Sustainable Personnel Development Based on Production Plans

J. Möhle[1(✉)], L. Nörenberg[1], F. Shabanaj[1], M. Motz[2], P. Nyhuis[1], and R. Schmitt[2,3]

[1] Institute of Production Systems and Logistics IFA, An der Universität 2, 30823 Garbsen, Germany
moehle@ifa.uni-hannover.de

[2] Fraunhofer Institute for Production Technology IPT, Steinbachstr. 17, 52074 Aachen, Germany

[3] Laboratory for Machine Tools and Production Engineering WZL, Campus-Boulevard 30, 52074 Aachen, Germany

Abstract. The production environment is in a constant state of change. This results in a continuous change of production processes. A key factor in mastering change is to increase flexibility. To achieve this, the targeted training of employees is essential. Within the framework of the research project "reQenrol", research is being conducted to sustainably design personnel development based on the competence and tasks of the employees. Manufacturing companies face the challenge to efficiently training their personnel for an increasing and dynamic range of tasks. Training measures must be adapted to personal skill level of employees as well as to requirements of individual tasks in production. As a basis for a competence-based workforce deployment and the realization of targeted training measures, a survey was conducted on the current training situation and the relevance of competences in production. The results are placed into the context of the concept for an assistance system that enables manufacturing companies to perform a dynamic, competence-based workforce scheduling and realize targeted employee training.

Keywords: Workforce scheduling · Personnel training · Quality · Survey · Workforce flexibilization · Competence development

1 The Need for Sustainable Personnel Development

Nowadays, the shortage of skilled workers, sickness-related absences, and a high product variance are forcing manufacturing companies to deploy their production personnel in a highly flexible manner [1, 2]. As a result, employees must handle a growing and frequently changing range of tasks with consistently high quality. In his vision of sustainable productivity, Boos 2021 identifies this social perspective of production as one of the four key dimensions that manufacturing companies must address to achieve sustainable economic success [3]. Accordingly, manufacturing companies should increase the flexibility of their workforce scheduling and adapt it to the individual competence levels of employees, this applies in particular to small and medium-sized enterprises (SMEs). At the same time, employees must be trained through targeted, quality-oriented

M. Liewald et al. (Eds.): WGP 2022, LNPE, pp. 677–685, 2023.
https://doi.org/10.1007/978-3-031-18318-8_67

qualification measures in order to continuously adapt their competences to a growing and dynamic range of tasks [4].

However, the extent to which specific competences impact the quality of products appears to depend on a specific product and its quality requirements. This raises the question of which competences have a particularly large impact on quality and thus should be prioritized for training. The authors conducted a survey on the current training situation and the relevance of competences in production to investigate this question.

2 Fundamentals of Quality and Competences

According to the normative definitions, quality is defined as the "*[…] degree to which a set of inherent characteristics of an object meets requirements"* [5]. However, this does not allow conclusions about the factors directly influencing quality. Definitions, such as the entrepreneurial quality concept, refer to the employees' authority as one of the critical influences on fulfilling those quality requirements [6]. The relevance of competences is also emphasized in other common quality-related approaches. For example, DIN EN ISO 9001 demands that quality management systems ensure essential employee competences. Total quality management concepts list an employee focus as a key success factor for achieving quality [7, 8]. As a result, competent employees represent a source of competitive advantages that are difficult to imitate [9].

In the context of production, a direct link between quality and employee competence exists for product characteristics that are directly created within manual tasks by employees. Examples are the error-free assembly of components or setting a welding seam by requirements. Typically, the requirements for these tasks are documented in worker instructions. In [10], this understanding of quality is referred to as the so-called quality of execution and will be referred to in the following as quality for short.

Just like the requirements placed by customers on products, the general understanding of quality is also subject to a high degree of dynamic [6, 11]. The resulting change in quality requirements leads to changes in the demands placed on employees to provide the required quality. To meet the corresponding requirements, a broad spectrum of competences is necessary. The term competence is defined as a system of skills necessary for successfully completing a task [12]. This system includes qualifications, knowledge, skills, behaviors, and attitudes [8, 13, 14]. In the literature, there are various of possible classifications for competences [14–17]. A classification suitable for production is provided by Bughin et al. 2018, who distinguish competences between physical and manual, cognitive, social and emotional, as well as technological skills [16].

Within the research project reQenrol, an assistance system for competence-based workforce scheduling and adaptive provision of training materials based on the personal skill level of employees is developed [18]. The basis of the approach is the comparison of actual and target competences for individual production tasks. However, some production-relevant competences such as reliability and the ability to work in a team are difficult to measure and quantify. In practice, such competences are usually assessed utilizing a self-assessment or a peer assessment [14].

3 Survey on Competence Development in Production

In March 2022, an online survey was conducted with production managers from different sectors of the German manufacturing industry. 16 companies from the sectors mechanical engineering (40%), electronics (20%), and vehicle manufacturing (20%) participated in the survey.

The survey was divided into three sections. In the first section, the participants answered whether and which aids training is carried out in their companies. Furthermore, they were asked to rate how satisfied they were with the existing training materials. The latter was measured on a discrete scale ranging from satisfied (1), neutral (2), and not satisfied (3). The second section examined the current and future relevance of selected competences for production tasks. Finally, the third section covered the influence of selected competences on quality based on a five-point Likert scale [19], ranging from elementary importance (1) to no relevance (5), which is the standard for self-assessments and assessments of competences by others [20]. To pre-select production-relevant competences for the survey, 132 job postings from manufacturing companies for production workers with manual tasks have been analyzed regarding the most frequently required skills.

The results show that half of the companies surveyed actively implement competence development measures. Companies that already carry out competence development measures indicated various methods for this. These include classic measures such as initial training, instruction, internal training, further education, further development and standardization of processes together with employees, comprehension training during production, skills matrices, learning platforms such as LinkedIn Learning, leading as a coach, and 'training on the job'. Training videos, images, and text provided in print or digitally serve as the primary media used for competence development. In addition, face-to-face training is also a standard method for communicating training content.

Figure 1 shows the assessment of companies' satisfaction with their existing training materials. Satisfaction was assessed regarding the aspects of creation effort, acceptance by employees, dissemination, learning support, content, topicality, and format.

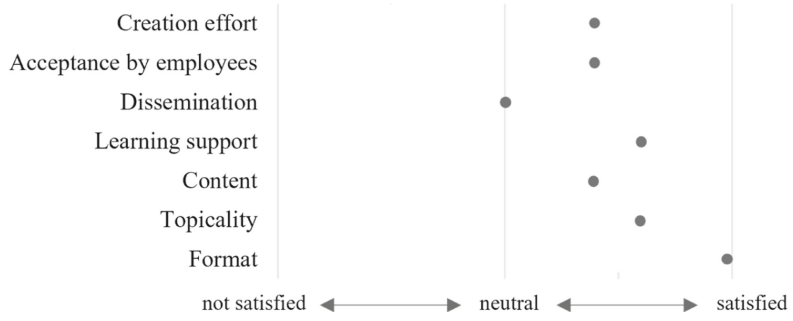

Fig. 1. Satisfaction with training materials

From the responses, it can be concluded that the most significant potential for improving training materials lies in the degree of dissemination. There is further potential for

improvement in the level of acceptance, the effort required to create training materials, and their content design.

The diagram in Fig. 2 shows the assessment of the relevance of competences today. Here, the competences on the y-axis are sorted in descending order according to how frequently they are mentioned in job postings for manual production tasks. In Fig. 3, the assessment of the influence of the competences on quality is shown, while Fig. 4 depicts the expected change in the relevance of competences over the next ten years.

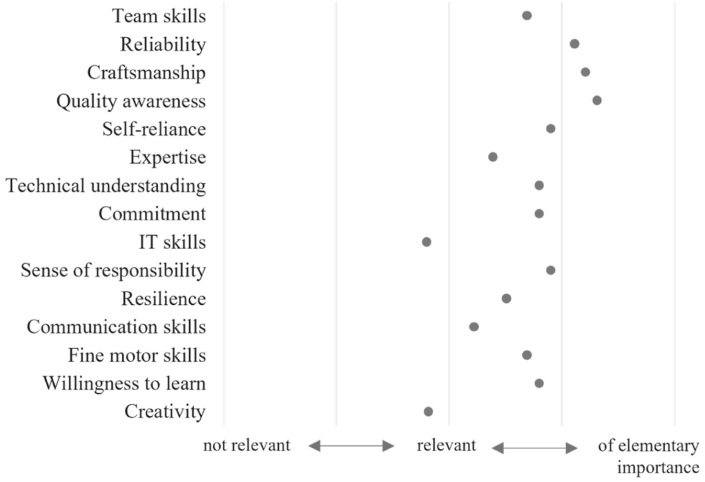

Fig. 2. Today's relevance of competences

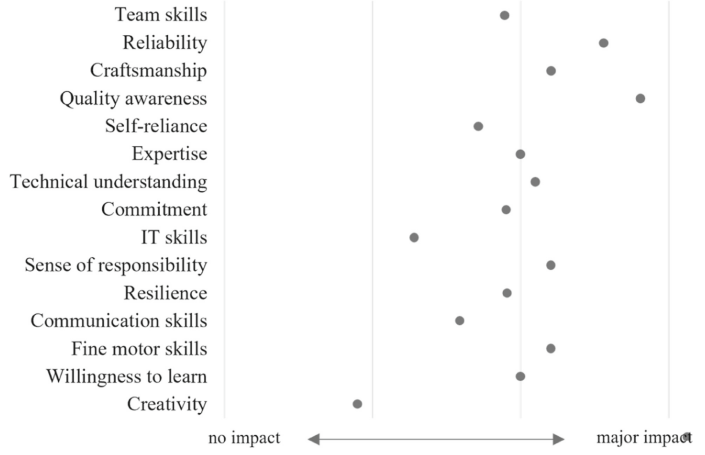

Fig. 3. Influence of competences on quality

The evaluation of the current relevance of competences (Fig. 2) shows a discrepancy between the competences requested in job postings and those relevant for production.

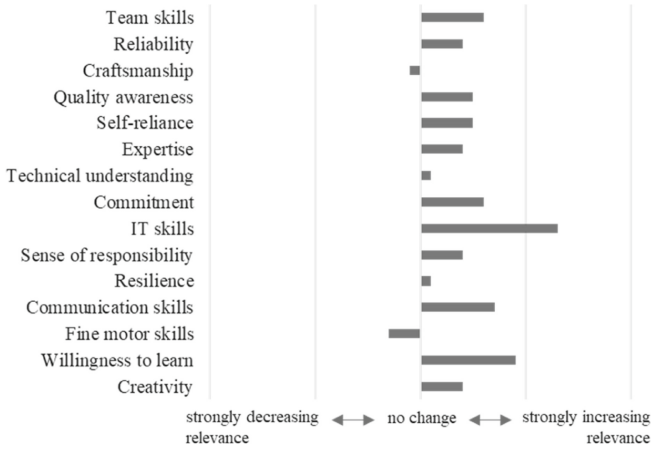

Fig. 4. Expected change in relevance of competences over the next ten years

Although quality awareness, craftsmanship, and reliability are rated as very important by the production managers, IT skills and creativity are currently assigned a relatively low relevance for production. Similarly, the competences of team skills, reliability and craftmanship are particularly often required in job postings, while fine motor skills, willingness to learn and creativity are among the less frequently required competences.

However, a comparison of diagrams in Figs. 2 and 3 underlines a high degree of agreement regarding the criteria most relevant to quality–quality awareness, reliability, and craftsmanship—and the criteria of IT skills and creativity, which are rated as having less influence. It can be concluded that competences with a great influence on quality are rated as particularly relevant by production managers. Figure 4 depicts the respondents expected extent to which a change in the relevance of production-relevant competences is expected over the next ten years. An exceptionally high increase in relevance is expected for IT skills and willingness to learn.

Overall, the survey results indicate that quality awareness, reliability, IT skills, and willingness to learn are key competences that manufacturing companies should prioritize in training to ensure sustainable personnel development aiming at maintaining a high level of quality in production. However, the number of participants is too small to derive statistically reliable statements about the whole manufacturing sector, so the survey would have to be expanded to achieve general validity. Nevertheless, the five-point Likert scale proved to be a suitable instrument for assessing competences in production that are difficult to quantify, as it enables an intuitive yet differentiated evaluation.

4 Competence Development Concept

Especially in SMEs, the lack of time, capacity, and budget often lead to a lack of adequate training measures, even though the need and benefits are well known [21, 22]. Therefore, forms of work-based learning are particularly attractive on the shop floor because of the reduced financial and time burden [19]. Furthermore, the selection of training measures

is often subject to a certain degree of randomness, as the proportion of companies with a documented training strategy is low, especially among SMEs [21, 23]. This behaviour is the primary motivation for the research project reQenrol. The project aims to support manufacturing companies with an assistance system for targeted training of employees on the shop floor. In particular, the goal is to systematize the selection of training measures and align them with the employees' individual training needs. Figure 5 outlines the logic based on which competence development measures are prioritized and selected.

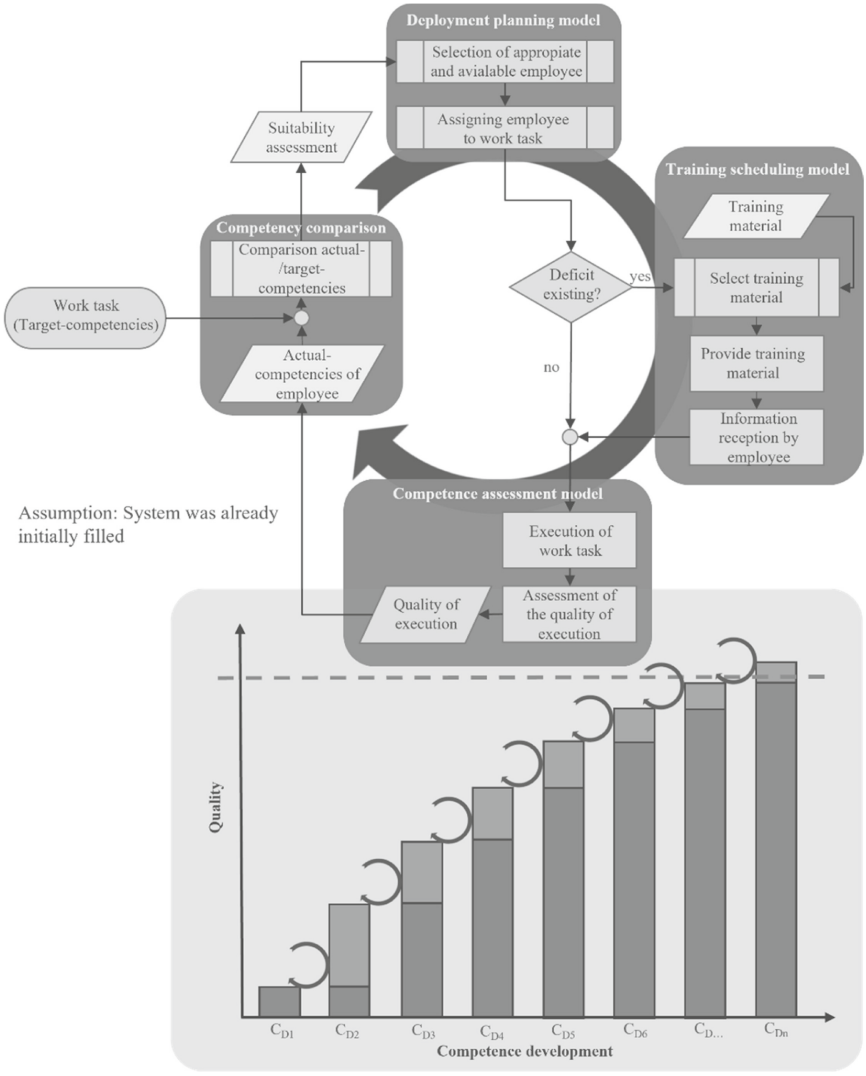

Fig. 5. Competence development concept

Figure 5 is divided into two parts. The diagram on the bottom illustrates that the training of specific competences has a varying influence on quality. For this reason, the sequence of competences to be developed is chosen so that the required quality (shown as a dashed line in Fig. 5) is achieved as quickly as possible by the sum of training measures $C_{D,n}$. The more influence a competence deficit has on quality, the earlier it should be trained. To achieve this, training materials are provided by the assistance system in a work-integrated manner. The training materials are tailored to the individual training needs, i.e. they address the competences that have the most significant impact on quality based on the personal skill profile. This way, employees should quickly be enabled to perform a task in production independently and in accordance with quality requirements.

The left side of Fig. 5 shows the competence development concept. This is divided into four sub-models. The starting point is the work task to be completed with the associated target competences necessary to complete the task successfully. This information, together with the actual skill profile of the employees, serves as the input for the first sub-model, the competence comparison model. When a work task is created, not only the competences required for it are assigned, but they are also weighted according to their influence on quality. In this way, comparing weighted target and actual competences results in a suitability assessment for individual employees. The calculated suitability level serves as an input for the deployment planning model. The second sub-model aims to select a specific employee for a production task from the set of available and suitable workers. Depending on the time urgency of a task, the model decides whether to select employees who can further develop their competences by absolving the task or select an employee with a higher skill level set and more experience. The former will typically require more time to complete the task. Furthermore, deploying an employee with less experience increases the risk of quality defects. Once the task has been assigned, a more detailed assessment of the skill deficit occurs (training planning model). Training materials appropriate to the individual skill level are selected and provided if there is a deficit. Depending on the type and criticality of training materials, the employees must either finish training before starting a task or can use the training material during the task execution. The execution of the task is followed by the quality assessment (competence assessment model). For this purpose, the assistance system records and analyzes quality defects reported by production employees or during scheduled quality inspections and analyzes them to update the skill profiles of employees. This is the basis for adapting the training materials to change employees' skills and systematically increase their deployment flexibility.

5 Conclusion

The results of the survey answered by production managers presented in this paper indicate that a significant change in the relevance of competences in production is expected in the next ten years and that the different competences of production employees have a varying influence on processing quality. To increase reliability, the terms used were defined at the outset. Since only 16 persons participated in the survey, who cannot be assigned to the sectors of manufacturing companies according to the job advertisements

evaluated to determine the required competences, the survey result cannot be assumed to be representative. Consequently, there is no general validity of the survey result. Nevertheless, the result indicates that continuous development of employees on the shop floor is necessary to be able to meet future challenges.

This is where the presented competence development model comes in. This model aims at increasing the flexibility of the employees through targeted competence-oriented qualification measures and forms the basis for sustainable personnel development with consideration of the increasing flexibility requirements. The competence development concept presented is based on four sub-models: Competency comparison, deployment planning, training planning and competency assessment. Embedded in an overarching assistance system, the models enable manufacturing companies to carry out competence-based personnel deployment planning, derive targeted qualification measures, and continuously measure and update the competence level of their employees in production. The competence development concept presented is based on four sub-models: competence comparison, deployment planning, training planning, and competence assessment. Embedded in an overall assistance system, the models enable manufacturing companies to carry out a competence-based workforce scheduling, derive targeted training measures, and continuously measure and update the competence level of their employees in production.

The tools of self-assessment and peer-assessment based on a five-point Likert scale have proven effective for assessing competences that are difficult to measure. Therefore, in addition to data-driven measurements based on quality data, these will be used for competence assessment in the further course of the research project reQenrol. In this way, companies are enabled by a work-integrated learning environment to ensure high quality and sustainably anchor knowledge even with increasing demands on staff flexibility.

Acknowledgments. The CORNET project (No. 21842N) of the Federation of Quality Research and Science (FQS), August-Schanz-Straße 21A, 60433 Frankfurt am Main, Germany, was funded by the Federal Ministry for Economic Affairs and Climate Action through the German Federation of Industrial Research Associations (AiF) under the Industrial Collective Research (IGF) programme on the basis of a decision by the German Bundestag.

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