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Unique Dashboard Needs of Construction Project Team Members

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Abstract

Performance metrics, such as cost, quality and safety, are units of measures that are used to monitor the execution of a construction project. Many researchers have studied this topic and identified a large number of performance metrics for construction projects. Utilization of all of these metrics to monitor a project can result in information overload for different team members in a project team, especially since neither all metrics are relevant nor they are important to each party. Hence, to minimize such information overload, it is necessary to understand specific performance metrics that each party prefers using. In order to understand varying metric needs of project team members we have conducted semi-structured interviews using dashboard concept as a way to distill important performance metrics useful for each team member of a construction project and hence to understand diverse dashboard needs of project team members. During these interviews, the interviewees design a dashboard by specifying which metric they like to see in what level of detail using what type of graphics in order to support their decisions. The results of this study show that each project team member indeed has unique requirements for what s/he would like to see on a project management dashboard, and hence there is a need for customization of dashboards to support those needs.

Keywords

Project performance monitoring, Construction project stakeholders, Decision dashboard

1. Introduction

Many types of documents related with the execution of projects are collected during the construction stage for monitoring the performance of the projects. These documents can create information overload for construction project team members (e.g. Leung et al., 2003; Haksever, 2000; Thorpe and Mead, 2001). Haksever (2000) stated the fact that "the construction stage has the highest probability of information overload and there is more than 50% chance of a project manager being in an overload situation." Moreover, Leung et al. (2003) claimed that "information overload results in a lot of time and energy being wasted trying to retrieve crucial information from a huge pile of information, much of which are irrelevant." Another effect of information overload as explained in Speier et al. (1999) is the case where the existence of information overload increases the time required to make decisions as well as the confusion regarding those decisions, thereby decreasing the quality of the decisions made. Hence, information overload of construction project team members should be minimized to increase their awareness about the progress of projects and the quality of the decisions made. To achieve this, there is a need to identify what exactly each project team member needs to monitor in order to make day to day decisions, with the assumption that these should be immediately available.

Performance metric is a unit of measure that is used to monitor the execution of a project and to assess its success. Examples of performance metrics include cost predictability (KPI Working Group, 2000), percentage of milestones achieved on time (Cheung et al., 2004), and percentage of quality control inspections passed at the first time of approval (Sinthawanarong, 2000). In order to track the progress of projects, project team members use various selections of these metrics depending on their responsibility in a project. Since each member has a different responsibility, to make sound decisions, s/he should track different kinds of information. Based on this assumption, literature review and initial interviews performed with a number of different project team members, we developed the hypothesis that there are differences in the information needs of team members in terms of the performance metrics to be monitored, the graphical aids used to represent them and the level of detail (LOD) of the information. The graphical aids and LODs of the performance metric needs of team members are out of scope of this paper; however, different metric needs are evaluated to check the validity of the first part of the hypothesis.

Dashboards provide a way of conveying project information to the users to increase their awareness and improve decision making. Similar to the role of car dashboards in providing information related with the speed, number of miles, and certain problems, project decision dashboards would help the stakeholders to observe the project visually, through only the information they need in the LOD that is the most beneficial. Differences in information needs of construction project team members necessitate having unique dashboards to support those needs.

To be able to identify the differences in the information needs of different project team members, we conducted semi-structured interviews with nine different stakeholders of different projects based on a designed dashboard card game. During the card game, we presented the participants with different visual aids and requested them to create their dashboards which contain a collection of graphical representation of different project performance metrics that they need. While creating their dashboards they selected the metrics, the graphics to represent them, and the LODs that they like to see these metrics in terms of time frame captured or units of time, units of spaces or zones and whether a task, an activity, a party or project level evaluation is performed. The details about the interviews and discussion of the analysis of the findings are presented in Section 3 and 4 of this paper.

2. Performance Metric and Dashboard Concepts

2.1 Performance Metrics

Performance metrics are also named as key performance indicators, or performance components in the literature. These metrics can be categorized according to the purpose of the measurement. For instance, final estimated contract sum vs. original contract sum, current months certified interim payment value vs. accumulated certified value, certified interim payment amount out of submission amount, and proximity of the engineer's estimated cost and the initial contract cost can be categorized as "cost". As a result of the literature review, we synthesized 287 metrics identified in previous research and categorized them into 24 groups. These categories of the metrics are time (e.g. Alarcon and Ashley, 1996), cost (e.g. Sohail et al., 2002), quality (e.g. Sinthawanarong, 2000), safety and health (e.g. Cox et al., 2003), environment (e.g. Cheung et al., 2004), people/partners (e.g. Cheung et al., 2004), client satisfaction/value (business benefit) (e.g. KPI Working Group, 2000), communication (e.g. Dawood et al., 2006), changes (e.g. Mahmoud and Scott, 2002), productivity (e.g. Dawood et al., 2006), rework/defects (e.g. Construction Institute, 2005), training and recruitment (e.g. Takim and Akintoye, 2002), financial/profitability/turnover (e.g. Construction Consultants Working Group, 2007), business performance (e.g. KPI Working Group, 2000), work progress (e.g. Abudayyeh and Rasdorf, 1993), lean production (e.g. Ballard and Howell, 1994), subcontractor performance (e.g. Ko et al., 2007), and project managers (e.g. Dainty et al., 2003), processes (e.g. Takim and Akintoye, 2002), research and development (e.g. Takim and Akintoye, 2002), public interest (e.g. Takim and Akintoye, 2002), scope (e.g. Korde et al., 2005), and project success/project performance/products (e.g. Korde et al., 2005).

The diversity in the identified metrics reveal that same performance metrics are not applicable to all projects to measure their performances. In other words, using all of the identified measures will create information overload in case of project performance measurement. Thorpe and Mead, (2001) stated that the existence of piles of irrelevant data in multiple formats causes information overload for a worker which hinders productivity. Furthermore, as stated in the introduction section Leung et al. (2003) and Thorpe and Mead (2001) stated that information overload causes loss of time, and energy and a decrease in the quality of the decisions made. These studies support the malign effects of information overload, leading us to emphasize the importance of providing relevant data to project team members. Not only the content of metrics, but also their LODs and format might differ for different members. For example, to assess the performance of a project, an owner may look at the Change Order (CO) trend for the last six months. A project engineer may look at the weekly schedule of activities and the productivity of the crews to understand the possible delays. Similarly, an area manager may look at the monthly schedule with the estimated and projected dates. Regarding different performance metrics, Cheng et al. (2005) studied on client perspective, Cox et al. (2003) on project management team and Sanvido et al. (1992) claimed that owner, designer and contractor has different criteria to evaluate the project success. Hence, there is a need to investigate the variance in the information needs of different team members and to provide them with the flexibility to generate customized metrics to increase their situation awareness and to support their individual and sometimes unique decisions.

2.2 Dashboard

Endsley (1995) defined Situation Awareness (SA) as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future”. In other words, SA is the observation, realization, understanding and evaluation of a condition capturing the actors, events and factors creating it and being able to forecast the possible future effects of the condition. In project monitoring, SA can be satisfied by understanding the current status of the project through tracking of the performance metrics to make daily decisions and predict the possible future status of the project based on existing data. Endsley (1995) stated that “In complex and dynamic environments, attention demands resulting from information overload, complex decision making, and multiple tasks can quickly exceed a person’s limited attention capacity.” Hence, in order to provide SA and minimize information overload, project team members should be presented with information that is categorized, highlighted, and summarized and leading to further interaction for analysis if needed.

There are different ways to view such critical information, one of which is a dashboard that can be thought of as an interface or control panel to organize the data generated and display and track key metrics. The concept of a dashboard for construction management purposes has been previously introduced in a few research articles. Song et al. (2005) used the dashboard idea to visually represent project metrics on 3D models. The components of a Building Information Model (BIM) are represented with different colors according to the values of the Schedule Performance Index (SPI), Cost Performance Index (CPI), float value or criticality. Kam and Fischer (2004) proposed the usage of a decision dashboard to represent and organize different Architecture, Engineering and Construction (AEC) decisions. Cheung et al. (2004) performed works on creating a web-based performance monitoring system to monitor the progress of a construction project and communicate with other project members in the form of reports and graphics. Mukherjee and Rojas (2003), who study Situation Simulations, identified two important components for effective visualization and stated them as the accurate mapping of information to visual entities and understanding how humans interface with visual information. In other words, it is important to select the most appropriate visual aid to present the information with required LOD and accuracy, and to enable the users to interact with the graphics to perform further analysis. Equally as important as the selection of the metrics is the selection of the visual representations of each metric with the intention of effective perception and rapid comprehension of the status of the project. In this way, dashboards, as a collection of the graphical representations of chosen performance metrics, will provide project awareness to the project team members and prevent them from experiencing information overload. In order to present individual project team members with the unique dashboards that they require, it is important to understand the extent of the diversity in their information needs. Hence, in the following section we present the method applied in the study conducted to identify information needs and dashboard designs of different construction project team members.

3. Requirements Elicitation Method

We conducted semi-structured interviews with nine construction project team members from projects/companies of different sizes that perform either building or highway projects. The interviewees from companies focusing on highway projects included an area manager, a project engineer, a superintendent, and a district manager working for a federal owner. The interviewees from companies focusing on building projects included a vice president of cost estimation, a project manager, a superintendent/field engineer and two project engineers.

The interviews were conducted using a hands-on activity that requires interviewees to design their "dream" project performance tracking dashboard. The main idea is to help the interviewee to be able to create and visualize the information s/he requesting. The interviewees were asked to collaborate with the interviewer to construct a mock-up of his or her "dream dashboard" via selecting the performance metrics, their graphical representation and LODs. During the interview, it was emphasized that as the interviewees select the components of their dashboards they should not limit themselves to what can be "realistically" gathered, available and reported, but rather should focus on what information they need to streamline their decisions on a daily basis. To be able to understand the usage of the components that they have defined for their dashboards, the interviewees were asked to describe the decisions that they will make based on each of the dashboard components that they have chosen. The interviewees were asked about the current availability of the information used to understand the shortcomings in either data collection or method of reporting. For each metric represented on the dashboard, they were also asked what interaction they would like to have with it. For instance area manager asked to see the comparison of the budget and costs, where the differences more than 15% are highlighted, and wanted to be able to click on any of the comparisons to view the details of the cost reports. Investigation of such interactions enabled us to trace the hierarchical, causal and sequential relations of the information items requested.

We compiled and analyzed the metrics identified in the interviews and looked for patterns related with the usage of each metric, and availability of data in order to question our hypothesis on the differences in the information needs of team members, to investigate the handling of the performance metrics and limitations of the current technology and applications. Availability of data describes whether the information displayed in the graphic is currently available in a format similar to what is needed, whether it needs modification such as filtering, integration or transformation, or whether the data is not available. The usage of the graphic describes whether each graphic created for the dashboard is used to make a decision, if so for what kinds of decisions, or whether it is used to have quick access to information that the interviewee finds useful but does not use to make decisions or gauge self-performance. We categorized the usage of information as predictive, explanative, descriptive, evaluative and prescriptive. These five categories are used by O'Shaugnessy (1972) as types of decisions and the first four by Liston et al. (2000) as types of tasks performed in construction review meetings. The dream dashboards of the interviewees were compared and cross-analyzed in several different ways to determine the ways in which the information needs and uses of the interviewees were similar or different. The next section describes some of the findings from the comparisons performed.

4. Analysis and Discussion of the Findings

As a result of the interviews the metrics requested by the participants are categorized as cost, information, overall, quality, resource, time, and safety. The cost, time, quality, and safety metrics are self-explanatory. The resources metric captures the materials, site, equipment and labor forces. The information metric captures Request For Information (RFIs), COs, submittals, punch lists, Employer Information Reports (EEO) and also regular meetings of the project team members. Overall metric is selected by head of cost estimation department and used to evaluate the success of their department by the ratio of bids submitted and awarded to date, and times spent on their cost estimations. After performing each interview, we created a dashboard as specified by each participant. Figure 1 is an example of a dashboard created after the interview with a project engineer working at a building project. This engineer is also listed as the seventh interviewee in Table 1.

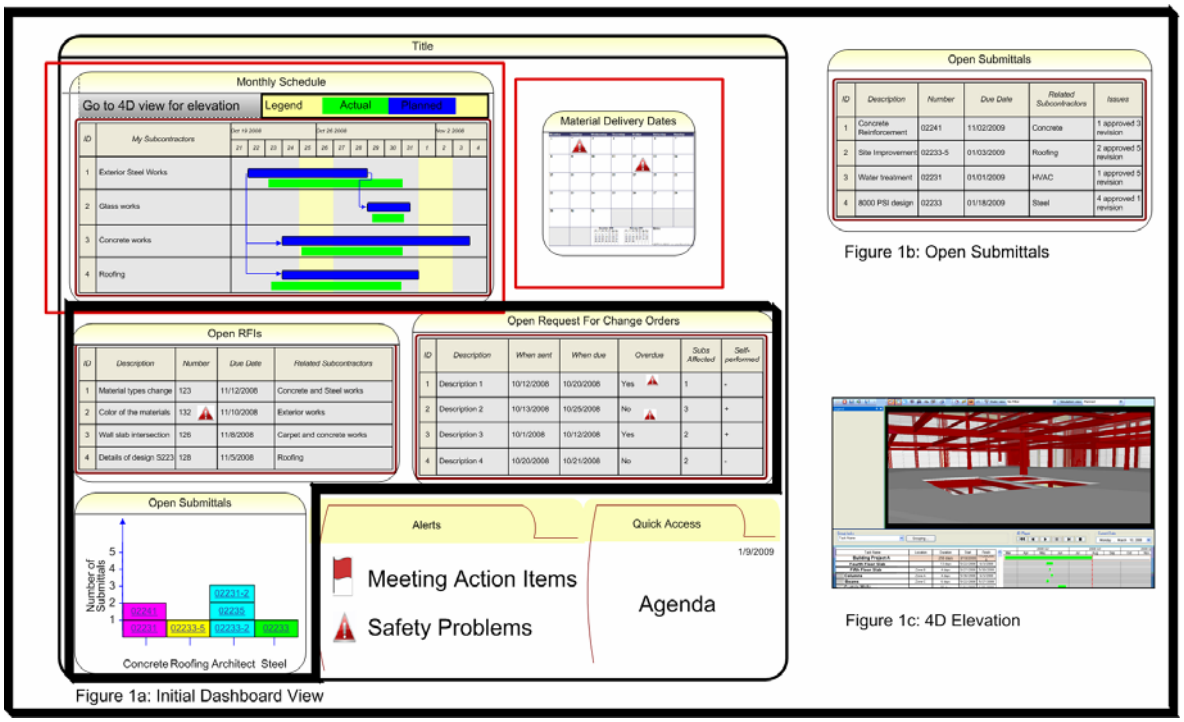

Figure 1: Dashboard of a Project Engineer Working in the Construction of a Building Project

Figure 1a is the initial dashboard view requested by the engineer and divided into five sections. Each of the graphics is visual representation of a metric. The upper two graphics are components of time and resource metrics, the bottom right two sections are used for alerts and quick access tools capturing links to safety issues, meeting minutes and the interviewee's personal agenda. Finally, the remaining three graphics fall under the information metric category. The item entitled "Monthly Schedule" in Figure 1a captures the time metric as a comparison between the current and planned monthly schedule. Project engineer asked to see 4D elevation of construction activities that she can access by clicking on the activities on the initial schedule. Figure 1c shows that view. In a similar manner, Figure 1b shows further details of the submittals referred to in the "Open Submittals" bar chart in Figure 1a that would be accessed by further interaction, such as clicking on the bars. The other two information metrics are the lists of open RFIs and COs, adding up to 4 information metrics as shown in Table 1. The last graphic on Figure 1a represents the resource metric and displays material delivery dates on a calendar.

The numbers in Tables 1 and 2 are the number of metrics/graphics the participants requested. In Table 1, the values for total number of graphics captures both the initial and the linked graphics for example that all of the graphics in Figure 1a are counted along with Figures 1b and 1c. The second column is only for the metrics that appear on the initial dashboard (e.g. only in Figure 1a). Alarcon and Ashley (1996) claimed that 4 to 5 performance measures are reasonable to obtain a relatively comprehensive evaluation of performance, however; in this research the average number of metrics required by the participants is 7. The number of graphics varies in the range of 5 to 11 with a standard deviation of 2. Time is the only category of metric which is requested by all of the participants. The information, cost and safety categories were also commonly requested. The cost estimation and budget status and the submission status of documents, such as submittals, and RFIs were the metrics for which participants most frequently requested further interaction with the graphic in order to obtain details, or learn the causes of problems.

Table 1: Current Availability and Usage of Metrics According to Responsibility of Team Members

*		Number of Graphics		Metrics						
	Responsibility	Total	Initial	Cost	Time	Quality	Resource	Safety	Information	Overall
H	Area Manager	13	11	6	2	1	1	1	2	
B	Head of estimation department	7	7	1	2		3			1
H	Project engineer	7	6	4	1			1	1	
H	Superintendent	5	5		1		4			
H	District manager	9	5	2	2			1	4	
B	Superintendent and field engineer	10	6		1	2	2	1	4	
B	Project engineer	8	8		2		1	1	4	
B	Project manager	8	7	3	2				3	
B	Project engineer	9	8	1	2			1	5	

* Stands for the type of the projects. H for Heavy civil and B for Building

We also searched to discover whether or not a pattern exists in the usage of the metrics to make decisions. The usages are organized into one of the five categories mentioned in section 3 and defined below. Explanative usage describes corresponding with somebody or looking at detailed reports to learn about the reasons of the current situation, descriptive is observing the current status and needs, prescriptive is notifying other team members of discrepancies, predictive refers to performing planning and future projection, and evaluative is for the purpose of making a self-performance evaluation. Although all of the interviewees identified a need for quick access information, it is not used to make decisions and so is not included in the analysis of the results. The distribution of usage according to the metrics is presented in Table 2. It is seen that while cost, time and safety metrics are mainly used to make descriptive decisions, resource metrics are largely used for both descriptive and predictive purposes, and information metrics are for descriptive and communicative purposes. In addition to usage, we queried the current availability of the information for participants which can be seen in Table 2. Of the information required to evaluate the performance of the projects, 88% either does not exist or is not in a format required by the people. For instance, in one interview it is identified that rework information is captured in daily progress reports and in order to measure the cost of rework, one needs to go through each of the reports to calculate the amounts and convert to monetary value. Hence, although the documents are kept in electronic format, they are not stored in a format to support easy access and navigation for the purposes of participants.

Table 2: Current Availability and Usage of Information According to Performance Metrics

	Cost	Time	Quality	Resource	Safety	Information	Overall	Total
Total	17	15	3	11	6	23	1	76
Usage for describing	10	7	2	5	4	9		37 (%49)
Usage for explanation	5	3	1	1	1	2		13 (%17)
Usage for prediction	2	3		5	1			11 (%14)
Usage for prescription		2				9		11 (%14)
Usage for evaluation						3	1	4 (%6)
Currently available	*4*	*1*		*1*	*2*	*1*		*9 (%12)*
Not available	*2*	*6*	*3*	*7*	*2*	*1*		*2 (%28)*
Need modification	*11*	*8*		*3*	*2*	*21*	*1*	*46 (%60)*

5. Conclusion

In this paper, we presented that there are numerous performance metrics to assess the progress of construction projects and developed a hypothesis that the information needs of different project team members vary in terms of the metrics they use to monitor the projects. Interviews with nine different project team members were conducted and current availability of data and their usage purpose of performance metrics were evaluated. The metrics selected by the interviewees were mostly related with cost, information, time and safety and total number of metrics chosen by each participant varied in the range of 5 to 11. It is realized that the current data collection and storage approaches mostly do not support the unique needs of team members. From this study, we can conclude that in order to support the decisions made by the project team members and to prevent them from information overload they should be provided with customizable dashboards to increase their understanding of the projects. The future direction of this study as a result of identification of different needs of project team members will be enabling the generation of customizable dashboards.

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