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EFFECTS OF DAILY MANAGEMENT ON DESIGN RELIABILITY

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ABSTRACT

Building Design Management (DM) is challenging due to the fragmentation of project partners, the iterative nature of design and the tradition of informal management of designers. Therefore, many contractors do not trust the promises of designers and protect the construction schedule with schedule buffers that increase project lead times. To act upon this situation, several researchers have suggested using the Last Planner™ System (LPS) as a method for DM. Using two case studies, we present how the use of the LPS method as a tool for Daily Management (DAM) increases the reliability of the design and how, correspondingly, *not* using it can affect design reliability. So far, very little attention has been paid to the role of DAM in DM, and this short article seeks to provide new insights into this research gap for both researchers in the field and DM professionals. These early and exploratory results, despite the limited number of cases, can be utilised in further research as well as in practical project management, especially when the reduction of schedule buffers between construction and design is targeted.

KEYWORDS

Lean construction, lean design management, last planner, PPC

INTRODUCTION

Lean is a production philosophy that focuses on customer needs, production flow and continuous learning (Huntzinger, 2002). In the construction industry, the lean philosophy has been applied for decades, and due to the special features of the construction industry in relation to factory production, the construction industry has developed its own applications of lean production and lean design. One lean method is the Last Planner System (LPS), which is used for production control and Design Management (DM) after its development (Fosse & Ballard, 2016). The LPS is based on continuous pull planning sessions, measuring the promises made by the parties to each other, and continuous learning (Ballard et al., 2007). Several studies have shown that in construction production,

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where the LPS method is introduced, relatively high Planned Percentage Completed (PPC) values are generally achieved (Kim & Jang, 2005; Bortolazza & Formoso, 2006; Khanh & Kim, 2013; Hicham et al., 2016).

DM in construction is a complex process, and its failure can shatter the entire project. Challenges in DM are a multidimensional phenomenon involving project management challenges, communication challenges, guidance challenges, competence challenges and technological challenges (Coates et al., 2004; Addor & Santos, 2014; Alaloul et al., 2016; Pikas et al., 2013; Mehrbod et al., 2019). In addition, the field of construction is known to develop slowly (Koskela et al., 1997; Chen et al., 2017). Despite the widespread use of traditional project management methods in the construction industry, these methods have been found to be ill suited for DM (Gray & Hughes, 2001). One alternative to traditional methods in construction design is lean design management (LDM) (Koskela et al., 1997; Tilley, 2005; Uusitalo et al., 2019).

LDM comprises many methods and tools (Uusitalo et al., 2017). LPS has been used in DM for visualizing the design workflow, optimizing the sequence of design work and phases, increasing the transparency of the design process, tracking the amount of work in progress, and controlling the design process (Koskela et al., 1997; Fosse & Ballard, 2016). Several companies have also seen the importance of daily ("huddle") meetings in the use of LPS, and DAM is considered to facilitate continuous improvement as an integral part of a lean philosophy (Salem et al., 2006). Behind DAM is the plan-do-check-act cycle (PDCA), also called the "Deming's cycle" by its developer (Koskela et al. 2019). In these short meetings, called "huddles," team members quickly report on the previous day's situation regarding their own work and whether there is a problem preventing the work from being promoted (Schwaber, 1995). This part of the LPS method is analogous to the Scrum methodology developed in the software industry.

Scrum is so-called agile method that iteratively and incrementally develops a product with the goal of maximizing customer value return, and these methods have been developed since the 1950s as a reaction to the traditional bureaucracy of engineering methods and the ever-changing business environment (Abbas et al. 2008). What distinguishes agile methods from lean methods is that agile methods respond to the complexity of a change of continuity in an unpredictable environment, while lean methods are a collection of functional techniques that focus on productive resource use (Sanchez & Nagi. 2001). However, while scrum is developed for software product development projects, it can also be applied to complex projects and design (Streule et al. 2016). The scrum framework consists of roles, artifacts, and events (Schwaber & Sutherland. 2013). Many previous studies (Koskela & Howell, 2002; Owen & Koskela, 2006; Owen et al., 2006) have provided concepts for adapting agile methods from software development to the design phase of construction projects, and some engineering companies in the Nordics have implemented these methods as part of their processes (Føreland & Halvorsen, 2018; Uusitalo et al. 2017).

Although many researchers have recognised the benefits of LPS in DM, most design-related studies have focused on LPS sessions and described their benefits (Daniel et al., 2015). Thus, the role of daily management (DAM) in DM has not been adequately studied, and this study therefore focuses on showing how using DAM as part of DM improves design reliability. This exploratory paper focuses on highlighting the impact of the DAM on design reliability and seeks to highlight the importance of further research on this connection.

The purpose of the DAM is to bring the team together and provide the team with a common platform in which team members visit the day-to-day work, report on obstacles they have encountered and progress in their own work (Lianying & Xi, 2016). Typically, a DAM meeting, also called a "huddle," is held daily (Salem et al., 2006). DAM also has other effects. For example, Salem et al. (2005) highlighted the effective outcomes of a detailed review of acute issues in construction site daily huddles. According to Seed (2014), the DAM meeting can prevent the construction industry's inherent tendency to suspend work when problems arise and to look for a new direction at the next meeting. He also emphasised that the daily huddle meeting agenda should be focused on the tasks among the parties, i.e., what is the progress of the tasks, what is currently ongoing and whether there are any restraints to proceedings (Seed, 2014). Reducing the postponement of design work by DAM may also allow the shortening of buffers. This highlights new possibilities for the design of more efficient production that aims at small batch sizes and buffers, as proposed by Lehtovaara et al. (2021). One of these possibilities is the importance of reducing batch size and WIP to ensure the reliability of the design work (Ballard et al., 2002; Uusitalo et al., 2019; Lappalainen et al., 2021).

Also, as part of the DAM, LPS sessions include root cause analysis, in which tasks that were not completed, despite planning, are examined in more detail (Ballard, 2000). These analyses aim to systematically categorise the root causes of work interruption and eliminate them so that similar future tasks will not be prevented for the same reasons (Fauchier & Alves, 2013). Ballard (2000) led the construction industry towards root cause analysis and emphasised its importance in lean construction. The classifications presented by Ballard et al. (2007) can be used to systematically document the root causes identified and to determine their frequency. Resources can then permanently eliminate the most significant and common root causes of delayed tasks. The classification of root causes in this study is fourfold: (1) a lack of instructions or guidelines, (2) a lack of conditions for starting the work, (3) a lack of resources and (4) problems in process. Ballard (2003) also identified the importance of the DAM; however, its importance has sometimes been overlooked (Dave et al., 2015).

Despite some efforts (Streule et al., 2016; Zender & de Soto, 2020; Poudel et al., 2020), the research in the construction industry to date has not paid enough attention to the role of DAM in DM. This paper attempts to show that focusing on DAM in DM may offer more rigorous and reliable control of the design process than traditional methods. As the problem of poor reliability and predictability in DM is universal and common in the industry, our research also serves as an awakener for both researchers and practitioners. Thus, our study makes a relevant contribution to the construction industry.

METHODS

The research problem required an exploratory approach, and the case study method was chosen as the research strategy (Algozzine & Hancock, 2017). The case study method also made it possible to assess the differences and similarities between cases (Yin, 1981). In the case study, the validity of the study is achieved primarily by using multiple sources instead of single source data (Algozzine & Hancock, 2017). In this study, we used two primary data sources: PPC measurements and root cause analyses. Second, to ensure the reliability of the study and reduce prejudice, the data collection and analysis methods of the study are presented in a transparent and detailed manner; therefore, this research is replicable (Gibbert & Ruigrok, 2010). Third, research and data collection have been done by multiple authors (Gibbert & Ruigrok, 2010). Researcher bias and the bias of a small sample were also identified and considered in the conclusive part of this paper.

The data were obtained from two Finnish case studies, and an exploratory design was used to determine the effects of DAM on PPC values. Case study A was chosen because it used DAM for underground pipe DM in a greenfield industrial project. Case study B, which did not use DAM, was a hotel renovation project. In both case studies, the detailed design phase and construction work were ongoing. The active research work lasted 9 months. The authors used only two case studies for comparison, mainly due to the limited length of this paper. The data collected from the literature and other projects monitored by the authors also corresponded to the PPC level of case study B selected for this study, and thus the comparison between these two cases is a sufficient sample for this purpose. Data were first collected from digital sources provided by the design teams and then edited and categorised by the researchers. In case A, the data was stored in a table in the Microsoft Teams workspace, from where it was transferred to Excel by the researchers. In Excel, the data was organized so that descriptive statistics could be calculated and PPC charts could be generated. In case B, the data were obtained from a project bank from which it was downloaded for use by researchers. The data in the project bank were in Excel and pdf formats, and the researchers transferred the data to a separate Excel file and descriptive statistics and PPC diagrams corresponding to case A were prepared.

CASE STUDIES

Case A was an ongoing industrial plant site with a gross area of approximately 200,000 m2. The corresponding design organisation consisted of a client representative who supervised the design (sub-area project manager) and a design project manager who worked for the design team and designers. The design project manager independently led the daily meetings after the initial phase. The sub-area project manager represented the owner at these meetings and made the necessary decisions regarding the design work. The agenda for the daily meetings was simple: what the designers were doing and whether there were constraints to be removed. The maximum size of the design team during the study was nine people. The designers and team leader actively participated in the daily meetings, except for isolated occasional absences. One of the researchers facilitated the LPS method, but soon after the principles of the LPS method became apparent to the designers, the design team and the client’s representative continued independently, and the researcher assumed the role of observer. The LPS method started with a joint LPS session, in which a phase schedule was prepared with the help of the master plan and preliminary task planning was done.

In the first session, the design team was introduced to the following LDM principles: (1) do only unhindered work, (2) remove all constraints before starting the task, and (3) publish drawings frequently and in small batches. Since the master plan had been assigned to the project before and without the use of LPS, the design team began scheduling in the first phase of the planning session. The first workshop lasted one working day, which was divided into two parts, and the phase plan was conducted in small groups. Because of the Covid-19 pandemic, the session was held remotely using teleconference software and an electronic whiteboard application. It was agreed that daily planning routines would include only the necessary planning tasks for the next five working days, and the size of the tasks was limited by scoring (maximum half-day job = 3 points, approximately one day job = 8 points, a couple of days job = 13 points, and a maximum of one week job = 34 points). The scoring method was borrowed from a similar method used by the facilitator in the IT field to steer the team's efforts towards evaluating the scope and complexity of the task and away from estimating the exact number of hours (Mahnič, 2015). At the beginning of the design, the tasks were mainly designed for one person, but exceptions to this principle were made during the work, and there were often other designers under one task who participated in the task. The amount of work in progress (WIP) was limited to 50 points at the beginning of the design, aiming for the design team to focus only on the agreed-upon tasks for a week and complete them during the week. The WIP limit also reduces the batch size of a task to a maximum of 50 points (approximately one week of work). The background to setting this limit is the intention to be familiar with lean and agile philosophies, where the amount of WIP is intentionally limited (Sutherland & Schwaber, 2013). Design work had started with limited resources in case A four months earlier without WIP restrictions and in the traditional way, although as construction approached, the parties decided to implement LPS as well as DAM.

Every fifth daily meeting on Fridays was 15 minutes longer than other daily meetings, and it was dedicated for planning the next week's tasks. Only constraint-free work was allowed to be placed on the next week's to-do list. In this regard, the designers followed LPS make-ready planning and weekly planning procedures. Learning took place in weekly meetings on Fridays, which always began by checking the implementation of the weekly work plan and PPC metrics. Tasks that were not completed despite make-ready planning were then reviewed through root cause analysis, and constraints were classified and removed during or shortly after the meeting. If the removal of the constraint took place, as was the case for a few tasks, no new tasks related to this constraint were taken under work until the constraint was removed. The duration of the weekly meetings was about 30 minutes, and the duration of the daily meetings was initially 30 minutes, although it was shortened to 15 minutes, as the group learned how to use the method. In addition to the DAM, the design team held normal design meetings with the client and other designers, with a focus on coordination issues with different design industries. The constraint log and to-do list were compiled on the digital cloud platform to which all parties had access. One of the authors observed 19 weekly meetings and 31 DAM meetings for 5.5 months. However, not all daily meetings were observed by the author, and at that time, the team met daily without the author's presence.

Case B was an ongoing hotel renovation site with a gross area of approximately 40,000 m2. The design of case study B was led by a construction management consultant, and LPS sessions were held with the design team on a weekly basis. In this case study, all design disciplines were represented. With a few exceptions, the design team regularly attended weekly sessions and planning meetings. The design work was planned according to the LPS method through the master schedule for phase scheduling, look-ahead planning, and weekly planning (Verán-Leigh & Brioso, 2021). The team used Excel spreadsheets at the beginning of the project, but as the project progressed, it switched to using a digital cloud-based whiteboard application to replace the traditional LPS board based on post-it notes. Also, during this project, the Covid-19 pandemic affected the work of the design team, and the sessions were held as remote sessions, except for the initial phase of the project. The exact number of designers was unavailable to the researchers, but there were dozens of them in the design organisations. The duration of the weekly meeting was about an hour, and one of the researchers observed 12 LPS sessions and went through the data of the LPS sessions for two years. The batch size was not limited in this case study, although the principle was that the tasks should be sized to be completed between the weekly sessions. Constraint logs were not used by the design team;

however, these constraints of design work were discussed in the weekly sessions with the aim of resolving them either in the session or shortly thereafter. In addition to the LPS sessions, the design team held separate design meetings, as the case study A team did, where they focused on technical design coordination issues rather than task management.

DATA ANALYSIS

The data consisted of weekly PPC measurement results as well as recorded root causes that prevented the completion of the planned design task. Both PPC results and root causes were compiled into tables using Excel. The root causes were classified in case study A into the following categories commonly used in the LPS method: (1) a lack of design instructions or guidelines, (2) a lack of conditions for starting work, (3) a lack of resources and (4) problems in process. The first root cause was, for example, situations in which changes were made to the design criteria while the design was already underway and ignorance of the design requirements and/or design guidelines. The second root cause was tasks in which the initial data or subscriber's decisions were missing or the previous work phase was in progress and prevented the work from being performed. The third root cause was related to tasks that could not be completed due to a lack of manpower or technical problems with the design software. The fourth root cause included tasks that were not completed due to miscalculation of time allotted for work, correction of errors and deficiencies in design coordination.

RESULTS

PPC

In case study A, PPC increased shortly after the start of daily meetings, with a mean of 91.8%. The amount of weekly estimated work was limited to 50 points, and the mean was 62.6 points. Figure 1 shows the evolution of PPC for case A over 19 weeks and weekly workload point estimates.

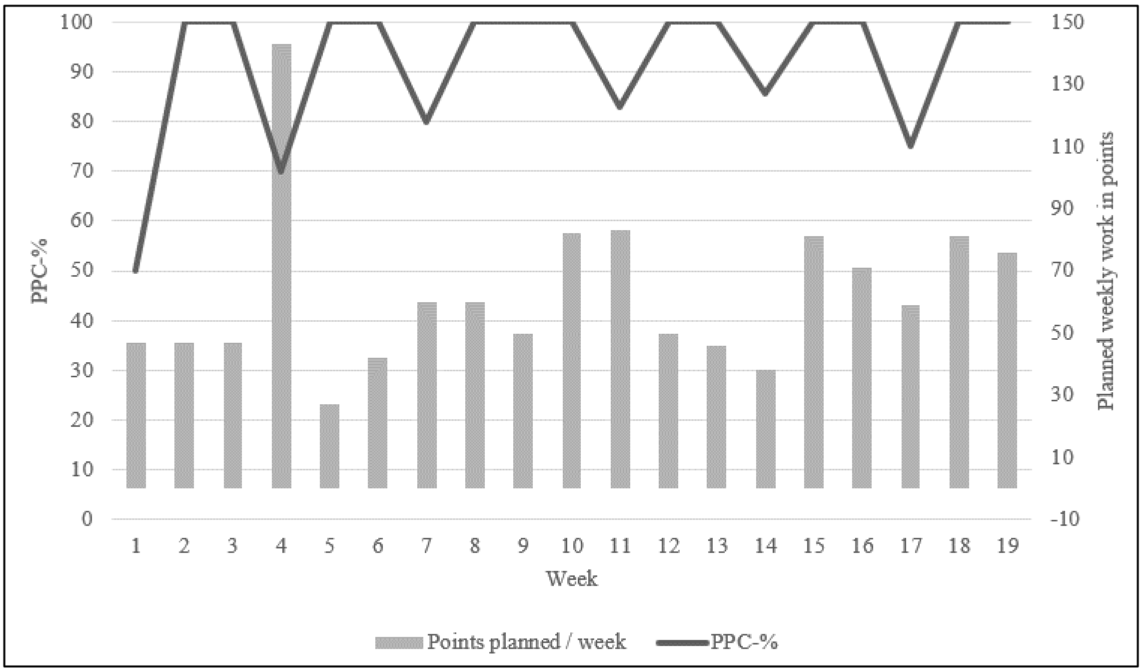

Figure 1. Case A – PPC and planned weekly work.

In case study A, weekly work was measured as points that reflected the estimated extent of work in approximate hours or days worked. However, it was not possible to determine from the data the actual work that had been done. In case study B, the PPC was clearly lower than in case A, with a mean of 58.8%. The amount of weekly estimated work was not limited, and the average number of weekly tasks was 29.9. Figure 2 shows the development of the PPC of case B over 42 weeks and the weekly tasks.

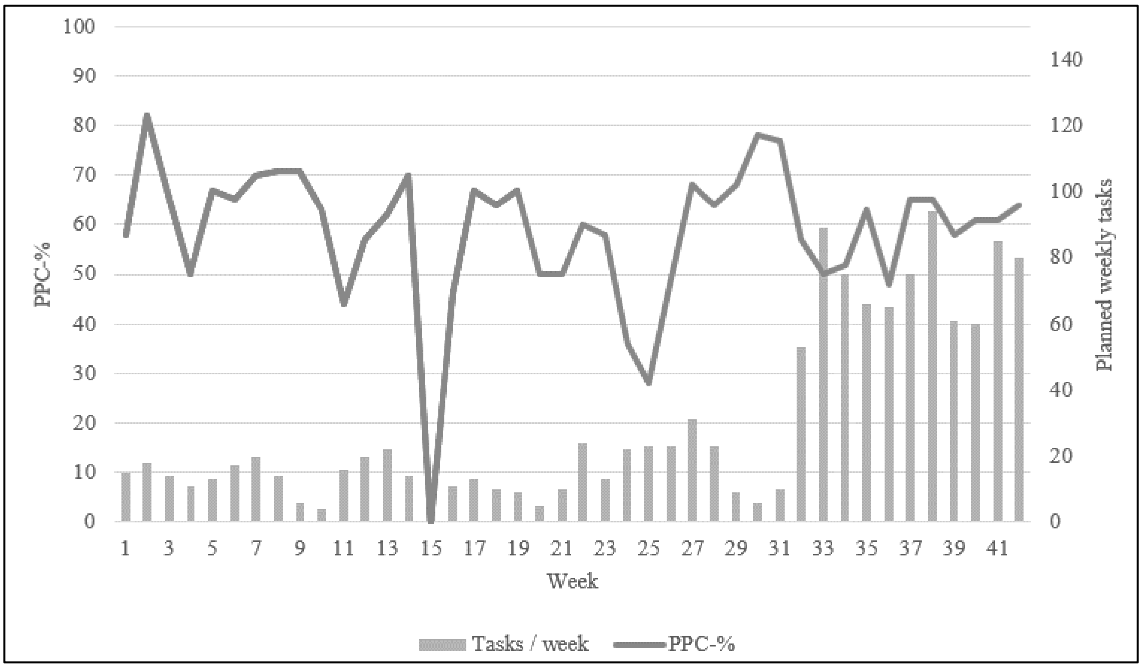

Figure 2. Case B – PPC and planned weekly work.

In case study B, weekly work was measured only as the number of tasks, so the estimated or actual workload could not be determined from the available data. The results also show that in both cases, there were no major improvements in PPC values, and the level of reliability was relatively constant in both. In case A, it is higher, and in case B it is lower.

ROOT CAUSE ANALYSIS

In case study A, which lasted only 19 weeks and involved only the underground pipeline design team, the number of root causes was naturally lower than in case study B, which had a follow-up period of 42 weeks and involved all design disciplines of the project. Table 1 summarises the data from both case studies for the root causes of the design assignments that were not completed as planned during the week.

Table 1. Root Cause Analysis Results

Root Cause	Case A	Case B
1	0	30
2	5	90
3	0	60
4	3	63
5	0	866

Root cause 1 = Lack of design instructions or guidelines
Root cause 2 = Lack of conditions for starting work

Root cause 3 = Lack of resources
Root cause 4 = Problems in process
Root cause 5 = Unknown cause

As can be seen from the table, in both case studies, root cause category 2, a lack of conditions for starting work, was the most significant factor hindering completion of the design tasks. Similarly, in both cases, deficiencies were found in the process that prevented the completion of the tasks. However, in case study A, no root causes 1 and 3 were found at all, while in case study B, these were identified, especially root cause 3, as problems in the process and as a common restriction to completing the tasks. In contrast, as a specific finding in case B, the number of unidentified root causes was remarkably high at 866 cases. It is evident that the coverage and purposive implementation of root cause analyses have suffered, especially in case B, due to the large number of discrepancies. Root cause analyses are laborious to implement, and if the number of anomalies starts to increase, as in case study B, the design resources will not be sufficient for detailed analyses. In case A, the daily processing of root cause analyses did not lead to a corresponding labour cost, which was naturally also affected by the smaller number of deviations.

SUMMARY

The results clearly show the differences between the cases, the most significant of which is the PPC value. In case study A, where DAM was used, PPC was at a higher level than in case study B, where DAM was not used. With the standard deviation of the PPC number being the same in both, the level of reliability in case study B was stable but lower than in case A. In both cases, the variation in workload does not appear to have affected PPC.

For root causes, similarities were found for root causes 2 (lack of conditions of work) and 4 (problems in process), but not for root causes 1 (lack of design instructions or guidelines) and 3 (lack of resources). The large number of unidentified root causes in case B and the researcher's observations of LPS sessions suggest that the root causes were not treated or handled with the same precision as in case A, with unidentified cases likely to have several root causes belonging to causes 1–5.

When comparing the discussions that took place in a project that used DAM to a project that did not use DAM, the most significant differences were that in a project that used DAM, each delay was addressed in daily meetings, and the root cause was eliminated. In a project where DAM was not in use, the root causes of the failure of the tasks were recorded weekly, but there was little discussion about eliminating them and no systematic effort to remove the root causes and restraints. The number of root causes in case A was small, which may be influenced by problem-solving practices resulting from the systematic and daily removal of barriers. The approach of case B, where the root causes were not systematically eliminated, seems to lead to a recurrence of the same work restrictions, and if the root causes are not eliminated, and thus PPC also appears to be permanently lower.

DISCUSSION AND CONCLUSIONS

Our findings imply that high PPC values are possible in design. Our exploratory study proposes that with DAM, it is possible to achieve a consistently high level of PPC. This result contributes to supporting, for example, the views of Koskela et al. (1997), Fossen and Ballard (2016), and Uusitalo et al. (2017) on the role of LPS in the use of LDM in construction projects. To develop a full picture of DAM, other researchers could replicate our findings in different projects, allowing the importance of DAM in terms of schedule buffer reduction, batch size, and WIP reduction to be assessed more comprehensively in this short paper. Further research should also investigate the possibilities of using DAM in takt production, in which case, for example, the pace of one-day construction production could be integrated into the daily management of design (Lehtovaara et al., 2021).

In case study A, which used DAM and prevented entry into work unless constraints were removed, the number of unfinished tasks was lower and PPC higher than in case B, where researchers found no systematic or daily process for removing constraints. Indeed, in the case of case B, it appears that the make-ready planning phase was missing the constraint removal process, and the reason for this needs to be further investigated. According to a previous study, it is possible that using make-ready planning would raise the level of PPC (Hamzeh et al., 2015). LPS was applied in slightly different ways in both cases. On the other hand, this has already been observed in previous studies and is partly human; different methods are applied in different environments and situations, individually and in different ways (Dave et al., 2015). Thus, we cannot say with certainty that DAM as such has a direct impact on a better PPC level, especially when the use of LPS in these cases differs in terms of make-ready planning.

The authors recognise that the sample is small and not random; however, through this short article, it is possible to share the experiences of DAM in DM. However, our research should be treated with caution, as our results are based on a small sample that is not random and is in a limited geographical area. Also, a research design comparing two distinctive projects – in one case monitoring only one relatively small design team and a single design discipline and the other tracking the entire design team – is a significant limitation on the generalisability of our results. It is conceivable that DAM might be easier when the design team is small and limited to a particular design field. It is also possible that factors other than DAM influenced the low PPC values of case study B; however, the researchers did not find anything specific in their observations during the sessions that could be the reason for the low PPC value. In this study, PPC was the only measure that would appear to be affected by DAM, but further research is needed, for example, on what other variables are affected. For example, the effects of differences in constraint log usage methods and the effects of differences in team leadership practices would be interesting areas for further research. Therefore, even though utilising DAM would improve the reliability of the design, the generalisability of our results should be treated with caution, and to achieve better generalisability, we recommend that researchers conduct similar studies in other project environments and in different countries.

Hopefully, this short paper will encourage design managers to experiment with DAM together with LPS in future projects. The organisation of similar studies is relatively uncomplicated and fast to implement, so comparative studies should be expected soon. This study will be complemented in the future by interview studies, which aim to discover the in-depth views of the designers and other parties involved in the study on the effects of DAM on their workdays. Future interviews will also provide additional information on the specificities of the cases and possibly other factors that may have contributed to the differences in PPC levels.

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