VISUAL MANAGEMENT IMPLEMENTATION STRATEGY: AN ANALYSIS OF DIGITAL WHITEBOARDS

Bárbara Pedó[1], Algan Tezel [2], Lauri Koskela[3], Patricia Tzortzopoulos[4], Carlos Torres Formoso[5], Elena Vrabie[6], and Stuart Robinson[7]

ABSTRACT

Visual Management (VM) is a communication strategy in which a visual workplace for close-range communication is created by using easy-to-understand sensory devices. It is adopted to increase process transparency and self-management capacity. VM discussions have been mostly device-centred to date, being concerned with the development of new devices, or understanding the impact of different VM attributes for different purposes. Explorations of VM as a strategy have been limited. This paper outlines the key elements of one part of an overall VM strategy, namely the implementation strategy (i.e., planning, introducing, executing, monitoring, and controlling, maintaining, and improving, and removing). It is based on an empirical study on the use of a specific type of VM device (i.e., digital whiteboards) at an infrastructure engineering design and consultancy company in the UK. The main sources of evidence were surveys with key representatives of the company and participant observation in the development and implementation of the device. Findings indicate that adopting VM through a systematic implementation strategy with coherent plans and actions is important to enable its successful application. Moreover, some future research opportunities are pointed out, such as to expand and evaluate the definitions proposed, and to test them in different contexts and device types.

KEYWORDS

Visual Management, Strategy, Digital Whiteboards, Lean, Design Management.

INTRODUCTION

Visual Management (VM) is a key element of the lean production philosophy and refers to a management strategy to increase transparency and self-management capacity at a workplace (Tezel et al. 2016). It is realised by employing VM devices that enable close-range, sensory (i.e., visual, auditory, olfactory, gustatory, and tactile) communication for different purposes.

---

[1] Ph.D. Student, Innovative Design Lab (IDL), University of Huddersfield, and Lean Manager at Arcadis, United Kingdom (UK), barbara.pedo2@hud.ac.uk, https://orcid.org/0000-0002-6520-0981
[2] Associate Professor, Civil Engineering and Management, University of Nottingham, UK, algan.tezel@nottingham.ac.uk, https://orcid.org/0000-0003-3903-6126
[3] Professor, IDL, University of Huddersfield, UK, l.koskela@hud.ac.uk, https://orcid.org/0000-0003-4449-2281
[4] Professor, IDL, University of Huddersfield, UK, p.tzortzopoulos@hud.ac.uk, https://orcid.org/0000-0002-8740-6753
[5] Professor, Building Innovation Research Unit (NORIE), Federal University of Rio Grande do Sul, Brazil, formoso@ufrgs.br, http://orcid.org/0000-0002-4772-3746
[6] Senior Technical Director, Country Digital and Automation Lead, Arcadis, UK, elena.vrabie@arcadis.com, https://orcid.org/0000-0002-0854-6484
[7] Technical Director, Arcadis, UK, stuart.robinson@arcadis.com, https://orcid.org/0000-0001-5350-6281

Bárbara Pedó, Algan Tezel, Lauri Koskela, Patricia Tzortzopoulos, Carlos T. Formoso, Elena Vrabie, and Stuart Robinson

Transparency can be defined as the communication ability of work elements with human beings (Formoso et al. 2002). The reliance on written and text-based communication in VM should be limited (Galsworth 2005). VM devices should be easy to understand and accessible at the point of use. Information must be integrated into the workplace, increasing information availability (Greif 1991; Galsworth 1997).

VM is widely used in the implementation of lean in the Construction industry, where diverse types of devices have been used (e.g., visual boards, *kanban* cards, *andon* boards). VM discussions in construction have been driven by the lean construction community, and it is colloquially dubbed as a "lean communication system" (Tezel et al. 2016). Previous studies have proposed new VM devices as outcomes of action or design science research efforts (see for instance Brady et al. 2018), while others have assessed different types of VM devices according to functions, benefits, requirements, and purposes (see for instance Tezel and Aziz 2017; Pedó et al. 2022; Brandalise et al. 2022). Therefore, most existing VM discussions are centred around VM devices or practices. This is not surprising, as devices represent the more tangible and practical side of VM.

However, the application of VM is not limited to companies involved in the implementation of lean philosophy, as it can be employed outside a lean background. In fact, VM can be regarded, in essence, as managerial communication strategy. Therefore, research on VM from a strategic perspective at an organisational level is required.

This paper reports on initial findings of research aiming to understand the dimensions and elements of one part of an overall VM strategy, namely an effective VM implementation strategy. To the best of our knowledge, VM implementation strategy elements have not been clearly outlined in the literature to date. This is done by analysing the design, introduction, and use of a specific type of digital VM device at a large engineering design and consultancy company from the UK.

The discussions start from the VM device, and move to the company's VM strategy, indicating whether some key implementation strategy elements have been adopted. The need for a VM strategy was emphasised in a digital and dynamic context, where a more structured approach is required for the development and implementation of digital VM (e.g., digital whiteboards). Thus, the main contribution of the paper is the understanding of the key elements that need to be defined for an effective VM implementation strategy, considering the context of digital civil engineering design projects.

VISUAL MANAGEMENT

Using sensory stimuli to manage people is not new. Signals, banners, and signs have been used in armies or for managing mega projects for millennia. However, the term VM has crystallised as a concept in the last 45 years with the diffusion of the lean production philosophy in different sectors (Tezel et al. 2016). Alongside containing some more established VM devices in its toolbox, lean practitioners also recommend not copy-pasting VM devices and experimentation with VM for different contexts and information needs (Dallasega et al. 2022).

The literature has explored VM in different settings. For instance, Hirano (1995) showed how VM devices can create workplace order. Greif (1991) demonstrated that VM devices can contribute to different managerial efforts in a "visual factory". Liff and Posey (2004) extended those examples beyond factory shop floors and into other work settings such as hospitals and offices. Galsworth (2005) proposed a VM device classification system and an implementation framework. Theoretical discussions emerged from those initial, practical VM discussions. Attempts at explaining the mechanisms of VM devices through the concepts of affordances (Beynon-Davies and Lederman 2017) or boundary objects (Bell and Davison 2013) have also been explored in the literature.

In construction, Formoso et al. (2002) illustrated how VM can increase process transparency on construction sites. The adaptation of some conventional VM devices from manufacturing to construction sites has also been reported (Kemmer et al. 2006; Jang and Kim, 2007). The use of VM in construction design management has been also investigated (Tjell and Bosch-Sijtsema 2015). The functions (Tezel et al. 2016) and requirements (Pedó et al. 2022) of VM for construction have been discussed. Although some indications of VM as a management strategy can be found in previous studies (Nicolini 2007; Tjell and Bosch-Sijtsema 2015; Tezel et al. 2016; Brandalise et al. 2022), the discussions have mostly focused on VM devices and practices to date.

VM AS A STRATEGY

Beyond the development of visual devices, the literature suggests that implementing VM requires tasks such as evaluating information needs (Hirano 1995; Galsworth 2005), analysing the readiness of the work setting and elements for a VM device (Tezel et al. 2015), monitoring and evaluating the practical use of devices (Greif 1991), devising improvement and maintenance measures for the VM devices (Nicolini 2007), and capturing new VM ideas from users (Galsworth 1997; 2005). Nicolini (2007) and Brandalise et al. (2022) argued that a VM practice encompass both VM devices (the visual work of a VM practice) and the non-visual work involved in the use of the devices. A VM system is a group of visual practices working together (Brandalise et al. 2022) in order to create a visual work environment (Galsworth 2005).

Therefore, VM can be defined as a strategy for creating a "visual workplace" enabling self-management of people through VM practices (Greif 1991; Tezel et al. 2016). Being a strategy, it encompasses plans and several decisions (Galsworth 1997; 2005), such as: the purpose of the VM, the types of VM devices to be used, how people will be trained and incentivised to use the VM devices, how those devices will be created, standardised, maintained, controlled and improved, and how the devices will be linked with other production system elements and with each other.

The authors of this paper assert that decoupling VM devices and those hidden activities is necessary for a better understanding of the VM concept and successful VM applications in practice. The lack of a VM strategy, i.e., the absence of those hidden activities, may limit the effectiveness of a VM system, considering that VM will be developed as a set of random, incidental, and isolated practices which result from a trial-and-error implementation approach.

According to Chia and Holt (2009), a strategy, or a consistency of action, can also emerge from non-deliberate interventions to support immediate concerns with absence of goals specified in advance. This, for instance, can clarify aspirations, constituting a recognisable strategy with enough consistency when analysed in retrospect. A strategy does not necessarily imply something deliberately pre-thought, and positive outcomes can emerge serendipitously as a result of actions without a strong coordination effort (Chia and Holt 2009). Thus, strategies (and visions) can be a result from a combination of deliberate and emergent actions (Mintzberg, 1987).

The latter can also be developed as a consequence of bottom-up actions, mostly focused on the details, i.e., through trial-and-error, in which a pattern could be recognised as suggested by Mintzberg (1987). A strategy can also be defined as a plan, describing how goals can be achieved, or as a decision or a system of elements, as suggested by Galsworth (2005), in which the different options selected can lead to future situations, as they interact and could impact each other. A strategic plan is a formalised approach towards strategic decisions (Mintzberg, 2000) to work out the implications of a strategy (Mintzberg, 1987). In fact, different types of strategies might be required to support VM, however this paper's focus is on the implementation strategy.

Bárbara Pedó, Algan Tezel, Lauri Koskela, Patricia Tzortzopoulos, Carlos T. Formoso, Elena Vrabie, and Stuart Robinson

Based on the literature, elements of a VM implementation strategy have been proposed, i.e., 1) planning, 2) introducing, 3) executing, 4) monitoring and controlling, 5) maintaining and improving. In the planning (1) element, decisions related to the readiness of the system need to be made, including actions such as: observe the process (Valente at al. 2019) and identify the problem or opportunities; analyse and identify user and VM requirements (Pedó et al. 2022); define visual attributes (Valente at al. 2019) by identifying patterns, coding, naming conventions or templates. The introducing (2) element of the strategy refers to training (Pikas et al. 2022) and is important to gain users' buy-in and give them autonomy to use and own the practices and devices. Implementing or executing (3) requires integration with the company system, e.g., linking with other existing VM practices and systems, as well as integrating with managerial routines (Valente at al., 2019) and identifying the types of integration and communication (Brandalise et al. 2022; Pedó et al. 2022) by pinpointing the number of users, information flow, and whether interactions are happening at the same or different location and time. By monitoring and controlling (4), the practical use of the VM devices should be assessed, as argued by Greif (1991), by adopting structured approaches for capturing users' feedback, solving problems, and managing change. Maintaining and improving (5) the device, as outlined by Nicolini (2007), was also identified as a relevant element of the strategy.

WHITEBOARDS AS VM

VM is also an approach for communication between individuals so that differing perspectives are considered towards developing shared understanding (Lindlöf 2014). (Physical) whiteboards have been shown as effective visual means of conveying concepts and ideas, facilitating discussion and collaboration among stakeholders (Shae et al., 2001), as well as establishing a common ground (Gergle et al. 2013). It is important to understand the intricate relationship of VM practices and users' cognitive processes (Valente et al. 2019), as visual aids can enhance comprehension.

In addition, in the design of digital systems, the coordination requirements are frequently ignored, such as the cognitive work of coordination and the dynamic interactions (Maguire 2019). Digital whiteboards, however, provide a flexible visual (and virtual) platform, akin to a white canvas, that enables the creation of artefacts to support remote communication and collaboration (Gumienny et al. 2013; Pikas et al. 2022). Digital whiteboards can support new routines, procedures, and activities by making it easy to pull information when required from an information field, i.e., there is an easy access to information at any time, place (or space) and device (Pikas et al. 2022).

RESEARCH METHOD

Case study was the research approach adopted in this investigation because it is suitable for studying phenomena in a real-life context, in which researchers have no control over events (Yin, 2003). The case study was part of a Knowledge Transfer Partnership (KTP) project aimed to improve collaboration between academia and industry. This project explored the integration of lean construction and digital design at an international civil engineering design and consultancy company, focused on the highways and rail sectors.

Digital whiteboards are the focus of this investigation, which were devised and disseminated through a bottom-up approach and emerged to support immediate concerns without specified goals. The case was used to recognise and refine key elements in a VM implementation strategy. Digital whiteboards were selected for this case study due to the fact that the platform presents the potential to cope with the dynamic interactions and collaboration in the context, and this is even more relevant when discussing the different elements of a VM implementation strategy. This is an ongoing research work, and more data from the company will be collected about its

strategy. Moreover, there are limitations in considering data from the implementation of a single VM type (i.e., digital whiteboards).

The study had three main stages: (1) problem understanding and solution development, i.e. implementation of digital whiteboards, i.e. Miro (www.miro.com) and Mural (www.mural.co), (2) assessment of the digital whiteboard implementation through users' feedback , i.e. survey, (3) reflection upon the solution and critical analysis. The authors were directly involved in the introduction and use of the digital whiteboard. The main sources of evidence are: (1) survey with key company users (27 responses); (2) participant observation, as the researchers were involved in many applications and collected feedback throughout the implementation process; and (3) document and digital whiteboard interface analysis.

The survey had three sections (see Table 1): (1) general information; (2) user experience in using the digital whiteboards (Likert scale); and (3) challenges, benefits, and future opportunities. In the second section (2), respondents were asked to evaluate ten statements concerning the digital whiteboard characteristics on the 5-point Likert scale (strongly agree, agree, neutral, disagree, or strongly disagree). The key aspects explored are associated with the requirements for digital VM proposed by Pedó et al. (2022): simplicity, standardisation, availability, accessibility, flexibility, traceability. The challenges, benefits, comments by the respondents, and improvement opportunities captured from the survey were compared with the key implementation strategy elements proposed in this paper, supporting the refinement of the elements. This was complemented with the authors' observations of the use of the digital whiteboards. The survey responses were clustered according to the VM strategy elements, exemplifying, and expanding its definition.

Table 1: Survey Questions

Section	Questions
1	1.1 What is your role or position? 1.2 Overall, how would you rate your experience with digital whiteboards? 1.3 How would you rate the user-friendliness of digital whiteboards interface? 1.4 Why did you start using digital whiteboards? Please identify the key reason or purpose 1.5 What are the key functions of the digital whiteboard? Please select at most three options 1.6 How useful is the digital whiteboard to you considering the functions you identified? 1.7 How often do you use a digital whiteboard? 1.8 Have you had any training for using a digital whiteboard? 1.9 Who creates the digital whiteboards templates?
2	2.1 Easy and clear to use and understand the objective or function 2.2 Board templates are available and adopted 2.3 Information is standardised and consistent throughout the board 2.4 Easy to find the information because there is no excess of information 2.5 Easy to find information when required (at the right time e.g., during a meeting) 2.6 Easy to access the board because it is located in the right place, or its link is shared with the team when required 2.7 Easy to adapt the template 2.8 Easy to adapt and update the information 2.9 Easy to organise, store and backup the boards 2.10 Easy to track the information owner and changes
3	3.1 What are the perceived challenges and barriers of using digital whiteboards? 3.2 What are the perceived benefits of using digital whiteboards? 3.3 What other technologies or trends could be facilitators for the implementation and integration of digital whiteboards with existing technologies and processes? 3.4 Considering that you have used digital whiteboards extensively, how likely are you to recommend it to your friends and colleagues?

RESULTS

The starting point was a practical problem identified by the company, which had decided to implement VM and digital solutions across to increase efficiency, to deal with the challenges related to the design disciplines' fragmentation and lack of process transparency. Moreover,

Bárbara Pedó, Algan Tezel, Lauri Koskela, Patricia Tzortzopoulos, Carlos T. Formoso, Elena Vrabie, and Stuart Robinson

most design teams interactions were held in virtual environments due to the Covid-19 pandemic, affecting ways of working and collaborating. Thus, the idea of managing collaborative remote design work through digital VM was the starting point for this investigation.

The implementation of digital whiteboards was done across different sizes and types of design projects and teams, and for different functions. The digital whiteboards supported dynamic interactions, involving uncertainty, negotiation, and collaboration to establish common objectives. The key functions identified were related to planning, process mapping, and brainstorming, representing 68% of the survey responses (Figure 1 shows the interface of two VM practices using digital whiteboards as the medium to implement it). These were followed by continuous improvement and lessons learnt, representing 12% of the responses. The key purpose for starting the digital whiteboards adoption was to aid collaboration and support continuous improvement (60% of the responses), followed by knowledge management and sharing information. The previous knowledge on how to use, the top-down support, and the platform availability and easiness of use also influenced its implementation. Thus, the whiteboard dissemination for other uses was also facilitated due to the fact that the teams became familiar with the whiteboard interface and its functionalities.
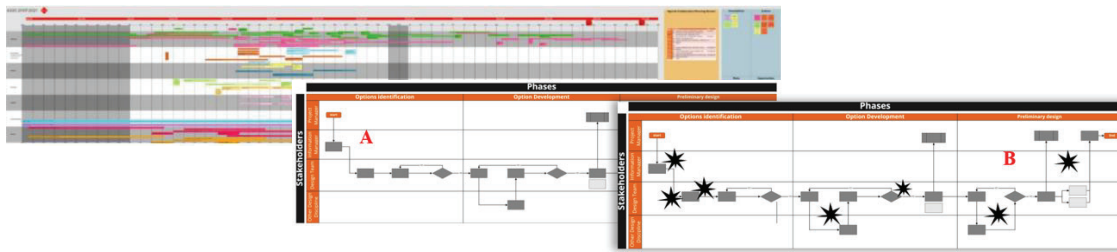

Figure 1: Digital Whiteboard Interface for 'Planning' and 'Process Mapping' Applications.

Most participants (68%) had not had any training on digital whiteboards. Nevertheless, the majority (78%) answered 'great' or 'excellent' for the user-friendliness of the digital whiteboards interface. In addition, 82% of participants answered 'great' and 'excellent' for their experience in using digital whiteboards, and the majority (85%) answered 'useful' and 'extremely useful' for the usefulness of the platform related to the key functions identified. Thus, 96% would likely or very likely recommend the platform to colleagues.

Most of the users can be described as BIM or digital managers and coordinators (30%), technical directors (22%), BIM or digital leads (19%), designers or engineers (11%), and others (18%), such as GIS coordinators or leads. There was daily and weekly frequency of use (17 responses out of 27), and the templates were usually developed by the continuous improvement practitioner or digital / BIM leads, not by the users.

Considering the user's experience in adopting the digital whiteboards for different functions, the comprehensibility, accessibility (right place), availability (right time) and information flexibility aspects were outlined as positive characteristics of a digital whiteboard (see Figure 2). The majority of the survey participants answered 'agree' or 'strongly agree' to 'easy and clear to use and understand the objective or function' (85.2%), 'easy to find information when required (at the right time e.g. during a meeting)' (70.4%), 'easy to access the board because it is located in the right place, or its link is shared with the team when required' (92.6%), and 'easy to adapt and update the information' (81.5%). In contrast, traceability and template flexibility were highlighted as negative or neutral aspects, considering most of the participants answered 'disagree' or 'neutral' to 'easy to adapt the template' (59.3%), 'easy to track the information owner and changes' (59.2%).
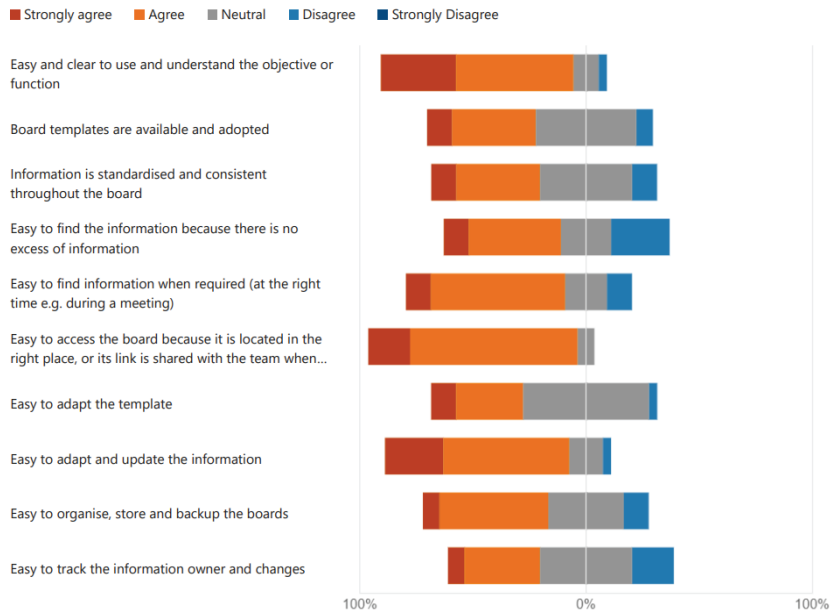
Figure 2: Users' Experience with Digital Whiteboards.

DISCUSSION

Table 2 presents the key VM implementation strategy elements (i.e., planning, introducing, executing, monitoring, and controlling, maintaining, and improving), based on the literature review, and refined considering the survey results and participant observations, i.e., the researchers' insights and observations as a source of evidence. The paper suggests that the VM implementation strategy elements proposed follow the plan definition or strategic planning, as suggested by Mintzberg (2000), however, they impact each other and some of the definitions could be analysed and interpreted through the decision lenses, in which there is a system of elements to consider as argued by Galsworth (2005), e.g., whether manual, digital or hybrid VM should be adopted or whether it should be implemented in production, administrative or management activities.

The 'planning' element relates to analysing the readiness of the work setting and elements for a VM device implementation (Tezel et al. 2015). It was emphasised by the challenges faced by the team members associated with the early identification of technical and system requirements, as well as with the early identification of the visual attributes. The team highlighted the need to have a plan regarding the correct number of licences (and financial implications), and permission in place before using the platform, as the lack of a full licence could restrict the adoption of some functionality. Setting up the boards' access and restrictions in early stages of the implementation was also identified as a key aspect, as this could avoid issues related to the security of information. The assessment of the need, process, problem, and opportunities is also a relevant aspect of the planning as identified by one of the users, avoiding the introduction of unnecessary boards. This is also related to an early identification and analysis of the VM application purpose and requirements. The definition and agreement on the visual device attributes (Valente et al. 2019), such as content and format, as well as identifying and prioritising relevant information (Hirano 1995; Galsworth 2005) was outlined as fundamental when working with a digital whiteboard, as the excess of information or space to work could be overwhelming for its users and it could become very disorganised. In addition, a clear and disciplined way of using such dynamic devices is a must have and it should be agreed in the planning stage (with room for improvement if required). It was suggested by one

of the survey respondents that having a governance process in place could provide support in overcoming those challenges by consolidating and standardising the digital whiteboard management process. One of the participants also identified the time required to develop [and maintain] the board as a challenge, which underlines the need to consider ideating, prototyping, evaluating, and selecting appropriate solutions when possible.

Table 2: VM Implementation Strategy Elements Refined.

VM strategy elements	Definition	Output	Source
Planning	Analyse the readiness of the system and users, by considering its processes, VM purpose, user and system requirements, problems, and opportunities (e.g., emerging technologies), visual and non-visual attributes, and prototype possible solutions.	Planning strategy including cost and implementation plan	Literature review and researchers' insights/observation
Introducing	Train users, provide guidance, facilitate initial applications, and handover to them.	Training and ownership-building plan	Literature review and researchers' insights/observation
Executing	Integrate in the company system by linking with existing VM practices and systems, as well as integrating with managerial routines, and communication and collaboration practices.	Execution plan	Literature review and researchers' insights/observation
Monitoring & controlling	Monitor and evaluate the practical use of VM devices, outline certain criteria for control, capturing the users' feedback through standard approaches defined by the company.	Evaluation plan	Literature review and researchers' insights/observation
Maintaining & improving	Identify key elements of the device or practice that needs to be adjusted or improved.	Maintenance and Continuous Improvement plan	Literature review and researchers' insights/observation
Removing	Identify practices that need to be removed from the system due to different reasons	Exit strategy	Researchers' insights/observation

The 'introducing' element of the VM implementation strategy refers to the effort required prior to the device implementation in order to ensure the users understand its purpose and how it works. It is not only related to training, but also associated with the initial support with its implementation aspects (Pikas et al. 2022) and facilitation required until the users feel confident in using and owning the device, when it can be handed over to the users. As stated by one of the respondents: 'willingness to adopt new digital tools sometimes limits people or their awareness. Sometimes there is a strong resistance from people to change as '[...] they are not prepared to adapt, change or flex to a situation'. This highlights the cultural challenges and emphasises the need for change management, including training, guidance, and ownership-building activities, before the platform implementation. Also, updates to the platform interface or functionality, as well as in the standards, might only be understood by the users with guidance. This would increase their awareness of the platform interface and its functionalities, but also the VM relevance and impact in their own tasks. Ensuring all staff know how to use the platform properly and acquire experience on it to gain the maximum benefit is required.

'Executing' focuses on the integration of the VM practice into the company systems by linking it with existing VM practices and the managerial routines, as suggested by Valente et al. (2019). Identifying the types of communication (i.e. face-to-face, asynchronous distributed,

asynchronous, synchronous distributed, and hybrid synchronous distributed & face-to-face), as well as the number of users and the type of interaction (e.g. one to one or many to one, as suggested by Brandalise at al. 2022) is essential to define the level of digitalisation of a device, e.g. if the device should be manual, digital or hybrid in order to meet the users' requirements. The digital whiteboards were often implemented considering an asynchronous distributed or synchronous distributed collaboration, as well as a high number of users. However, the digital whiteboard adoption through face-to-face or hybrid synchronous distributed and face-to-face approaches is still considered a challenge by the company members due to the staff lack of previous experience and knowledge on how to use it.

The integration of the digital whiteboard into the company processes was facilitated by its user-friendly interface (i.e., clear to use and understand its objective), easy access (stored in the cloud and accessible via website without the need to download apps), and all information being available in one place. In addition, the board templates and information flexibility encouraged its application for different functions, e.g., planning, process mapping or brainstorming. They enhanced collaboration through an efficient connection between the users, by allowing them to access the space and interact to each other in a similar way they would interact face-to-face.

The 'monitoring & controlling' element emerged as a relevant aspect of a VM implementation strategy and it was emphasised by the digital whiteboards due to their flexible and dynamic character. Information management was a challenge identified by the company members, as information could be easily changed without any notification, requiring even more coordination and structure. Regular backups and version control were also found to be essential for the monitoring and controlling process, even this could be considered challenging. A better integration of the digital whiteboard with other existing platforms commonly adopted by the company (such as Task Planner in Microsoft Teams, SharePoint, the scheduling software, or Excel) was suggested as an improvement by the users to support the control activities, as tracking of historical tasks was still considered a challenge. Thus, great benefits could be achieved through a better integration across other software already adopted by the company. As future opportunities, the teams also identified programming, e.g., to automate tasks, as a high-potential aspect that could support this integration.

On the other hand, the users also stated that information was centralised, acting like a source of truth, and avoiding having multiple revisions of documents due to the collaborative nature of the work. Digital whiteboards allow everyone to use the same board at the same time remotely, in a virtual space, and make changes simultaneously, highlighting the importance of the controlling and monitoring elements of a VM implementation strategy. In addition to this, capturing the users' feedback through standard and regular approaches defined by the company, e.g., a survey or the method of plus and delta, or management's observation were also identified as good practices to monitor the current implementation, as well as to identify improvement opportunities and guide future applications. In short, how the users interact with a VM device, and whether they use some or all parts of it as intended should be monitored and controlled, as argued by Greif (1991), with predefined mechanisms. This also includes adopting certain criteria and indicators for the control.

The 'maintaining & improving' element is related to identifying key elements of the device or practice that needs to be adjusted or improved, as well as to creating a maintenance and improvement plan to support those changes, corroborating with Nicolini's (2007) suggestion for devising improvement and maintenance measures. Due to the flexibility and collaborative nature of the whiteboards, it is easy for users to diverge from standard templates, adapting existing templates or using other areas of the boards, which can make it difficult to easily identify relevant information, as stated by one of the respondents. As argued by another team member, over a period of time, the boards become a massive information repository as it is very easy to add information by different people. The amount of time required to update the boards

Bárbara Pedó, Algan Tezel, Lauri Koskela, Patricia Tzortzopoulos, Carlos T. Formoso, Elena Vrabie, and Stuart Robinson

could also become a challenge. Thus, keeping the board structured and maintained is even more relevant, highlighting the importance of the board owner's role to do the housekeeping from time to time. Regular lessons learned shared on its adoption were observed by the researchers as a best practice to support continuous improvement and capture new VM ideas of people, as suggested by Galsworth (1997; 2005). To this end, VM devices can be subject to the Plan-Do-Check-Act (PDCA) continuous improvement cycle. Idea capturing activities, such as workshops, brainstorming and benchmarking sessions, suggestion boxes/boards, can also be adopted.

The 'removing' element is about recognising when a VM practice is not achieving the desired outputs and removing it from the system. This could happen due to different reasons, e.g., when the practices are obsolete or not aligned with their purpose, when the context changes, or due to the end of a project or activity. Without harming the users' view of the strategy and affecting their work, a VM device exit plan should be in place. This includes a communication plan with the users for the reasons of removal, the timeframe for removal, what is going to happen to the information recorded on the VM device to be removed, alternative information channels to substitute the VM device to be removed, new arrangements between the management systems and routines and the VM device to be removed, and future actions in line with the lessons learnt after the removal.

An emergent expansion of the VM device application, through trial-and-error, was noted; people started to adopt the digital whiteboards for different functions and purposes, as the teams became familiar with the whiteboard interface and its functionalities, facilitating its dissemination for other uses. In order to support spontaneous innovations, like the digital whiteboards, an emergent and flexible strategy should be considered where only a few elements could be implemented, e.g., monitoring & controlling, maintaining & improving, and removing. However, as soon as a spontaneous innovation is recognised, the other elements of the VM implementation strategy could also be adopted (such as planning, introducing, and executing), and a deliberate or planned strategy could be devised. This corresponds to the bottom-up approach to VM, which often yields to effective VM solutions for people's information needs, if managed properly (Galsworth 2005).

CONCLUSIONS

VM is often perceived as an intuitive concept executed over sensory devices. This is a limited view to VM, and partly due to the seemingly effortless effectiveness of sensory communication. However, to be able to implement VM as a strategy for creating a visual workplace catering to different contexts and needs, coherent plans and decisions should be in place. These include the VM implementation strategy elements which were explored in this paper at an engineering design organisation as a case. The findings showed the need to understand and address the strategy elements for a successful VM implementation, the absence or deficiencies of which could lead to various challenges and questions during the implementation.

Digital whiteboards are expanding the scope of VM application and the need for a VM implementation strategy has been emphasised to cope with the dynamic interactions in the analysed context. In practice, some of the strategy elements (e.g., colour scheme to be used in VM devices as part of defining visual attributes during the planning) could be adopted as a standard for many VM devices within an organisation. Some of the VM strategy elements still need to be reviewed and tailored for each VM device or practice separately (e.g., integrating with company systems and managerial routines during the executing). The proposed VM strategy elements are initial and by no means definitive. Future research can look at expanding and evaluating definitions and implementation of the strategy elements for different contexts (e.g., construction sites, facilities operations), for different VM purposes (e.g., information sharing, controlling, and limiting human actions), and for different VM device types (i.e.,

manual, digital or hybrid). The VM strategy elements can be further investigated for the top-down and bottom-up implementation modes. The strategy definitions can also be expanded and broken down to tactical level practices or other choice elements.

ACKNOWLEDGMENTS

REFERENCES

Bell, E., & Davison, J. (2013). Visual management studies: Empirical and theoretical approaches. *International Journal of Management Reviews*, 15(2), 167-184. https://doi.org/10.1111/j.1468-2370.2012.00342.x

Beynon-Davies, P., & Lederman, R. (2017). Making sense of visual management through affordance theory. *Production Planning & Control*, 28(2), 142-157. https://doi.org/10.1080/09537287.2016.1243267

Brady, D.A., Tzortzopoulos, P., Rooke, J., Formoso, C.T. & Tezel, A. (2018). Improving transparency in construction management: a visual planning and control model. *Engineering, Construction and Architectural Management*, 25(10), 1277-1297. https://doi.org/10.1108/ECAM-07-2017-0122

Brandalise, F. M., Formoso, C. T., & Viana, D. D. (2022). Development of a Typology for Understanding Visual Management Concepts and Their Relationships. *Journal of Construction Engineering and Management*, 148(7), 04022041.

Chia, R. C., & Holt, R. (2009). *Strategy without design: The silent efficacy of indirect action*. Cambridge University Press, Cambridge, UK.

Dallasega, P., Schulze, F., & Revolti, A. (2022). Augmented Reality to overcome Visual Management implementation barriers in construction: a MEP case study. *Construction Management and Economics*, 41(3), 232-255. 10.1080/01446193.2022.2135748

Formoso, C.T., Santos, A.D. & Powell, J. (2002). An exploratory study on the applicability of process transparency in construction sites. *Journal of Construction Research*, 3(1), 35-54.

Galsworth, G.D. (1997). *Visual Systems: Harnessing the Power of Visual Workplace*. AMACOM, New York, NY.

Galsworth, G.D. (2005). *Visual Workplace: Visual Thinking*. Visual-Lean Enterprise Press, Portland, OR

Gergle, D., Kraut, R. E., and Fussell S. R. (2013) Using visual information for grounding and awareness in collaborative tasks. *Human-Computer Interact*. 28 1–39

Gumienny, R., Meinel, C., Gericke, L., Quasthoff, M., LoBue, P. and Willems, C. (2011) *Tele-Board: Enabling Efficient Collaboration In Digital Design Spaces Across Time and Distance Design Thinking*. Berlin, Heidelberg: Springer Berlin Heidelberg. vol 15, pp 147–64

Greif, M. (1991). *The Visual Factory: Building Participation through Shared Information*. Productivity Press, Portland, OR.

Hirano, H. (1995). *5 Pillars of the Visual Workplace: The Sourcebook for 5S Implementation*. Productivity Press, Portland, OR.

Jang, J.W. & Kim, Y.W. (2007). *Using the kanban for construction production and safety control*. In Proceedings of the 15th Annual Conference of the International Group for Lean Construction (IGLC-15), University of Michigan, Ann Arbor, MI.

Kemmer, S. L., Saraiva, M. A., Heineck, L. F., Pacheco, A. V. L., Novaes, M. D. V., Mourão, C. A. M. A. & Moreira, L. C. R. (2006). T*he use of andon in high rise building*. In Proceedings of the 14th Annual Conference of the International Group for Lean Construction (IGLC-14), Santiago, Chile.

Liff, S. and Posey, P.A. (2004). *Seeing is Believing: How the New Art of Visual Management Can Boost Performance Throughout Your Organization*. AMACOM, New York, NY.

Lindlöf, L. 2014. *Visual Management - on Communication in Product Development Organizations.* PhD Diss., Department of Technology Management and Economics, Chalmers University of Technology, Sweden

Maguire L. M. D. (2019). Managing the hidden costs of coordination. 71–93

Mintzberg, H. (1987). *Crafting strategy*. Harvard Business Review. 66-75.

Mintzberg, H. (2000). *The rise and fall of strategic planning*. Pearson Education.

Nicolini, D. (2007). Studying visual practices in construction. B*uilding Research & Information*, 35(5), 576-580. https://doi.org/10.1080/09613210701355732

Pedó, B., Formoso, C. T., Viana, D. D., Tzortzopoulos, P., Brandalise, F. M., & Whitelock-Wainwright, A. (2022). Visual Management Requirements to Support Design Planning and Control within Digital Contexts. *Sustainability*, 14(17), 10989.

Pikas, E., Pedó, B., Tezel, A., Koskela, L., & Veersoo, M. (2022). Digital Last Planner System Whiteboard for Enabling Remote Collaborative Design Process Planning and Control. *Sustainability*, 14(19), 12030.

Shae, Z. Y., Tseng B., and Leung W. H. (2001). Immersive Whiteboard Collaborative System. *Ann. Softw. Eng. 12* 193–212

Tezel, A. & Aziz, Z. (2017). "Benefits of visual management in construction: cases from the transportation sector in England". *Construction Innovation*,17(2), 125-157. https://doi.org/10.1108/CI-05-2016-0029

Tezel, A., Koskela, L. & Tzortzopoulos, P. (2016). Visual management in production management: a literature synthesis. *Journal of Manufacturing Technology Management*, 27(6), 766-799. https://doi.org/10.1108/JMTM-08-2015-0071

Tezel, A., Koskela, L., Tzortzopoulos, P., Formoso, C. T., & Alves, T. (2015). Visual management in Brazilian construction companies: taxonomy and guidelines for implementation. *ASCE Journal of management in engineering*, 31(6), 05015001.

Tjell, J., & Bosch-Sijtsema, P. M. (2015). Visual management in mid-sized construction design projects. *Procedia Economics and Finance*, 21, 193-200. https://doi.org/10.1016/S2212-5671(15)00167-7

Valente, C. P., Brandalise, F. M. P., and Formoso, C. T. (2019). "Model for Devising Visual Management Systems on Construction Sites." *Journal of Construction Engineering and Management*, 145(2), 04018138-1 04018138-17.

Yin, R. K. 1994. "Case Study Research: Design and Methods (London, Sage Publications)." Inc