waste – the waste of employees' potential – is overcome. By the shift of decision rights from supervisors to employees, they can be trained in wider application fields and obtain multiple skills [7]. Therefore, the managers have to act as coaches to train their employees in methodical aspects of their work. Presence on the shop floor and focus on employees are general, underlying principles of shop floor management.

A more practical component represents the utilization of KPIs to create a transparent work atmosphere [6,21,22,32]. A very important aspect is not only the collection of KPIs, but their visualization. This should take place on the shop floor, as close as possible to the points of influence on those KPIs [6,33,34]. Workers should collect, represent, and interpret their own KPIs for their working area, since their relation to them and possibility to influence them is the highest [25]. An important aspect is also the selection of KPIs. There should be as few as possible but as many KPIs as needed [35]. So the creation of transparency is another main constituent of shop floor management.

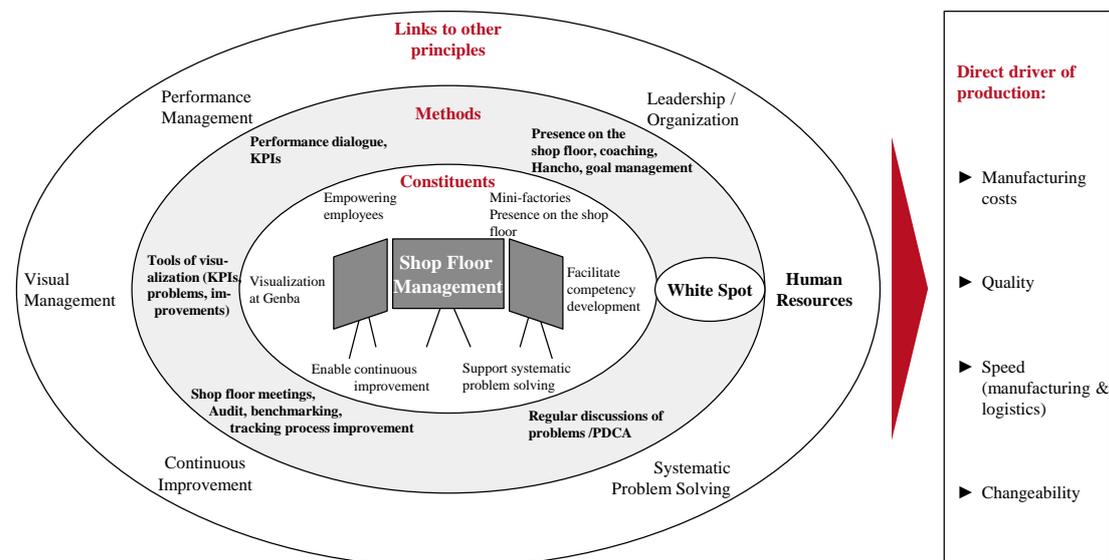


Fig. 1: The shop floor management system and its links to other managerial systems (for the direct drivers of production see [1]).

Apart from that, shop floor management implies a reorganization of the work environment. Production should be organized in smaller teams, which are responsible for their own area [36,37]. By the introduction of so called mini-factories the identification of employees with their work is enhanced and a focus lies on

the communication with other mini-factories [7,26,30]. Shop floor management represents also a means to support other activities, especially lean production methods and principles.

By visualization at shop floor boards and through daily meetings processes like the continuous improvement process or the problem solving process can be enhanced [5,38]. This leads to a sustainable and optimized implementation of those processes, which in turn allow the rise of both, the operational figures and the acceptance of new concepts by the employees. Shop floor management can support those processes and also the creation of transparency by techniques like A3-reports, shop floor boards, and the improvement KATA [21]. Also the general training of problem solving skills is part of shop floor management [39]. By the utilization of T-cards, management processes can be linked with the improvement process [21].

In order to summarize and categorize the constituents of shop floor management five different aspects can be concretized. Shop floor management uses the principles of focusing on and empowering the single employee and his skills as well as the presence of leading personnel on the shop floor (see Performance Management and Leadership/ Organization in Fig. 1). Besides, multiple techniques of transparency creation are put into use and new organizational practices as mini-factories are employed (Visual Management and Leadership/ Organization in Fig. 1). In addition to that processes as problem solving and continuous improvement complement the constituents of shop floor management (see also Fig. 1).

As shop floor management emerges from the context of lean production, it certainly has links to many other lean methods. The above mentioned components themselves are partly known as components of other lean principles like visual management and performance management. For the reason that today's research lacks a general accepted definition of shop floor management, some differentiation to other methods has to be drawn. Fig. 1 points out the intersection with other managerial principles, mostly connected to the fields of lean production. Links to performance management, leadership systems, visual management, continuous improvement process and systematic problem solving can be detected. Components which are applied in the above presented understanding of shop floor management are displayed. In the intersections with those general principles applicable methods are specified. As one outcome of the analyzed objectives and constituents of shop floor management, it exhibits great influence in the topics of Human Resources. Nevertheless, in this field up until now, it is unclear by which means the specific training or qualification of employees should be carried out. Techniques like Training Within Industry focus primarily on supplying job instructions for a quick adaption of workers but neglect the continuous development of the workers [12,40]. Hence, a white spot of how shop floor management can fill up this gap can be identified (see Fig. 1).

In conclusion, this paper defines shop floor management as an integrated managerial system that facilitates the communication, control of performance, and implementation of lean methods on the shop floor – it contains six main areas:

- Empowering every single employee and utilizing their full potential,
- presence of leading personnel on the shop floor,
- using various concepts of visualization,
- introducing new organization forms like mini-factories,
- fostering the application of improvement and problem solving processes,
- and facilitating competency development on the shop floor.

These constituents are used to improve hard KPIs, i.e. the direct drivers of production (see Fig. 1), but also to develop both leaders and single employees and to support other lean activities, while shop floor management contains many links to other managerial principles like performance management, leadership, visual management, constant improvement and systematic problem solving. Nevertheless, there are also links to the fields of human resources and many suggestions to use the concept of shop floor management for competency development in the manufacturing area. However, specified approaches and methods as core elements of shop floor management are not yet defined. In this paper, a suggestion to fill up this spot – an approach on how to use shop floor management as a facilitator for competency development – is presented.

3. Competency development and its importance

‘Competencies are in general dispositions to act independently’ [41]. Chomsky introduced this terminology in 1965, following White’s linguistic theory of competencies as the requirement for performance [42,43]. Fig. 2 shows the relationship between the concept of competence and knowledge in the narrow sense as well as qualifications. Here, competencies incorporate knowledge, qualifications, rules, and norms. They can be classified into different competency classes, namely:

- Technical and methodological,
- Social and communicative,
- Personal, and
- Activity and implementation competencies.

The characteristics of these competency classes become visible through actions performed and knowledge reproduced. Developing employees’ competencies is a crucial prerequisite for a competitive, future-oriented production since it enables fast problem solving and continuous improvement in the entire production process [29]. In order to develop competencies one must face real problem situations without already knowing the solution for these problems. Addressing these real problems and finding innovative and creative ways to solve them, facilitates the competency development process [44,45]. In complex environments like the shop floor, employees need to decide every day which one of the many possible actions to perform. Hence, it is important to be able to act self-organized, independently, and in a creative way [41,46].

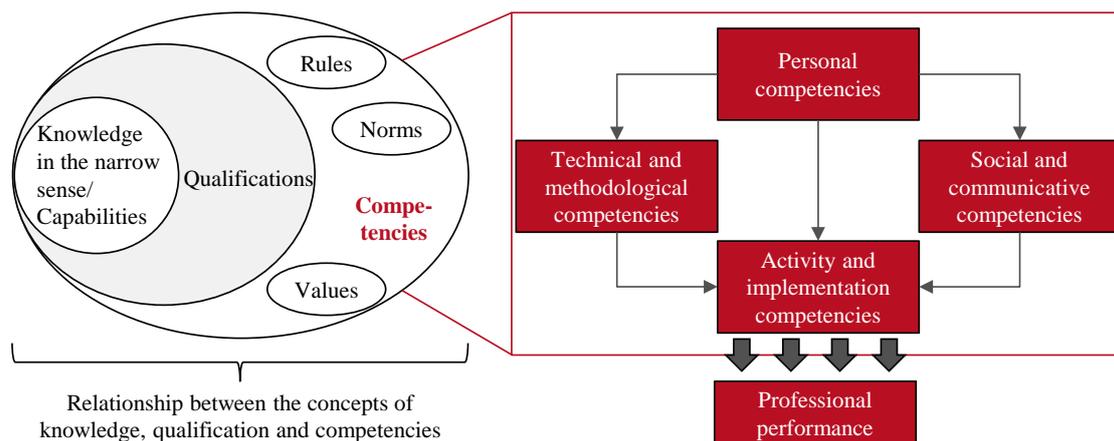


Fig. 2: The concept of competence and its relationship to knowledge and qualification (on the basis of [41,47]).

There are many approaches to systematically develop competencies for production, though most of them do not take place in the direct work environment. Such approaches are often classified as work-based or work-connected in delimitation to work-bound competency development [48]. Some examples of work-based competency development are training workshops, training centers, practice firms, or learning factories [3]. On the other hand, work-bound competency development in production is usually carried out during the work process informally, i.e. without a formal learning framework. Therefore, an emerging challenge is the question how to support competency development in a shop floor environment.

Until today, usually everyday problems are addressed through experience and executives acting as experts rather than through systematic problem solving (for systematic problem solving see [49–51]). Therefore, competency development happens randomly and unpredictable instead of systematically and continuously.

In order to facilitate a systematic and continuous competency development, the following questions need to be considered:

1. Who needs to learn what?
2. How to match shop floor employees with specific problems to facilitate competency development?
3. How to integrate competency development into day-to-day routines?

The first question needs to be addressed by human resources and might involve new forms of data management [3]. How to answer the latter questions is described in the following chapters.

4. How to use shop floor management as a facilitator for competency development

Shop floor management continuously tracks the actual state of production against a defined target state by using KPIs and target state descriptions. That way, the team is able to detect deviations, analyze them, solve the according problems and define the needed improvement measures. The implementation results of these measures as well as their effectiveness are discussed through structured meetings right on the shop floor and lead to an improved target state. This new target state itself is then the foundation for the next improvement cycles [22].

The designated approach uses shop floor management to integrate competency development into the day-to-day business in production. However, the shop floor management system itself is not sufficient and needs to be expanded to the problem resolution cycle. The problem resolution cycle describes the process from problem recognition through resolution and prevention [50]. In order to look further into the problem resolution cycle, the complexity of the problems needs to be narrowed down first. It is assumed that detailed standard descriptions as well as a problem resolution process are in place so that everyone in the hierarchy of production knows when to elevate / escalate a problem (see [50]). Therefore, with rising complexity of the problem, the responsibility for the problem shifts upwards. Fig. 3 shows a problem complexity classification for problems recognized in a standardized production environment. The classification of problems into complexity classes is an important step in the problem solving and escalation process [38,52,53]. The focus lies on problems which are elevated to the team leader and can be solved within the team (plus involved, supporting functions like maintenance).

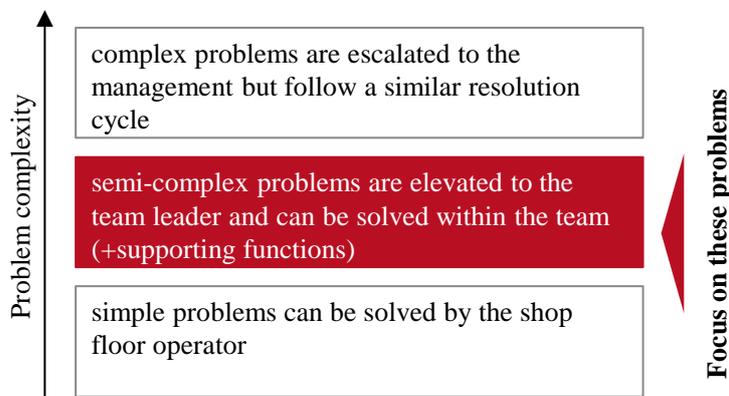


Fig. 3: Problem complexity classification.

On the basis of Liker [50] this paper presents a problem resolution process that takes into account the shop floor management systems. Fig. 4 depicts the problem resolution process starting with the recognition of a problem and ending with a satisfying solution which leads to an adjusted standard / target state.

In the following the six steps are described in detail:

- **Step 1: Recognition and Elevation**

A problem in production arises and is detected – either through target state / KPI deviations or other means. If the problem is recognized by a shop floor operator it is escalated to the team leader because of its complexity as defined in the standards. This step closes with the team leader taking over responsibility for the problem.

- Step 2: Evaluation and Elevation Cycle**
 The team leader evaluates the problem regarding its magnitude – if it's an isolated problem or a major problem concerning several departments. For the latter case, the evaluation and elevation cycle continues upwards in hierarchy depending on the magnitude of the problem. But since the following steps stay similar for the different hierarchies, it is assumed here the evaluation results into a problem for the team (see Fig. 4).
- Step 3: Presentation and Communication**
 In this phase the team leader presents the respective problem to the team and other involved functions during a shop floor meeting.
- Step 4: Assignment**
 During this step, the problem is assigned to specific personnel who are then responsible for solving it. This step is crucial not only in terms of effective problem solving, but also for systematic competency development.
- Step 5: Systematic Problem Solving (Control and Contain)**
 This phase represents the systematic problem solving process described in literature (see [49], [50]). The responsible personnel usually work through the plan-do-check-act cycle until a satisfying solution is found.
- Step 6: Presentation of Solution (Prevention)**
 The systematic problem solving process is closed by presenting the solution during a shop floor meeting and adjusting the standard / target state accordingly. Here the focus shifts to preventing the problem from occurring again.

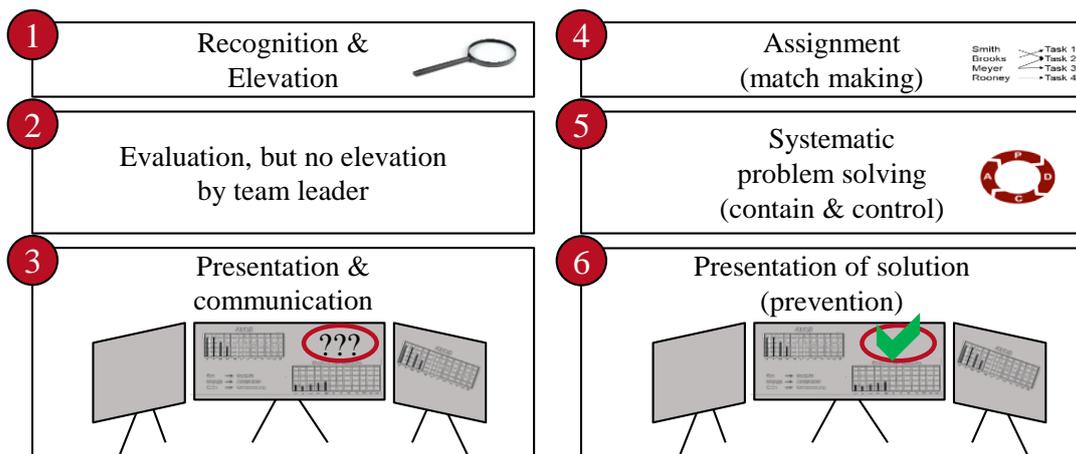


Fig. 4: The problem resolution process with shop floor management (on the basis of [50]).

As the content of step 5 has been described in much depth already and has received proper attention in the last years (additionally to Liker and Kepner / Tregoe please see [51]), this paper claims that step 4 is crucial in initiating a systematic competency development on top of the problem resolution process. One major aspect of the ZielKom research project is a thorough understanding of the assignment process and its interdependence with competency development. Here, the focus lies on the further development of existing technical and methodological competencies, as well as building problem solving and improvement competencies in production. The target group is employees of every age as well as their respective management.

5. Further steps in the project

The ZielKom project aims to further research competency development processes on the shop floor and assess the influence of the assignment step during the problem resolution process. These tasks are planned to be done in four phases (see Fig. 5). Starting with a thorough understanding of relevant competencies in production environments, this phase builds the basis for the rest of the project. In pilot areas of the

companies involved in the ZielKom project actual and needed / target production relevant competencies are collected and evaluated in order to identify gaps for the competency development.

Subsequently, the project develops a concept for competency development through shop floor management. A major aspect of the phase is the problem resolution process described in chapter 4. This concept is implemented at the process learning factory CiP on the Technische Universität Darmstadt campus, with the learning factory serving as a test bed for the work-based variant of the developed concept. After evaluating the learning factory implementation the concept is applied by partner companies of the project. At the end, findings are evaluated and the concept is generalized for other processes and sectors. The four phases are shown in Fig. 5 in a chronological order.

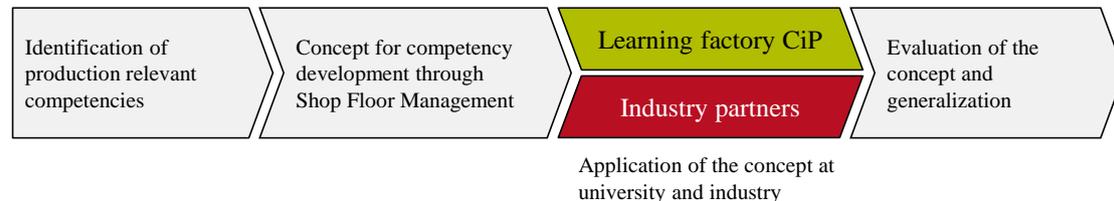


Fig. 5: Phases of the ZielKom project.

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