Visual communication of performance measures supporting continuous improvement – challenges and opportunities for manufacturing SMEs

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Abstract

This paper provides a holistic view of visual communication of performance measures supporting continuous improvement in manufacturing SMEs. This is done by a theoretical part with a literature review, and an empirical part with case studies, including both the managers' and the operators' perspectives, and by focusing on manufacturing SMEs. The paper identifies five challenges and one opportunity in visual communication that SMEs perceive when using visual communication of performance measures, supporting continuous improvement.

Keywords

Visual communication, Performance measures, Continuous improvement, SME

Introduction

Visual management, performance measurement and communication are three well researched and mature research areas (Lindlöf, 2014, Neely et al., 1995, Mortensen, 2008). Unlike most previous studies this paper focuses visual communication of performance measurement supporting continuous improvement in manufacturing SMEs. A performance measure could for example be quality measured as number of reworks at the department compared to production, also having continuous improvement activities in the department focusing on quality. Communication is seen as a critical success factor for continuous improvement (Jayaraman et al., 2012, Kumar et al., 2009), and visually supported communication improves performance of production management by increased information quality (Maltz, 2000). Visual management also simplifies communication and fosters continuous improvement (Tezel et al., 2009).

Visual management have been researched on different levels. On operational level, Bilalis et al. (2002), set recommendations for improving the workplace visually, and Jaca et al. (2013) identifies visual management elements for improving the workplace. On strategic level Bititci et al. (2015) have developed a model showing that a visual management system have impact on communication, performance measurement, and continuous improvement, and Parry and Turner (2006) give a set of guidelines for implementing visual management tools. Many of these visual management models lack the view of the operators (i.e. Parry and Turner (2006)), which is identified as a gap in existing research (Bititci et al., 2015). Visual communication of performance measures is the focus of this paper, including both the managers' and the operators' perspective and filling the identified gap.

A literature review in the area shows that communication of performance measurement in small and medium-sized enterprises (SMEs) has not been paid much attention, although SMEs play a significant role in for example the European economy (European Comission, 2015). SMEs have specific characteristics and might need to adapt managerial practices to their specific characteristics (Cagliano et al., 2001). Specific characteristics, like poor managerial skills, entrepreneurial orientation and limited resources (Ates et al., 2013), might affect SMEs' visual communication of performance measures. Very little research of performance measurement supporting improvement initiatives for SMEs have been carried out (Anand and Kodali, 2008), and increased knowledge in performance measurement communication for SMEs is needed (Larsson et al., 2014). This paper aims at contributing with experiences from the current practice in manufacturing SMEs, and to SMEs specific challenges and opportunities concerning visual communication of performance measures supporting continuous improvement.

The purpose of this paper is to provide a holistic view of visual communication of performance measures supporting continuous improvement in manufacturing SMEs. This is done by including both the managers' and the operators' perspectives, and by focusing on manufacturing SMEs. The paper specifically address: 1) how visual communication is used in the production area, 2) strengths with visual communication that could be used as opportunities in succeeding with visual communication of performance measures supporting continuous improvement in manufacturing SMEs, and 3) weaknesses with visual communication that could be seen as challenges in succeeding with visual communication of performance measures supporting continuous improvement in manufacturing SMEs. The paper seeks to answer the question: *What challenges and opportunities do manufacturing SMEs perceive when using visual communication of performance measures supporting continuous improvement?*

Theoretical background

Visual communication is an expression of visibility, intended for a group and not just for an individual (Greif, 1991). This paper was based on this definition, treating all attempts to make communication visible as visual communication. Visual communication is close connected to visualization, which is defined as the graphic representation of data, information and knowledge (Eppler and Platts, 2009, p.43). In theory the terms visual communication, visual management, visual representation, and visualization are used, why the term used in the paper referred to will be kept in the theoretical background. Visualization has been used for communication between people way back (Lindlöf, 2014), and plays an important role in problem solving and knowledge transfer (Nonaka, 2010, Rieber, 1995). Visual communication can also be seen as close connected to encoding and decoding of communication (figure 1). This communication model is based on a model by Berlo (1960).

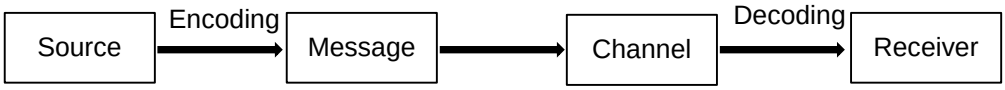

Figure 1. Communication model based on Berlo (1960).

Visual communication of performance measures could for example show production outcome per working hour, presented as a graph showing target and development the past year. Visualization is identified as important in improving management communication and decision making (Eppler and Bresciani, 2013). Visual management in manufacturing act as an extension to metrics, and predict probable outcome if no actions are taken (Parry and Turner, 2006). It supports communication and standardization, and should be used as an integral management system to guide the company in its journey of continuous improvement (Jaca et al., 2013). Jaca et al. (2013) also mean that the impact and effectiveness of visual management is underestimated. Bititci et al. (2015) look into SMEs, and shows that visual management support performance measurement, improve communication, and support continuous improvement for SMEs. Eppler and Platts (2009) identifies five strengths of visualization, it; 1) facilitates information compression, 2) enables new perspectives of thinking, 3) simplifies recall of information, 4) can integrate different perspectives and simplifies mutual understanding, mutual coordination and alignment, and 5) can engage, inspire, motivate and convince. Visual management is of high importance, and visual tools facilitates performance measurement and communication (Jaca et al., 2013, Parry and Turner, 2006). This paper focuses on how to use these strengths as opportunities to succeed with visual communication of performance measures, supporting continuous improvement.

Also pitfalls and things to avoid in visual communication is covered in theory, in this paper specified as weaknesses of visual communication, looked into as challenges needed to overcome in order to succeed with visual communication of performance measures. Wainer (1984) set up a list of things to avoid in order to succeed with visualization, summarizing that the most important is to examine the data to know what to say, and then visualize that with a minimum of adornment, i.e. focus on simplicity. In manufacturing companies a common set-up for visual communication of performance measures is a whiteboard filled with diagrams and tables. Setting up whiteboards is also seen as a critical success factor for the implementation of lean six sigma (Jayaraman et al., 2012). The challenge of a whiteboard design is squeezing a lot of useful and often disparate information into a small amount of space while preserving clarity, telling people what's happening and helping the immediately recognize what needs their attention (Few, 2006). Unlike the dashboard in a car or in an

aircraft, which is professionally designed, dashboards in manufacturing companies are often less consciously developed. Few (2006) means that well-designed dashboard information is; 1) Exceptionally well organized, 2) Condensed, 3) Specific to, and customized for the dashboard's audience and objectives, and 4) Displayed using concise media that communicate the data and its message in the clearest and most direct way possible. Few (2006) specifies goals in the visual design process, meaning that unnecessary pixels need to be eliminated. This could be graphics inserted as decoration, 3d-graphs without any purpose of the third dimension, color variation without any specific purpose, delineation of sections by colors or lines not needed, or unnecessary grid lines. Further, Few (2006) means that pixels that are necessary but not the main message need to be muted.

The analysis of weaknesses in visual communication for SMEs is well covered by a recent, thorough literature review of visualization pitfalls by Bresciani and Eppler (2015). The review is divided into cognitive, emotional and social pitfalls, but also according to if the cause of the visualization problem is the encoding or the decoding (table 1), based on a model by for example Bürgi and Roos (2003).

Table 1 - Visualization pitfalls (Bresciani and Eppler, 2015)

Encoding:	**Decoding:**
Cognitive pitfalls:	
Visualization might be ambiguous, misleading, or implicit. It might use unusual symbols or formats, or use symbols inconsistent. It might use inadequate templates, not have a clear logic, or be so polished that criticism is prevented. Visualization might distract from the main goal, hide important insights, or leave too much room for interpretation regarding purpose or main message, constraining the users' thought in one direction, or lead to incorrect conclusions. Illustrations might be improper, depict elements more complex than necessary, leave out essential elements for simplification, or be cluttery. It might also take disproportional much time to do.	Visualizations can be difficult to understand due to complex relationships, that changes can go unnoticed, or direct thinking in appropriate direction. People can see different things due to physical or cultural factors, or focus on low relevance items. Knowledge is sometimes needed to understand visualization or visual conventions like how to read a picture. The viewers' senses might be overloaded if too many visual elements are presented at the same time. Abstract concepts might be considered as concrete, or the viewer might focus on the wrong issue.
Emotional pitfalls:	
Images might cause harm, be uninteresting or boring, have a suboptimal, non-aesthetic form, or be confusing or unappealing due to inadequate use of colors or combination of colors.	Previous experience of the visualization might influence willingness to use it, and some visualization might get more attention than others because they fit the cognitive preference. Some patterns (e.g. stripes) might cause illness.
Social pitfalls:	
A visualization might signal the wrong kind of required activity, result in unequal possibilities to contribute, or lead to participants being less outspoken about certain issues. It might also make a viewpoint or idea too fixed, guide a conversation in a certain direction, or lead to unequal participation.	Visualization might affect the behavior of the user, and hide individual differences. Visualization symbols or colors might be misinterpreted due to cultural issues, visualization might be different interpreted due to different organization levels, or the broader context might be lost. A visual board might take attention away from body language and gestures, and group discussions based on visualization might require more time than verbal discussions.

To identify specific weaknesses and strengths of visual communication of performance measures in SMEs, SME characteristics need to be identified. An SME is a company that

have less than 250 employees, and a turnover of less than or equal to 50 million Euro or a balance sheet total of less than or equal to 43 million Euro (European Commission, 2005). SMEs also have some specific characteristics than other companies, shown in table 2.

Table 2 - SME characteristics
(Wong and Aspinwall, 2004, Zach et al., 2014, Ates et al., 2013)

Area	**SME characteristic**
Ownership & management	Owned by entrepreneur, multi-tasked owner-manager
	Centralized, short-term, intuitive decision making by few decision makers
	Directive and paternal management style, command and control culture
	Top management highly visible at shop-floor
	Poor managerial skills
Structure	Simple, flat structure with few layers of management and hierarchy
	Flexible structure and information flows
	Division of activities limited and unclear, low degree of specialization
Culture & behaviour	Unified, organic and fluid culture with low departmental mindset
	Operations and behaviour of employees influenced by managers
	Results, short-term operation focus
Systems, processes & procedures	Simple planning, evaluating, reporting and information systems
	Flexible and adaptable processes
	Informal, unclear rules and procedures and low degree of standardization and formalization
	Limited knowledge of and limited management attention to information system
	Packaged information system applications subordinated to the accounting function
Human resources	Modest know how with tacit knowledge and few experts, limited resources, ad hoc and small scale training and employee development
	Close, informal working relationship
	Low incidence of unionization
	Low resistance to change
	Modest financial resources

Method

The paper was based on a theoretical and an empirical part. The theoretical part was a literature review in visual communication of performance measures. In the search for visual communication, search term used were *visualization*, *visual management*, *visual communication* and *visual information*. The review covered both weaknesses and strengths. In the search the term *strength* was complemented with the terms *opportunity, enabler* and *advantage,* and the term *weakness* was complemented with the terms *challenge, problem, pitfall* and *hinder*. SME characteristics were also identified in literature.

The empirical part of the paper started with an initial case study in four manufacturing SMEs, focusing on weaknesses and strengths in visual communication. The case study was based on the research strategy by Yin (2014), and consisted of interviews and of observations of existing written formal communication of performance measures in all four companies, ensuring construct validity. The interviews were made with managers, middle managers, white collar workers and operators, giving a holistic view. The same questions were used in all interviews, and the same things were studied in all companies, ensuring external validity. The analysis of the visual communication material followed the review by Bresciani and Eppler (2015), identifying weaknesses and strengths by looking into cognitive, emotional and social pitfalls as presented in table 1. A case study protocol and multiple sources were used, i.e. both interviews and analysis of documentation, ensuring reliability and construct validity. Finally, in the data analysis, internal validity was ensured through pattern matching between theory and empirics. Citations were translated to English.

In the initial case study, company D was identified to have well developed performance measures that was communicated throughout the company, and used visual communication to communicate performance measures. This was identified as good prerequisites for studying visual communication deeper, why company D was chosen for the deeper case study. In the deeper case study, both interview questions and observations were based on the visual communication review by Bresciani and Eppler (2015), ensuring the external validity in this single-case study (Yin, 2014). Also in this case study, interviews were made with managers, middle-managers, white-collar workers and operators. Reliability, construct validity and internal validity was ensured in the same way as for the initial case study. The analysis of both the interviews and of the visual communication material followed the review by Bresciani and Eppler (2015), identifying weaknesses and strengths by looking into cognitive, emotional and social pitfalls in encoding and decoding visualization, as presented in table 1.

In both case studies, it was analyzed to what extent visual communication was used in the companies, and the connection between visual communication and continuous improvement. This analysis was based on identified strengths of visual communication, and the connection between visual communication, performance measures and continuous improvement (Bititci et al., 2015, Jaca et al., 2013, Eppler and Platts, 2009).

Empirical findings and analysis

Company A was a privately owned, medium-sized manufacturer, producing high volumes of few products, and with a high level of automation. The company had approximately 250 employees. Performance measures were visually communicated in two ways; on-line on screens in the production area and on computers in offices, and through whiteboards in the production area. The on-line communication of performance measures was presented as written sentences telling the outcome, where the figures were highlighted with ten different colors. Production results were presented as percentage remaining of the day, divided into different parts of the production, colored every other row white and grey. Production lines not producing for the moment were red, and one line is yellow (not explained why and the employees interviewed not knowing why). In the computer on-line presentation it was possible to go further into the numbers and get more information. A middle-manager meant that the on-line visual communication of performance measures was not used among operators and middle-managers, and that it didn't add anything, and an operator meant that the on-line communication of performance measures actually didn't say anything. Identified weaknesses in the on-line visual communication according to Bresciani and Eppler (2015) was not having a clear logic, and the coloring being cluttery, and essential elements, i.e. targets, was left out.

On the whiteboards in the production area in company A, production results were presented. Five tables and four graphs were presented on one A4-paper. Tables were presenting production results per shift and per day, and some of the tables were also presented as graphs. One manager thought that the communication worked well, another manager meant that not everyone needs to know everything, and yet another manager saw a need of communicating targets in the visual communication of performance measures, which wasn't done today. Identified weaknesses according to Bresciani and Eppler (2015), was being over-complex and cluttery, showing both tables and graphs on the same performance measures, and giving much information on the same page. The visualization was also leaving out essential elements, i.e. not visualizing targets in the graphs and tables on the whiteboards. Based on the strengths of visual communication (Bititci et al., 2015, Jaca et al., 2013, Eppler and Platts, 2009), two weaknesses were identified; visual communication was not used in all parts of the company, and continuous improvement was not communicated visually.

Company B was a company-group owned, small-sized manufacturer producing one piece at a time in a low-automated production, and with products often adapted for the customer. The company had around 25 employees. Performance measures were visually communicated in one way; visual communication supporting oral communication of performance measures, also placed on a whiteboard in the lunch room. The visual communication was presented with figures and graphs. A manager meant that the communication *"should not be too complicated"*, and white-collars and operators meant that it was simple to understand the monthly presentations. Style, colors and language varied between the graphs. A manager meant about the visual communication that *"I would like it a bit stricter and more formalized, actually"*. Three of the company targets were followed up with graphs. On the whiteboard there was a list of the company's financial targets, presenting some topics that also were presented in the graphs, and some other topics. Besides the financial targets, there was a list of improvement activities. Identified weaknesses in company B, according to Bresciani and Eppler (2015), was not including essential elements, i.e. specification of axis, and not specifying if the target should be above or below the target line. Another identified weakness (Bresciani and Eppler, 2015) was that the visualization might guide the conversation in a

specific direction, only visualizing one of the company targets. Based on the strengths of visual communication (Bititci et al., 2015, Jaca et al., 2013, Eppler and Platts, 2009), two weaknesses were identified; visual communication was not used in all parts of the company, and continuous improvement was not communicated visually.

Company C was a privately owned, medium-sized manufacturer with both machining and assembly and a huge number of similar products made of few materials. The company had around 100 employees. Performance measures were visually communicated one way, a visual communication placed on an information board at the entrance of the production area. It was a follow-up of discarded products presented as a graph. One operator saw the need of discarded products in relation to production which wasn't presented, while another didn't see any need of written communication at all. Managers were focused on improving performance measures, and did not have any opinion of visual communication of performance measures. Identified visual communication weaknesses in company C, according to Bresciani and Eppler (2015), was not including all essential elements in visualization, i.e. the target, and that the visualization might guide the conversation in a specific direction, only visualizing one of the company's targets. Based on the strengths of visual communication (Bititci et al., 2015, Jaca et al., 2013, Eppler and Platts, 2009), two weaknesses were identified; visual communication was not used in all parts of the company, and continuous improvement was not communicated visually.

Company D was a company-group owned, medium-sized manufacturer with line production with few base products and many different options, including both manufacturing and assembly. The company had around 250 employees, and performance measures were visually communicated in three ways; whiteboards for daily visual communication, whiteboards for monthly visual communication, and a visual communication supporting monthly oral communication of performance measures. All performance measures were communicated visually. There was a connection between continuous improvement targets and other targets, and the managers and middle-managers meant that they wanted to connect them even more in order to drive continuous improvement better. The visual communication in the company was divided into company level, department level, and working group level, and new employees got an education in the performance measures and how to understand them. This company was chosen for a deeper study of the visual communication of performance measures.

The whiteboards for daily visual communication in company D was a visual presentation of each target per day, where green meant that the target is reached, red meant that the target is not reached, and if the color was red a comment was added. One manager meant that *"we are explicit when we communicate, at least on our whiteboards".* Employees were well aware of this visual communication, meant that it was easy to understand, and that it was simplified but not too simple. The quality of the visualization were consciously thought of when doing the encoding, and resources had been put into visualizing the performance measures with a logical grouping and simplicity. The templates and grouping of the visual communication on whiteboards were the same for all performance measures. Several strengths were identified in this visual communication (Bresciani and Eppler, 2015), such as avoiding over-complex and cluttery visualization, including all essential elements in visualization, use symbols consistent, and have a clear logic.

The whiteboards for monthly visual communication of performance measures in company D included more information than the daily boards. They consisted of graphs showing the trends over the year, including the target. The same template was used for all graphs, but

some graphs used a smiley to show on what side of the target you should be, some graphs used an arrow to show it, and in some graphs it was not shown. Operators meant that they were not used to read these visual communication, and did not see the need of it. Middle managers and managers appreciated the monthly follow-up, and meant that it showed trends, and initiated actions if results were going down, being a complement to the daily visual communication. One weakness was identified in this visual communication (Bresciani and Eppler, 2015), not using symbols consistent.

The last visual communication in company D was visual communication supporting oral company communication of performance measures. A manager told that *"continuity is important"*, and that they used the same agenda and almost the same tables and graphs at every monthly oral communication meeting. The template for the presentation had a colored line, and the company name in three places on each page. In the presentation, a table and a graph concerning the same topic was shown on the same page, and the manager presenting was telling where to look to draw conclusions. Targets were shown in some of the tables and graphs, and the colors red, green and yellow were used in tables (unexplained). Operators meant that they did not understand the pictures themselves, but needed an explanation of what to look at and what conclusions to draw. One operator meant that the understandability came from the manager sending the information and not from the visual communication, while another operator meant that *"I actually have very hard to understand this"*. Among managers, middle-managers and white-collar workers the opinions were scattered. One meant that the visualization was good, while another meant that this visual communication was tremendously too complex, and that it should be much simpler visualized. Yet another meant that the visual communication was understandable, but that it probably was too complex for the operators. Smileys and colored thumbs turned up or down was used to visualize on what side of the target line you should be. Middle-managers, white-collar workers and operators meant that the symbols increased the understandability. This visual communication also included pictures for visualizing recent happenings or improvements.

Weaknesses identified according to Bresciani and Eppler (2015), was over-complex and cluttery visualization (template and use of colors), not all essential elements included (targets and specifying axis in graphs), and inconsistent use of symbols (smileys and thumbs). Based on the strengths of visual communication (Bititci et al., 2015, Jaca et al., 2013, Eppler and Platts, 2009), two strengths were identified; use of visual communication in all parts of the company, and continuous improvement communicated visually. Identified weaknesses and strengths identified per company were summarized in table 3, and identified weaknesses and strengths identified per visual communication in each company were summarized in table 4.

Table 3 – Identified weaknesses and strengths in visual communication of performance measures based on (Bititci et al., 2015, Jaca et al., 2013, Eppler and Platts, 2009)

Company:	A	B	C	D
Use visual communication in all parts of the company	No	No	No	Yes
Communicate continuous improvement visually	No	No	No	Yes

((empty)- not identified, yes- identified strength, no- identified weakness)

Table 4 – Identified weaknesses and strengths in visual communication of performance measures based on (Bresciani and Eppler, 2015)

Company and visual communication:	A		B	C	D		
	On-line screens	Whiteboards	Supporting oral communication	Information board	Whiteboards for daily follow-up	Whiteboards for monthly follow-up	Visual communication supporting oral company
Avoid over-complex and cluttery visualization	No	No			Yes		No
Include all essential elements in visualization	No	No	No	No	Yes		No
Use symbols consistent					Yes	No	No
Have a clear logic					Yes		
Not guide a conversation in specific direction			No	No			

((empty)- not identified, no - identified weakness, yes - identified strength)

Discussion and conclusion

Discussion

Though theory shows a connection between visual communication of performance measures and driving continuous improvement, together with significant strengths using visual communication (Jaca et al., 2013, Eppler and Platts, 2009), the empirical findings indicated that many SMEs do not use visual communication in all parts of the company, and that they do not communicate continuous improvement visually. The empirical findings also indicated that including all essential elements, such as targets, explanation of what side of the target line to be, or explanation of axis in graphs is a common weakness in SMEs, present in all four case study companies. Other identified weaknesses, present in at least two of four case study companies, were; over-complex and cluttery visualization, and guiding a conversation in a specific direction. A visual communication without any identified weakness was the whiteboards for daily follow-up in company D. This indicated that daily, visual communication could be a strength for SMEs. On the other hand, and although the use of visual communication in all parts of company D, the visual communication of company information had three identified weaknesses, indicating that visual company communication might be a weakness in SMEs. These identified weaknesses could be seen as challenges, needed to overcome in order to succeed with visual communication. The identified strength could be seen as an opportunity for SMEs to succeed with visual communication.

Challenges and opportunities identified were compared to SME characteristics (table 3 and 4). A typical SME characteristic concerning ownership and management is that SMEs have poor managerial skills. This might affect negative the use of visual communication in all parts of the company, and to communicate continuous improvement visually. Another SME characteristic in ownership and management is directive and paternal management style, which might have a negative effect on guiding a conversation in specific direction. On the other side, SME management often are highly visible at shop-floor, which might support the daily, visual communication, often done at departmental level. Concerning structure, SMEs

often have a simple, flat, flexible structure with few layers, and flexible information flows. This might support the daily, visual communication. Typical culture and behavior for SMEs is, among other things, a short-term operational focus. This might discourage the use of visual communication in all parts of the company, and the visual communication of continuous improvement. On the other hand, it might strengthen daily, visual communication, having the operational focus. Concerning systems, processes and procedures, SMEs often have low degree of standardization, which might discourage the use of visual communication in all parts of the company. Finally, concerning human resources, SMEs often have limited resources, possibly discouraging all identified weaknesses in visual communication, but also the strength. Summarizing table 4, it can be concluded that all identified weaknesses and strength in visual communication of performance measures are connected to specific characteristics of SMEs.

Table 4 - SME characteristics affecting weaknesses and strengths in visual communication of performance measures

	Ownership & management	Structure	Culture & behavior	Systems, processes and procedures	Human resources
Use visual communication in all parts of the company	-		-	-	-
Communicate continuous improvement visually	-		-		-
Avoid over-complex and cluttery visualization					-
Have a clear logic					-
Not guide a conversation in specific direction	-				-
Daily, visual communication	+	+	+		-

*((empty) No effect, **+** Positive effect, **-** Negative effect)*

Conclusions

This paper identifies five challenges and one opportunity for manufacturing SMEs using visual communication of performance measures. Perceived challenges are to: 1) use visual communication in all parts of the company, 2) communicate continuous improvement visually, 3) avoid over-complexity and cluttery visualization, 4) have a clear logic, and 5) not guide a conversation in specific direction. The only identified opportunity in visual communication of performance measures in manufacturing SMEs is communicate daily, visual communication. Being aware of these challenges and opportunities might strengthen manufacturing SMEs in visual communication of performance measures, supporting continuous improvement.

Limitations and further research

The empirical results are based on case studies in four manufacturing SMEs in Sweden. A possibility for future research is to broaden the view to include other cultural contexts, larger companies or other types of companies and organizations. The paper contributes to increased knowledge in visual communication of performance measures for SMEs, which could help SMEs improve their performance measurement communication, supporting continuous improvement. The originality of this study is the focus on visual communication of performance measures in manufacturing SMEs with a holistic perspective, including both managers' and operators' perspective.

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