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VISUAL PERFORMANCE MANAGEMENT FOR MC

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Abstract: *Mass customization (MC) is typically characterized by high variety and complexity and visual performance management (VPM) can enhance robust process capabilities. However, research on VPM is scarce and there is limited research dealing with various manufacturing settings. The purpose is to explore key aspects of VPM adoption in MC. Based upon a case study, detailed insights to employees' needs related to the introduction of VPM to ensure continuous flow in a company are presented. Critical aspects include employees' understanding of the production system dynamics, differentiated performance management approaches to individuals and teams, and considerations to product and resource variation.*

Key Words: ***Robust processes, Continuous improvement, Performance measurement***

1. INTRODUCTION

Mass customization (MC) implies high variation in the production situation and high levels of complexity [1]. Visual management is recognized as a tool for continuous improvement related to lean. Also, rapid developments of digitalization imply major opportunities for visual management in manufacturing. Even though visualisation in MC is often related to virtual prototypes and presentation of products in customized product development and visual configuration [2, 3], visual management is a lean principle that is applicable in most MC manufacturing environments [4]. It may support adaptive human capacity in MC which is a key element of the robust process design capability [5].

The starting point of this research is that visual process management is especially relevant for MC manufacturing settings due to high complexity related to efficient manufacturing of customized products. Visual support has been deployed in manufacturing for a long time [6]. The topic is often mentioned in lean production research, although there is little empirical evidence available in literature [7]. Only few research studies present practical guidelines for efficient visual management [e.g. 8, 9]. Moreover, there is a need for further research on visual support in performance management [10] and work that take into account the employees' view on visual support [7]. There is further limited research dealing with visual support in various manufacturing settings, including MC.

The purpose of this research is to investigate how suitable visual process management support in MC can be developed by providing more detailed empirical insights to critical aspects from the perspective of employees. The objective is to contribute to the development of new methodologies for enhanced development of such support, and to more efficient implementation and practical use of visual tools for process management in MC environments.

2. METHODOLOGICAL CONSIDERATIONS

This research adopts a case study approach, including a literature review on design of visual management support in MC settings and empirical investigation of issues related to the design of a visual support system to ensure flow in manual assembly in a case company.

The investigation is part of a four-year R&D project on MC integration. Empirical data is collected at one of the project partner companies, seeking to identify needs and issues related to the design of suitable visual management support in manual assembly. The company is a leading MC manufacturer of customized furniture in Europe and is selected for this study because of their participation in the R&D project.

Empirical data is collected at one of the company's plants during spring 2017 from interviews with employees in assembly and meetings with managers. Selected respondents participated in improvement work groups or had the role of super users with extensive experience from working on the assembly line. Each interview lasted for about 30 minutes. An interview guide was applied, and interviews included questions about continuous flow, planning and control information as well as disruptions/deviations and their causes. Several visits to the factory were also carried out. In addition, data was collected from internal company documentation.

3. LITERATURE REVIEW

3.1 Robust process design in MC

Robust process design is a key capability of mass customization and implies the reuse or re-combination of existing organizational and value chain resources to fulfil

differentiated customer needs [5]. The capability can for instance be developed by flexible automation and process modularity. However, since companies have to build capacities to deal with new and ambiguous tasks and make managerial decisions, employees and managers are also key to successful MC [5].

In lean manufacturing, visual management is a key principle, emphasizing the need to use simple visual means to control operations [11]. In an MC setting, the VM principle may help to develop the robust process design capability, to develop systems and tools that can enable people to make decisions and deal with challenging and varying tasks. While lean production is mainly based upon high volume production of standard products, it can be assumed that MC settings require VM systems that take variation and flexibility into account to a higher degree.

Performance measurement is often a key feature of VM. To ensure high attention among employees metrics should be linked to rewards and recognition, and be based upon input of reliable data [12].

3.2 Aspects of visual management

Visual management (VM) is the practice of visualising information or displaying requirements to set directions [13]. VM tools may be used to manage performance and promote continuous improvement. Visual control is further an essential principle in lean to improve flow, by designing just-in-time information to ensure fast and proper execution of operations and processes [11]. For this study, visual performance management (VPM) is considered the practice of managing performance and enable continuous improvement by the help of visual tools to communicate information.

Based upon a literature review, Tezel et al. [14] propose a set of generic functions that can be used to describe how VM may be applied in work settings and contribute to an organization. These functions are used to construction [15], and are further discussed in a production management perspective in another literature review [7]. In a recent study, Eaidgah et al. [13] presents a similar overview explaining the purpose of an integrated VM approach, linking VM with performance management and continuous improvement, based upon empirical observations and a literature review including works by Tezel et al [14, 15]. It overlaps to a large extent with the framework by Tezel et al [14].

In this study the VM frameworks by Tezel et al [14] and Eaidgah et al [13] are used as a starting point for identifying critical implementation factors and key VM features in the MC case company. The framework by Eaidgah is selected because it emphasises the integration of VM with performance management and continuous improvement, which are central elements in MC. Tezel adds a few additional functions to the framework.

Table 1. *VM functions (based upon [13] and [14])*

VM functions	Description
Simplify flow of information	Ensure availability of system wide information based upon needs of individuals and teams to easily make sense of the organizational context
Job facilitation	Ensure to ease people's efforts on routine and already known tasks
Provide information at the point of use	Avoid double handling of information
Empower employees	Enable process owners to participate in decision-making with responsibility of their own processes
Unification	Create empathy within the organization through effective information sharing
Facilitate continuous feedback and goal communication	Provide immediate and relevant feedback on the state of the system to teams on their performances
Increase transparency	Ensure communicative production processes with people, provide feedback to managers and workers in an open manner, facilitate self-control
Improve discipline	Make a habit of maintaining proper procedures, motivate people to adhere to correct procedures by making process and team performance available to others
Create shared ownership	Utilize team performance as a team image, communicate each process owner's impact on team performance to create motivation to improve
Promote management by facts	Collect data and make observations on desired objectives and provide it to all stakeholders, use facts and data-based statistics
Boost morale	Ensure openness and willingness to share ideas and information, avoid rumours and misunderstandings
Support continuous improvement	Provide required data, establish environment that stimulates and engages employees
On-the-job training	Learn from experience, integrate working with learning

4. FINDINGS

4.1 Empirical setting

The company is a major European producer of furniture. Main operations are organized in a semi-automated assembly line, with assembly teams located at different work stations along the line. The production plan is issued on a daily basis. There is high variation in the product mix and assembly sequence every day, i.e. one-piece assembly. The objective is to reach the daily production goal defined in number of finished products. The line is designed for balanced flow, according to an average takt level of finished products. Flow is necessary to acheive the goal. However, the flow is often negatively affected by disruptions and deviations, leading to delays. This in turn implies that overtime is often required to complete the planned production.

To deal with these issues and acheive better flow performance, the company seeks to explore ways to improve current VPM practices. A mapping activity was initiated to identify major problems and causes of

deviations and delays and to explore needs and requirements of VPM support that may help to deal with flow related issues.

4.2 Identified VPM needs

Findings regarding employees' needs of VPM support in the MC case company are presented. The empirical findings are structured according to the VM functions.

Simplify flow of information: Overviews of plans, status and performance information are necessary to establish a good understanding of the work situation. Current displays of overall performance give only limited support and there is need for more detailed information, especially in case of deviations from original plans such as changes in plans, progress and status updates, disruptions and deviations.

Job facilitation: There is a need to increase the understanding of when the assembly performance is within expected range and when it does not meet expectations. With immediate feedback of deviations from expected performance range, employees can get more detailed and timely information of their performances. Feedback on when employees are working within the expected range can be useful. Emphasis should however be on deviations, so that employees are not disturbed too much.

Provide information at the point of use: To ensure flow on the assembly line, information needs to be communicated on relevant work stations. Displays for team and individual performance can be combined. Information also needs to be based upon reliable sources and be stored in one place to avoid risk of data duplication. Screens and displays can be placed on all work stations along the line, as well as in joint meeting areas.

Empower employees: Employees are expected to make own decisions and take responsibility of their own work, individually and in teams. Information is needed that support this behaviour and attitude. They especially need information that enable them to make decisions and deal with issues and deviations. They are collectively responsible for flow on the assembly line and thus need information support that triggers engagement and decision-making.

Unification: Information needs to be shared between teams and individuals; all employees have a part of the total system performance. A thorough understanding of interdependencies between processes on the assembly line is required. To avoid misunderstandings and support engagement, there is a need for better information of where problems occur, and that the same information of plans, changes and deviations is available to all employees.

Facilitate continuous feedback and goal communication: Employees have easy access to real time progress status of overall finished products (amount and time). However, additional KPIs reflecting flow performance is necessary to achieve more balanced flow. Also, more detailed performance feedback related to product mix is needed. Daily plan information with more details regarding mix of products and sequence can be improved and performance feedback take these details into consideration. Early alerts may stimulate proactive handling of potential failures and avoid delays.

Increase transparency: Continuous feedback of overall performance should be combined with more detailed direct feedback to individuals and teams of their performance related to flow. Managers may use these reports to follow-up on performance and improve planning and control of resources and products.

Improve discipline: Information on flow performance is needed that can help to ensure discipline and acknowledge good behaviour among individuals and teams. The performance information should be open and made available to other colleagues, teams and management. Elements of challenges or gaming can help to address focus on performance improvements.

Create shared ownership: Team performance feedback is necessary to build identity and culture. Employees are proud of high performance and it should be better communicated among employees. Employees express strong loyalty to colleagues and the company, and shared performance feedback may help to further strengthen this loyalty.

Promote management by facts: Information should be based upon data extracted from existing systems including ERP and MES systems, and performance presentations should be automatically visualized. Quality of information is critical, both in plans and performance measures; plans need to take product mix into account and performance measurements should be considered in relation to mix.

Boost morale: Differences in individual and team performances need to be openly communicated. All employees are jointly responsible for the flow performance and trust and willingness to improve are necessary to solve issues. Shared performance feedback based upon trusted facts is necessary to deal with problems and engage and motive employees.

Support continuous improvement: To stimulate improvement efforts, there is a need to visualize information giving feedback on the development of key performance indicators over time. Also, "real time" information indicating problems that risk disrupting flow is necessary to identify and deal with problems without delay. Information needs to be open and accessible by several individuals and teams to stimulate collective responsibility of improvement work.

On-the-job training: To increase learning, employees need information about their own performance compared to a target level or "best in class" in addition to their own progression. They need to get feedback on what part of their jobs that can be improved and how their performance develops over time. An element of sports or competition may trigger and motivate employees to engage in training to become better at their work. It is also important to show information on how individual behaviours influences overall performance to increase the understanding of the system. Support is needed to ensure that employees learn the right behaviour that results in flow of the entire assembly line. Learning should thus be an integrated part of the daily work.

4.3 Aspects of VPM in MC

The empirical investigation of the case company revealed several critical aspects for developing and designing VPM support. In the case company manual assembly is critical to ensure highly efficient customization. This implies that the flow performance of the system is influenced by the employees' understanding of assembly line dynamics, which is characterized by high variation and complexity. Challenges are related to establishing suitable incentives for individuals and teams to ensure efficient flow, that can be implemented by visual management.

The identified aspects for developing VPM in MC settings fall into three major categories;

Systems level understanding: Information that enhances employees' understanding of overall system dynamics, performance (in the case this was flow performance) and challenges caused by high variation should be shared and visible to employees and managers. Plans should also take aspects of production variety and dynamics regarding for instance resources, capacities and products, into consideration. Performance status should also be communicated among employees. In an MC environment, it is critical that employees share a joint understanding of expected performance and status of the entire system to be able to efficiently deal with variation in their work. A thorough understanding of systems objectives and interdependencies is fundamental to stimulate an optimal behaviour among employees. VPM support that can establish and enhance such joint overall understanding in MC environments is relevant, as an aid to cooperatively deal with variation and complexity.

Differentiated approaches to individual and team performance; A VPM should contribute to enhanced performance of individuals and teams for instance by facilitating learning, providing status feedback, motivating and engaging employees and enabling continuous improvement. Expected performance levels and status related to expectations may be communicated. Type of feedback mode e.g. type of information, frequency and visual appearance, may be customized to fit to individual needs and preferences regarding motivation. There are many opportunities for designing and adjusting VPM features to specific conditions and preferences.

Moreover, information regarding high/low performance as well as improvements should be emphasized. A VPM should further help to avoid misconceptions and confusion of high variation production environments and guide employees to make optimal decisions and stimulate right behaviour. It is important that it is clearly communicated who has access to key information to ensure transparency and trust. Also, information that contributes to increased responsiveness to deviations and disruptions, such as alerts, should be emphasized in MC environments.

Considerations to mix and variation; The high degree of variation in MC settings requires high awareness of differences between products and resources, that influence production performance among employees. Plans should be reliable and take variety into account, for example in terms of product mix and sequence, and mix of resources and skills. By measuring the performance of individuals and teams in terms of managing variety, plans can be defined based upon reliable data. Progress and status feedback related to consistent plans will give employees better insights to performance variations related to product and resource differences.

In the development and adoption of VPM support, variation should be highlighted and differences in performance that depend upon variation should also be clearly communicated.

5. CONCLUSION

This study contributes to the growing body of research on VPM in manufacturing. It adds in-depth insights to critical aspects concerning the development and implementation of VPM in MC. Findings emphasize the importance of mix and variation for VPM in MC. Specifically, the study suggests that VPM adoption in MC should take the following aspects into account; employees' understanding of the production system dynamics, differentiated performance management approaches to individuals and teams, and considerations to product and resource variation.

While most previous research has had a managerial focus, the empirical findings of this study are primarily based upon data collected from interviews with employees as primary users. A user-centric approach in the development of VPM solutions may increase chances of successful adoption.

5.1 Implications

For visual management research, the empirical insights provided in this research emphasize the importance of taking critical aspects into consideration in research addressing adoption issues in various manufacturing settings. Also, for MC research, the aspects are proposed to be considered in investigations of how robust process capabilities can be enhanced by VPM.

The empirical evidence presented in this study may be helpful to practitioners seeking to develop and adopt new VPM solutions or to improve existing VPM practices. Besides MC settings, managers in other high-complexity manufacturing environments may also find the results useful for developing and implementing VPM support.

5.2 Suggested further research

Empirical insights on VM functions and aspects may be used as a starting point for further development of frameworks and methods for developing VPM support in MC. Adoption aspects may guide MC practitioners seeking to design and implement VPM and researchers investigating VPM adoption.

The study is based upon evidence from a single-case of one MC company seeking to achieve continuous flow. To develop further knowledge of contextual aspects that influence VPM adoption, research is suggested that encompass several companies in different MC settings.

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