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Design management using knowledge innovation and visual planning

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ABSTRACT

An open platform used for industrialised house-building imposes restrictions on the flexibility of the product offering when developing design standardisation. How design process standardisation incorporates variations in products has not been widely studied. The aim of this research is to explain how design breakdown enables Lean Product Development Flow (LPDF) and look-ahead planning in an industrialised house-building context where an open platform is used. A case study was conducted of how one of the leading industrialised house-building companies in Sweden introduced the LPDF tool Knowledge Innovation/Visual Planning (KI-VP) into their design process. The implementation of KI-VP led to an increased cross-functional understanding of relationships between activities, which are an important factor in achieving flexibility and a synchronised workflow. By using design standardisation, look-ahead planning was implemented and used in the management of design flow. Standardisation through design breakdown provides a basis for knowledge innovation that enables improvement of the open platform using a bottom-up approach and increases the production flow.

1. Introduction

Providing a turn-key solution for a client forces a contractor to optimise the product, from design and manufacturing through to assembly and delivery of the finished building. When the contractor controls the design, there are many opportunities for them to improve the design process using work breakdown structures and lean principles [1]. For residential construction, the use of either an open or closed platform makes it possible for the contractor to produce a standardised work process [2]. The platform is a collection of the contractor's assets, used repeatedly for different construction projects, thus creating industrialised processes [3]. When closed platforms are used, the design process is part of production and is organised using configuration tools based on modularisation [4]. Using an open platform, where the client can specify requirements outside the configurable solution space, is a challenge since such variation affects design and production planning [2]. Tribelsky and Sachs [5] identified how stable design information flow could be managed to handle variations in construction design, through mechanisms such as creating small batch sizes, maintaining small quantities of work in progress, by having short design review and response cycle times, as well as identifying and removing bottlenecks. There has been little research about the breakdown of design processes into activities that could be used to manage the information flow during the design phase in industrialised house-building. Lean Product Development theories and methods, described in manufacturing literature, have been used in this research as a lens to capture design process standardisation. For example, the use of visual planning of standardised work tasks, in combination with experience feedback, is known to enhance the transparency of processes. Continuous improvements in design can be achieved by combining various lean methods to create a visualisation of knowledge creation [6]. This technique forms the practical method called "Knowledge Innovation/Visual Planning" (KI-VP) [7]. The lean method of look-ahead planning provides another practical approach, focusing on achieving precision in the planning of the design process [8]. A combination of practical Lean Product Development Flow (LPDF) tools and look-ahead planning methods form the analysis of the design management of house-building platforms. The aim of this research is to explain how the management of design breakdown enables the use of LPDF in combination with look-ahead planning in an industrialised house-building context where an open platform is used. A case study investigated how one of the leading industrialised house-building companies in Sweden implement and use KI-VP in their design process.

2. Frame of reference

Lean Manufacturing strategies have evolved from the Japanese manufacturing industry and are widely used to improve manufacturing, with the primary aim of identifying and eliminating waste across the entire value chain [9]. The need for efficiency in the product realisation chain places demands on actors to understand the requirements of their customer's customer and the conditions for their suppliers' supplier [10]. In industries producing complex and expensive products (such as house-building), product development is often part of the design process [11].

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LPDF is described by Oppenheim [12] as being based on the five principles of lean for design management: value measured using throughput time for the customer; the use of takt time by mapping the process in an Obeya room to give current and future states; regular face-to-face meetings to minimise waste in the flow; identification of internal customers and understandable deliverables to enable pull in the value stream, and team training to continuously improve planning and product quality in the pursuit of perfection. An Obeya room is a room where on-going activities are visualised and design meetings held. By manufacturing small batches of products, with frequent transactions and fewer interruptions, stable design information flows and a higher quality of construction design documents can be achieved [5].

As a practical application of LPDF, the concept of KI-VP was incorporated by Japan Management Association Consultants [7]. The KI-VP concept is based on having an Obeya room, planning schedules on boards, the use of standard operations sheets (SOSs) capturing activities, daily experience feedback, and process analysis. When implementing the KI-VP concept with tools, techniques and methodologies, Hines et al. [13] discussed the need for understanding both lean thinking at the strategic level and lean production at the operational level, to create knowledge flow within and between projects. They described the approach as bottom-up, where the participants in the process are the people who establish the existing process state, decide what to improve and how to improve it. To handle tight development schedules and support queue management, Rossi et al. [14] suggested the idea of visual planning in an Obeya room. Visual planning is a method that allows the simultaneous planning and visual communication of streamlined work processes and the interdependencies between activities [9]. The method is simple: activities and deliverables are outlined and illustrated on a physical planning board (often a whiteboard) and updated at frequent meetings in the Obeya room [15]. Visualisation and physical movement of design activities on the board give a sense of flow, while the frequent meetings provide an environment to share knowledge and discuss problems [15]. The use of magnetic visual boards is often the first step in the implementation of a lean strategy for service processes to identify bottlenecks, obtain operational transparency, and enable a fast visualisation of flow-related problems [16]. Visual boards are used to display the process, the progress of projects, and opportunities for improvement [17]. In a case study carried out by Viana et al. [6], it was shown that visual planning can reduce the complexity of process management in an industrialised construction context, where multiple projects are designed simultaneously.

An SOS is a detailed listing of all work tasks in an activity related to a particular stage. It is a lean manufacturing tool that aims to improve the process as a whole by standardising parts [18]. By capturing the current lowest level with an SOS, the activity can be improved, leading to the creation of a new SOS.

In a tool-based analysis of visual planning in construction, Viana et al. [6] identified an increased adherence to planning targets when companies worked with work breakdown structures and visual boards. The idea behind using planning boards is the visualisation of the company's goals for all production units. Little is known about the process of capturing production knowledge and developing it as a source for improvement of design work in house-building companies [2]. When managing projects, the long-term investments in integrating design and construction competences are traded against short-term efficiency and long-term innovation [19]. Short-term efficiency focuses on project performance; distributed work practices limit incremental innovation from project experience [20]. Long-term innovation can be achieved through continuously developing a house-building platform to create robust design work with feedback channels [2]. “Knowledge Innovation” refers to using the upstream flow of experience feedback and the transparency of visual planning to learn and improve the process [13]. Hines et al. [13] described how each activity can be analysed to help fulfil project goals, and also why unscheduled activities occur and whether they should be included in KI-VP standardisation or not. The resolution of activities described in the SOSs is difficult to visualise in an overview on a physical planning board since there can be hundreds of activities in a process. The use of manual boards and physical artefacts e.g. magnets, presents an overview but can make it difficult to store and share knowledge [15]. Daily meetings and the breakdown of activities contributes to the enhancement of operational integration, cross-functional communication and visualisation of potential problems [17,21]. Using a design breakdown structure, the decomposition of processes into activities organised by size, duration and responsibility can be detailed in task descriptions covering the questions what, who, when and how [22]. In this way, it is possible to define a master schedule template that can be used as a basis for planning and process improvement [13].

The development of look-ahead planning in the field of lean construction [23] resulted in a method of improving the project performance and creating a predictable flow in production that was realisable. Look-ahead planning consists of a master schedule, a look-ahead schedule and a weekly work plan [23]. The master schedule is defined at the beginning of each project, based on status and forecast information, enabling an overall view of the project in the look-ahead schedule. The plan for a few weeks ahead is refined, enabling coordination between design activities and deliveries. Activities are further refined in the weekly work plan, which usually specifies what these activities are, but not how and why to carry them out [24]. A case study of a hospital project Hamzeh et al. [8] showed how look-ahead planning was applied to plan the information flow in the design process. The complexity of identifying the design process is due to the interdependency of activities, numerous design iterations, and the need to continually re-plan [8].

3. Methodology

A case study approach was used since it gives an in-depth view of the studied phenomenon [25]. Data were collected by combining interviews with data from documents and observations. A single case provides the opportunity to make in-depth analysis of relationships and meanings in the context at the loss of generalisability. Therefore, case study results are compared to existing theory when drawing conclusions. The most successful industrialised contractor in Sweden was chosen as the company to be studied due to their extensive use of lean thinking in design and production. The case study was longitudinal, with data about the structure of visual planning and its use in daily work being collected between 2006 and 2010. Building on that study, the company was revisited in 2015 to discover how their KI-VP implementation had developed since 2010.

The first data collection in 2010 involved the mapping of the design breakdown based on personal time reports, external consultant invoices, site visits and project-specific time reports for 26 building projects between January 2005 and June 2009. The implications of design activities, and the relationships between them, were identified through observations and notes from project meetings in the Obeya room at the company during the process of refining the standardised design work. By tracking how much time the employees spent on each activity and the interdependence between activities, it was possible to breakdown and analyse the design process for standardisation. To analyse the flow, the starting point for the process analysis was the first manufacturing step in the factory and from there each delivery and activity was traced backwards through the design process.

In 2015, the improvement strategy and the implementation of the KI-VP system were recorded using site visits and interviews with two project managers and the lean coordinator at the company. The sales manager was also interviewed regarding how the sales process was organised from a flow perspective. By using a semi-structured approach in the interviews, it was possible to capture the interviewees' thoughts on the design breakdown process, and to ask follow-up questions [25]. All interviews were recorded and fully transcribed. The content of the