Integration between planning and control of building production and costs using building information modeling

BACKGROUND

The construction industry is composed of several desktop environments and disciplines that integrate even with its characteristics (Mueller, 1986). Systems integration related to cost control and planning has been a matter of great concern to researchers and professionals of the construction industry (Fan *et al*., 2015). The integration of production and cost planning systems enables better planning and management of the construction by combining production planning and cost data with their respective control data. For the integration of planning and cost, a common project breakdown structure with sufficient level of detail must be defined, allowing an automated method for acquiring and storing this sort of information (Rasdorf and Abudayyeh, 1991).

However, many construction projects are subject to ineffective control due to an inefficient flow of information, especially regarding to the quality of the information that is provided by these control systems (Rasdorf and Abudayyeh, 1991). Thus, the use of emerging technologies such as Building Information Modeling (BIM) has proved to be a facilitator of integrating project information so that decision-making is taken from a cost and schedule perspective. BIM can improve the technical work already in the design phase, creating 3D models that integrate all the resources of the building, in addition, these models can be improved if linked to schedule data (4D) and of costs (5D) (Jrade and Lessard, 2015).

The main aim of this work is to propose and implement a method for integrated production and cost planning and control with the support of BIM, by analyzing the flow and exchange of information since project design office to the control on field production.

RESEARCH METHOD

The research approach adopted was Design Science Research, which was used to develop a method for integrated production and cost planning and control with the support of BIM through cycles of development, implementation and refinement in two empirical studied (CS1 and CS2) carried out in two different projects from the same construction company, according to the following steps.

In the investigation of the problem stage, the construction company selected already used BIM at initial stage of implementation, but their production and cost processes were not integrated without or with BIM. Thus, a diagnosis was made concerning the current information flow of BIM modelling, planning and cost process, identifying the main responsible parties, software, type of information passed along the flow, as well as the main obstacles to integrate the information between BIM, cost, and planning, from the office environment to the production control on the field in the two construction projects studied. The data was collected from interviews with managers, engineers and trainees, direct observation and documents analysis.

The Solution Proposal stage and the Implementation stage of the method were developed through three design and implementation cycles in the CS2, during a period of six months, in which the proposed method was improved along implementation was carried out. In each cycle an evaluation was made regarding simplification of the processes, quality, integration and feedback of the information, in order to identify the improvements that should be made in the proposed method. In this stage, ten meetings and four interviews were carried out for data collection. Participant observation and document analysis were also used as source of evidence.

The evaluation of the proposed method is under development and is focusing on the analysis of the operability of method, including the efficiency and efficacy of the information flow regarding to the automation and simplification of the processes, barriers and benefits to the implementation, as well as degree of generalization and replicability of the method proposed. This stage will carried out through participant and direct observation and document analysis.

RESULTS

The CS1 diagnosis indicated that although the project had BIM 3D models and a standard WBS (work breakdown structure), the planning and budgeting process, as well as the modeling team were still working isolated in their process, because the WBS was only be using in the BIM model. The lookahead planning and short-term planning were carried out in the field without taking into consideration the long-term planning and the information of cost provided by the office teams. In addition, the production monitoring was done by a customized company's software, but it did not promote an effective feedback of the information, once a different WBS was used, generating only monthly reports of the actually developed activities. In CS2, the BIM model provided a quantitative take-off and a sequence of activities developed by the field engineer that supported the construction of the BIM model and budget, but there was no exchange of information regarding to the definition of the work packages, the budget values did not fit the model, the BIM model was not sent to the field and the production monitoring data was not integrated with the planned planning data.

In order to overcome the identified difficulties, an integrated method was proposed involving three different information flow, having a common WBS. This method was conceived and refined along the study. A total of three method versions were developed along the CS2. The first version of the method referred only to the integration between the systems used by the company (Revit, Navisworks, MS Project, TOTVS (company's budgeting system) and CPObras (customized production monitoring system), how they would be interoperated between them. The second version was developed through cyclical and participatory process between those responsible for the elaboration of long-term planning and the BIM 3D model, through the definition of work packages. The goal was to create a 3D model which could represent how construction would take place in the field, supporting the preparation of lookahead and short-term planning, as well as making the visualization of the constructive processes easier through 4D simulations. In this case, the use of a standard WBS was responsible for the integration between BIM model, budget and planning process, and the information was centered on a MS Project worksheet that served as database. The third version of the method, include all feature related to information flow proposed in the first two methods, extending to the integration of production and cost planning to the production monitoring, facilitating the adjustments of production and cost goals, and using comparative 4D simulations of progress and use of line of balance.

CONCLUSIONS

The proposed method allowed to meet the need to integrate information among the work environment of the construction company studied, by improving quality and increasing the transparency of information exchanged between field and office, since the use of a standard WBS facilitated the exchange of information that maintains faithful information throughout the flow and is centralized in a database in MS Project available to all involved. Some processes were automated and simplified through the development of programming routines in Dynamo and encoded and standardized insertion of information in both the BIM model and the database in MS Project. The method can be adapted for future projects of the company studied, since it is only necessary to make adjustments in the standard WBS, and of other companies, because the proposed changes in information flows and processes can be extended to other organizational structures independently of the programs used.

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