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Visual Management – A General Overwiev

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Abstract
Visual Management has been evolving and effectively employed in some manufacturing and service organizations for a long time. It is an essential element of the lean production system that can be approached from different scientific disciplines as well. The aim of this paper is to present a general overview of Visual Management, covering its definition, distinct attributes, brief history and identified functions within an organization. The anticipated future directions of Visual Management and the past research efforts, related to this field in construction management, were also discussed in detail. An extensive literature review and an analysis of the findings were performed accordingly. The necessity of a better understanding of how to effectively implement Visual Management in the construction environment was noted as an important future search opportunity.

Keywords
Visual management, Functions, Future directions, Lean construction

1. Introduction

People constantly face torrents of data from their environments (Edley, 2003), which are sometimes the by-products of complexifying technology and innovation, meant for easing their lives, and constantly increasing expectations (Hollnagel and Woods, 2005). Some manufacturing and service organizations have been conciously using simple,yet cognitively effective visual tools to filter this data torrent and make quality information (necessary, relevant, correct, immediate, easy-to-understand and stimulating) flow for people to use in their day-to-day work transactions (Harris and Harris, 2008). This effort is generally called Visual Management. Visual Management can be defined as a management system that attempts to improve organizational performance through connecting and aligning organizational vision, core values, goals and culture with other management systems, work processes, workplace elements, and stakeholders, by means of stimuli, which directly address one or more of the five human senses (sight, hearing, feeling, smell and taste) (Liff and Posey, 2004).

Managing projects and groups of people with visual clues is not a new concept and dates back almost 4500 years with The Egyptial Royal Cubit. Robert Owen, as a pioneering industrilization figure, resorted to highly visual artefacts (e.g. the Silent Monitor) to manage human resources in the early 19th century. In 1977, Sugimori et al (1977), the Toyota managers, and Ashburn (1977) published the first papers in the English language on the highly acclaimed Toyota Production System, which extensively integrates Visual Management in its operational and managerial activities (Liker, 2004).

1.1 Visual Workplace

Visual Management is realized in visual workplaces, which are structured with information giving, signaling, limiting or guaranteeing (Mistake-proofing/ Poka-yoke – see Shingo (1989)) visual devices to communicate with “doers”, so that places become self-explanatory, self-ordering, self-regulating and self-improving (Galsworth, 1997). Visual elements create an information field for people to pull the necessary information from and help people make sense of the organizational context at a glance by merely looking around (Greif, 1991). An exemplary visual workplace can be seen in Figure 1

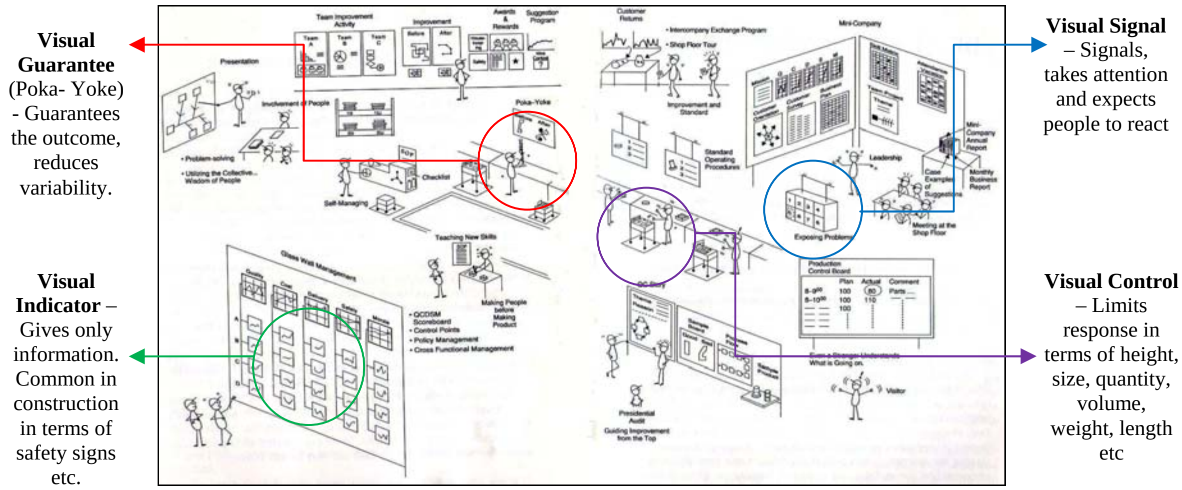

Figure 1: Visual Workplace (Adapted from Suzaki, 1993:14-5)

2. The Functions of Visual Management

Visual Management takes supportive role in other managerial practices. Visual production control, the Kanban; visual workplace organization, the 5S or visual quality control, the Andon are some of various examples of these roles. The relations between Visual Management and other managerial practices can be seen in Figure 2

Figure 2: Visual Management and its Relations

Taking a supportive role in other managerial practices, Visual Management can also serve a broad range of functions within an organization, particularly at the operational level. These functions are summarized in Table 1. For the detailed explanations of the functions, see Tezel et al. (2009)

Table 1: The Functions of Visual Management

Function	Definition	Alternative Practice
Transparency	The ability of a production process (or its parts) to communicate with people (Formoso et al., 2002).	Information held in people's minds and on the shelves.
Discipline	Making a habit of properly maintaining correct procedures (Hirano, 1995).	Warning, scolding, inflicting punishments, dismissing etc.
Continuous Improvement	An organization-wide process of focused and sustained incremental innovation (Bessant and Francis, 1999).	Static organizations or big improvement leaps through considerable investment.
Job Facilitation	Conscious attempt to physically and/or mentally ease people's efforts on routine, already known tasks by offering various visual aids*.	Expecting people to perform well at their jobs without providing them any aids.
On-the-Job Training	Learning from experience (Mincer, 1962) or integrating working with learning (Sumner et al., 1999).	Conventional training practices or offering no training.
Creating Shared Ownership	A feeling of possessiveness and being psychologically tied to an object (material or immaterial) (Pierce et al., 2001).	Management dictation for change efforts, vision and culture creation.
Management by Facts	Use of facts and data based on statistics (Gunasekaran et al., 1998)	Management by subjective judgment or vague terms.
Simplification	Constant efforts on monitoring, processing, visualizing and distributing system wide information for individuals and teams*,	Expecting people to monitor, process and understand the complex system wide information on their own.
Unification	Partly removing the four main boundaries (vertical, horizontal, external and geographic) (Ashkenas et al., 1995) and creating empathy within an organization through effective information sharing*.	Fragmentation or "this is not my job" behavior

* The definition made by the authors.

3. Future Directions in Visual Management

There are two rapidly developing technologies, from which extensive support for Visual Management can be received. These are Information and Communication Technologies (ICT) and the concept of nano-engineered Smart Materials,

3.1 ICT and Visual Management

The relationship between ICT and Visual Management has been developing within three categories. One of the categories involves the direct ICT replacement of conventional Visual Management practices, in which conventional practices are automated with ICT, sometimes also with added functionality. Ford's Electronic Kanban, which works on low frequency radio waves is used also for asset tracking (Lean Manufacturer Advisor, 2003) or Internet/Intranet connected electronic takt monitors (Lean Manufacturer Advisor, 2005) can make examples for this category.

The second category is about using visual elements and their principles to increase software and interface usability and heuristics. Nielsen's (1994) canonical ten usability heuristics, like visibility of system status, making information appear in a natural and logical order, error prevention etc**.** are realized through various visual systems, partly similar to their production environment counterparts. These principles are also in accordance with Norman's (1998) user centred design approach and cognitive system development efforts (Hollnagel and Woods, 2005). The undo or redo functions in software, for example, are typical examples of a type of mistake-proofing principle, the facilitation of the correction of errors (Shingo, 1989).

The Ubiquitous Computing (UbiComp) or "ambient intelligence" movement constitutes the third category. UbiComp aims at integration of computing in people's working, domestic, and leisure lives, functioning invisibly and unobtrusively in the background and freeing people to a large extent from tedious routine tasks. Ubiquity will have been achieved only when computing has become invisible (i.e., microprocessors are embedded in the everyday object we use but we are largely unaware of it) and there is "intelligent" communication between the objects that "anticipate" our next move (Weiser, 1991). In order to make the computer disappear (at least in the user's perception), the interaction has to be seamlessly integrated with the primary task of the user. The user still interacts with the tools that help them to do a certain job, but their focus is on the task itself (Schmidt, 2002). The UbiComp's evolution has recently been accelerated by improved wireless telecommunications capabilities, open networks, continued increases in computing power, improved battery technology, and the emergence of flexible software architectures (Lyytinen and Yoo, 2002); e.g. hand-held personal digital assistants (PDAs), digital tablets, laptops, and wall-sized electronic whiteboards. Ubicomp applications need to be context-aware (such as location and identity), adapting their behavior based on information sensed from the physical and computational environment (Abowd and Mynatt, 2000). Face recognition, biometric identification, Bluetooth, RFID-based smart labels, infrared systems, wireless networking are some of the used tools to achieve context awareness.

Visual Management and the UbiComp concept overlap in a sense that they both try to make communication essentially transparent for users, to create context (Who, Where, Why, When etc) and situation awareness and are integrated into environment or artefacts for people to pull information. The UbiComp concept may offer some advantages over conventional Visual Management practices with its information richness (type and content), computational power, high degree of interactivity – if necessary or desired, easy, frequent and correct information update, flexibility (When mobility is essential, like the construction environment, mobile applications can be dominant. When the settings are fixed, like healthcare or facilities management, pervasive systems can be dominant), highly customised – context and situation specific - information presentation and innovative systems/applications with advancing technology. In spite of these advantages, financial and technical feasibility, usability-acceptance and privacy issues can be problematic. Conventional Visual Management practices offer simple, low-cost tools, yet they possess some advantages over complex ICT systems with their immediate, widely accessible, flexible, inexpensive and responsive nature (Mann, 2005).

3.2 Smart Materials and Visual Management

Rittel (2006:8) defines the concept of "smartness" in material technology as such:

> Smart materials is a relatively new term for materials and products that have changeable properties and are able to reversibly change their shape or colour in response to physical and/or chemical influences e.g. light, temperature or an application of an electric field. Non-smart materials have no such special properties; semi-smart materials are notable for their ability for example, to change their shape in response to an influence once or a few times. With Smart Materials these changes are repeatable and reversible.

Smart Materials have already been used for construction elements (particularly in architectural and interior design). Without dwelling on the phyical and chemical structures of these materials, a list of some of the Smart Materials with their corresponding input/outputs can be seen in Table 2 (Addington and Schodek, 2004:82):

Table 2: The List of Selected Smart Materials

Type of Smart Material	Input	Output
Thermomochromics	Temperature difference	Color Change
Photochromics	Radiation (Light)	Color Change
Mechanochromics	Deformation	Color change
Electrorheological	Electric potential difference	Stiffness/viscosity change
Photoluminescents	Radiation	Light
Light-emitting diodes	Electric Potential Difference	Light
Piezoelectric	Deformation	Electric Potential Difference

Interactive form and attribute change as a reaction to specific differences in a material is a way of information convayence through sensory stimuli at the same time. As an example, a surface covered with a material that immediately changes its color or radiates light when it is touched (heat transfer) or squezzed (under pressure) can find a place in Visual Management practices. It is highly a matter of experimental ingenuity, feasability and awareness of these technologies.

4. Visual Management and Lean Construction

The research in Visual Management has been generally presented in the lean construction related literature. A concise definition of lean construction is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value" (Koskela et al. 2002). Lean Construction takes its roots from the principles of the Toyota Production System or Lean Production, a term which was coined by Womack et al. (1990), and deals with the adaptation of the lean production practices into the construction environment.

The deficiencies in the current practice of project realization in construction have been discussed intensively. One of the theoretical proposals for complex, project-based construction production systems to improve their performance is the Transformation-Flow-Value (T.F.V) approach. Incorporating in the craft production, mass production, lean production compositions and value generation for the customer goal, Koskela (2000) asserted the necessity of the T.F.V approach for a wider understanding of construction. Information flow and transparency are essential elements of the flow understanding for construction production systems. Both the transparency concept and efforts in adapting visual management practices from manufacturing operations into the construction environment have promoted the Visual Management research in construction.

In the lean construction literature, it can be observed that the general tendency is to adapt the proven lean manufacturing tools for the construction industry through various case studies. Dos Santos and Powell (1999) discussed the applicability of Poka-Yoke devices in the construction environment and identified a gap for research in this area. Tommelein (2008) displayed some mistake-proofing examples in design, construction and maintenance later, and announced the research effort on mistake-proofing in Project Production Systems Laboratory (P^2SL) at the University of California at Berkeley, California. Formoso et al. (2002) discussed the obstacles in the application of the transparency principles in the construction environment through six case studies in the U.K and Brazil. Dos Santos et al (2002) identified the importance of the visual elements in the cell production attempts in construction. Arbulu et al. (2003) showed an application of the Kanban in on/off site material supply. Kemmer et al. (2006) displayed an application of the Andon and the Heujika Box in a high-rise building construction. Saurin et al. (2006) identified the link between Safety Management in construction and Visual Management. Jang and Kim (2007) showed an application of the Kanban in production control and safety with the Last Planner System in construction. Khalfan et al. (2008) demonstrated an application of the supplier Kanban to deliver selected products from preferred suppliers and manufacturers to site on a just-in-time basis in operations and maintenance of housing stocks

5. Conclusion and Remarks

A general overview of the Visual Management concept was presented in this paper. The functions of Visual Management and two main expected directions for the near future were identified. The past research efforts were summarized within the lean construction concept. Visual Management is a highly practical and intuitive solution for different operational and managerial problems, yet an academic research in this field may be performed in a multi-disciplinary fashion, covering information design, system engineering, cognitive ergonomics, semiotics, Gestalt psychology, computer science and even nano-engineering. It is also applicable throughout the whole construction life-cycle, namely design, construction and facilities management. Nevertheless, an important question still remains unanswered: What are the parameters of a successful Visual Management implementation in the construction environment? Finding a satisfactory answer to this question necessitates rigorous study of construction environments, which are thought to be successful in their Visual Management applications.

6. References

Abowd, G. D. and Mynatt, E. D. (2000). "Charting past, present, and future research in ubiquitous computing". *ACM Transactions on Computer-Human Interaction*, Vol. 7, No. 1, pp. 29–58.

Addington, M. and Schodek, D. L. (2004). *Smart Materials and Technologies in Architecture*, Architectural Press, Burlington, USA.

Arbulu, R., Ballard, G. and Harper, N. (2003). “Kanban in construction”, *In Proceedings of the 11th IGLC Conference,* Blacksburg, USA.

Ashburn, A. (1977). "Toyota's famous Ohno system". *American Machinist*, Vol. 21, No. 7, pp. 120–123.

Ashkenas, R. N., Ulrich, D., Jick, T. and Kerr, S. (1995). *The Boundaryless Organization: Breaking the Chains of Organizational Structure*, Jossey Bass, San Francisco, USA.

Bessant, J. and Francis, D. (1999). "Developing strategic continuous improvement capability". *International Journal of Operations and Production Management*, Vol. 19, No. 11, pp. 1106-1119.

Formoso, C. T., Santos, A. D. and Powell, J. (2002). "An exploratory study on the applicability of process transparency in construction sites". *Journal of Construction Research*, Vol. 3, No. 1 pp. 35-54.

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

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

Gunasekaran, A., Goyal, S. K., Martikainen, T. and Yli-Olli, P. (1998). "Total quality management: A new perspective for improving quality and productivity". *International Journal of Quality and Reliability Management*, Vol. 15, No. 8/9, pp. 947-968.

Harris, C. and Harris, R. (2008). *Lean Connections: Making Information Flow Efficiently and Effectively*, Productivity Press, New York, USA.

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

Hollnagel, E. and Woods, D. D. (2005). *Joint Cognitive Systems: Foundations of Cognitive Systems Engineering*, CRC Press, Boca Raton, USA.

Kemmer, S. L., Saraiva, M. A., Heineck, L. F. M., Pacheco, A. V. L., Novaes, M. d. V., Mourão, C. A. M. A. and Moreira, L. C. R. (2006). "The use of andon in high rise building", *In Proceedings of the 14th IGLC Conference*, Santiago, Chile.

Khalfan, M. A. A., McDermott, P., Oyegoke, A. S., Dickinson, M. T., Li, X. and Neilson, D. (2008). "Application of Kanban in the UK construction industry by public sector clients", *In Proceedings of the 16th IGLC Conference*, Manchester, UK.

Koskela, L. (2000). "An Exploration Towards a Production Theory and its Application to Construction", PhD. Thesis, VTT Building Technology, Espoo, Finland.

Koskela, L., Ballard, G., Howell, G. and Tommelein, I. (2002). "The Foundations of Lean Construction", Best R. and Valence G. d. (Eds.), *Design and Construction: Building in Value*, Butterworth-Heinemann, Oxford, UK.

Lean Manufacturer Advisor (2003). "Ford's Electronic Kanban Makes Replenishment Easy.", Vol. 5, No. 5.

Lean Manufacturer Advisor (2005). "Problems Become Obvious by Displaying Takt vs. Actual.", Vol. 6, No. 11.

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, USA.

Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*, McGraw-Hill, New York,USA.

Lyytinen, K. and Yoo, Y. (2002). "Issues and challenges in Ubiquitous computing". *Communications of the ACM*, Vol. 45, No. 12, pp. 62-65.

Mann, D. (2005). *Creating a Lean Culture: Tools to Sustain Lean Conversion*, Productivity Press, New York, USA.

Mincer, J. (1962). "On-the-job training: Costs, returns, and some implications". *The Journal of Political Economy*, Vol. 70, No. 5 (part 2), pp 50-79.

Nielsen, J. (1994). "Heuristic Evaluation", Nielsen J. and Mack R. L. (Eds.), *Usability Inspection Methods*, John Wiley & Sons, New York, USA.

Norman, D. A. (1998). *The Design of Everyday Things*, MIT Press, London, UK.

Pierce, J. L., Kostova, T. and Dirks, K. T. (2001). "Toward a theory of psychological ownership in organizations". *The Academy of Management Review*, Vol. 26, No. 2, pp. 298-310.

R.Endsley, M., Bolté, B. and G.Jones, D. (2003*). Designing for Situation Awareness*, Taylor & Francis, London, UK.

Ritter, A. (2006). *Smart Materials in Architecture, Interior Architecture and Design*, Birkhauser, Basel, Switzerland.

Santos, A. d., Moser, L. and Tookey, J. E. (2002). "Applying the concept of mobile cell manufacturing on the drywall process", *In Proceedings of the 10th IGLC Conference*, Gramado, Brazil.

Santos, A. D. and Powell, J. (1999). "Potential of Poka-Yoke devices to reduce variability in construction", *In Proceedings of the 7th IGLC Conference*, Berkeley, California.

Saurin, T. A., Formoso, C. T. and Cambraia, F. B. (2006). "Towards a common language between lean production and safety management", *Proceedings of the 14th IGLC Conference*, Santiago, Chile.

Schmidt, A. (2002). "Ubiquitous Computing: Computing in Context", PhD. Thesis, Lancaster University, UK.

Shingo, S. (1989). *A Study of the Toyota Production System from An Industrial Engineering Viewpoint*, Productivity Press, Portland,.USA.

Sugimori, Y. K., Kusunoki, K., Cho, F. and Uchikawa, S. (1977). "Toyota production system and Kanban system: Materialization of just-in-time and respect-for-human system". *International Journal of Production Research*, Vol.15, No.6, pp. 553 – 564.

Sumner, T., Domingue, J., Zdrahal, Z., Millican, A. and Murray, J. (1999). "Moving from on-the-job training towards organisational learning", *In Proceedings of the 12th Workshop on Knowledge Acquisition, Modelling and Management*, Alberta, Canada.

Suzaki, K. (1993). *The New Shop Floor Management: Empowering People for Continuous Improvement*, The Free Press, New York, USA.

Tezel, A., Koskela, L. and Tzortzopoulos, P. (2009). “The functions of visual management”, *In Proceedings of the International Research Symposium*, Salford, UK.

Tommelein, I. D. (2008). “'Poka-Yoke' or quality by mistake proofing design and construction systems”, *In Proceedings of the 16th IGLC Conference*, Manchester, UK.

Weiser, M. (1991). "The computer for the 21st century." *Scientific American*, Vol. 265, No. 3, pp. 94-104.

Womack, J. P., Jones, D. T. and Ross, D. (1990). *The Machine that Changed the World*, Maxwell Macmillan, Oxford, UK.