PROCESS TRANSPARENCY ON CONSTRUCTION SITES: EXAMPLES FROM CONSTRUCTION COMPANIES IN BRAZIL

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ABSTRACT

Process transparency is the core concept in Visual Management (VM), which is one of the founding blocks of the Toyota Production System. This paper presents the preliminary results of a collaborative research conducted between Brazil and the UK, as part of a research effort focused on the application of Visual Management in construction. How process transparency is realized on construction sites is the main research question of the paper. The use of this concept and the implementation of the transparency theory were investigated through multiple case studies, carried out in nine different construction companies. The findings are explained through six theoretical transparency increasing approaches. The affecting parameters in the application of, the management's perception of and several methods in process transparency in construction were identified. Further work, especially exploring the functions of process transparency on construction sites and reflecting the worker perception of the issue, is necessary to elaborate the process transparency concept.

KEY WORDS

Process transparency, Visual Management, lean theory implementation.

PROCESS TRANSPARENCY

Process transparency is "the ability of a production process (or its parts) to communicate with people" (Formoso et al., 2002: 38). Koskela (1992: 22) suggests a set of approaches that can be used to improve process transparency: reducing the interdependence between production units, using visual devices to enable immediate recognition of process status, making the process directly observable through appropriate layout and signage, incorporating information into the process, maintaining a clean and orderly workplace and rendering invisible attributes visible through measurements.

Those approaches should not be understood as separate notions. For example, it is hard to observe something on a construction site, even with appropriate layout and

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signage, without maintaining a clean an orderly environment. Process transparency is achieved by using information giving, signalling, limiting or guaranteeing (mistake-proofing or *poka-yoke*) visual tools to communicate with people so that work settings expectedly become self-explanatory, self-ordering, self-regulating and self-improving (Galsworth, 1997). In fact, the term sensory tools seems to be more appropriate, since those tools may not address only the eye.

Transparent organisational entities radiate information through physical artefacts or remove the blockage for improving information flow. Some aspects of transparency such as the goal of delegation of decision making from higher to lower organisational levels and increasing information availability for individuals coincide well with the fundamental requirements of the organisational empowerment practice (Bowen and Lawler, 1992). Moser and Santos (2002) have discussed the main practical impacts of process transparency in a work environment.

Information design, information modality (visual, auditory, tactile, gustatory and olfactory) and semiotics (the study of symbols) should be of the important concerns in process transparency (Lehto and Buck, 2007; Ware, 2004).

Formoso et al. (2002) investigated the transparency approaches proposed by Koskela (1992) through the brick laying process on six construction sites. It was found that the nature of production units (mobility), lack of awareness of the concept and construction end-product itself (as the constructed identity barriers transparency) partially hinders increased transparency efforts.

Another research approach on transparency in construction is to demonstrate the application of a well-known manufacturing based, transparency increasing tool for the construction industry through various case studies (see for example Arbulu et al., 2003). Some of the concepts, like the *poka-yoke*, has reportedly not yet diffused in construction as desired, despite repeating calls in years (Tommelein, 2008). Various attempts to increase process transparency in construction through IT do also exist (see for example Akinci et al., 2002).

The research presented in this paper was designed to focus on construction sites and construction companies in general, rather than a single, isolated construction process (e.g. brick layering). Based on the theoretical propositions for process transparency proposed by Koskela (1992), the research aims to understand how process transparency is applied in the construction phase of a project and the affecting parameters in application at a macro level. The research targeted the VM practices of nine different construction companies, with data collected between June-July, 2009, in the Brazilian cities of Porto Alegre and Fortaleza. Due to the page limitation, only the preliminary results can be presented to a certain degree in this paper. Process transparency is a part of VM. The possible functions of VM in an organisation were discussed in Tezel et al. (2009). A more comprehensive description of the application of VM in construction can be found in Tezel et al. (2010).

THE RESEARCH METHODOLOGY

The research methodology for the study is multiple exploratory case studies. According to Yin (2003), the case study is suitable when the “how” and “why” questions are asked to a contemporary event over which the investigator has little or no control. In management research, cases have often been used to study events that are unusual, noteworthy, unfamiliar and involve change. Cases are frequently used to

explain the implementation of new methods and techniques (McCutcheon and Meredith, 1993).

Nine different building construction sites (generally, high-rise residential buildings with a reinforced concrete load bearing structure and brick partitions) of nine different construction companies were visited. The companies are small/mid size companies operating locally. A research protocol, which had been devised in the UK, was fully completed with five companies, and with the rest of the companies a partial completion of the protocol could be achieved. The research protocol consists of semi-structured interviews with management (company manager, site manager and foreman), documentation of practices with photos and analysis of archives. The principal researcher was assisted by the local researchers in establishing connection with the companies and translations.

There are some limitations in the research: the limited overall research time, the absence of worker view on the subject, the language barrier (the principal researcher was dependent on the local researchers to communicate in Portuguese), the busy construction conditions and tight construction schedules, the "research fatigue" (of some companies as they have frequently been subjects for research) can be noted as limitations. In the rest of the paper, the preliminary findings of the research will be presented through the approaches for process transparency by Koskela (1992).

REDUCING THE INTERDEPENDENCE BETWEEN PRODUCTION UNITS

This principle was most frequently observed in the pre-assembly of the electrical junk box on brick units before brick layering. The on-site prefabrication of the mortar at a specifically designed station, in order to guarantee homogeneity for a high quality mixture, was also documented in one company (see Figure 1).

Figure 1: On-Site Prefabrication and Reducing Interdependence

USING VISUAL DEVICES TO ENABLE IMMEDIATE RECOGNITION OF PROCESS STATUS

The andon system (light board) for immediate recognition is common particularly in Fortaleza, as the companies studied there systematically benchmark each other and learn from the academia through formal meetings. One of the companies was technically ready to implement the andon on one of their high-rise building construction site. However, the company manager told that they had postponed the implementation, as various input flows for production were not standardised enough. The system does not necessarily have to be complex and for high-rise building construction exclusively; as in one construction company building 13 villas, the system was implemented with simple cards, yet of course at the expense of the signalling and grabbing attention capabilities (see Figure 2).

Figure 2: Two Different Andon Systems

Although it is an achievement to give the worker the power to stop production in case of disruptions in the input flow, the essence of the andon system is to identify and ultimately solve the real cause of a disruption through continuous improvement efforts. The site manager of a company that is known to have been advanced in process transparency in Fortaleza complained that they struggled in identifying the real cause of a disruption. The level of continuous improvement seems an issue that needs to be improved by the management in these companies.

Immediate recognition of a process status is often achieved by imposing a change on a workplace object. In Fortaleza, some companies use the heijunka box for the production levelling of concrete mixers. The mixer operator attaches two beads on a wheelbarrow. One bead is to indicate the type of the concrete mix and the other is to show what floor the wheelbarrow will be transported to. A wheelbarrow with those two beads attached (imposed change) gives the signal of completed concrete-mix production for the transportation worker, in addition to the information on the type of the mix and its transportation direction.

MAKING THE PROCESS DIRECTLY OBSERVABLE THROUGH LAYOUT AND SIGNAGE

Site layout and fencing should support transparency well. The main function of these items is to provide transparency through making processes observable and enabling information flow. Glass as a translucent material is used for increased transparency on the perimeter walls and doors of the site office buildings. Increased transparency through glass is also used for marketing purposes to display a maquette of the completed project to potential customers. The frequently preferred fencing types are those which permit seeing and being seen through, along with providing a safe enclosure, such as chain link or welded wire fences. Site perimeters, warehouses, allocated areas (e.g. dining areas, elevator control rooms, workstations and material storage zones etc) are deliberately enclosed with those specific types of fences, where climate and construction conditions permit (see Figure 3).

Figure 3: Making the Process Directly Observable

Moreover, it was found that the application of transparency is cascaded from top to bottom in the companies. In one company, the foreman, knowing the principle of transparency, organised the site to unload the transported sand, gravel and cement directly into the basement, in order not to hinder the site visibility and ruin the site

order. The foreman stated that he had observed that the cleanliness and order on the site had a positive impact on visitors' and the public's perception of the company (see Figure 4).

Figure 4: A Layout Organisation by the Foreman

Signage is typically used to identify spatial elements including the construction end products (e.g. building, floor, beams, columns etc) and temporary construction production units (e.g. workstations, warehouses etc). In one company, mobile signs that warn against "possible fall" on the location were identified. Examples of this kind of mobile signage were scarce (see Figure 5).

Figure 5: The Mobile Signs

INCORPORATING INFORMATION INTO THE PROCESS

System wide information, either directly or indirectly process related, that satisfies the need to know and makes people aware of their environment was in display in a few organisations. A monthly calendar printed on a standard A3 paper, posted around the construction site, summarising all kinds of important events and milestones (e.g. the visit of an academic to the site, an intern starts working, the start of the 2nd floor painting, the monthly company breakfast etc.) coming from internal or external environment a month in advance is an example of this kind. In order to raise empathy for the value of construction consumables (e.g. nails or timber), which may be wasted easily on the site, depending on how carefully they are used by the worker, materials were shown together with a worker's important life consumption (e.g . bread, sugar etc) in a company to establish a connection between the two (see Figure 6).

Figure 6: Connecting Worker's Life with Production

Integrating information into the working environment is sometimes spontaneous. Several practices that resulted from improvisations were observed on construction sites (see Figure 7). In fact, these are more frequently seen as part of quality check or quality assurance efforts. In one company, it was revealed that a worker team had devised a colour coded communication system for processed pipes, which was even unknown by the site management.

Figure 7: Improvised Process Transparency

Some traditional methods as visual aids, generally on the floor, facade and walls to give a direction (e.g. the direction of floor tiles) and a level (e.g. the thickness of the floor screed, wall plaster or facade elements) of reference for production are still in use in the companies visited (see Figure 8).

Figure 8: Traditional Work Facilitators

Sometimes the level of transparency, sufficient for a group of people, may not be comprehensible enough to interpret by another group. In one case, a colour coded line of balance production scheduling was communicated over a magnetic board devised by the management to increase the communication ability for the workers (see Figure 9).

Figure 9: Transparency for Different Groups

The prototyping and sampling concepts are used to integrate information into the environment. In prototyping, a repeating part of the end product (e.g. a complete flat prototype in a building construction or the piping system of a toilet that should be constructed again and again in a project) is put on display for workers and management. Sampling is commonly used to couple materials with their location of use and equipments with their corresponding worker teams. It is a concept to match different production elements (material/space or equipment/personnel) by using a real sample of the material and/or equipment in question. See Figure 10.

Figure 10: Prototyping and Sampling

In some cases, the process information that could act as a visual aid/ facilitator was misplaced; far from where the information need actually occurs. In one company for example, a process chart was located next to the site office, instead of the production area where the chart is needed for production.

MAINTAINING A CLEAN AND ORDERLY WORKPLACE

In order to maintain a clean and orderly workplace, people on the site are identified by using colour coded helmets, locations of materials stored on the site are standardized by putting the material's photo and technical specifications on display, just in front of the storage location (by that way, the corresponding material is not stored anywhere else but the identified location), construction end products (houses, walls, columns etc) are identified with numbers and/or names, a great deal of importance is given to the site warehouse organization, transportation routes (flow routes) – with direction marks on the surface- and transportation means (generally standard sized hand barrows) are visually identified, regular site cleaning and colour coded waste containers for recycling are observed to be in practice (see Figure 11).

Figure 11: Maintaining a Clean and Orderly Workplace

In some companies, the efforts of maintaining clean and orderly workplace were tried to be systematised by implementing a 5S programme. According to a site manager in one of the construction companies implementing the 5S, the most difficult part in the 5S application is to sustain the effort throughout the construction phases. Indeed, there may be various parameters affecting its implementation on a construction site, along with the workers' ownership. For example, in one case, the client had bought and stocked all the reinforced concrete steel required for the project at once by the contract; later the scattered steel piles created a disorganised situation on the site for the contractor, which tried to implement the 5S. This can make an example for the contractual relations' effect on the order of the workplace.

RENDERING INVISIBLE ATTRIBUTES VISIBLE THROUGH MEASUREMENTS

Various types of information and their corresponding metrics are measured and displayed in the companies from the macro level system wide information to work gang related operational information (performance metrics). In one company that is

locally known to have been advanced in process transparency, the company manager stated that they had decided to reduce the amount of information presented, as too much information created confusion and distracted attention, instead of understanding. There are three interesting cases worth mentioning.

In one case, the figures were used for marketing purposes for the public through a construction progress board in the bar chart format with the final completion and last update dates.

The evaluation of the suppliers'/subcontractors' performance by different metrics (e.g. quality, security, contract compliance etc) is sometimes put on display either at the entrance for anyone on the construction site or on the perimeter fences for the people outside as well (public benchmarking- see Figure 12). However, in one case, the manager of a company stated that he believed too much "transparency" could be "inappropriate", when asked why they had not displayed the supplier/ subcontractor performance figures on the building site. He thought too much transparency could affect the company's relations with its suppliers/ subcontractors negatively.

In one of the contractor companies, the site manager stated that the "near miss" metric (safety) and the corresponding near-miss bench to record near miss events were not working as intended. Later, it was identified through discussions with the local academics working closely with the company that the owner of the building (the client) had not been demanding enough for near-misses, as one the contractor's safety performance criteria, to raise attention for the metric in the company. This can be noted as the effect of an external factor on process transparency.

Figure 12: Subcontractor/ Supplier Evaluation Boards

CONCLUSIONS

VM exists on construction sites on a wider scale than generally understood (as visual controls). The conceptualisation of the research theme (VM and correspondingly process transparency) was hard for the interviewer and interviewees. It remains as a vague concept and can sometimes be confused with different management approaches. In general, the management in the companies investigated, particularly the site management, seemed to find visual tools helpful, but had not given much of a thought to their application purposes. It is perceived and developed as a part of the "lean construction initiative".

Simplicity and financial feasibility (as visual tools generally do not cost much) were cited as their important features. They create an "easy to see and understand" work environment for both the management and the workforce. Additionally, two types of transparency; process transparency for everyone and transparency for some or a specific individual/group of people were observed.

The management generally attribute the effectiveness of visual tools to the fact that the workforce is poorly educated (even illiterate in some cases) and visual tools

present easy to understand visual communication media for the poorly educated workforce. This claim needs to be checked against the opinions of the workforce.

The application process is generally from top to bottom. People are allowed to make modifications but whether or not they do so in reality is open to discussion. Training (may take some time) and patience in the beginning, especially with the workforce, to modify their conventional working habits for working with the visual elements, are important. It is essential to get the foremen's and site management's participation and consent, as they are the ones who are directly responsible for the execution.

The use of some important concepts, such as process transparency through design, sampling, prototyping and mistake proofing were documented. Process transparency is also a highly intuitive concept, which can be realised through some improvisational tools. The close cooperation between the companies, particularly the ones from Fortaleza (sharing the operational practices with one another on a regular basis through formal meetings and workshops), and with academia in general provides the companies with different modes of learning.

The comparatively more advanced companies in process transparency have been trying to capture and document their transparency efforts, so that they can be transferred from one project to another and communicated to newcomers in a systematic way. In terms of IT, the companies do not possess complex IT systems but they heavily rely on the prominent business software package. The management underline that any proposed IT systems to replace the current tools should be affordable, easy to use and resistant to the harsh conditions of construction.

Further work, which focuses on the functions of process transparency on construction sites, explains the effects of different implementation contexts and reflects the worker perception of the issue in depth, may be necessary to elaborate the concept.

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