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Procedia CIRP 115 (2022) 190–195

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10th CIRP Global Web Conference – Material Aspects of Manufacturing Processes

Shopfloor Management Acceptance in Global Manufacturing

Magnus Kandler *[a], Lukas Dierolf[a], Matthias Bender[a], Louis Schäfer[a], Marvin Carl May[a], Gisela Lanza[a]

[a]*wbk Institute of Production Science, Karlsruhe Institute of Technology (KIT), Kaiserstr. 12, 76131 Karlsruhe, Germany*

* Corresponding author. Tel.: +49-1523-950-2611 ; fax: +49-721-60845005. *E-mail address:* magnus.kandler@kit.edu

Abstract

Industry 4.0 and the digitization provides unprecedented technological opportunities for digital Shopfloor Management (dSFM) in a globalized world. Nevertheless, technology, involves millions of workers, each with different backgrounds, expectations and dreams. Thus, the effectiveness of implementing dSFM depends on the acceptance of local workers. Therefore, we proposes an acceptance model for dSFM, which can be used to evaluate the local and individual acceptance of dSFM in global manufacturing. The results of a preliminary validation showcase this localization need. In a nutshell, global manufacturing and its digitization solely achieve future proofness by local worker acceptance and the implementation of localized dSFM.

Keywords: Shopfloor Management; Global Manufacturing; Worker Acceptance

1. Introduction - Acceptance for digital Shopfloor Management

Progressive digitization and Industry 4.0 are currently permanently changing existing production systems [21]. Production systems constitute a vital element of global production networks, however, the socio-technical nature of manufacturing makes their performance heavily dependant on local skills and knowledge [17]. As global production networks are deliberately planned [17] and strategically localized [18], Shopfloor Management and its acceptance is crucial for maintaining competitiveness. Due to the disruptive nature of these changes invoked by digitization and innovation, not only the technologies applied are changing, but increasingly the associated organizations and management systems change [13]. The Shopfloor Management, is, thus, directly affected by these changes [3]. Against this background Shopfloor Management, its localization and acceptance have to challenged repeatedly.

Due to the advancing digitization of sensor technologies, real-time capable Shopfloor Management is becoming realistic [3]. The prerequisite for transparency, however, is not only collected data, but also the sensible, target-oriented and comprehensible processing of this data into key performance indicators [21]. With the help of these key figures, production can then be controlled directly on the Shopfloor in daily Shopfloor Meetings and decentralized self-organization of production teams can be realized, resulting in highly efficient production systems [13]. However, the increased transparency and associated digitization of Shopfloor Management pose challenges [3]. For example, the potentials identified can only be realized when Shopfloor Management is successfully implemented at all hierarchical levels in the company. A frequent challenge is the acceptance of employees for a real-time capable and Shopfloor Management (dSFM).

Acceptance is not only necessary in the context of the introduction of (digital) Shopfloor Management, but also during its application in the daily management work in production. For this reason, this paper presents an acceptance model which shows influencing and success factors of Shopfloor Management and can therefore be used to determine the success and acceptance of Shopfloor Management. Relevant research work is presented in Section 2. Based on this, Section 3 presents and explains the development of the acceptance model as well as its individual components. A brief discussion follows in Section 4 and the paper is concluded in Section 5.

10.1016/j.procir.2022.10.072

2. State of the Art - Relevance of an acceptance model for digital Shopfloor Management

In order to be able to evaluate the existing research approaches in a structured way, the following criteria are defined, which also function as requirements for the acceptance model developed hereafter. The first three criteria relate to dSFM and its holistic, customizable nature through toolboxes [14] (criteria 1), the integration of maturity models to asses a status quo [3] (criteria 2) and the phase-based road-mapping implementation approach [21] (criteria 3). Criteria 4 and 5 require external factors such as human-centeredness [13] to be recognized (criteria 4) and specific acceptance fostering measures [14] to be presented (criteria 5). The following two criteria relate to the operationalization of acceptance through explicitly regarding interrelations (criteria 6) and validate progress through surveys (criteria 7). Finally, criteria 8, necessitates a possible adaption of the acceptance model to address challenges in the local adaption of the Shopfloor Management in global manufacturing.

1. Presentation of a method toolbox for dSFM
2. Consideration of a maturity model
3. Phased approach for the operational implementation of dSFM
4. Consideration of factors influencing acceptance
5. Naming of specific measures for fostering acceptance
6. Consideration of the relationships between acceptance factors and acceptance measures
7. Usage of employee surveys
8. Consideration of challenges in the local application

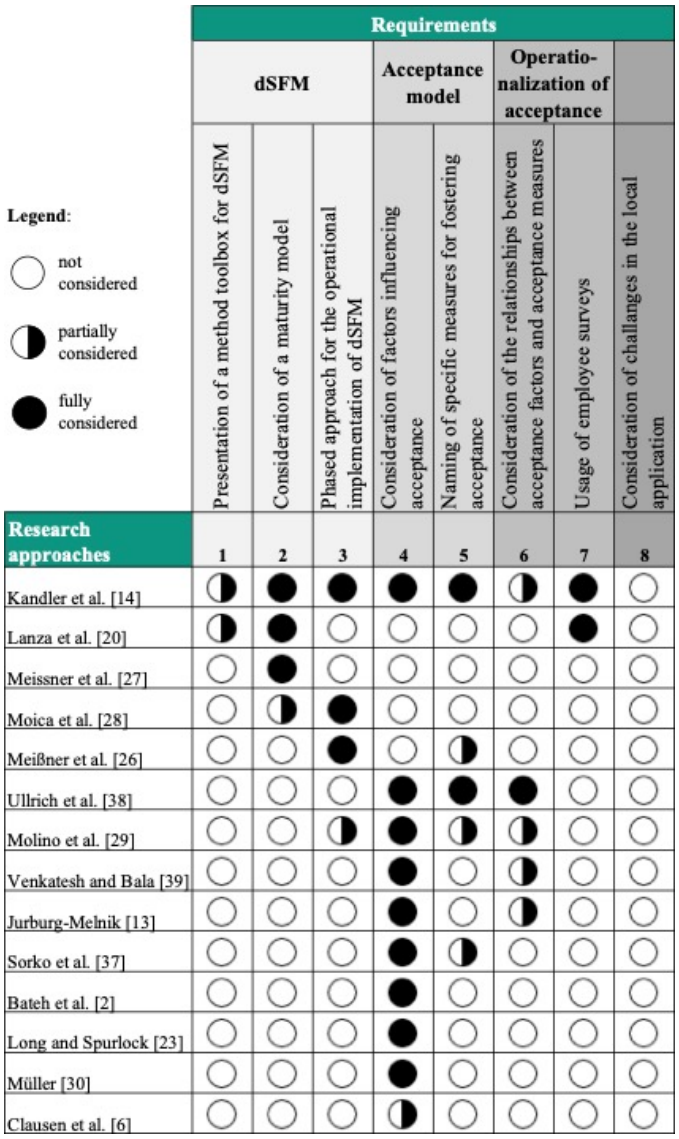
2.1. Literature Review

Kandler et al. [13] develop a model for the introduction of Industry 4.0 taking into account people, technology and organization that supports companies in adapting their socio-technical work system to digitization. The basis for this is that existing implementation strategies often focus solely on technology and decentralized decision-making by employees. A socio-technical implementation strategy for dSFM, including acceptance measures, is therefore developed. The result is a step-by-step approach with suitable implementation methods in each case and acceptance methods linked to them. The next implementation steps are selected based on the current readiness for change and the state of development. Lanza et al. [19] present a maturity-based action guide to support companies in introducing individually tailored Industry 4.0 methods. With the help of so-called ”quick checks” and the maturity model, the 4.0 methods that fit the respective situation of a company are identified and prioritized. A toolbox of potential Industry 4.0 methods is provided for this purpose. Liebrecht et al. [21] extend this approach and envision localization in global production networks. Meissner et al. [26], Moica et al. [28], Meißner et al. [25], Bretz et al. [3] also deal with maturity levels and phased implementation of dSFM. Based on existing acceptance research, Ullrich et al. [38] develop a model for a complete spectrum of behavior, from opposition to tolerance to acceptance, and relate this to change management measures. The work identifies individual willingness to change and ability to change as crucial factors influencing acceptance, which must be promoted with measures. The developed model enables the evaluation of the effectiveness of measures on the influencing factors. Molino et al. [29] examine the personal and organizational prerequisites for technology acceptance in the context of Industry 4.0. Reasons for employee resistance to the introduction of new technologies as well as positive factors influencing acceptance are provided. For instance, a positive correlation is found between resilience, information and training opportunities and technology acceptance, which in turn is positively related to work engagement. A three-stage approach to change leadership actions is proposed to promote technology acceptance: a company-wide information and communication program, technical and social training for all employees, and specific training programs to develop effective users of the new technology. Venkatesh and Bala [39] develop the ”Technology Acceptance Model 3” (TAM 3) in their work. It describes the need for an understanding of how the known factors influencing employee IT use can be addressed through measures. This understanding should enable managers to select specific measures to promote acceptance and IT use. The underlying TAM [8] describes these two factors influencing intention to use IT: perceived usefulness and perceived ease of use. The TAM 3, its predecessor TAM 2 and its extensions [23, 40] provide, in varying degrees and detail, external determinants of influence on the two basic determinants of TAM. The TAM 3 supports employees in making decisions about IT use and managers in making decisions about the design of the IT implementation process. Several research approaches deal with the factors influencing acceptance. Jurburg-Melnik [12] develops a model to understand the factors influencing employee participation in the continuous improvement process, lacking both global application and the localization of measures. Sorko et al. [37] explore which factors influence employee acceptance of the digital technologies ”augmented reality” and ”virtual reality”. Bateh et al. [2] categorize different types of employee resistance to organizational change. Long and Spurlock [22] provide factors influencing acceptance, reasons for employee resistance to change, and recommendations for management on how to design the implementation of new technologies. Müller [30] addresses social barriers and concerns of employees in the introduction of Industry 4.0. Clausen et al. [6] examine the barriers and driving forces for the introduction and use of digital Shopfloor Boards.

The following Table in Fig. 1 shows a complete overview and evaluation of existing research approaches and clusters their relation to the earlier introduced requirements about dSFM, acceptance model provision, acceptance operationalization and localization for application in global manufacturing.

2.2. Research gap

Based on the provided research review, it becomes clear that there is no approach in existing research that fulfills all of the requirements placed on an acceptance model, with the work of Kandler et al. [13] representing the most advanced approach.



	Requirements							
	dSFM			Acceptance model		Operationalization of acceptance		
Research approaches	Presentation of a method toolbox for dSFM	Consideration of a maturity model	Phased approach for the operational implementation of dSFM	Consideration of factors influencing acceptance	Naming of specific measures for fostering acceptance	Consideration of the relationships between acceptance factors and acceptance measures	Usage of employee surveys	Consideration of challanges in the local application
	1	2	3	4	5	6	7	8
Kandler et al. [14]	◑	●	●	●	●	◑	●	○
Lanza et al. [20]	◑	●	○	○	○	○	●	○
Meissner et al. [27]	○	●	○	○	○	○	○	○
Moica et al. [28]	○	◑	●	○	○	○	○	○
Meißner et al. [26]	○	○	●	○	◑	○	○	○
Ullrich et al. [38]	○	○	○	●	●	●	○	○
Molino et al. [29]	○	○	◑	●	◑	◑	○	○
Venkatesh and Bala [39]	○	○	○	●	○	◑	○	○
Jurburg-Melnik [13]	○	○	○	●	○	◑	○	○
Sorko et al. [37]	○	○	○	●	◑	○	○	○
Bateh et al. [2]	○	○	○	●	○	○	○	○
Long and Spurlock [23]	○	○	○	●	○	○	○	○
Müller [30]	○	○	○	●	○	○	○	○
Clausen et al. [6]	○	○	○	◑	○	○	○	○

Fig. 1. State of the art comparison of requirements

Moreover, there is no approach in the research that takes into account that the acceptance of SFM depends on local challenges at the particular production site, especially on the prevailing culture there. When selecting a location, the local culture needs to be factored in. The implementation of SFM is therefore also dependent on the culture at the respective location [17]. With the exception of Kandler et al. [13], most research approaches consider only two or three of the posed requirements and are therefore not comprehensive or complete. By far the most considered evaluation criterion is that of factors influencing acceptance. Acceptance factors are, thus, quite extensively studied in the existing literature. However, the known acceptance factors are rarely linked or associated with the other requirements. For example, there is a lack of necessary connections between acceptance factors and potential measures to increase acceptance. The criteria most often considered after acceptance factors are that of the maturity model and that of the phased approach to operational implementation of dSFM. The evaluation also shows that the existing literature has little reference to dSFM. Thus, much of the research on acceptance does not take place in the context of dSFM. In particular, toolboxes for dSFM rarely exist. There is also a lack of measures to promote acceptance and to target the multitude of known acceptance factors. Regarding the operationalization of acceptance, the necessary effective relationships between acceptance factors and acceptance measures are established only sporadically and to a limited extent. Employee surveys to determine the maturity and development stage of an organization are also rarely considered and only used in two research approaches. This state of research clearly shows the need for a comprehensive acceptance model that takes all requirements into account and brings them in line with each other in order to close the identified research gaps. It is necessary to unify and extend the existing approaches to develop a model that provides an added value to research in particularly to the industry in the practical implementation of dSFM and potential application in global manufacturing.

3. Acceptance Model for digital Shopfloor Management

In order to develop an acceptance model, a systematic literature search is conducted to identify the factors influencing acceptance that are relevant in the context of this paper and to, thus, map existing research. The existing literature is searched for the keywords “(digital) Shopfloor Management”, “Change Management”, “Industry 4.0” and their combination with the keywords “acceptance factors”, “employee acceptance”, “increasing acceptance”, “technology acceptance” as well as “implementation”, “challenges” and “instruments”.

3.1. Acceptance Model and acceptance factors

In the following section the identified factors influencing acceptance are reviewed. Since these are related in a hierarchical effect relationship, a target system for acceptance is developed. For this purpose, a distinction is made between three different parameters:

- target parameter: superordinate parameter that is to be optimized
- regulating parameter: Parameter that directly influences the target parameter
- manipulating parameter: Parameter that indirectly influences the target variable via the controlled parameter.

Acceptance is the target parameter that is to be optimized via the target system. The regulating parameters for acceptance are also called acceptance factors here. The following Fig. 2 shows the developed target system for acceptance.

3.1.1. Change readiness

The first acceptance factor is change readiness, which is most commonly defined as a persons beliefs, attitudes, and intentions about the extent to which change is required and the

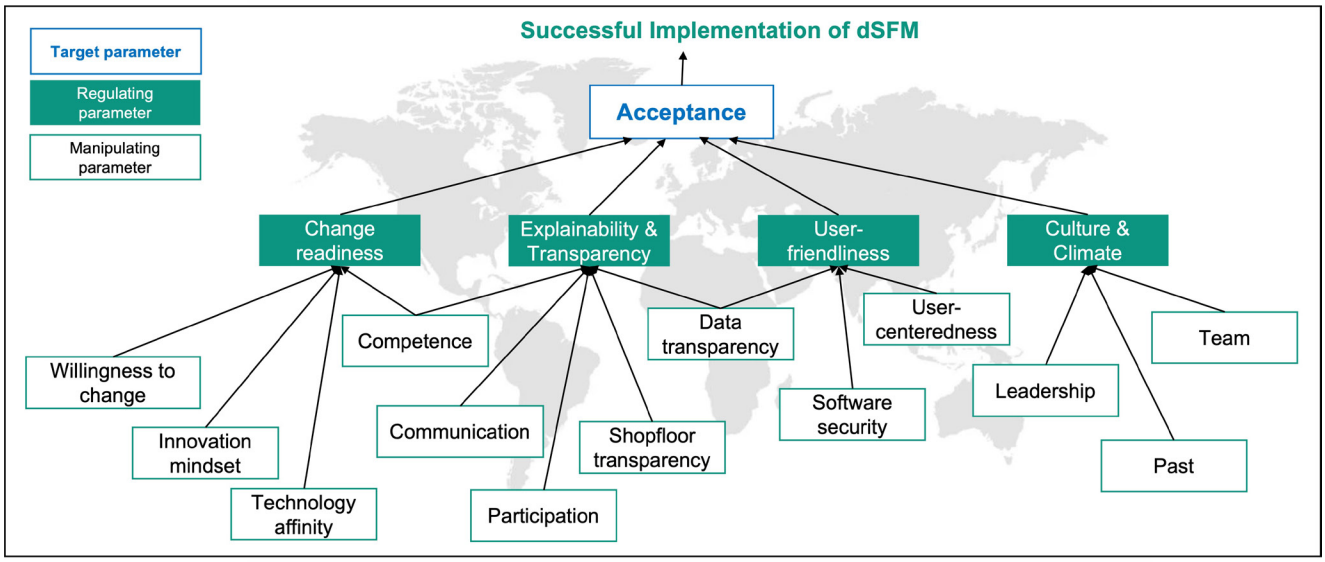


Fig. 2. Target system for the acceptance of shopfloor management

organizations ability to successfully implement those changes [33]. Change readiness is not a fixed characteristic but a variable state that can change over time, depending on a persons experience within the organization and its culture during the change phase [10]. Thus, employees also have different levels of change readiness at different points in time. Aspects such as experience and motivation to recognize the urgency of change [2], knowledge about as well as ability to change [6, 37], and willingness to take risks [22] can also be allocated to change readiness. The following four manipulating parameters for change readiness can be identified from the literature: willingness to change [5, 20, 22, 37], innovation mindset [5, 37], technology affinity [23, 29, 30, 38] and competence for the change implementation [6, 37].

3.1.2. *Explainability & Transparency*

The second acceptance factor is explainability, which is here is used in combination with the term transparency and stands for the comprehensibility of issues and the change processes themselves. For employees, all information about the implementation process is available and they can comprehend and understand the approach, the solutions, and the decisions. Explainability also includes the exchange between managers and employees and their joint learning process, in terms of the understandability, manageability and reasonability of dSFM [4]. Five manipulating parameters for explainability and transparency can be identified from the literature. These are competence [37], communication [24, 34, 36, 38], participation [5, 9], shopfloor transparency [13, 14, 16] and data transparency [6, 7, 41].

3.1.3. *User-friendliness*

User-friendliness is the third acceptance factor and describes the characteristics of systems to be easy to learn, effective to use, and aligned with users' ways of thinking and working. User-friendliness is manipulated by data transparency, software security and user-centeredness [30, 38, 27]. User-centeredness is thereby composed of task appropriateness, self-descriptiveness, controllability, compatibility to expectations, failure tolerance, customizability, consistency, support and ease of learning [35]. Task appropriateness means that all information and functions are provided to the user for task performance without being disruptive. Compatibility describes a system design that fits the users thinking capacity and thus minimizes the users cognitive transformation steps. A system is failure-tolerant if it allows format-free and variable input. A customizable system allows users to adjust the user interface according to their own needs. A consistent system meets user expectations for reliability, predictability, and predictability. Support here means that the system can provide help or information. [35] These criteria can be complemented by the utility of the system [12, 29, 31] as well as its performance and stability [38]. User-friendly systems should be designed in a user-centric way [34].

3.1.4. *Culture & Climate*

Culture and climate represent the fourth acceptance factor, which represents both the ethnic culture at a production site and the corporate culture. The ethnic culture must be taken into account because the cultural conditions at a production site influence the implementation of SFM. For example, an SFM implementation strategy that is successful in Germany does not necessarily have to be successful in Eastern Europe. Corporate Culture can be described via common fundamental assumptions, core values that are communicated to the public, internal corporate values, norms and artifacts [11]. Zettl et al. [42] describe corporate culture as the result of a collective learning process within the organization in which successful beliefs, values and behaviors are passed on as core assumptions to new members of the organization. The resulting corporate culture guides the

actions, feelings, perceptions and thoughts of managers and employees. The authors develop a values-based organizational culture in which employees can rely on the values practiced, can act on their own responsibility within certain limits, and managers see themselves as coaches [42]. Regarding acceptance, a climate of support [29], commitment [1], and psychological safety for all employees [15] should also be considered. Culture and climate differ in the same company on the globe [17] and are manipulated by the leadership [22, 30] the employee experiences with previous changes and their success [5], as well as the parameter team, which refers to clear roles and responsibilities [32] and the cooperation between departments [30].

3.2. Acceptance improvement process

The defined acceptance factors including their manipulating parameters form a target system for the acceptance model with acceptance as the target parameter to be optimized. A five step process is proposed in order to improve the acceptance of dSFM by local employees in Fig. 3. In the first step each acceptance factor is transformed into standardised survey items and a survey of local employees is performed. While the survey items are standardized, the key process is surveying employees locally and not over aggregating responses. Thus, in the second step, the individual responses from the survey are used to determine the current level of acceptance. Thirdly, an acceptance increase is target, based on the observed acceptance and role of the regarded production system in a global production network. The latter refers for instance to lead plants, individual phenotype and global manufacturing attitude [17]. Since the acceptance of SFM depends on individuals, the acceptance model is designed in a modular way and includes a catalog of potential acceptance measures (on manipulating parameter level). These acceptance measures are linked to the manipulating parameters of the target system in the fourth step, which realizes the operationalization of acceptance. Thus, in the fifth step, based on the item surveys, appropriate acceptance measures can be selected in a targeted manner for each individually considered SFM team to promote acceptance. The individual consideration of acceptance is important because even if two different teams show the same low level of acceptance, the reasons for this can be very different. The acceptance model therefore provides a steady target system of acceptance and a constant catalog of acceptance measures, but the actual acceptance measures used differ depending on the individual survey results of the employees in the different teams and the different production sites.

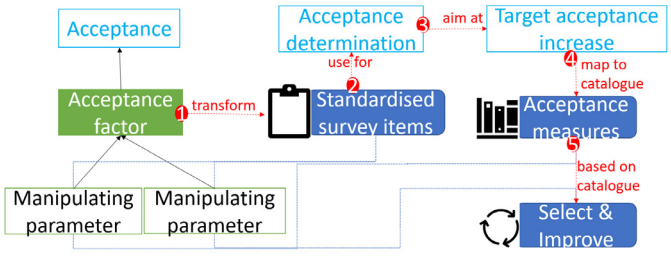


Fig. 3. Five step process to improve dSFM acceptance with localized measures

The presented acceptance improvement process is generalized and has to be targeted to the individual company, region and production system with respect to survey intensity and individualized acceptance measured that are feasible within the individual setting. However, realizing an operationalization through frequent follow ups is crucial in all settings, as acceptance is time-variant [2] and influenced by the selected measures.

4. Discussion

Shopfloor Management and its digitization can only strive if acceptance by local employees is high. Thus, it is important to measure the acceptance and select targeted measures for increase. As a validation the process was conducted within a two day workshop and 12 employees in Germany and a subsequent follow comparison with individual experiences from Chinese colleagues. The results of the preliminary workshop suggest that a low digitization competence and missing innovation mindset hindered the acceptance of a Shopfloor Management digitization in Germany. As a reaction improvement can be given through advanced training and innovation workshops. On the contrary, in the other group culture affected by low mistake tolerance leadership styles is a major issue. This can dealt with through training of the leadership personnel.

Nevertheless, the results, due to the survey based nature of the approach, cannot be holistically pieced together, to a general analysis. For an in-depth analysis not only of measures that increase the acceptance but time-spatial improvement observation, a larger study group with frequent follow up surveys and continuous measure implementation are necessary. Additionally, the mapping from measures to their effects could be summarized after several successful applications.

5. Conclusion and Outlook

In summary, a target system is developed which evaluates and explains the success and acceptance of Shopfloor Management. By combining this with targeted and iterative employee pulse surveys, targeted measures can be taken with the aim of increasing the benefits and acceptance anywhere in global manufacturing. The key advantage of this locality agnostic approach is the integration of employee surveys that in contrast of deriving global averages develop acceptance through localized measures, based on local culture, change readiness and survey results. This allows employees to be actively involved in the change process, which means that the wishes, requirements and also fears of employees can be taken into account in the digitization and application of Shopfloor Management in a truly global manufacturing setting.

In future in-depth follow up work, the developed acceptance model must be validated over a longer period of time. The current evaluation can only provide a snapshot due to its short application. Only through the iterative application of the model over several quarters and years can the effectiveness for measuring the success of Shopfloor Management be determined.

Acknowledgements

This research and development project KARL is funded by the Federal Ministry of Education and Research (BMBF) and the European Social Fund (ESF) as part of the program "Future of Value Creation" (funding code: 02L19C251) and is supervised by the Project Management Agency Karlsruhe (PTKA).

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