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DIGITALIZING COLLABORATIVE PLANNING IN DESIGN – A CASE STUDY

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ABSTRACT

Collaborative Planning in Design (CPD) has been used in Norway by the contractor Veidekke since 2009. One of the main principles, collaboration, has previously taken place through co-location of the various actors that take part in the design phase. The COVID-19 pandemic placed restrictions such as social distancing, which led to the digitalization of certain elements in CPD. This paper, based on a construction case in Norway, looks at the effects of the digitalization of CPD. This is done using three research questions: How is digitalized CPD achieved, what strengths and weaknesses arise when CPD is digitalized, and how can the digitalization of CPD improve?

The research was done through a literature study and qualitative interviews of eight design participants from the research case.

Findings show that the digital start-up session should not be used further, as it has negative ripple effects later in design in the form of less collaboration. Fully digital ICE sessions are effective and worth continuing in the future but are dependent on what type of work is scheduled. Phase scheduling should try to use physical post-it notes during a physical meeting, and later convert the schedule to a digital format.

KEYWORDS

Design Management, Last Planner® System (LPS), collaboration, phase scheduling, digital

INTRODUCTION

Design management problems are major contributors to the failure of construction projects (Uusitalo et al., 2019). How to best manage the design phase effectively and efficiently is not so clear either (El. Reifi & Emmitt, 2013). Even though the Last Planner® System (LPS) mostly is applied to the production phase, projects benefit from using an adapted version of this lean methodology in the design phase (Fosse & Ballard, 2016). This indicates that development and adaptation of lean construction in design is worth continuing in the future.

Collaborative Planning in Design (CPD) is a lean construction methodology developed by the Norwegian contractor Veidekke to make the design process more efficient (Veidekke, 2013). The most important aspect of CPD is to involve everyone

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participating in the design process (Fundli & Drevland, 2014; Veidekke, 2013). All design participants should be involved in planning their own work. This part is, as the name suggests, done through collaboration.

The collaboration was mainly conducted through co-location before the COVID-19 pandemic surfaced in 2020. The pandemic led to several restrictions which influenced the use of existing lean construction methods. One of the restrictions was social distancing. CPD, which heavily relies on physical meetings among the participants, had to switch over to digital alternatives to compensate.

This paper will look at how digitalization affected CPD. Three research questions have been prepared with the intention of looking closer at the digitalization of the CPD methodology:

- *How is digitalized Collaborative Planning in Design achieved?*
- *What strengths and weaknesses arise when Collaborative Planning in Design is digitalized?*
- *How can the digitalization of Collaborative Planning in Design improve?*

There were several thematic limitations to this case study. It was decided to only dive deeper into three of the elements in CPD, namely the start-up session, ICE sessions, and phase scheduling through the post-it note technique. The research connected to the case will only be angled towards the digitalization of CPD.

Methodical limitations such as time have constricted the case study. This is because the research is a part of a master thesis, and time to work is limited. It would have been preferable to analyze more than one project, and over a longer timespan to observe which parts of the digitalized CPD endured over time, and which parts are opted out.

THEORETICAL BACKGROUND

LAST PLANNER® SYSTEM (LPS) AND COLLABORATIVE PLANNING IN DESIGN (CPD)

Last Planner® System (LPS) is a lean construction methodology developed by Glenn Ballard (Ballard, 2000). LPS was initially designed to improve the controlling and planning of production in projects (Ballard & Tommelein, 2021). Fuemana et al. (2013) point out that LPS should be implemented completely from design to utilize the methodology's full potential. Implementing LPS in design shows significant benefits (Fosse & Ballard, 2016; Mota et al., 2019). Some of the benefits were increased transparency of the process, better team alignment, and a clearer task description (Fosse & Ballard, 2016).

Veidekke, a Norwegian contractor, adapted a version of LPS named Collaborative Construction management, which has been in use since 2006 (Veidekke, 2008). This methodology was further developed to fit the design phase and was named Collaborative Planning in Design (CPD) (Veidekke, 2013). The work on improving and adapting CPD to better suit design has been in progress since 2009 and is still ongoing (Aslesen & Bølviken, 2017). The methodology is used to manage the progress of the design process (Veidekke, 2013). This is done by creating flow and optimizing the process. The literature study revealed there are only a few papers that are written about CPD.

A paper by McHugh et al. (2021) looks at how the COVID-19 pandemic has affected LPS in production. It is a case study that shows how a digital version of LPS can increase productivity while maintaining the health and safety of the workforce. Salhab et al. (2021)

also look at a similar topic. Here, a framework used to introduce LPS in a virtual environment is presented. Both papers look at the digitalization of LPS in production. The literature study revealed that there is close to no literature which looks at the digitalization of CPD.

START-UP SESSION

The start-up process of a CPD project begins with a start-up session (Knotten & Svalestuen, 2016). The start-up session is held before the detailed design phase and consists of one or more meetings (Veidekke, 2017). The participants in the meetings are the client, project manager and design team, construction manager, foremen, and the primary subcontractors (Fundli & Drevland, 2014). The purpose is to create a mutual understanding of the tasks, goals, and to provide insight into how CPD is used as a methodology (Veidekke, 2017). Another aspect of the start-up session is getting to know the other design participants (Veidekke, 2013). Getting to know each other through these meetings will promote cooperation and trust between the participants.

INTEGRATED CONCURRENT ENGINEERING (ICE)

For the meeting structure in CPD, it is strongly proposed to use Integrated Concurrent Engineering (ICE)-sessions, and special meetings when there is an additional need for it (Veidekke, 2013). This is because the activities in design have interdependencies with other disciplines, decisions, or activities (Knotten, 2018). The design participants are more mutually dependent compared to participants in the production process (Veidekke, 2013).

ICE sessions are collaborative work that involves the various actors required in the design (Eastman et al., 2008). It is used to solve interdisciplinary problems (Veidekke, 2017). ICE sessions are often used during Building information modeling (BIM) work or phase scheduling. ICE puts everyone involved in the same room, which creates an opportunity for discussion (Eastman et al., 2008). This technique helps search for faster solutions from all the participants present in the room. Including ICE sessions when important decisions are made makes it possible to speed up assessments of various alternatives. A large part of the design manager's task is to find out which parties are needed in the ICE sessions (Veidekke, 2013).

PHASE SCHEDULING PROCESS USING POST-IT NOTES

CPD uses a post-it note technique that is widely used in Veidekke's projects during phase scheduling. The phase schedule divides the design process into phases which contain the most important activities in the design work, with time indications (Bølviken et al., 2010; Veidekke, 2013). The plan describes requirements for, and when design documentation, decisions, and drawing deliveries are needed (Veidekke, 2017).

Together with the client, architect, designer, and the relevant subcontractors, the phase schedule is made using the post-it note technique (Veidekke, 2017). All design activities are written on post-it notes and are attached to a physical grid on a wall where columns are divided by week number. Each row on the grid corresponds to each discipline, and each discipline will be assigned its own post-it note color. This makes it easy to create an overview of what each discipline needs from the others, and from whom they need it. The post-it note technique ensures everyone involved in design gets involved in the plans and increases the ownership they have to these plans (Lillestøl, 2016).

METHODOLOGY

The work on the paper started with a literature study. Then, after being assigned the research case, the interview guide was prepared.

LITERATURE STUDY

A literature study was the chosen method to gain insight into the topic. The literature study started in the fall of 2021 and has been a continuous work in progress. Since Collaborative Planning in Design (CPD) is further developed from the Last Planner® System (LPS) literature about CPD and LPS in design was systematically reviewed.

Most of the literature that covers CPD is based on the Norwegian contractor Veidekke's guides, and papers written by the creators of the methodology. This is since CPD is a lean methodology developed and adapted by Veidekke. Other international sources were used to supplement where necessary.

The reviewed literature consisted of peer-reviewed publications, as well as Veidekke's websites related to the topic. To cover the topic in the best possible way, a combination of different databases were used. These databases were selected based on credibility, the relevance of the hits, and the possibility of filtering and delimitation during searches. The selected databases were thus *Web of Science*, *Oria (NTNU University Library)*, *Science Direct*, and *Scopus*. In addition to these databases, it was also decided to supplement with searches for relevant literature on *The International Group for Lean Construction (IGLC)* website.

RESEARCH CASE

The case is one of Veidekke's construction projects. The project is in Trondheim and has a turnkey contract of 300 million NOK (ca 34 million USD). At the time of writing, the project is at the end of the detailed design phase. The finished product is a large office building, with great environmental ambitions both during construction and in operation (Veidekke, 2020). The total size of the project will be a total of 15 000 sqm spread over seven floors. The contract also involves the redevelopment and demolition of an existing building, the construction of a parking basement of approximately 2 000 sqm, and an outdoor facility that will safeguard biological diversity and urban ecology.

The design takes place with the help of BIM, and the detailed design phase started in January 2021. The detailed design phase is planned to last until March 2022. The detailed design phase was divided into two phases due to the lack of details in the early stages. Each phase lasted approximately half a year. The construction started at the same time as the detailed design phase, i.e., January 2021, and will be concluded in March 2023.

As can be seen, the planning started during the COVID-19 pandemic. This means the design phase had to be in accordance with regional guidelines that had been introduced. Thus, it was a necessity to have an increased focus on using digital collaborative tools. Most notably the meeting structure changed to virtual meetings, and the physical post-it note technique was carried over to a digitalized version.

QUALITATIVE INTERVIEWS

The data from the case was collected through qualitative individual interviews in a span of five months. A combination of face-to-face interviews and digital interviews were used. The structure of the interview guide was decided after the initial literature study. It was found how to structure the paper, and in which order the different elements should be presented. The interviews further confirmed that the structure was sensible.

A total of eight interviews were conducted. There were three representatives from Veidekke, the turnkey contractor in the project, four representatives from their subcontractors, and one from the architect. The roles of the interviewees were as follows:

- Design manager (Newly graduated) – turnkey contractor
- Design manager (Experienced) – turnkey contractor
- Construction manager – turnkey contractor
- Consulting Engineer (Plumbing) - subcontractor
- 2 x Consulting Engineer (Construction) - subcontractor
- Consulting Engineer (Fire) - subcontractor
- Architect

The reasoning for choosing interview candidates from both the contractor and subcontractors was to triangulate their answers. This helps create a more objective picture of how CPD works in practice. Candidates from the contractor's side had the responsibility for the execution of digital CPD, and the subcontractors experienced their execution first-hand.

FINDINGS

The findings from the case are presented below. Every research question is reviewed under each headline. The findings follow the same structure as the interview guide.

START-UP SESSION

How Digitalization of the Start-up Session Is Achieved

The digital start-up session was held on the business communication platform Microsoft Teams. The session was fully digital, and all participants attended on their own electronic devices. Everyone needed in the design phase attended the meetings which spanned two workdays. The design manager took responsibility for convening all relevant parties to the meeting. Day one was focused on the participants introducing themselves and introducing Collaborative Planning in Design (CPD). All meeting participants prepared a PowerPoint slide with brief information about themselves in advance of the first day. This allowed the various meeting participants to learn about each other. The turnkey contractor used day two of the start-up session to present all necessary information about the tasks, goals, and expectations for the project.

Strengths and Weaknesses of a Digital Start-up Session

According to the interview candidates, there were only a few strengths in having a digital start-up session. It was found that a digital start-up session is better than not having one at all. The biggest strength was timesaving in the form of traveling. In addition, the turnkey contractor did not have to find a location, which can be both time and cost-saving.

There were several weaknesses in having the start-up session digitally. The greatest weakness was the disappearance of the social aspect that accompanies a start-up session like this. The participants missed the personal contact with those they collaborated with, so it took longer to get to know each other. This thus influenced how well the collaboration was perceived by the participants at later stages in design. Another weakness was that some of the meeting participants found it more difficult to stay focused during the meeting since it was digital. It was taxing to look at a screen for long periods

of time. This led to them missing information during the meetings. It was mentioned that not so many breaks were taken. This could be because the threshold to interrupt an ongoing presentation and ask for a break was higher when meeting the other participants digitally for the first time. Time usage on the start-up session was longer than it would normally have taken if it had been held physically. Mainly because of the great number of participants and the conversation limitations that accompanies digital meeting platforms.

How Digitalization of the Start-up Session Can Improve

One of the improvements to a digitalized start-up session was the introduction of teambuilding activities that are not related to the project. This could contribute to getting to know each other better and increases cooperation and trust. Such activities would have helped further when working together at later stages. Another aspect is that everyone should spend more time on the presentation slide about oneself so that others could get a better impression of who that person is. It was suggested that the turnkey contractor use more time on making sure the participants get to know each other.

DIGITAL ICE-SESSIONS

How Digitalization of the ICE Sessions Is Achieved

Only digital meetings were used during the ICE sessions. Both fully digital and semi-digital meetings were used. Semi-digital meetings means that some people joined a digital meeting on one common electronic device, while others joined on their individual devices. ICE sessions were held every Thursday at the start of the detailed design phase and were later reduced to every other Thursday. It was mandatory to have the camera on during the ICE sessions. This was to make sure everyone could see each other and counter some of the barriers that come with having digital meetings. The meeting plan was set up by the design manager in relation to a meeting agenda. Special meetings were sometimes needed. These were often held parallel to other special meetings during the ICE sessions. The design manager had to set up several different digital meeting notices when special meetings were needed. Towards the end of the ICE-days, a joint gathering was held where everyone who had participated gathered and summed up in plenary. An experience from the digital ICE sessions was that the participants now had the opportunity to work on other things if they were not immediately needed during the session. Those who physically sat in the office and participated in digital ICE sessions had better experiences than those who participated from home. The participants who sat in their offices were often surrounded by colleagues from the same subject area or field. This made it easier to discuss with colleagues and ask for help. Another aspect was that the home is often not an ideal setting as a workplace, and more distractions were therefore experienced. Meetings with fewer participants were preferred since fewer participants made it easier to communicate digitally. At these meetings, the differences between a physical meeting and a digital meeting were minimal, especially if the participants knew each other. It was easier to speak up, notice body language and facial cues, and small talk was possible.

Strengths and Weaknesses of Digital ICE-sessions

Clear strengths could be seen by having digitalized ICE sessions. All the meeting participants saved time since they did not have to travel. This further led to more meetings being held during one ICE session. It turned out that digitalization was streamlining the efficiency of the ICE sessions. The ability to share the screen with everyone else who participated in the meeting proved to be greatly beneficial. Especially when working with

BIM. The attendees had the possibility to get in and out of the meetings sensibly, based on the need for competence. This would ensure that only the most relevant disciplines were present during the meetings. The disciplines that were not needed for the task were thus on "stand-by" and could work on other things. In digital ICE sessions, it was easier to split up into smaller groups if needed. Digitalization made it easier to document everything that was done throughout the ICE sessions.

One weakness was that the major disciplines, which most often had to sit in digital ICE sessions throughout the entire day, felt it was demanding. It was taxing to sit in front of a screen the entire day and be focused. Another weakness due to digitalization is to invite disciplines who are thought to be relevant to the meeting, and not just those who were relevant. This is because the invitation when scheduling a meeting was just a click away, which led to less thought being put into planning which disciplines to invite. As a result, too many people participated in the ICE sessions, and the meetings got cluttered. It ended up with disciplines that were not needed just sitting and observing, or they worked on something else. They had the possibility to leave the session and come back when needed, but this was rarely done due to social norms. Where special meetings were used, it was experienced that the decision-maker was not present. Even during the joint summary at the end, it was not possible to go through all the decisions that were to be made, which led to important decisions being delayed until the next meeting. Using semi-digital meetings worked very poorly. One consequence was that those who sat physically together had the session between them, and there was a high threshold for those who sat digitally to be able to join the discussions. One aspect that was mentioned is that the lack of small talk decreased the number of impromptu solutions that could have been discussed over lunch, or on the way to the car. The major disciplines (such as consulting engineering construction, consulting engineering plumbing, and the architect) believed that digital ICE sessions were demanding. They had to sit through entire days of digital meetings, which were heavy because they missed out on a dynamic workday and the social aspects.

How Digitalization of the ICE Sessions Can Improve

A possible solution to the lack of a decision-maker during digital ICE sessions was to include more representatives from the client. This ensures that a decision-maker will always be present when needed. Another solution was to schedule more time for the joint summary, so decisions could be made in plenary. Better planning of which disciplines actually are needed in the meetings was also suggested.

PHASE SCHEDULING PROCESS USING VIRTUAL POST-IT NOTES

How Digitalization of the Phase Scheduling Process Is Achieved

The alternative to the physical post-it note technique is a software named Miro. Digital ICE sessions was the meeting structure used to work on the phase schedule in Miro. The ICE sessions using this post-it note technique were held prior to each of the two phases in detailed design. The sessions often started with a joint introduction. All design participants were present during this introduction. After the introduction, the participants were split into smaller groups, based on what was on the meeting agenda. Those who were not needed were on "stand-by" so that they could participate in the discussions when needed. The virtual post-it notes were created by each discipline on their own. The placements of the virtual notes on the timeline was jointly done by everyone attending the ICE session. A prerequisite for using Miro in the best possible way is to have access to two screens. This gave a better overview of the different dependencies.

Strengths and Weaknesses of a Digital Phase Scheduling Process

A strength of Miro is that the turnkey contractor saves time on further handling of the phase schedule. When the post-it note technique was physical, part of the work was to transfer the plan to a digital form. This step was avoided by using a digital form of the post-it note technique. Another strength is that the software is relatively easy to learn. The design participants did not have to spend a lot of time learning the software. A major advantage of using Miro was that the updated post-it note plan was digitally available regardless of location or time. If you were to discuss a specific note during a meeting, it was relatively easy to share the screen and point out exactly which note you are talking about.

When it comes to weaknesses of the virtual post-it note technique, it could be seen that it was harder to get the desired interaction between the disciplines. The discussions did not flow as well digitally, and therefore it was difficult to find out the needs the different disciplines had. The discussions became more static when digitalized since only one person could speak at a time. The interdisciplinary aspect of using the post-it note technique was reduced because of this. The digital ICE meeting with phase scheduling using virtual notes also suffered the problem of inviting too many irrelevant participants. Miro does not provide as good opportunities for making changes in the plan, in the form that a small change could be time-consuming. This was something that affected the efficiency. It was difficult to keep track of the digital post-it notes since one had to zoom in and out, and thus it was difficult to form an overall picture of the dependencies between the design activities. A big part of the physical phase scheduling grid was to stand in front of it and get an overview of the whole phase, which makes it easier for the disciplines to collaborate and discuss. It was difficult to have an overview of milestones and what the other disciplines were to deliver. It thus required more attention and focus from the participants to get the same results as the physical counterpart. The participants felt they had a less sense of ownership when using the virtual post-it note technique. It was experienced as easier to postpone a task to a later time, and this caused delays for other disciplines which were dependent on that specific task to be finished.

How Digitalization of the Phase Scheduling Process Can Improve

Improvements will be to ensure that good conversations are facilitated and that interdisciplinarity is maintained with this type of work methodology. This can be done by good planning by the design manager. This is by only including the most relevant disciplines in the meetings and getting the relevant parties to participate in conversations they may be important in.

DISCUSSION

The discussion is structured based on the three digitalized CPD elements. The research questions are reviewed under each element.

As the guide to Collaborative Planning in Design (CPD) by Veidekke (2013) states, a part of the start-up session is to promote cooperation and trust between the participants. This was barely achieved when it was digitalized. Getting to know each other and promoting good cooperation and trust was not emphasized enough. It turned out that the lack of focus on the social aspect in the digital start-up phase has consequences for the collaboration in later stages of design. If the start-up session is to be conducted digitally, it is therefore recommended to focus more on getting to know each other. A teambuilding activity can be a good starting point for getting people to collaborate and trust each other

more. Another improvement is to schedule breaks better and stick to that schedule. To get optimal results, however, it is recommended to have the start-up session physically in the future. This will ensure that cooperation and trust get promoted to the fullest, which probably will lead to better collaboration between the CPD participants.

Of the three elements that have been looked at in this paper, digital ICE sessions is the one that came out the best from digitalization. It was easier to communicate effectively, it was easier to document, and all parties saved time. These strengths are applied when the ICE session focused on BIM related work and not for phase scheduling using virtual post-it notes. The weaknesses with digital ICE sessions can be reduced, to provide a meeting structure that can be better used in the future. Optimal digitalized ICE sessions can be done through the following recommendations prepared from the findings:

- Mandatory to have the camera on.
- Only use fully digital meetings, not semi-digital ones.
- Spend more time figuring out who is most needed to invite to the meeting. The rest of the participants should be on stand-by.
- Encourage all participants to sit in their offices.

Based on the findings the suggested method for the future is to use a hybrid solution of both digital and physical ICE sessions, dependent on what type of work is scheduled for the session. This is to get the collaboration benefits of physical meetings, and the effectiveness of digital meetings. The ratio between digital and physical ICE sessions should be determined through discussions between all the participants, and through trial and error. The suggestion of using digital ICE meetings is mainly when working with BIM, and not when working with phase scheduling using virtual post-it notes.

The post-it note technique is very dependent on good dialogue between the various participants. This is difficult to achieve through digital meetings. It is important to plan well who will be present at the meetings so that there will be as few as possible in the meetings. This will make sure that communication and collaboration will be better. In the future, it is recommended to not have digital ICE sessions when working with the phase schedule. The phase scheduling grid should be on a physical wall during the ICE sessions and should immediately be converted to a virtual format after the session. This is because it was much easier to collaborate, keep track and see the dependencies between the different design activities with a physical grid. It will be an extra step to convert to a virtual phase scheduling grid, but the usefulness and efficiency are both increased when the grid is on a physical wall.

CONCLUSIONS AND FURTHER WORK

The purpose of this case study was to find out how digitalized Collaborative Planning in Design (CPD) is achieved, its strengths and weaknesses, and how it can be improved. CPD is a version of LPS adapted for design and is used to manage the progress of the design process. The focus of this paper was on three elements from CPD. The elements are the digitalization of the start-up session, the ICE sessions, and the phase scheduling process. The findings show that the digitalization of CPD has worked to varying degrees, and some parts of it are here to stay. In the future, it will be important to keep and develop the strengths, while eliminating or compensating for the weaknesses.

A limitation of this case study is that only one project was researched, and this project was only researched for a limited time. The long-term consequences have not been

considered and these findings will therefore not apply to all projects. However, one can learn from this project. There should have been follow-up interviews of the interview candidates from the turnkey contractor. This is to present the findings from their subcontractors and see if the turnkey contractor can further elaborate.

The theoretical contributions of this paper collected Veidekke and their subcontractors' experience with digitalized CPD. The findings show that some aspects of digitalization probably will continue to be used in the future. Mainly the use of digital ICE-session, and phase scheduling using virtual post-it notes. The strengths of digitalization are mainly time-saving and effective meetings through video conferences. The weakness is the lack of collaboration between the CPD participants because of the digital medium.

The practical contribution is how Veidekke can make use of this paper's findings. This will include the use of a physical start-up session when possible, the use of both fully digital and physical ICE sessions when working with BIM, and making sure collaboration is possible in phase scheduling using post-it notes. For phase scheduling, it is suggested to mainly use the physical alternatives and convert the plan to a digital format. An overview of improvements for the different elements in digital CPD looked upon in this paper is presented in Table 1.

Table 1: Improvements of the digitalized Collaborative Planning in Design (CPD) elements

Elements in digital CPD	Improvements
Start-up session	Teambuilding activities
	More focus on the personal presentation slide
	Have the start-up session physically if possible
	Schedule breaks better and stick to the schedule
ICE-sessions	Include more decision-makers during the special meetings
	Schedule more time for the joint summary at the end of a session
	A better plan of which disciplines were needed during the session
	Mandatory to have the camera on
	Only use fully digital meetings, not semi-digital ones
	Encourage all participants to sit in their office
	Use of both digital and physical meetings (depends on the task)
Phase scheduling process	A better plan of which disciplines were needed during the session
	Have the phase-scheduling process physically if possible
	Converting the physical grid to a virtual format immediately after a session

For further work, it will be beneficial to look at the long-term effects of digitalization and try to find trends that apply to several projects. This will validate the findings given in this paper. It will then be possible to form a correct picture of which elements of digitalization are lasting, and which changes were only a response to the restrictions of the pandemic. It may also be interesting to see if there are any correlations between the average age of the design participants and their experiences with the digital execution of CPD. Looking at the differences between digital CPD when working from home versus working from the office could indicate how the use of digitalization will develop in the future.

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