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VISUAL MANAGEMENT: PRELIMINARY RESULTS OF A SYSTEMATIC LITERATURE REVIEW ON CORE CONCEPTS AND PRINCIPLES

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ABSTRACT

Visual management (VM) is one of the core categories of practices of Lean Production systems, providing the foundation for other improvement approaches to be implemented and, therefore, may be adopted as one of the first steps of a continuous improvement program. However, there are some challenges regarding the implementation of VM in construction sites: these are usually very large and changing environments, teams and equipment are often spread in large areas, etc. The fact that VM practices and tools are very intuitive hinders the explicit presentation on papers of concepts and principles behind this approach. Therefore, a more robust and comprehensive understanding of the term, its concepts and associated principles is necessary. Moreover, there is a gap in knowledge about the understanding of VM in construction from other knowledge areas such as visual languages, design, infrastructure, mechanics of human visual perception, among others. This paper is part of a wider research project and presents preliminary results of a systematic literature review on core concepts and principles of VM. The aim of this study is to contribute to a better understanding of VM, by collecting information from other relevant research areas.

KEYWORDS

Visual Management, Transparency, Systematic Literature Review.

INTRODUCTION

The increase of process transparency, which has been pointed out as one of the core principles of the new production management paradigm, is concerned with making the production process observable in order to facilitate control and improvement (Formoso et

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al. 2002). The same authors define process transparency as the ability of a production process (or its parts) to communicate with people.

Koskela (1992) suggested a set of practical approaches to increase process transparency: (a) reducing the interdependence between production units; (b) using visual devices to enable immediate recognition of process status and deviations from standards; (c) making the process directly observable through appropriate layout and signals; (d) incorporating information into the process at workstations, tools, materials and information systems; (e) keeping a clean and orderly workplace through 5S programs; and (f) rendering invisible attributes visible through measurements.

There is a certain consensus in the literature from the Lean Construction community on the understanding of VM as a way to promote greater transparency of processes and discipline in the production environment (Tezel, Koskela and Tzortzopoulos 2009). Those authors identified seven other functions for VM: promote continuous improvement, facilitate the work, create a sense of shared ownership, support on-the-job training, enable management by facts, provide simplification and unification. However, it is important to consider that the VM can perform many other functions, such as communication and collaboration, as suggested by Nicolini (2007) and Ewenstein and Whyte (2007). In fact, Tezel, Koskela and Tzortzopoulos (2009) argue that a more complete understanding of the term is necessary for a better use of it. Thus,

In another attempt to better understand the VM practices, Tezel et al. (2015) identified fourteen taxonomic elements for VM, proposed in accordance with: the purpose of the devices, application methods and their management goals. They are organized as follows: removing visual barriers, standardization, 5S program, production control, production leveling, quality at workplace, prototyping and sampling, visual signals, work facilitators, improvised VM, performance management by VM, distribution of information through VM, error-proofing systems and prefabrication on site. However, a taxonomy based on practices can become obsolete very quickly because visual tools and practices emerge from new and different needs. For instance, BIM (Building Information Modeling) related visual devices, for example, have not included in that study despite the existing potential for increasing process transparency.

This study aims to contribute to a better understanding of VM through a systematic literature review, by bringing into discussion knowledge from other relevant research areas in which this topic has been investigated. Traditionally, the term Visual Management has been used to describe the visual management practices in the manufacturing and construction industry. However, in the field of information and knowledge management, some similar practices can be found under the terms of information visualization and knowledge visualization (Eppler and Burkhard 2007). In the visual communications and computing field, the term visual languages is often mentioned in academic studies (Zhang 2012, Eppler and Bresciani 2013). Moreover, in the medical field of neuroscience much research has been developed on the mechanism of human visual perception and theories of cognition and perception (Moore 2001). Therefore, a wide range of knowledge areas has been investigating issues related to VM from quite different perspectives.

THE RESEARCH METHOD

According to Petticrew (2001), systematic literature reviews (SLR) are widely used as an aid to evidence based decision making, and consist of a method of locating, appraising, and synthetizing that evidence. It is important to understand that systematic reviews are not just big literature reviews, and their main aim is not simply to be "comprehensive" but to answer a specific question, to reduce bias in the selection and inclusion of studies, to appraise the quality of the studies considered, and to summarise them objectively (Petticrew 2001). The same author also states that, once done, SLR can often identify the need for additional primary studies as they are an efficient method of identifying where research is currently lacking.

The research question that guided the SLR through the databases was: Which are the core concepts or principles of Visual Management? A first run of searches was made in Google Scholar, in order to identify relevant databases. The databases chosen for the searches were: Science Direct, Scopus, Web of Science, ASCE, Emerald, IGLC e Google Scholar. The logical expressions used for primary searches in databases are shown in Figure 1.

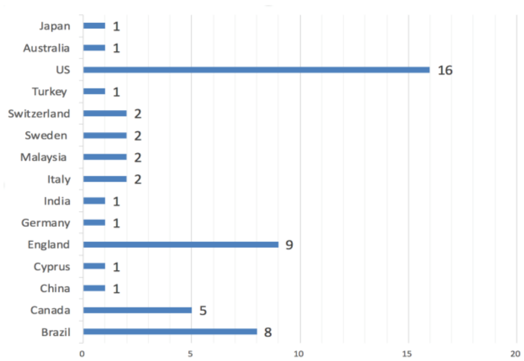
1 - Visual Management	2 - Concepts or Principles	3 - Industry
(Visual AND (Management OR Workplace OR Control OR Factory OR Tools OR Communication))	(Concept* OR Ideas OR Foundations OR Principles OR Elements OR Fundamentals OR Essentials OR Rules OR Tenets)	(Manufacturing OR Construction OR Industry)

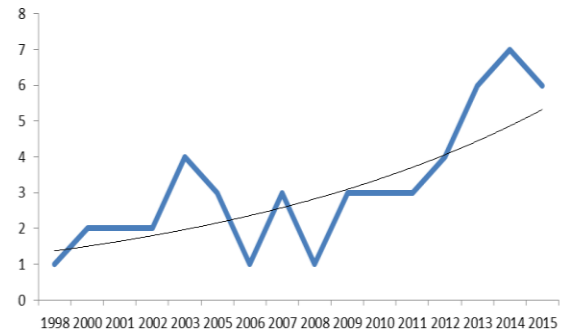
Figure 1: Logical expressions for database searches

Some inclusion and exclusion criteria regarding the title and abstract of papers were used to refine the list of papers selected. For inclusion, the papers had to be English only, theoretical or empirical, define or present a definition of visual management, and focus on sets of tools. Papers containing at least one of the following features were excluded: single tool implementation, forensic and disaster studies, brain research, medical experiments and diseases, geographic information systems or VBA (Visual Basic for Applications) Programming Platform. After this refinement, 60 papers (out of 7,949) were selected for the following phase of the SLR.

For this following phase, some quality criteria were applied to papers: a simple assessment of each paper's background, method, findings use and generalisation was made within a scale of absence (0) to high (3). The papers with the sum below 6 points would be excluded from the list. Also, during the reading of all papers, relevant excerpts of text regarding concepts, principles, benefits, impacts and opportunities for improvement were extracted. After this stage, 53 papers remained in the SLR.

Regarding the origin of papers, more than 60% of them came from the United States, England and Brazil (Figure 2), confirming the known contributions from those countries on the subject for a long time. Regarding the evolution along time, data indicated that visual management has become increasingly recurrent and how the number of publications have increased substantially in the past 15 years (Figure 3).





Figures 2 and 3: Origin of papers and Number of publications per year of analysed papers

One of the most surprising results of the systematic literature review is concerned with the different areas of expertise found. Due to the focus of the systematic review concentrated on management areas, 58% of the articles are within the areas of construction, project management, business and manufacturing. The remaining percentage is distributed by various knowledge fields such as social sciences, neuroscience and visual languages and computing (Figure 4). Such publications, particularly, provided insights for the understanding of visual management in construction from different perspectives.

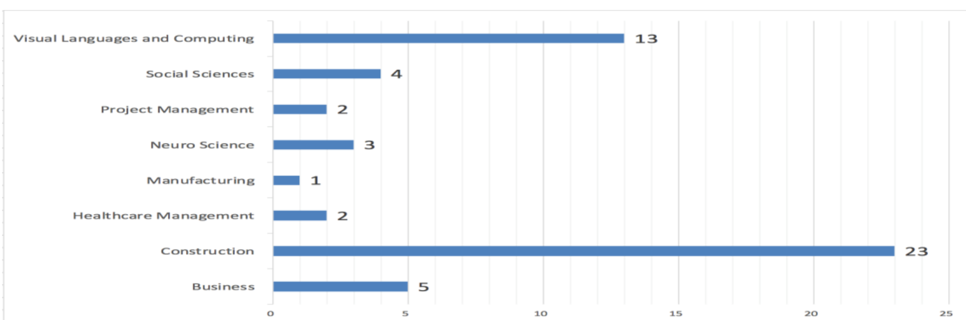


Figure 4: Knowledge fields of analysed papers.

CONTRIBUTIONS FROM THE IGLC COMMUNITY

For IGLC community, the main process transparency definitions are presented by Koskela (1992) and Formoso et al. (2002). Regarding VM definitions most widely used basically are the ones of Greif (1991) and Galsworth (1997). There seem to be a certain confusion in the understanding of the difference between process transparency and VM. Valente and Costa (2014) seek to clarify that process transparency is a principle and VM is a set of practices that have increased transparency as one of its objectives. In fact, Tezel et al. (2013) pointed out that there is no consensus that process transparency is a direct result of VM.

In any case, over the 12 reviewed papers, the authors discuss the relationship of process transparency and other concepts, such as variability (Saurin et al. 2006), management-as-organising (Viana et al. 2014), decision-making decentralization (Bowen and Lawler 1992 apud Tezel et al. 2010), complexity (Viana et al. 2014), rhetoric (Koskela 2015), autonomation (Saurin et al. 2006) and pulled information (Moser and Santos 2003).

Regarding the principles of VM, most IGLC papers are unanimous regarding the use of devices and VM practices that are affordable, portable or mobile, easy to understand and to have information updated, flexible in relation to users' needs, accurate, and financially viable. Other authors also suggest that the VM tools should mitigate system complexity related problems (Viana et al. 2014), contribute for a cultural change in the company (Valente and Costa 2014), be designed for simplicity of functioning (Saurin et al. 2006), match designers and users' mental models (Saurin et al. 2006) and have a behavior-oriented approach for achieving targets (Neto et al. 2014).

In terms of the effects of using VM devices, the readings provided a number of positive impacts: clarify expectations, greater consistency in decision-making, greater participation and motivation of employees, improve the distribution of information (Valente and Costa 2014, Brady et al. 2013), avoid idleness or overload teams, promote collaboration and continuous improvement (Viana et al. 2014, Brady et al. 2013), establish and reinforce a common ground of values and information (Koskela 2015), increase productivity, reduce defects and errors, improve communication, safety and performance in relation to meeting deadlines (Laine et al. 2014).

Tezel et al. 2010 already discussed the importance of information design, information modality and semiotics in the application of VM, which confirms the strong relationship that visual management has with the field of information management. Laine et al. 2014 pointed out that, from an information management perspective, the principles of visual management are difficult to apply to the information flow in digital systems.

CONTRIBUTIONS FROM OTHER RESEARCH AREAS

NEUROSCIENCE

Neuroscience and neuropsychology are concerned with the mechanism of human visual perception and how visual representations stimulate cognition through statistical analyses and different treatments. Spagnol et al. (2015) confirm that illustrations have a more important role in cognitive memory than words and assist in communicating complex messages with simplicity. Regarding the implementation of the steps of the 5S program, for example, that study indicated that 5S visual patterns facilitate the brain pathways for processing information, requiring less new cognitive demands, which can be very useful at construction sites where the majority of employees have low levels of education. By the way, Moore (2001) presented concepts of cognition and visual spatial perception for the communication of concepts of production and construction techniques. That author considers the importance of previous experiences and mental models of users in the desired interpretation of visual information.

Cao and Chen (2014) reported the importance of new discoveries in the visual psychology field for the development of safety facilities in highway traffic. Principles like the effect of persistence of vision and the visual superposition have been used for designing anti-collision equipment and intelligent speed limit signals.

Pavlova et al. (2010) report that not only the visual spatial abilities of navigation and mental rotation are impacted by gender differences, but also that some aspects of social cognition are dependent on this factor. The latest findings indicate that women overperform on visual social cognition tasks, reflecting the dependence of gender in processing of visually acquired social information.

Milner and Goodale (2008) state that visual information is transformed in different ways for different purposes, which suggests a distinction in visual system into vision for perception and vision for action. Those authors also understand that the connection between the two pathways is flexible and indirect, in which cognitive operations like memory and planning play a major role.

SOCIAL SCIENCES AND VISUAL COMMUNICATION

The papers from social and behavioural sciences address the term visual in different ways, emphasising the relationship between visual communication and design and education, culture, society and the formation of skilled and creative professionals.

Dur (2014), in a paper about the reflection of culture in poster design, establishes that visual in "visual culture" can be defined as "everything that is visual, functional, communicational or having aesthetic purpose produced, interpreted or formed by people". The same author also states that a culture and society's beliefs, behavioral patterns, values and traditions can influence design processes. In design, establishing effective communication requires the designer to use a visual language that the target audience can understand. In fact, it is important to make effective visual use of cultural codes by first learning, understanding and analyzing the culture of the society in question.

Turgut (2013) highlights the importance of the design and layout of data in a readable, attractive and effective way, in order to support the visual identity of institutions. For this purpose, it is important for all the visual elements of the product to be designed in accordance with the aims of the institutional identity.

Sekeroglu (2012), in an overview of art and design education, understands that visual communication design, which was developed alongside a number of art and design movements and was established upon a contemporary system, has become an indispensable part of mass communication. The author also states that an education system that does not nurture creativity, which essentially constitutes the backbone of the creation process, makes it almost impossible to cultivate individuals who can contribute to the fast changing field of communication design.

Sekeroglu (2012) and Adiloglu (2011) also recognize the different skills professionals of visual communication must develop since childhood and how it is difficult for the society to support the creative thinking for visual communication through educational policies. Moreover, the latter considers visual communication to be an interdisciplinary field. Mange et al. (2015) pointed out the importance of visual environments for the development of visual thinkers.

VISUAL LANGUAGES AND COMPUTING

In the field of visual languages and computing, a fairly different perspective on the subject is adopted. At first, it was concerned with proposing classes, frameworks and methods for conceiving visual languages and representations, in order to promote enough freedom for designing and facilitating the process (Bottoni et al 1998, Costagliola et al. 2002). As this field has rapidly evolved in recent years, the most recent publications address the issue of knowledge visualization, management visualization and collaborative dimensions of visualization (Zhang 2012, Eppler and Bresciani 2013, Yusoff and Salim 2015, Alexander et al. 2015), which can be very useful in the construction industry.

Bottoni et al. (1998), for example, discuss the adoption of dialog controls as a crucial component of visual interactive systems. They argue that a demanding requirement is that it both allows freedom to perform actions according to the user's intentions and yet ensures that only legal actions may be performed, which could be understood as digital poka-yokes. To meet this requirement, they propose a formal method based on the definition of human-computer interaction as generation and interpretation of visual sentences which constitute a visual language. Ahead of its time, that paper described a step in a research program aimed at establishing a user-centered approach to design and implement visual interactive systems.

Costagliola et al. (2002) presented an important step in the design of visual languages: the specification of the graphical objects, and the composition rules for constructing feasible visual sentences. The presence of different typologies of visual languages, each with specific graphical and structural characteristics, yields the need to have models and tools that unify the design steps for different types of visual languages. Thus, when designing a visual language, it can be useful to first analyze its characteristics in order to associate it to an appropriate class. It may be helpful to understand visual management in construction from that perspective, in a way that we must develop models and methods for conceiving and designing new tools, not only try to classify what already exists.

In a more recent paper, Zhang (2012) claims that the discussion of visual communication in management can be considered one of the important topics in the framework of managerial aesthetics, an emerging multi-disciplinary subject which emphasizes the critical roles of visual elements (e.g. in art, design and visualization) in modern management. He also strongly advocates that visual thinking in general and art and design courses in particular should be included in the MBA and executive education curricula.

Eppler and Bresciani (2013), in a response paper to Zhang (2012), highlights how visualization can enhance collaborative activities in organizations beyond cognitive and communicative advantages. That paper reports qualitative visualizations such as conceptual diagrams, metaphors or sketches used as collaboration catalysts to facilitate a variety of tasks, from idea generation to decision-making, planning, knowledge sharing and learning. They also present the notion of collaborative dimensions of visualization: these dimensions can be used to describe the key features of a visual language and determine whether it is suitable for a certain management task or not. They believe that the field of knowledge visualization will establish itself next to information visualization as a separate branch of visualization studies.

Yet around the subject of visualization for collaborative purposes, Yusoff and Salim (2015) define collaborative visualization by the shared use of computer-supported interactive visual representations of data by more than one person with the common goal of contribution to joint information processing activities. They define the use of shared visual representation as how data or knowledge can be captured, represented, presented and analyzed among the users involved.

Lastly, Alexander et al. (2015) recognize the rapid proliferation of visual aids for knowledge work like mind mapping software, screen sharing applications, interactive whiteboards, etc., making visuality to gain a new urgency. In this context, visual restrictiveness, conceived as the constraints imposed by a graphic template on the process of knowledge work, is a highly relevant dimension. The findings of that paper show that visual representations can have a significant impact on the process and outcomes of experience sharing, mediated by the structural pattern of their appropriation.

CONCLUSIONS

The preliminary results of this Systematic Literature Review has indicated that a list of relevant topics related to visual management has been investigated in other research areas. Some of those topics have not yet been addressed neither by the IGLC nor by the Lean Manufacturing community, and deserve special attention. The concern with the visual identity, the social and cultural issues, the association with family mental models and the creative process of developing visual devices should be more emphasised in the construction industry, with the aim of properly implementing in construction projects. It should be possible, for example, from a deeper understanding of these issues, appropriate them to a specific training for the preparation and interpretation of visual devices.

It is also worth noting how visual devices are used for different purposes in contrast with production management. On one hand, the aim of many VM practices in production management is process standardization for rapid detection of deviations. On the other hand, in some social science related fields, the devices aim to stimulate the creativity of users, joint processing of information and collaboration. In fact, they use the terms collaborative visualization and shared visual representations to emphasize the collaborative dimensions of practices.

Finally, it is essential to understand the complex relationship between cognitive process and VM practices. Generally, we associate visual devices to facilitating the cognitive processes of perception, learning and memory, but we do not investigate the inverse relationship. How cognition processes can result in better visual practices? How can we develop better visual devices from a better understanding of human cognitive processes? How can we nurture more visual thinkers in our construction community? These issues deserve further research.

Lastly, some existing knowledge gaps that can be jointly addressed: the absence of a conceptual model that defines information display for strategies without restricting the type of tool to be used, ensuring greater flexibility and the possibility of innovation (as visual languages address); and the need for understanding the visual representations of information as related specifically to each type of user in construction sites, identifying the need to know how to perform their activities as well as why, how and when (in a user-centered approach).

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