TRANSPARENCY, PROCESS MAPPING AND ENVIRONMENTALLY SUSTAINABLE BUILDING PROJECTS

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ABSTRACT

As Toyota's production system matured, line managers made important use of visual controls with their kanban system and andon boards. Since encapsulated as transparency, these systems were remarkable for their ability to convey the wellbeing of production at any moment. This paper describes research investigating the impact of process mapping on transparency. This research will help determine whether process mapping may be a valuable tool to assist sustainable project delivery – where transparency is a key requirement. This paper has several contributions. First, a working definition of transparency based on lean theory is developed. A literature review follows that, using the framework provided by the transparency definition, presents evidence of transparency-related benefits provided by process mapping. Finally, the current progress and future plans of an ongoing project examining the relationships between transparency, process mapping, and sustainable project delivery at Penn State's Office of Physical Plant (OPP) are described. Specifically, the development of process maps and a methodology to study their transparency impacts at OPP are discussed.

KEY WORDS

Sustainability, transparency, project delivery, process mapping.

INTRODUCTION

Sustainable buildings optimize site potential and energy use, protect and conserve water, use environmentally preferable products, enhance indoor environmental quality, and optimize operational and maintenance practices (NIBS 2006). Despite these important benefits and rapid growth, sustainable buildings make up less than 2% of the total construction market in the U.S. (Yudelson 2007, U.S. Census 2006). Because buildings accounts for 40% of all material and energy flows worldwide (Roodman 1995), increasing the market share of sustainable buildings is a necessary component to any realistic plans for global sustainability. Ultimately, it is hoped that this study will help contribute to reducing the first cost of sustainable building projects, which is considered the greatest barrier to an increased market share for sustainable buildings (BD&C 2004, Landman 1999).

Sustainable buildings often incur an up-front or first cost premium (U.S. GSA 2004). This premium may be a result of value adding "investments" in better quality building components, like HVAC systems and super-insulated building envelopes; that can achieve significant operational savings extending over the life of the building. The up-front cost premium for sustainable buildings may also be contributed to by wastes including rework,

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delays, changes, and overproduction as a result of not using the best delivery processes for these projects.

The optimal delivery processes for sustainable buildings are not the same as those for traditional buildings. To achieve their performance benefits, sustainable projects use intense, interdisciplinary collaboration during design, highly complex modelling and analysis, and careful material and system selection particularly early in the project delivery process. If certification, such as that under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED), is sought, extensive documentation may add time and cost to the project. Process waste can both undermine the achievement of sustainable outcomes and limit the business case for sustainability (Lapinski et al. 2006, U.S. GSA 2004).

Seminal references for sustainable construction in the U.S. recognize the importance of transparency to sustainable project delivery. Initial development of a methodological framework for sustainable construction includes transparency as an integral concept on the process axis, measuring process effectiveness based on how stakeholders work together to meet sustainability objectives (Pearce 1998). More recent references also recognize the importance of transparency in sustainable building, pointing out that delivery methods which inhibit transparency are not optimal (Kibert 2004).

Following are two examples that illustrating how transparency can contribute positively to sustainable building projects:

- Transparency can help incorporate input from building operations at the appropriate point in design. When building operations staff recognize the status of the delivery process and designers recognize interdependencies (that they need to consult with building operations staff), it is more likely that building operations staff will provide timely and valuable design input. Operations input can provide insight into maintenance costs for and observed performance of different technologies being considered. This insight holds increased importance for sustainable projects, where unfamiliar technologies ranging from waterless urinals to the next generation of HVAC control systems are integral to achieving sustainable goals.

- Transparency can also help clarify roles and responsibilities surrounding the commissioning process. Commissioning is a fundamental component of sustainable building, helping to ensure that the building operates as it was designed. Because commissioning is a relatively new and evolving process, there is often confusion regarding responsibilities during this process. Increased transparency would help reinforce responsibilities, making the commissioning process more efficient.

TRANSPARENCY

Transparency is most simply defined as process visibility. Lean theory recognizes transparency as the most important "spur to perfection" and defines transparency as the ability of all stakeholders in a system to see everything, making it "easy to discover ways to create value" (Womack 2003). Researchers studying product development[2] have adapted the lean definition of transparency to:

"providing people with a clear understanding of different aspects of the current system performance and status, giving them feedback of performed activities and helping in making

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[2] Product development is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product (Morgan 2002).

decisions, letting them recognize interdependencies, and, as a result, enabling higher levels of improvements" (Bauch 2004).

This transparency definition from product development provides the structure for the definition applied to this study. Transparency is defined by the degree to which the following elements are present for a process: *recognition* of status, problems, responsibilities, and interdependencies; *facilitation* of understanding, feedback, communication, and improvements; and *enabling* of decision-making. Table 6 lists each attribute of the transparency definition along with further description of the attribute and the primary reference supporting the inclusion of the attribute in this definition.

Table 6: Attributes of the Transparency Definition

Recognition	
Of status	stakeholders understand the position of the process (Bau 2004)
Of problems	stakeholders can identify areas of concern in the process (Womack 2003)
Of responsibilities	stakeholders understand their role in the process (Bauch 2004)
Of interdependencies	stakeholders understand how they will impact and be impacted by others for the process (Bauch 2004)
Facilitation	
Of system performan understanding	stakeholders can evaluate process efficiency (Womack 2003)
Of feedback on perform activities	stakeholders can determine whether their actions are correct (Bauch 2004)
Of communication	stakeholders are given tools allowing effective communication (Graebsch 2005)
Of improvements	stakeholders can identify methods to eliminate waste and create value, enabling continuous improvement (Bauch 2004)
Enabling	
Decision making	stakeholders are given the necessary tools to be comfortable making decisions based on a total process understanding (Womack 2003)

PROCESS MAPPING

Because of the importance of transparency for sustainable project delivery, there is value in tools that increase delivery process transparency. By providing a visual representation of delivery processes, application of process mapping has the potential to increase transparency and therefore, improve sustainable project delivery. Discussion of the benefits of process mapping is often focused on improvements that result from revising processes based on future-state process maps (Rother 1998). In these situations, the original process is mapped, and this map is used to identify ways to improve the original process. The result is represented by a future-state map, which is then applied to modify, and hopefully improve, the original process. It is important to distinguish these future-state benefits of process mapping from the benefits examined in this study, those benefits obtained by developing and using maps prior to improving the processes themselves.

Lean construction literature discusses both process mapping and transparency. However, the discussion of transparency is limited to physical site operations (Kemmer 2006, Santos 1998) and neglects delivery processes. Discussion of process mapping in lean construction literature does not explicitly address its relation to transparency. It is therefore necessary to examine literature from other fields to frame this study of process mapping and transparency.

PROCESS MAPPING LITERATURE

NEED FOR FURTHER STUDY

A review of literature discussing process mapping reveals a need for further study of its transparency-related benefits, and the study at OPP (described later in this paper) will help satisfy this need. Researchers studying process mapping recognize that there is limited evidence of the benefits of process mapping, regardless of whether these benefits are related to transparency or not. Sedera (2002) suggests that evidence is lacking in all industries, not just construction:

> "While there has been much research on alternative process modelling techniques, little attention has been focused on post-hoc evaluation of process modelling success (Sedera 2002)."

In response, a multi-year study is underway to measure process mapping success in areas including pandemic planning, airport security, and organization asset management (Bandara 2007). The study will examine causes for success in business process mapping (e.g. committed management) and appropriate success measures (e.g. user satisfaction). Although the study does not explicitly identify transparency as a success measure for process mapping, there are several related success measures including "modeller satisfaction" and "user satisfaction" (Bandara 2005).

As there is little evidence of the benefits of process mapping for general business processes, it is not surprising that the same issue exists for the construction industry. One conclusion from a comprehensive literature review of process mapping in construction is:

> "The need for a better conceptualization of implementation as a practically oriented phenomenon is clear. The development of a more holistic and integrated theoretical body of knowledge on process implementation will offer appropriate guidance for companies aiming to successfully implement process models (Tzortzopoulos 2005)."

There is a significant gap in literature with respect to implementation, as opposed to design, of process models (Tzortzopoulos 2005). In response, one of three research questions resulting from the literature review of process mapping in construction is: "What are the actual improvements to current practices brought about by process models devised/implemented in construction firms (Tzortzopoulos 2005)?" The study at OPP will help address this important research question.

PROCESS MAPPING BENEFITS RELATED TO TRANSPARENCY

While there is certainly a need for further study if the transparency-related benefits of process mapping, existing literature does provide useful background information for this further study. Well-known process mapping references discuss (but do not demonstrate) benefits related to the "facilitation of improvements" and "facilitation of communication" attributes of the transparency definition (Smith 1999, Damelio 1996). This anecdotal evidence helps justify further study in this area. There is also literature that provides examples of

transparency-related benefits of process mapping. These references are listed in Table 7, which separates the refereed and non-refereed articles, and indicates which attributes of the transparency definition each reference discusses.

Table 7: Literature Discussing Transparency-Related Benefits of Process Mapping

	Non-Refereed	(Wreden 1998)	(Keller 1999)	(Pojasek 2006)	Refereed	(Austin 2001)	(Kagioglou 2002)	(Buchanan 1998)	(Vakola 2000)
Recognition									
of status			x	x			x	x	x
of problems			x					x	x
of responsibilities		x	x	x				x	
of interdependencies		x	x	x				x	
Facilitation									
of system performance understanding								x	x
of feedback on performed activities			x						
of effective communication						x	x		x
of improvements			x	x			x	x	x
Enabling									
decision making				x					

Non-Refereed Articles

Evidence of the transparency-related benefits of process mapping is present in articles discussing companies including: Deloitte Consulting, Cambridge Management Consulting, Taro Pharmaceuticals, and Farmer's Insurance. While the articles providing this evidence are not refereed, the information provided is still valuable.

Both Deloitte Consulting and Cambridge Management Consulting recognize process mapping benefits similar to the "recognition of responsibilities" and "recognition of interdependencies" attributes of the transparency definition (Wreden 1998). These consulting organizations found:

> "perhaps the biggest value derived from business modelling is not from the tools themselves, but from the regimen of documenting business processes… even cross-functional discussions of what the company is doing and should do can reduce what's been called "cubicleism" – that head-down focus on individual tasks at the expense of corporate collaboration (Wreden 1998)."

Similar to Deloitte Consulting and Cambridge Management Consulting, Taro Pharmaceuticals realized immediate benefits of process mapping. At Taro, these benefits included increased awareness of the impact of one operation on another, and reduced instances where no one is performing a task because they think others are (Wreden 1998). Process mapping at Farmer's Insurance also demonstrates transparency-related benefits. Process mapping applied in the auditing group of Farmer's is found to:

> "assist employees in better understanding their roles in the organization and how their work affects everyone else. They learn about overall operations as well as the basics of controls (Keller 1999)."

These benefits at Farmer's are related to attributes of the transparency definition including: "recognition of status," "recognition of responsibilities," "recognition of interdependencies," and "facilitation of feedback on performed activities." Farmer's also believes they are seeing benefits related to the "recognition of problems" and "facilitation of improvements" attributes of the transparency definition (Keller 1999).

A management consultant specializing in facilitating programs for sustainability provides further discussion of process mapping's transparency-related benefits (Pojasek 2006). Process mapping is considered a valuable communication tool, which is aligned with the "facilitation of effective communication" attribute of the transparency definition. Other transparency-related benefits identified include:

> "Providing visualization of process functionality, encouraging participants to ask questions about the process, involving employees in looking for process improvements, and creating a sense of "system exploration" by showing how every aspect of the process is linked to everything else (Pojasek 2006)."

These benefits are similar to the "recognition of status," "recognition of responsibilities," "recognition of interdependencies," and "facilitation of improvements" attributes of the transparency definition. Evidence of benefits related to the "enabling decision-making" attribute is also provided:

> "It (process mapping) is a vehicle for expressing and releasing the knowledge, creativity, and energy that reside within every group of employees, regardless of their position or level within the organization (Pojasek 2006)."

Evidence of the transparency-related benefits of process mapping is also present in the construction industry. Several of the espoused benefits of process mapping listed in Table 8 (Adapted from Tzortzopoulos 2005) are directly related to attributes of the transparency definition including: better communications and better and timely information exchanges (both related to "facilitation of effective communication"), and reduce errors and rework (related to "facilitation of improvements").

Table 8: Espoused Benefits of Process Mapping (Adapted from Tzortzopoulos 2005)

Organization	Process	Client
Competitiveness	Less time and costs	Better product quality
Consistency through replication	Better planning	Fitness for purpose
Optimize predictability	Better and timely information exchanges	Delivered on time
Support partnering and contractual agreements	Better communications	Delivered to cost
Basis for IT systems	Reduce errors and rework	
Educate new employees	Benchmark for improvement	

Refereed Articles

Several refereed articles provide evidence of the transparency-related benefits associated with process mapping. Related benefits are found in studies of organizational learning in construction organizations and in case study research from a hospital environment.

Similar to construction projects, responsibilities in hospitals are fragmented, and workers frequently focus only on the activity within their particular occupational group (Buchanan 1998). It is widely accepted that hospital staff often function independently in their dealings with patients (Buchanan 1998). Process mapping is found to help mitigate this issue:

> "Process mapping, in whatever form, encourages a process orientation and overview. Process mapping with staff participation broadens cross-functional awareness and understanding, potentially fosters mutual respect for different contributions to the patient trail, and can deepen appreciation of the extent to which problems are shared, the extent to which activities may be unnecessarily duplicated, and also of how problems can be unwittingly passed on from one stage on the trail to another (Buchanan 1998)."

These observed benefits are directly related to attributes of the transparency definition that include: "recognition of status," "recognition of problems," "recognition of responsibilities," "recognition of interdependencies," and "facilitation of system performance understanding." There is also evidence that supports the "facilitation of improvements" attribute of the transparency definition. Process mapping was found to encourage improvement suggestions from many different staff because the process orientation encouraged those involved in the process to visualize their own contribution and the interlocking contributions of others.

In addition to the hospital case study, there is also literature from the construction industry discussing how process mapping impacts transparency. The contribution of process mapping to transparency is explicitly recognized:

> "Process mapping has also been used as a means of illustrating the various processes and information flows within the design and construction process and has proved to be beneficial in terms of transparency (Kagioglou 2002)."

Any evidence that process mapping is "beneficial in terms of transparency" to construction processes is valuable for this research. However, the origins of this quotation, while valuable to help shape the proposed research, still leave room for exploration of the transparency-related benefits of process mapping. The most relevant study forming the basis of this statement is related to the "facilitation of communication" attribute of the transparency definition. In this study, the benefits of following process maps to guide a design process were evaluated for three groups in a design competition (one using maps rigidly, one using maps as a reference, and one not using maps.) The primary benefit for the team using the maps rigidly was an improvement in team atmosphere. Interestingly, these benefits did not translate to the final result, as the team not following the process maps was judged as having the best design (Austin 2001).

Vakola (2000) studied process mapping's impact on organizational learning in construction organizations. Case studies of three construction organizations found these organizations were initially unclear of their existing processes, and all three organizations eventually realized benefits from mapping these processes. Process mapping was recognized as providing an "overall overview of their processes and facilitating the identification of potential weaknesses (Vakola 2000)." This statement is related to the "recognition of status," "recognition of problems," and "facilitation of system performance understanding" attributes

of the transparency definition. The three construction companies also recognized benefits related to the "facilitation of communication," and "facilitation of improvements" attributes of the transparency definition as a recognized contribution of the process mapping was "improved process and information communication within these companies (Vakola 2000)."

OPP CASE STUDY

OPP represents an outstanding opportunity for examining transparency impacts of process mapping. A culture of mapping processes is embedded at OPP, where Continuous Quality Improvement (CQI) is applied to map and improve building delivery processes. Tapping into this existing culture, a mapping protocol has been developed to add structure and consistency to OPP's mapping efforts. Existing literature, OPP input, and researchers' experiences are all contributors to the Lean and Green (L&G) modelling protocol (Klotz 2007). Using the Lean and Green (L&G) protocol, macro-level and micro-level maps have been developed at OPP. These maps can be accessed by OPP employees and the public via the internet[3].

PROCESS MAPPING AND TRANSPARENCY AT OPP

The use of process maps in employee training at OPP will be studied. Transparency-related benefits will be examined for a macro-level process map, showing OPP's entire building delivery process, and for two different micro-level maps, showing OPP's contracting process and closeout process.

For each of the three process maps, two different quizzes (Quiz A and Quiz B), of approximately equal difficulty, are developed. Each quiz has nine questions, with one question related to each attribute of the transparency definition. To account for any difference in difficulty between the two quizzes, half of the training participants will complete Quiz A prior to the training session and Quiz B after the training session, while the other half will complete Quiz B prior to the training session and Quiz A after the session[4]. It is anticipated that approximately 15 OPP employees will attend the training session. The number of correct responses before using the process maps will be compared to the number of correct responses after using the process maps to determine the impact of using the maps on transparency. Further, since each attribute of the transparency definition is represented by one question, insight can be gained into the impact of map use on each attribute of the transparency definition.

To complement the quizzes, participants in the training will also complete a subjective survey designed to gather their opinion on the transparency-related benefits of the process map use. Combining the results from both the subjective survey and the more objective quizzes will provide greater certainty of the transparency-related benefits of the process map use at OPP.

CONCLUSIONS

An examination of literature reveals evidence that process mapping can improve transparency. As a result, process mapping may have potential for assisting sustainable building delivery. Findings of an ongoing study at Penn State's OPP will add to the limited body of knowledge on the transparency-related benefits of process mapping in both general

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[3] OPP's process maps can be viewed at, http://www.opp.psu.edu/about/divisions/dc/manual/index.html
[4] Quizzes and the subjective survey are not included in this paper, but will be gladly shared by the author on request.

industry and in the construction industry. In addition, these findings will provide insight into the potential use of process mapping to improve the delivery of sustainable building projects.

ACKNOWLEDGEMENTS

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