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The Last-Planner-System's impact on project culture

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Abstract

Purpose – The purpose of this paper is to investigate the Last-Planner-System's impact on project cultures in terms of partnering.

Design/methodology/approach – A case study was performed using multiple data gathering approaches. The project cultures of three projects not applying the Last-Planner-System were compared with three projects that apply the Last-Planner-System. In total, 30 participants were involved in the study. Semi-structured interviews were held and analysed by applying qualitative content analysis. Also, the "organizational culture assessment instrument", which belongs to the "competing values framework", was used by means of an online survey.

Findings – The Last-Planner-System leads to increased levels of mutual understanding and control about the tasks and issues of the other parties. This detailed overview leads towards a more distinguished evaluation of the trustworthiness of individuals. This does not necessarily lead to a partnering project culture.

Originality/value – The contribution to research is that higher levels of transparency and mutual understanding do not necessarily lead to a high level of trust. Rather, transparency could be seen as a controlling mechanism that leads to better-founded estimations about the trustworthiness of others in the project.

Keywords Construction project management, Partnering, Lean construction

Paper type Research paper

Introduction

The number of necessary stakeholders grows with the project's complexity in the construction industry (Chen *et al.*, 2019) and has increased in the past decades (Ranf, 2010). To control and manage the different stakeholders, progress meetings are usually held frequently, where the current progress is discussed, problems are identified and contractual issues and requirements are reviewed (Foley and Macmillan, 2005). During such meetings, different project objectives and individual motivations lead to individual choices whether or not to share information, which, in turn, leads to information asymmetries between the parties (Cerić, 2016). This leads towards common construction project cultures, which are characterized by adversarial and distrustful relationships, antagonistic behaviours (Ng *et al.*, 2002; Beach *et al.*, 2005) and escalating relationships (Eschenbruch, 2008) instead of partner-like behaviours (Barlow *et al.*, 1997; Eschenbruch, 2008; Turner and Zolin, 2012).

The "Last Planner® System of Production Control" (LPS) (Ballard, 2000) is a progress meeting approach, which promises to lead to different conditions and towards collaborative

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project cultures (Mossman, 2015; Ballard and Tommelein, 2016) in contrast to the described common project cultures. "Collaboration" describes the stage of "partnering" between "cooperation" and "coalescence" (Thompson and Sanders, 1998), where the project members jointly strive for common goals by solving issues together (Roschelle and Teasley, 1995; Kolfschoten, 2007). LPS is not standardized and varieties in terms of different components are seen in practice (Priven and Sacks, 2013; Ballard and Tommelein, 2016). In contrast to traditional meeting and scheduling approaches, LPS' main idea is the joint planning process with an active involvement of the project members that actually fulfil the work (Fauchier and Alves, 2013; Ballard and Tommelein, 2016). These are called the "last planners", the last persons in the value chain (Ballard and Howell, 1994). As the Last Planners plan jointly, they share, at least partly, their individual knowledge with the other stakeholders. This knowledge sharing process can improve relationships between the meeting's participants, and enhance innovative solutions of mutual issues (Rajabion *et al.*, 2019).

However, recent studies (Priven and Sacks, 2013; Uusitalo *et al.*, 2020) show that applying LPS does not necessarily lead towards more trust between LPS's participants, which is next to mutual understanding, one crucial ingredient of a partnering culture (Nyström, 2005). The reason might be rooted in the relation between trust and control:

Based on the "subsidiary perspective" there is a dilemma between trust and control (Jørgensen and Åsgård, 2019), as monitoring and controlling, which is executed in detail at LPS is a clear signal of distrust (Mayer *et al.*, 1995; Kadefors, 2004) and their application might hinder the development of trust (Schoorman *et al.*, 2007). On the other hand, the relationship between trust and control can be considered under a "complementary perspective", with mutually supportive effects (Jørgensen and Åsgård, 2019). Risks can be reduced through communication (Cerić, 2016) and if these risks can be reduced to a certain level, trust can overtop the residual risk (Schoorman *et al.*, 2007). Direct and open communication within flat hierarchical structures and on the lowest possible hierarchy level, which is performed at LPS, promotes a trustful project culture (Barlow, 2000). In addition, shown cooperation and trust can strengthen each other (Kadefors, 2004).

The question arises if LPS's application impacts project cultures under the aspects of partnering or if it essentially is a controlling tool that not necessarily contributes to collaboration. No earlier research was found, however, on actual LPS projects' cultures, nor on the comparison between projects not applying LPS and those applying LPS. This paper aims to close this gap by comparing those project cultures, to explore LPS's impact on project culture.

This knowledge enables practitioners to decide whether and for what reason LPS should be implemented and applied. The value for scholars is the further exploration of the alleged trust and control dilemma.

This paper is structured as follows: Firstly, a theoretical framework is described that covers partnering and LPS by presenting their interfaces and their contradictions, resulting in different cultural characteristics that need to be investigated to measure LPS's impact on project culture. Afterwards, the various cases and the investigations about the similarities and differences within the two groups of projects are presented: three projects that do not apply LPS and three projects that apply LPS. Next, these two groups are compared. Finally, the investigations are discussed, the research question (RQ) is answered and a conclusion is drawn.

Theoretical framework: Interfaces and contradictions between partnering and Last Planner® System

The competing values framework (CVF) is one of the most applied frameworks (Ferreira, 2014) for measuring cultures. It contains two axes and four poles. A shape in this framework

represents the measured culture by its characteristics from the four poles (Figure 1). The first axis describes the cultural degree of focusing on internal orientation and cooperation ("clan" quadrant), respectively, external orientation and competition ("market" quadrant) (Ferreira, 2014). The pronunciation on the second axis represents the degree of control and order, clear responsibilities and processes ("hierarchy" quadrant), respectively, flexibility and creativity ("adhocracy" quadrant) (Ferreira, 2014). Especially the distribution on the Clan-Market axis represents a traditional, and a partnering project culture whereas traditional cultures are especially characterized by features from the Market quadrant, and partnering cultures are pronounced by the features from the Clan quadrant (Lühr *et al.*, 2020).

To go more into detail about the critical components of a partnering culture, Nyström (2005) created a framework with defines high levels of "trust" and "mutual understanding" as necessities. "Predetermined dispute resolution methods", "economic incentive contracts", a "facilitator", "openness", "continuous and structured meetings", the "choosing of working partners" and "relationship building activities", are as "hard factors" helpful add-ons to improve trust and mutual understanding.

Based on this concept, there are some obvious interfaces between partnering and LPS and some ingredients that are not covered by LPS. The interfaces are that LPS is executed

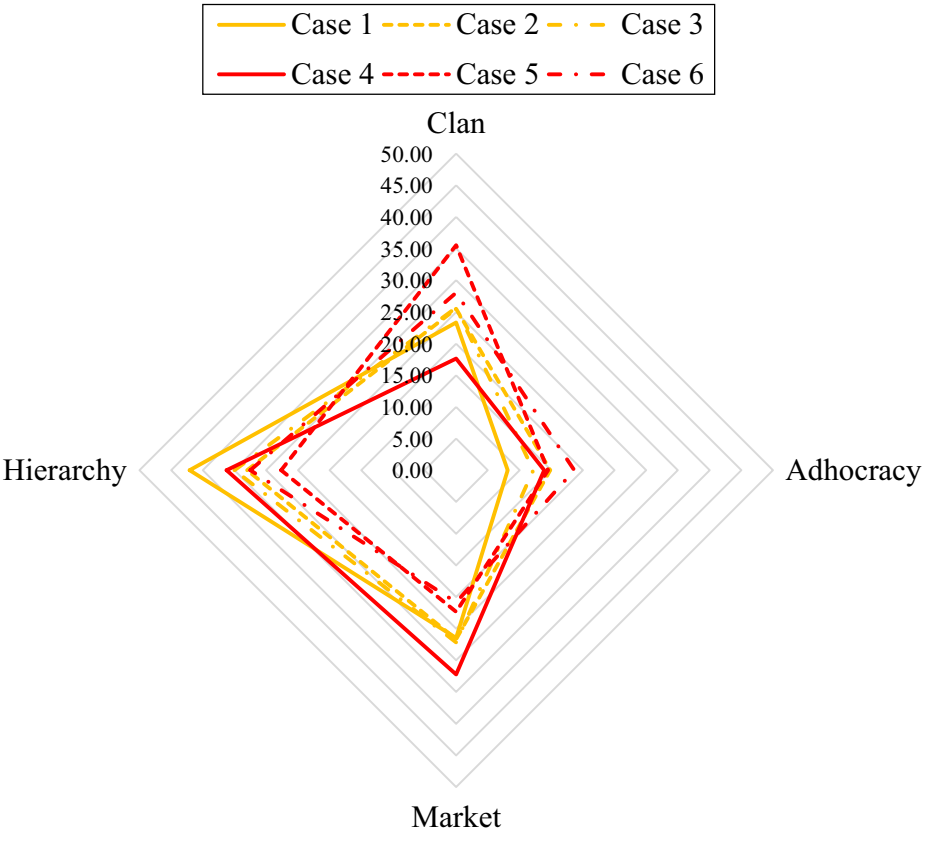

Figure 1.
CVF with the results from the OCAI

through a facilitator (Pellicer *et al.*, 2015) and is a continuous and structured meeting application (Mossman, 2015). At LPS, predetermined dispute resolution methods are not necessarily applied if those are not connected with the LPS meetings. LPS has also no influence on the choice of working partners and there is no connection to the economic incentives of the contracts between the various parties. As trust and mutual understanding are the necessities, the interfaces and contradictions between partnering and LPS are considered in more detail next.

Trust

Trust is a complex issue and is influenced by multiple factors (Khalfan *et al.*, 2007). One definition of trust, which represents the dilemma between trust and control (Jørgensen and Åsgård, 2019) and LPS's focus on joint monitoring and controlling, is by Mayer *et al.* (1995):

> "Trust [. . .] is the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party".

Priven and Sacks (2013) and Uusitalo *et al.* (2020) show that the level of trust differs between the project participants that apply LPS. However, there is no information on how projects that apply LPS and those that do not differ in terms of the trust. This aspect will be discovered in this paper.

Mutual understanding

Mutual understanding is the reciprocal understanding and respect for the interests of other parties, even if single components are not aligned to the own interests (Nyström, 2005). It improves the achievement of compromises as it is understood that achieving individual goals can lead to successful projects for all parties in the longer term (Nyström, 2005). A high level of mutual understanding about the perspectives of others can lead to more partner-like behaviours as project members understand the others' issues and behave more in the project's interests than following the individual contractual work specifications (Barlow, 2000).

One main component of LPS, which seems to have an impact on the level of mutual understanding is the weekly work planning meeting, where the work packages get usually visualized through sticky notes (Daniel *et al.*, 2017) in different colours, one colour representing one discipline. The Last-Planners define their tasks and the necessary starting conditions, place their work packages on the sticky notes on a schedule and coordinate, discuss and negotiate them with the other Last-Planners (Ballard and Howell, 2003). Through this, LPS forces the participants to openly commit to their upcoming tasks, which leads to an improved willingness to complete these tasks as promised and stimulates collaboration between the participants (Ballard and Tommelein, 2016). The past work packages get reviewed in retrospective and the schedule is updated, discussing the reasons for unfulfilled tasks, determining the reasons for failures and developing improvements to prevent the repetition of failures (Fauchier and Alves, 2013).

There is no information about the level of mutual understanding in projects that apply LPS, but it is suggested that it is raised through the transparency of upcoming tasks and the structured review of the latest tasks and issues during LPS meetings leads to mutual understanding between all participating parties.

Research design

There is a general gap in the literature about the impact of LPS on project culture, especially under the necessary aspects of partnering: a high level of trust and mutual understanding

within the project team. This gap can be closed if project cultures that do not apply LPS are compared with those that apply LPS. Therefore, the following RQs were defined:

RQ1. What are the characteristics of project culture in construction projects not applying LPS?

RQ2. What are the characteristics of project culture in construction projects applying LPS?

RQ3. What is the difference in project culture between projects that apply LPS and those that do not?

To answer the questions, in-depth case studies are carried out. These are suitable to investigate questions and relationships that are too complex for alternate methods as surveys or experiments (Brookes *et al.*, 2016; Maylor *et al.*, 2017; Yin, 2018). A multiple case study approach is chosen for two reasons, namely, firstly, to identify similarities and differences within the groups of projects that do apply LPS and those that do not apply LPS (Maylor *et al.*, 2017) and secondly, to compare the findings of these groups. As LPS is not standardized, there are varieties of components that are applied in practice (Priven and Sacks, 2013; Ballard and Tommelein, 2016) and the multiple case study approach will show how LPS is actually applied in practice. As each project culture consists of a unique mixture of the ways of thinking and behaviour of project members, the stakeholder's perceptions were weighted equally to investigate the mean project culture. This paper focuses on the German construction industry as the desire for a shift towards partnering is recently noticeable (Boldt, 2020; Haghsheno, 2020).

Case study design

The cases were selected as a stratified sample (Flyvberg, 2006) by the following criteria:

- Turnkey building construction projects in Germany;
- Same type of work/sector/phase;
- All participants work at least for three months in the project; and
- No contractual focus on partnering.

Criterion 1 was set because of the industry's desire to change project cultures towards partner-like conditions (Boldt, 2020; Haghsheno, 2020). Criterion 2 was set to make the cases and their work, interfaces, common issues and involved stakeholders comparable. All chosen cases are in the same construction phase with the interior- and technical building equipment work. The chosen projects have a gross floor area between 5,000 m^2 and 22,000 m^2. Because the project culture as one system is of interest for this research, stakeholders with various functions were chosen to participate in the study. As the core members of multidisciplinary construction teams in this phase, client's project managers (CL), main contractor's (MC) and sub-contractors (SC) site managers and/or foremen were chosen to participate. Criterion 3 was defined to ensure that the participants were representative for defining the cultural aspects. Hofstede *et al.* (2010) named especially for short assignments, such as projects, an experienced time of three months for acculturation. For each project, between four and six project members participated. Criterion 4 was defined to keep the projects comparable by ensuring that the project cultures were not affected by specific contractual partnering arrangements. In total, six projects were selected, three not applying LPS and three applying LPS.

Applied research methods

To investigate the cases in-depth, a combination of and a quantitative and qualitative investigation was chosen to triangulate the findings (Maylor *et al.*, 2017).

Quantitative method – the organizational culture assessment instrument. The Organizational Culture Assessment Instrument (OCAI) is the survey that belongs to CVF. It was applied as an online survey. The OCAI is clustered in six categories and each of these items consists of four statements describing the characteristics of one of the CVF's four quadrants. The participants have to divide 100 points among the four statements to reflect their project environment (Cameron and Quinn, 2011). The analysis is conducted by calculating the mean scores from all project's participants for all categories. To interpret the data and make them comparable with the findings from the qualitative methods, each axis was evenly divided in three sections for each axis (Clan/Balanced/Market, respectively, Hierarchy/Balanced/Adhocracy). If one side of the axis is only slightly pronounced, it means that features from the other pole are also present.

Qualitative method – semi-structured interviews and qualitative content analysis. To get a deep understanding of the CVF's findings, semi-structured interviews were held with the study's participants. Such interviews allow for investigations about human affairs, actions and personal views (Yin, 2018). The interviews were conducted after the named online survey was conducted.

The interview set up followed the same categories of interest, with open questions to cover each category:

- General information about the projects' meetings;
- Project culture in terms of CVF's categories;
- Trust vs control; and
- Mutual understanding.

The interviews took between 30–60 min each. All interviews were conducted via telephone and documented through written keywords. Interviews were transcribed and later approved by the participants.

To analyse the interviews, qualitative content analysis (QCA) was applied as this is suitable to analyse data in terms of cultures and their attributes in specific contexts (Krippendorff, 1989). A deductive approach was chosen by pre-defining the patterns as a first step of the analysis (Mayring, 2015), similar to the named categories. Similar to the OCAI's results, the QCA's findings for each case were clustered in three evenly divided sections for each category. These sections were the same as for OCAI's results. For trust and mutual understanding, results were categorized into "low", "balanced" and "high".

To triangulate the data, the quantitative and the qualitative data were compared for each case as within-case analysis. It is assumed that both research approaches have the same significance. If the results from the two methods differ, a mean of both is determined.

Next, a cross-case analysis was conducted for each of the two groups (not applying and applying LPS) to investigate common patterns or differences (Maylor *et al.*, 2017). Finally, the findings about the two groups were compared to investigate the impact of LPS on project culture.

Results cases not applying Last Planner® System

Firstly, the meetings' structures for each case is presented, based on the QCA of the interviews. Next, the categories "CVF", "mutual understanding" and "trust vs control" for

three projects of each group are compared, based on the QCA and the investigations of the surveys.

Case 1

Meeting structure. Case 1 conducts irregular production control meetings. The MC's site managers invite the site managers and foremen of the various SCs if he perceives such meetings as necessary, and members of all actual trades participate at these meetings. There is no consistent structure for the meetings, and they get organized in order of the current project priorities. The perception of the review of issues is different along the parties. Whilst the MC's site manager reports that issues get discussed each day directly on site, the SCs report that this is conducted during the production control meetings or via written correspondence.

All participants agree that the usual planning of processes and interfaces between the trades is conducted through the staff of the MC and that the updated schedules get distributed via email. The MC's site manager reports in this context, that he prepares different schedules for the CL and the SCs, which differ based on different strategical motivations.

Within-case analysis. Case 1's project culture is characterized by the features from the Hierarchy quadrant, so clear responsibilities and processes and only a few spontaneous and creative behaviours (Table 1). On the Clan-Market axis, it is slightly characterized by partnering features from the Clan quadrant (Table 1), which gets also expressed through the high level of trust among the participants despite a high perceived level of control (Table 2). Nevertheless, the culture includes also remarkable competitive features, which are expressed through the different distributions of mutual understanding between the stakeholders as presented in Table 3. It shows that the MC has a high level of knowledge about the tasks and issues of the others, whereas the other stakeholders have only a rough overview about the other trades. This imbalance is also expressed through the MC's attitude to share or not to share his knowledge, as current schedules because of his strategic motivations.

Case	Project culture OCAI	Summary	Project culture, QCA	Summary	Conclusion
1	Clan: 23.33 Market: 26.46	Balanced	3 * clan 1 * market	Clan	Slightly clan
	Hierarchy: 42.08 Adhocracy: 8.18	Hierarchy	3 * hierarchy 1 * adhocracy	Hierarchy	Hierarchy
2	Clan: 25.50 Market: 26.67	Balanced	4 * clan 1 * balanced	Clan	Slightly clan
	Hierarchy: 33.00 Adhocracy: 14.83	Hierarchy	4 * balanced 1 * hierarchy	Balanced	Slightly hierarchy
3	Clan: 25.67 Market: 27.17	Balanced	3 * clan 2 * balanced	Clan	Slightly clan
	Hierarchy: 35.00 Adhocracy: 12.17	Hierarchy	1 * hierarchy 1 * balanced 3 * adhocracy	Adhocracy	Balanced
Summarizing cases not applying LPS	Clan vs market Hierarchy vs adhocracy	All projects very similar: slightly pronounced by clan Different at the projects, but the tendency to hierarchy			

Table 1.
Competing values framework: comparison of data gathered through interview's QCA and OCAI – projects that do not apply LPS

Case 2

Meeting structure. Weekly meetings are applied, where the site managers and foremen from the MC and the SCs meet to discuss the current construction processes. The meeting is equally structured every time, starting with a review of the processes from the past week through the staff from the MC. Hereafter, the MC attendants present the updated detailed schedule for the upcoming 2–4 weeks and discuss it with the SCs. For scheduling the most important milestones, a joint discussion with the SC takes place during the meeting. The MCs take the input from the SCs into account for his planning and present the updated strategy during the next meeting. The perception of the review of issues is different along the parties. Whilst the MC's site manager reports that issues get discussed, each day directly on site, the SCs report that this is conducted during the production control meetings or via written correspondence.

Table 2. Qualitative content analysis of cases not applying LPS: level of trust and level of control

	Level of trust		Level of control	
Case	Distribution	Summary	Distribution	Summary
1	4 * high	High	4 * high	High
2	4 * high 1 * distinction between different project participants	High	5 * high	High
3	3 * high 1 * continuously changing (ranked as balanced) 1 * low	High	5 * high	High
Summarizing cases not applying LPS	–	High	–	High

Table 3. Qualitative content analysis of cases not applying LPS: level of mutual understanding

Case	Distribution	Summary
1	1 * MC: High for all trades 1 * CL/2 * SC: Detailed knowledge about own trade and tasks, a rough overview of the other trades and issues	MC has a high level of mutual understanding and the other stakeholders a detailed knowledge about own trade and tasks, a rough overview of the other trades and issues
2	2 * MC: High for all trades 2 * CL/2 * SC: Detailed knowledge about own trade and tasks, rough overview of the other trades and issues	MC has a high level of mutual understanding and the other stakeholders a detailed knowledge about own trade and tasks, a rough overview of the other trades and issues
3	2 * MC: High for all trades 1 * CL/2 * SC: Detailed knowledge about own trade and tasks, rough overview of the other trades and issues	MC has a high level of mutual understanding and the other stakeholders a detailed knowledge about own trade and tasks, a rough overview of the other trades and issues
Summarizing cases not applying LPS	MC has a high level of mutual understanding and the other stakeholders a detailed knowledge about own trade and tasks, a rough overview of the other trades and issues	

All participants agree that the usual planning of processes and interfaces between the trades is conducted through the staff of the MC and that the updated schedules get distributed via email. Also, the client receives an updated schedule each week or the latest all two weeks. The MC's site manager reports in this context, that he prepares different schedules for the CL and the SCs, which differ through different strategical motivations.

Within-case analysis. Case 2's project culture is slightly dominated by the features from the Hierarchy quadrant, so clear processes and responsibilities. Nevertheless, also some spontaneous and creative characteristics are noticeable (Table 1).

Similar to Case 1, Case 2's project culture is slightly dominated with cooperative behaviours with remarkable competitive features (Table 1), which are expressed through an uneven understanding of the other's tasks and issues, whereas the MC has a lot of knowledge and the others only have a rough overview about the others' (Table 3). Also similar to Case 1, the MC decides who gets which knowledge about the actual processes strategically through different schedules that he shares or rather not shares with the different parties.

The level of control is, as well as the level of trust, perceived as high in the project whereas one participant reports that he has to differentiate who is trustworthy and who is not (Table 2).

Case 3

Meeting structure. The interview results from Case 3 show that the participants perceive the continuity of the meetings differently. Whilst the MC's site manager and senior site manager report that production control meetings take place only irregularly and only if absolutely necessary, the SCs report from weekly meetings with the MC's staff. If meetings take place, the constellation of participants changes due to the current issues. One could interpret that such meetings indeed are not scheduled regularly, but still take place in a weekly frequency. The client is not involved in such meetings.

There is no consistent structure for the meetings and they get organized in order of the current project priorities. The production control is conducted through daily site observations by the MC's staff. Hereby, all actual issues and necessary planning changes get discussed daily on various discussions between different persons from the MC and different staff from the various SCs on site. Whilst the MC's staff perceives these planning processes as solely done by himself, the SCs perceive it as joint planning.

The MC has commissioned one company for updating the schedule monthly. The MC's site managers give this company information about the actual state of work. This updated schedule gets not shared with the other stakeholders as the MC's site manager declares that it is not true anymore as soon as it is prepared.

Within-case analysis. Case 3's project culture is perceived as balanced between the features from the Hierarchy- and the Adhocracy quadrant (Table 1). So, features from both quadrants are remarkable to a certain level.

On the other axis, the project culture is slightly dominated by the cooperative features from the Clan-quadrant and remarkable features from the competitive Market-quadrant.

Table 2 shows that both: the level of trust and the level of control are perceived as high.

The level of mutual understanding differs along the stakeholders, whereas the MC has a high level of understanding the actual situation of the others, and the other parties have a good overview about their own tasks and issues and a rough overview about the others. As in Cases 1 and 2, this uneven level of information gets amplified through the MC's withholding of information (Table 3).

Cross-case analysis: cases not applying Last Planner® System

Meeting structures. The regularity and structures of the production control meetings differ at all three projects that do not apply LPS. The meeting's participants are site managers and

foremen of the MC and the SCs. The meeting participants differ at some projects, whereas the MC decides who is necessary, dependent on his perception of the actual issues of the project. In none of the cases, employees from the client participate. The meetings take usually place on a weekly basis, whereas also daily site visits are used by the MC's staff to control the construction progresses and to investigate and solve actual issues.

The projects do not use a systematic meeting structure, but discuss the topics based on MC's perception of relevance.

Competing values framework. Figure 1 visualizes the OCAI's results and Table 1 shows the OCAI's and the QCA's results and the conclusions, which are drawn by combining both in terms of the CVF. It is striking that the shapes of all three project cultures are very similar on the Clan-Market axis. They are slightly dominated by the cooperative Clan-features, but the noticeable features from the competitive Market quadrant are perceptible.

In contrast, the results on the Hierarchy-Adhocracy axis differ between the cases, even if there is a tendency for the features from the Hierarchy quadrant remarkable, so for clear processes and responsibilities. It is concluded that there are no equal cultural characteristics remarkable.

Trust vs control

The levels of trust and control are perceived as high in all cases, which do not apply LPS (Table 2). The high level of trust reinforces the investigations from the CVF that the project culture is by tendency partner-like and the high level of control does not seem to influence this in a negative way.

Mutual understanding. Table 3 shows that the level of mutual understanding is similar at all three cases, which do not apply LPS: the MCs have a good overview of the actual construction processes and issues of the various participants. The other parties have only a rough overview of the processes and issues from the other project parties, but a good overview of their tasks. The different levels of mutual understanding get controlled by the MC's through sharing different information about the current processed through different schedules. This behaviour must be evaluated as competitive and not partner-like.

Results of cases applying Last Planner® System

Results are presented in the same order as for the cases not applying LPS. Firstly, the meetings' structures for each case is presented, based on the QCA of the interviews. Next, the categories "CVF", "mutual understanding" and "trust vs control" for three projects of each group are compared, based on the QCA and the investigations of the surveys.

Case 4

Meeting structure. The production control meetings take place on a weekly basis. The various site managers and foremen from the MC and the different SCs participate. None of the client's staff participates. The project applies the visualization of the work packages through sticky notes with different colours, one for each trade, as a tool from LPS. One site manager acts as the facilitator of the meetings.

The meetings are structured as follows. Firstly, the past week is reviewed. The facilitator asks the representative of the respective work package if it could be fulfilled as planned in the past week. If yes, the sticky note gets removed from the schedule. If not, the reasons for not-fulfilment get discussed. Next, the facilitator updates the milestones for the next 10-12 weeks. The MC's staff defines events that he perceives as mostly crucial as milestones. As an orientation, the MC has an overall schedule for the entire project, which is updated monthly. The MC does not share this schedule with the other stakeholders as he perceives

that this is not necessary as they get all relevant scheduling information during the LPS meetings. The client says that he did not get any updated schedule since the beginning of the project and estimates this as a drawback and presumes that this is strategically motivated by the MC.

In the next step, the next 4–6 weeks get jointly planned in detail whereas the not-fulfilled tasks are included in this planning process. The focus is on finding solutions to reach all milestones. If this is not possible, the single milestones get moved backwards and all participants try to find ways to catch up with other processes to fulfil the target of the project's completion date.

The MC's site manager takes pictures of the not-fulfilled tasks and the updated schedule and stores them, without sharing. Some SC's foremen take pictures from the updated scheduling wall and use them for their work-preparation and -control.

Within-case analysis. Table 4 shows that Case 4's project culture is slightly dominated by the features from the Hierarchy quadrant with remarkable features from the Adhocracy quadrant. The Clan-Market axis is perceived as levelled. This estimation gets reinforced by the participant's clear statements that they are distinct about the trustworthiness of the different project members as this differs between the individuals (Table 5). The level of control is perceived as high between all stakeholders (Table 5) and all participants report that they have a high level of understanding about the tasks and issues of all other parties (Table 6), despite the information asymmetry through the MC's withhold about the updated overall project schedules.

Case 5

Meeting structure. The production control meetings take place on a weekly basis. Various site managers and foremen from the MC and the different SCs participate, but none of the client's staff. The project applies the visualization of the work packages through sticky notes with different colours, one for each trade, as a tool from LPS. In Case 5, the percent

Case	Project culture OCAI	Summary	Project culture QCA	Summary	Conclusion
4	Clan: 17.64 Market: 32.22	Balanced	2 * clan 3 * balanced 1 * market	Balanced	Balanced
	Hierarchy: 36.25 Adhocracy: 13.89	Hierarchy	1 * hierarchy 3 * balanced 2 * adhocracy	Balanced	Slightly hierarchy
5	Clan: 35.53 Market: 22.33	Balanced	5 * clan	Clan	Slightly clan
	Hierarchy: 27.63 Adhocracy: 14.50	Balanced	2 * hierarchy 2 * balanced 1 * adhocracy	Balanced	Balanced
6	Clan: 28.03 Market: 20.83	Balanced	3 * clan 1 * balanced 1 * market	Clan	Slightly clan
	Hierarchy: 32.50 Adhocracy: 18.63 Adhocracy: 15.67	Balanced	3 * hierarchy 1 * balanced 1 * adhocracy	Hierarchy	Slightly hierarchy
Summarizing cases applying LPS	Clan vs market Hierarchy vs adhocracy	Project 4 differs with Balanced, Projects 5 and 6 slightly clan Differences between the projects: two times slightly hierarchy, one time balanced			

Table 4. Competing values framework: comparison of data gathered through interview's QCA and OCAI – projects that apply LPS

Table 5. Qualitative content analysis of cases applying LPS: level of trust and level of control

Case	Level of trust		Level of control	
	Distribution	Summary	Distribution	Summary
4	2 * high 4 * distinction between different project participants	Balanced/distinction	4 * high 1 * few control (client, not participating at LPS)	High
5	4 * high 1 * distinction between different project participants	High	5 * high	High
6	1* high 4 * differentiate between single individuals	Balanced/distinction	5 * high	High
Summarizing cases applying LPS	–	2 * balanced/ distinction 1 * high	–	High

Table 6. Qualitative content analysis of cases applying LPS: level of mutual understanding

Case	Level of mutual understanding Distribution
4	6 * high about all trades and issues
5	5 * high about all trades and issues
6	2 * MC: high for all trades 1 * CL/2 * SC: detailed knowledge about own trade and tasks, rough overview about the other trades and issues
Summarizing cases applying LPS	2 * high between all trades 1 * (Case 6): high from MC over tasks from SC and from CL over tasks from MC and SC

plan completed score is calculated. Only the MC that acts as LPS' facilitator roughly knows the average score (80%).

The meetings are structured as follows: firstly, the past week is reviewed. The facilitator asks the representative of the respective work package if it could be fulfilled as planned in the past week. If yes, the sticky note gets removed from the schedule. If not, the facilitator asks for the reasons for the not-fulfilment, but does not question them much in detail. The MC's staff reports that they did so earlier by using an evaluation chart about the reasons for not-fulfilments of commitments, but that this led to a tense atmosphere as participants felt offended. Thus, the MC's staff decided that issues get not discussed in detail to keep a peaceful atmosphere, as long as the issues do not critically affect the overall schedule.

After the review of the past week, the facilitator updates the milestones for the next 12 weeks. The MC's staff defines the milestones. The MC has an overall schedule for the entire project, which is updated all two three months, but not shared with other stakeholders.

In the next step, the next six weeks get jointly planned in detail whereas the not-fulfilled tasks are included in this planning process. The focus is on finding solutions to reach all milestones. If this is not possible, the single milestones get moved backwards and all participants try to find ways to catch up other processes to fulfil the target of the project's completion date.

Within-case analysis. Table 4 shows that the project culture is balanced in terms of the Hierarchy- and the Adhocracy quadrant. Furthermore, it is slightly pronounced by the cooperative features from the Clan quadrant and only remarkable features from the Market quadrant. This evaluation gets reinforced by the high level of trust within the project team, despite the perceived high level of control between the parties (Table 5).

As in Case 4, all participants rank the level of mutual understanding as high between all trades (Table 6) despite the information asymmetry, which arises through the withholding of the overall schedule through the MC.

Case 6

Meeting structure. Case 6 applies weekly production control meetings where the site-manages and foremen from the MC and the different SCs participate, without client involvement. The project applies the visualization of the work packages through sticky notes with different colours, one for each trade, as a tool from LPS.

One MC's site manager acts as the facilitator of the meetings. The meetings are structured as follows: firstly, the past week is reviewed. The MC's staff reports that they prepare for this review in detail and internally discuss the past week's performance before the LPS meetings. The necessary information is gathered through daily site observations from the MC's site managers and foremen.

At the internal preparation meeting, the project MC's project members discuss already how the schedule must be updated to reach the crucial project milestones. This process actually differs to the core idea of LPS – the inclusion of the Last-Planners in the scheduling process. The MC's senior site manager reports that this is a strategic decision as the involvement of the Last-Planners in past projects has led to long discussions during the meetings, which were not perceived as expedient by the MC's staff. Therefore, the MC's company implements LPS without joint planning with the other stakeholders at all of its projects. The milestones are defined through an overall schedule, which is updated on a monthly basis by the MC, but not shared with the other stakeholders. During the LPS meetings, the MC's facilitator asks the SCs about the fulfilments of the planned tasks of the past week. The fulfilled tasks, represented by the coloured sticky notes, get removed from the schedule. The unfulfilled tasks stay on the wall. The reasons for not-fulfilled tasks are not discussed in detail as the MC perceives to know the reasons, and the solutions to improve the processes. After this procedure, the MC's staff presents the updated schedule for the next 4–6 weeks towards the SCs by rearranging all sticky notes. The updated schedule is then discussed with the SCs.

Within-case analysis. Table 4 shows that the project culture is slightly pronounced by the features from the Hierarchy quadrant, which also means that features from the Adhocracy quadrant are still remarkable. Furthermore, the culture is slightly dominated by the cooperative features from the Clan quadrant, so also with remarkable features from the Market quadrant.

As in Case 4, the participants distinguish clearly between the trustworthiness about the single project members and the perceived level of control between the project team is perceived as high (Table 5).

Differently to the other two cases that apply LPS, the level of mutual understanding differs between the stakeholders (Table 6), whereas the MC has a high level of knowledge about the tasks and issues from the others and the other stakeholders have only a rough overview about the processes of the other parties.

Cross-case analysis: cases applying Last Planner® System

Meeting structures. The regularity of the production control meetings is equal at all LPS cases. The weekly LPS meeting's participants are site managers and foremen of the MC and

the SCs. None of the clients participates. Visualization of the work packages through sticky notes is the only used tool from LPS used in the three cases. At only one case, the percent plan completed score is determined, but not discussed during the LPS meeting. All LPS meetings are characterized by a clear and equal structure: a site manager acts as the facilitator. A review about the past week's tasks is done.

The projects differ regarding the discussion on reasons for the not-fulfilments. Whilst Case 4 discusses the reasons in detail with all participants to avoid repetition and to improve the processes, Case 5 avoids such a discussion with the motivation not offending anybody in front of the others, thereby risking the partner-like atmosphere. Case 6 does not discuss reasons for not-fulfil tasks as the MC perceives to know the reasons for the issues.

After the review, the next weeks get planned at all projects in different ways. Cases 4 and 5 updates the milestones for the next 10–12 weeks. Hereafter, they plan the tasks towards the milestones of the upcoming 4–6 weeks jointly with the SCs in detail.

At Case 6, the MC plans the processes for the upcoming 4–6 weeks before the LPS meetings in detail and presents this schedule towards the participating SCs. This process actually differs to the core idea of LPS – the inclusion of the Last-Planners in the scheduling process. The MC's senior site manager reports that this is a strategic decision as the involvement of the Last-Planners in past projects has led to long discussions during the meetings, which were not perceived as expedient by the MC's staff. Therefore, the MC's company implements LPS without joint planning with the other stakeholders at all of its projects.

At all three projects, the MC updates an overall schedule uses this as an orientation for the LPS meetings, but does not share these versions with the other stakeholders.

Competing values framework. Figure 1 visualizes the OCAI's results about the individual project cultures. Table 4 shows the combination of these results and the QCA. It becomes clear that the project cultures show especially varying characteristics from features of the Clan- and Market axis. This statement gets supported by the OCAI's scattered scores and the multiple statements that the project members differentiate who is trustworthy and who is not. The cultural features on the Hierarchy-Adhocracy axis differ slightly. Nevertheless, they all are especially characterized by features from the Hierarchy quadrant with recognizable pronunciations of the Adhocracy quadrant.

Trust vs control

Table 5 shows the different trust levels of the projects that apply LPS. Especially the project members from Cases 4 and 6 reports that are influenced by their experiences about the fulfilment of tasks of the others, which becomes visible during the LPS meetings and that these experiences influence their perception of the trustworthiness of the individual persons. The level of control is also perceived as high, especially through the application of LPS (Table 5). Nevertheless, the interviews have shown that the SCs do not perceive this as a negative control mechanism, but as self-control about the upcoming tasks, which is helpful for their work-preparation.

Mutual understanding. The level of mutual understanding about the different tasks and issues from all project participants is high at the two cases where the Last-Planners are involved in the planning process (Table 6). At Case 6, where the updated planning is done by the MC, they only claim to have a high level of understanding of the current work packages and issues from all stakeholders. The SC's report that they have detailed knowledge about their own trade, but only a rough overview about the other trades.

Comparing projects not applying Last Planner® System and projects applying Last Planner® System

Meeting structures

The production control meetings are less structured at projects that do not apply LPS than at those which apply LPS. The projects applying LPS apply a more structured and weekly review of the past processes as an indigent of the LPS meetings, even if they get supported by daily conversations on site. At all six projects, the MC update frequently schedules for the entire project whereas he creates for strategical reasons different versions, which he shares with the different stakeholders as the CL and the SCs.

Competing values framework. Figure 1 shows the CVF with the shapes of the different project cultures, based on the OCAI. The project cultures in both groups differ with their pronunciation on the Hierarchy-Adhocracy axis. This represents different levels of clear processes and responsibilities vs creative and spontaneous behaviours and that these are very individual, despite not applying or applying LPS. As shown in Tables 1 and 4, these findings were confirmed through the QCA's results.

On the Clan-Market axis, a pattern can be recognized that distinguishes the two groups of meeting systems.

All projects that do not apply LPS are very similar, which can be also clearly seen in Figure 1. The triangulation with the QCA's results has shown that these project cultures and slightly characterized be the cooperative features form the Clan quadrant, which indicates remarkable behaviours from the Market quadrant (Table 1).

Figure 1 shows that the OCAI results about the project cultures that apply LPS differ on this axis much more, which indicates different perceptions about cooperative or rather competitive behaviours within the projects. The triangulation with the QCA's results has confirmed that there are remarkable differences on this axis (Table 4). The project culture from Case 4 is balanced on this axis, so it is evenly characterized by cooperative as competitive features and Cases 5 and 6 are slightly characterized by the cooperative characteristics from the Clan quadrant and remarkable features from the Market quadrant.

Trust vs control

At the projects, where LPS is not applied, the level of trust and the level of control are perceived as high. At two of the three cases that apply LPS, the participants distinguish very clearly whom they trust and whom not. It must be mentioned that Case 6, where the SC are not involved in the planning process, is one of these cases.

Thus, it can be concluded that LPS's structure and the visualization of the tasks and their fulfilments, respectively, not fulfilment impacts the level of mutual control and trust whereas the less structured meetings lead to less knowledge about the tasks, issues and interfaces and through this towards a high level of trust. This does not necessarily mean that projects applying LPS have are characterized by a lower level of trust, but more over by a more specific estimation about trustfulness.

Mutual understanding. The four cases where the SCs are not involved in the planning processes differ from the two cases where the SCs are involved in the planning process of the work packages and the interfaces of the upcoming weeks. The involvement of the active planning and discussion process affects especially the knowledge from the SCs about the current tasks and issues of the other SCs, and thus, the level of mutual understanding, which is one necessity for partnering culture. At the four projects without SC's involvement, only the MCs claim that they have a good overview about the tasks and issues form all parties. The SCs and CLs perceive that they have only a rough overview about the tasks and issues from the other parties and a good overview about the own ones. At the two cases where the

SCs are involved, all meetings participants report that they do not only have a good overview about the own tasks and issues but also about those of the other parties.

Discussion

The previous sections have shown that projects that do not apply LPS differ from those that do apply LPS.

RQ1 about the characteristics of project cultures in construction projects not applying LPS was answered as following: in terms of mutual understanding, these project cultures are characterized by MC's high level of knowledge about the tasks and issues of all other stakeholders. Those have detailed knowledge about their own tasks and issues, but only a rough overview about the other stakeholders. The level of trust in these projects was high and the level of mutual control was low. Regarding the dilemma between trust and control, it seems the "subsidiary perspective" (Jørgensen and Åsgård, 2019) applies in these projects with high levels of trust but this seems only based on a lack of information and mutual understanding. In terms of the CVF, the projects not applying LPS are slightly dominated by Clan-features but also noticeable features from the Market quadrant. All projects differ on the Hierarchy-Adhocracy axis, which expresses the different levels of clear structures, respectively, spontaneous decisions at all projects.

RQ2 about the characteristics of project cultures in construction projects that do apply LPS was answered as following: in terms of mutual understanding, those projects are characterized by a high level of knowledge about the tasks and issues from all stakeholders. The members of projects applying LPS differentiate about the trustworthiness of the other project members. This is also recognizable as the cases that apply LPS differ on CVF's Clan-Market axis. It was concluded that this is based on the high level of information and mutual understanding which is achieved through the LPS meetings. Therefore, regarding the dilemma between trust and control, the "subsidiary perspective" (Jørgensen and Åsgård, 2019) cannot be confirmed for LPS projects as this perspective would mean that the combination of a high level of trust and a high level of control would rule each other out. Instead for LPS projects, the "complementary perspective" (Jørgensen and Åsgård, 2019) seems suitable for the relationship between trust and control, under the condition that people in the project act trustworthy. The cultural differences between projects not applying and applying LPS were investigated to answer *RQ3*. It was shown that the higher level of mutual understanding which is achieved through LPS, leads towards a higher level of mutual understanding and mutual control and through this to a clearer distinction about the trustworthiness of the other project members.

What is striking is that at all six cases, the level of control is perceived as high. This control differs between two groups of projects: those where the MC updates the schedules by his own and where he presents the results towards the other stakeholders (Cases 1–3 and 6), and the projects where the review of the past tasks and issues and the update scheduling of the upcoming tasks are performed jointly (Cases 4 and 5). In the first group, the control is unilateral, as only the MC has high knowledge about the tasks and issues of all parties, which is expressed through the different levels of mutual understanding between the stakeholders. In the second group, the joint review and planning lead towards a high level of mutual understanding between all stakeholders, which is an indicator for partnering.

Nevertheless, it is striking is that the project members at all three projects that apply LPS (jointly, and with the corresponding high level of mutual understanding as in Cases 4 and 5 and not jointly without a high level of mutual understanding as in Case 6) name and distinct explicitly about the trustworthiness of single project participants. This ability to differentiate about the trustworthiness might be rooted in the structured review of the past tasks and the

upcoming work packages, interfaces and correlations, which are easy to understand through LPS's visualizations. This investigation about the different assessments about who is trustworthy, confirms the findings from Priven and Sacks (2013) and Uusitalo *et al.* (2020). As this differentiation is so noticeable, it must be questioned if LPS really leads to an improved willingness to complete tasks and promises as described by Ballard and Tommelein (2016) or if it becomes just clear who keeps his promises and who does not.

This means in terms of the relationship of trust and control that a high level of mutual control does not preclude trust, but that it enables to judge whether the other person is trustworthy or not. Appropriately, the high level of trust at the projects that do not apply LPS represents basically trusting without really knowing the past and the upcoming tasks and who acts trustworthy and who does not.

Higher levels of trust lead towards a higher willingness to accept individual risks (Mayer *et al.*, 1995; Schoorman *et al.*, 2007). Therefore, project members of projects that do not apply LPS, so with a high level of trust based on the lack of control, would take more risks, whereas project members of projects that apply LPS are enabled to decide whether taking risks or not, based on the high level of mutual control and individual differentiation about the others' trustworthiness. These different risk-taking behaviours could affect the individual but also the common project objectives. These more qualified bases of decision-making might be one reason for improved project results, which are associated with LPS, such as reduced costs, reduced time of project delivery, improved productivity (Fernandez-Solis *et al.*, 2013).

The study's findings were discussed with an MC, which applies LPS at all of his projects in his meetings to investigate what the impact of the investigations are from a practitioner's point of view. The feedback was that the MC will continue to apply LPS as it is perceived as a good controlling method and as such as a good "early warning tool" to foresee issues earlier that without applying LPS and to be qualified to judge about the trustworthiness of the others.

This statement, in combination with this study's investigations at all six cases, that show that the MCs do not share all information (schedules) with the other stakeholders, but that they prepare them for different strategic motivations and use their unique knowledge to control the others, represents the current cultural state of the German construction industry: collaboration is not really intended, but LPS is seen as a method to structure and control the construction processes better than traditionally.

Conclusion

This paper investigated the impact of the LPS on project culture, especially under the main aspects of collaboration as one level of partnering: trust and mutual understanding. The main RQ was if LPS's application leads towards more collaboration between the participants.

To investigate this question, a multiple case study approach was chosen where quantitative and qualitative research methods were used to compare three projects that did not apply LPS with three projects where LPS was applied.

The study has indicated that LPS is applied differently at projects and that if it is used as a joint planning process, which is its original idea, it leads towards a high level of mutual understanding between all participants, which is next to trust one necessary aspect of a partnering culture. The study's main finding, however, is that LPS leads especially towards a high level of mutual control, which enables all project participants to differentiate who behaves trustworthy and who does not. In addition, such a high level of mutual control does not necessarily lead towards more trustworthy behaviours, which was shown through the participants' distinct differentiation about the trustworthiness of the other individuals. In

contrast to Mossman (2015) and Ballard and Tommelein (2016), we show that it must be rejected that LPS's implementation leads necessarily towards collaboration To build a collaborative culture, which is characterized by trustfully behaviours and a common strive for mutual goals, other approaches should be sought.

Nevertheless, LPS's implementation can be recommended to improve mutual control, which affects the risk-taking behaviours and which can lead to the early detection of issues through the joint awareness about upcoming issues.

Limitations and recommendations

One limitation of this study is that it covers not all ingredients of the partnering framework from Nyström (2005). For instance, economic inventive contracts and the choice of working partners are named in this framework to have possible influences on culture in terms of partnering. The participants' satisfaction their contractual situation and the choice of the other project members was not investigated in this study. Such collaborative procurement methods and contracts that focus on shared common project objectives promise to change project cultures towards partnering (Emuze and Smallwood, 2014). There are recent investigations and pilot projects in Germany such as "integrated project delivery" contracts (Boldt, 2020; Haghsheno, 2020), that focus on these aspects. Further studies should investigate if such contractual arrangements have a bigger impact on project cultures than the implementation of LPS.

This study is limited on the German turnkey building construction industry with its unique history and culture. As inter alia Uusitalo *et al.* (2020) describe, national cultural circumstances also influence project cultures. Therefore, there might be differences of the impact on LPS on project cultures in other cultural environments. One example could be that the described social pressure affects the willingness to complete tasks and promises as promised in front of the project team (Ballard and Tommelein, 2016) differs at cultures, where the national cultures are more pronounced by collective behaviours than the German culture, which is especially pronounced by individualistic features (Hofstede Insights, 2018). Therefore, future studies could investigate the relation between LPS's implementation and national cultural backgrounds. The added value could be different components of LPS that fit better or worse to particular environments.

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