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COLLABORATION IN THE DETAILED DESIGN PHASE OF CONSTRUCTION PROJECTS – A STUDY OF INTERDISCIPLINARY TEAMS

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ABSTRACT

Collaboration in construction projects has become a primary requirement in common delivery methods, especially in the detailed design phase to achieve value for the client. The involvement of multiple organisations, such as the client, architects, design consultants, project managers, contractors, and subcontractors, increases the complexity of implementing successful collaboration. Recent studies have focused on the financial aspect of collaboration but undervalued the social dimension which reflects behavioural actions that can lead to goal misalignment. There is less known about the highly dynamic nature of collaboration at a project level between participants with different views, objectives, and working practices. Through a study of two interdisciplinary teams in the detailed design phase of large-scale construction projects, participants' perceptions of collaboration were analysed to reveal that participants have different ways of viewing their collaboration, ranging from facilitation factors, working processes, and outcomes. The study advances the theory of collaboration in design management by adopting an inter-organisational practice-based perspective to assess collaboration. The findings suggest a more tailored management approach based on understanding the processes and outcomes and regular monitoring of the behaviour actions for collaboration to succeed.

KEYWORDS

Collaboration, interdisciplinary teams, design management, early contractor involvement

INTRODUCTION

Collaboration in large-scale construction projects is challenging due to the presence of multiple organisations and skilled professionals representing the client, architects, design consultants, project managers, contractors, and subcontractors forming interdisciplinary teams (Emmitt 2010; Winch 2009). Although these participants have different backgrounds, goals, and preferred working practices that affect their discussions and methods of resolving conflicts, they are required to work closely as a cohesive team to improve value for the client (Baiden, Price & Dainty 2006). In common delivery methods such as design and build and managing contractor, the detailed design phase involves several design reviews and evaluations between designers and contractors to finalise design decisions and the associated cost, which requires a good understanding of the interdependent relations between these actors (Kalsaas, Rullestad & Thorud 2020).

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In large-scale construction projects, the finalisation of design documents during the detailed design phase can take more than a year, creating challenges for participants to maintain their collaboration efforts and exchange information and technical knowledge constructively (Walker, Davis & Stevenson 2017). Recent research on the detailed design phase revealed designers' concerns about delays and late changes when finalising designs due to the uncertainty of receiving feedback from the contractors in a timely fashion (Kalsaas, Rullestad & Thorud 2020). Further, late design changes in the design phase are the leading cause of rework in the construction phase, according to research showing that the average cost of design changes was up to 14.2% of the construction cost (Lopez & Love 2011). A such, managing interdisciplinary teams in the detailed design phase is particularly challenging as the contractors' focus shifts to cost and scheduling to finalise design documentation, which conflicts with the iterative nature of architects' work (Forbes & Ahmed 2010). These differences in working practices are reflected in design documents that may be incomplete and not precise enough for the subsequent disciplines in the supply chain (Ballard et al. 2007; O'Connor James & Koo Hyun 2020; Tzortzopoulos, Kagioglou & Koskela 2020).

Successful traits of collaboration in multi-party projects included sharing risk and reward models and aligning financial interests (Walker & Lloyd-Walker 2020). These traits tend to focus on the financial aspect of collaboration and undervalue the social dimension reflected in behavioural actions that can lead to goal misalignment and miscommunication among interdisciplinary teams (Manata et al. 2020; Suprapto, Bakker & Mooi 2015). Understanding the highly dynamic nature of collaboration is therefore important at a project level where interdisciplinary teams include different personalities, objectives, and working practices (Bresnen & Marshall 2002; Eriksson & Westerberg 2011).

Given these insights, this paper presents an empirical investigation on collaboration as a perception-based phenomenon to understand how participants perceive and evaluate their collaboration and the impacts on their working practices in detailed design meetings of large-scale construction projects in Australia. It draws upon the inter-organisational theory that differentiates between antecedents of collaboration, processes, and outcomes and pays special attention to the subjectivity aspect of collaboration (Gray 1989; Gray & Purdy 2018; Huxham & Vangen 2013) to study the research question*: How can team members' perceptions of collaboration in the detailed design meetings of construction projects provide insights into improving interdisciplinary collaboration?*

LITERATURE REVIEW

Interdisciplinary collaboration is considered a solution to persistent issues in large-scale construction projects, such as adversarial relationships, poor communication, schedule and budget overruns and high uncertainty (Deep, Gajendran & Jefferies 2020; Walker, Davis & Stevenson 2017). Successful collaborative practices that rely on multi-party contracting frameworks have demonstrated an ability to control cost and improve performance in construction projects. However, recent studies have reported practical problems such as lack of commitment, inefficient communication, sharing limited financial information, conflicting personalities, and lack of team building activities and workshops to rectify goal misalignment (Koolwijk et al. 2018; Manata et al. 2020). Contracting frameworks are not considered sufficient to shift participants' mindsets to a fully collaborative one in large-scale construction projects due to the gap between agreements at the formal organisation level and what happens at the project team level (Bresnen & Marshall 2002; Suprapto, Bakker & Mooi 2015).

From an inter-organisational perspective, collaboration is defined "as the process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their limited vision of what is possible"(Gray 1989, p. 5). This definition is adopted for this research, as it focusses on the interactive process of interdisciplinary collaboration and recognises that participants have different backgrounds, which aligns with this research. However, the integration of knowledge and experience in design and construction to collaboratively solve complex problems in construction projects needs some clarification.

Interdisciplinary collaboration has been discussed extensively in the lean construction literature to cope with uncertainty, reduce process waste and improve workflow to deliver value to the client by using tools that follow structured methods and procedures (ex.Ballard et al. 2007; Pedó et al. 2022; Tzortzopoulos, Kagioglou & Koskela 2020). The formation of an interdisciplinary team at the outset of the project is a fundamental aspect to improve the design processes and reduce constructability problems (Nguyen, Lostuvali & Tommelein 2009; Raviv, Shapira & Sacks 2022).

In the design phase of construction projects, set-based design (SBD) approach integrates construction expertise into the process of selecting design solutions to align viewpoints regarding design concepts from the start of the design phase to reduce negative design iteration (Parrish et al. 2008). Another useful method is the Choosing by Advantages (CBA) which is a structured approach of multi-criteria that prioritises the importance of advantages when making decisions by integrating construction knowledge into the design decision-making process (Schöttle, Arroyo & Christensen 2020).

Lean construction tools also focus on cost control in the design phase by integrating design and construction knowledge through the adoption of the target value design (TVD) concept. The TVD approach encompasses various lean methodologies and tools such as SBD, co-location of the project team in a common space, and expands to address constructability issues (Nguyen, Lostuvali & Tommelein 2009; Smoge, Torp & Johansen 2020). The TVD concept allows interdisciplinary teams to collectively manage and control target cost by moving money across trade packages to optimise the project as a whole (Ballard & Pennanen 2013).

The interactive process of interdisciplinary teams was also examined in the integrated project delivery (IPD) approach that operates at the project level by integrating design and construction teams, working practices and the business structures of organisations involved in a construction project (El Asmar 2012). The IPD method is an adaption of the Australian project alliancing approach, which shares a similar project delivery approach and has been commonly used in the infrastructure projects (Walker & Lloyd-Walker 2020). Research on the collaborative working environment in IPD projects has focused on identifying features of integrated teams, such as sharing information, defined roles and responsibilities, co-location, and trust in expertise (Abdirad & Pishdad-Bozorgi 2014; Baiden, Price & Dainty 2006; El Asmar, Hanna & Loh 2013).

Collaboration traits of interdisciplinary teams can be categorised into antecedents, interactive processes and outcomes (Salam, Forsythe & Killen 2019). These traits are 1) antecedents such as defining roles and responsibilities, having a common goal, co-locating the team in a common place, and a common means of sharing information, 2) interactive process traits including interactive coordination, collective decision making, and aligning cost interests, 3) outcomes traits include achieving value for the client, cost and time efficiencies, and trust in expertise. The interactive process has the least traits and still needs some clarification.

To advance the discussion on the interactive process in construction projects involving multiple organisations and skilled professionals, the role of the inter-organisational theoretical approach is discussed next to gain a deeper understanding of what conceptually constitutes interdisciplinary collaboration processes in the detailed design phase of construction projects.

Theoretical background

Theoretically, the inter-organisational practice-based stream differentiates between antecedents, processes, and outcomes of collaboration (Gray 1989; Gray & Purdy 2018; Huxham & Vangen 2013; Thomson & Perry 2006). Gray's (1989) collaboration model

focuses on processes and outcomes, and advocates that collaboration efforts proceed linearly: 1) problem setting, 2) direction setting and 3) objective and 4) subjective outcomes.
In the *problem setting* phase, participants define the problem by performing a detailed analysis to develop a common understanding of each other's concerns. They then proceed to the *direction setting* phase where they refine the solutions and agree collectively on the best solution that satisfies their technical concerns. *Objective* measures are then used to document the implementation of the solution while *subjective* measures monitor participants' satisfaction with the results achieved (Gray 1989; Gray & Purdy 2018). The inter-organisational practice-based stream also recognises the long-term nature of the collaboration process (Gray 1989; Gray & Purdy 2018). As Gray notes, "respect for differences is an easy virtue to champion verbally and much more difficult to put in practice in our day-to-day affairs" (1989, p. 11). In conflicting situations, participants tend to forget that their underlying concerns are primarily intertwined and that their interdependence is much needed to solve complex problems (Gray 1989; Gray & Purdy 2018).
These inter-organisational concepts align with the practices of participants in the detailed design phase of large-scale construction projects due to the long duration, where conflicts are expected to occur between designers and contractors due to the inherent differences in their working practices and procedures (Eynon 2013). These circumstances put designers and contractors under continuous pressure in the detailed design phase to achieve the design objectives within the project time and budget constraints, which might influence participants' perception of their collaboration efforts (Winch 2009). Building on the perspectives of the inter-organisational theory to conceptualise collaboration, this study is expected to contribute to our understanding of project team dynamics in the AEC industry. Moreover, the study of the perceptions of participants about their collaboration in large-scale construction projects can help managers and professionals recognise and monitor the working process, foresee the impacts on the outcomes and potentially take actions to improve performance.

METHOD

To better understand collaboration as a perception-based phenomenon and how participants perceive their collaboration and the impacts on their working practices, the study collected collaboration scores in detailed design meetings of two large-scale construction projects in Australia followed by interviews. The research design adopted a longitudinal case study approach utilising replication logic (Yin 2017) to explore interdisciplinary collaboration in the detailed design phase of two contrasting case studies having different design environments. The two case studies were part of the same overarching educational building project and in methodological terms, this aimed to help minimise the effects of intervening variables such as different contract types, means of sharing information, and location and building type. The selection of the case study was based on (i) the case had enough stakeholders representing the client, architect, design consultant, main contractor, and subcontractor to form the interdisciplinary team, and (ii) the case represented a different degree of design complexity to reflect the contrasting design environments.

The chosen overarching educational building project included a five-storey podium (case study B), and a 10-storey tower (case study A). Case study A involved a relatively standard façade design, which used a closed-cavity façade (CCF) system developed by the subcontractor firm and demonstrated fewer design challenges due to the extensive knowledge of the subcontractor about the facade components. Case study B involved a bespoke façade type that created several challenges related to the design of the supporting structural system. These cases were treated as two separate work packages in terms of subcontractors' firms and budgets. Representatives of the client, main contractor, architects, and façade consultant were the same for both case studies. The different participants were the subcontractors' representatives assigned to each façade package.

Data collection and Analysis

A simple perception-based method was used to capture the collaboration rating of the participants after each meeting over a year to cover the detailed design phase. Each firm assigned a key participant as the point of contact for the projects. These key participants were involved in the data collection method and were asked to rate their collaboration experience after each meeting using a Likert (1932) scale level of quality of 1–9, where 1 is very poor, 5 is neutral, and 9 is excellent. The perception question was emailed to each key participant shortly after the meeting to make sure that participants rated their collaboration very soon after the meeting to capture their emotive thoughts as well as objective outcomes. The survey question was: *Can you please rate your collaboration experience in [insert trade package name] meeting [insert date] using a scale of 1 to 9 (where 1=very poor, 5=neutral, 9=excellent)?* A total of 215 collaborating ratings were collected. The ratings were analysed following a systematic approach using quantitative statistical results to direct the next step in data collection.

The perception measure was followed by targeted interviews focused specifically on participants who gave contrasting collaboration scores from the same meeting. These interviews included an open question asking for the reasons behind their extremely low or high collaboration ratings. A total of 34 interviews were conducted and analysed using pattern matching (Miles, Huberman & Saldana 2014), where the codes were categorised and grouped according to the antecedents of collaboration and the four phases of Gray's (1989) collaboration model discussed above.

FINDINGS

The client procured the overarching project as a managing contractor with a cost-plus contract. Another set of separate consulting contracts existed between the client and the architectural firm and the façade consulting firm. The main contractor had a separate design, construct and maintenance contract with each of the subcontractor firms. Although this procurement setting has a traditional essence, it was found suitable for this study as the proposed collaborative environment is imperative in the detailed design phase to achieve value for the client (Koolwijk et al. 2018). In addition, the integrated business model used in the multi-party contractual setting is still limited in commercial construction projects in Australia (Rankohi, Bourgault & Iordanova 2022).

Case study A

The detailed design phase for case study A included 21 meetings and a total of 100 collaboration scores collected after each meeting. Key participants involved in the data collection (ratings and interviews) were the client's delivery manager (L1), the main contractor's project engineer (C1), the architectural firm's senior architect (R2), the façade consultant (F1) and the subcontractor's senior project manager (T2) for case study A. Figure 1 below, collaboration scores for case study A are presented on the y-axis in the 21 meetings (shown as Mtg) on the x-axis.

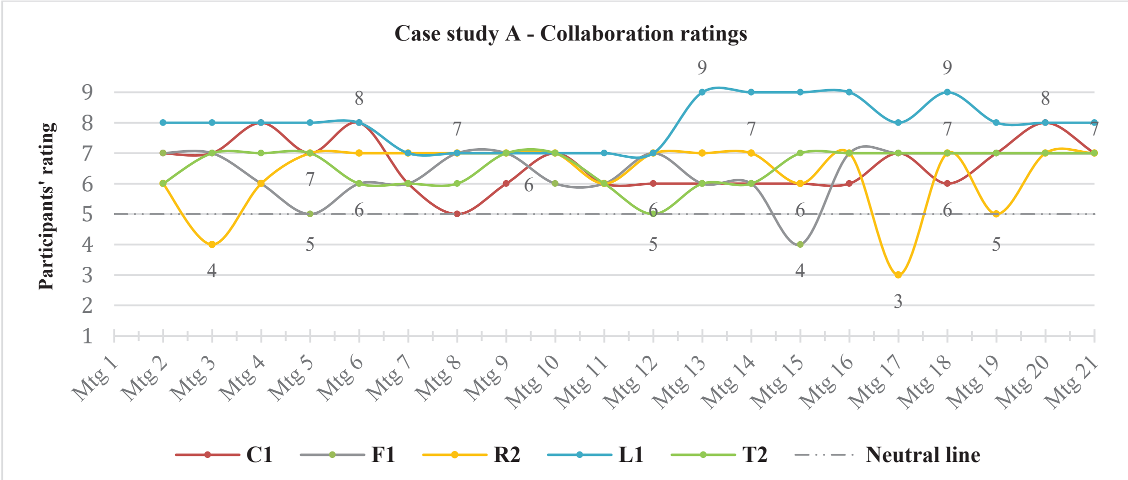

Figure 1: Case study A – Collaboration ratings by meeting

Analysis of the ratings revealed that there was no consensus among participants about their collaborative experiences, as the ratings did not align at any meeting. The most common ratings were 7 (50%) and 6 (26%). Most of the ratings were in the positive part of the graph above the score of 5, and only three ratings were below the neutral line. The client (L1) believed that collaboration was excellent (rating 9) in meetings 13, 14, 15, 16 and 18. The client was assured that the subcontractor firm could accommodate the design requirements and match the architects' vision, given that they developed the closed cavity façade CCF system as explained in a targeted interview: *"The process is positive because they know their system; they are looking at winter gardens, glass curves and everything. The meetings are generally positive" [L1, rating for meeting 6].* The constant satisfaction with the collaborative environment in the meetings was also seen in the subcontractor (T2) ratings which did not change much as the majority were 6 or 7. Subsequent interviews revealed that the subcontractor's senior project manager rated collaboration positively due to the team formation, including the designers and client. The formation of such an interdisciplinary team allowed the subcontractor to get instant feedback on the proposed design solutions from the designers and the client's approvals as quoted: *"Because the meetings are mainly related to the facade. So, it wasn't just a normal meeting that has everybody else on the project in the meeting, but for the façade to have an understanding of the design" [T2, rating of 6 & 7 for meetings 8 and 9].*

A different view of the collaboration experience was seen in the ratings of the main contractor (C1), architect (R2) and façade consultant (F1) which fluctuated between a high of 8 and a low of 3. For instance, the senior architect (R2) gave a low score of 4 in meeting 3 indicating an early sign of dissatisfaction. In the early meetings of the detailed design phase, the discussions included the scope register, information about façade components and their costs, and explanations about the façade system and how it works. The architects were concerned about whether the subcontractor had fully understood the design intent before approving the scope as quoted in the interview: *"I guess it is a complex façade stepping in stepping out, twisting... it is a closed cavity façade system and there is a lot of sort of services and extra constraints along with that façade type...it is just more complex than a traditional façade type" [R2, rating of 4 for meeting 3].*

Despite the above two low ratings of collaboration experience, the senior architect (R2) showed satisfaction with the working experience because of the subcontractors' continuous detailed feedback given in the meetings about the proposed design options, including dimensions, manufacturing process, installation processes and tolerance needed for the construction crew to secure connections, and cost breakdown. These thorough explanations including the cost associated with each design component informed the designers about which part of the design was expensive thus they could choose the best design solution that satisfied both practicality and cost as quoted: "*They gave us how much it costs; they break it up for us, it is easy to see if we make this decision, it will cost this much money" [R2, rating of 7 for meeting 8]. "They are really receptive towards our idea; they do not just say no and don't back it up with any sort of information… they seem to take on board what we want… giving us choices" [R2, rating of 7 for meeting 18].*

The contractor's project engineer (C1) had constant positive collaboration ratings above the neutral line. However, the ratings decreased from 7 in meeting 10 to 6 in meetings 11 and 12 due to excessive design reviews and coordination actions. Some of the minor design tasks required investigation including design options, cost analysis, and seeking the client's approval which generated several coordination tasks to gather and disseminate information and was rejected later due to cost overrun causing dissatisfaction to the main contractor (C1) quoted in the interview: *"I sent many correspondences between meetings outlining everything fully, it takes me a lot of time to outline the history, the marked-up drawings, and this is option A and this option B, but no response" [C1, rating of 6 for meeting 12].*

CASE STUDY B

The detailed design phase for case study B included 24 detailed design meetings where 115 collaboration scores were collected after each meeting. The key participants involved in the data collection (ratings and interviews) were the client's delivery manager (L1), the main contractor's project engineer (C1), the architectural firm's senior architect (R2), the façade consultant (F1) and the subcontractor's project manager (P3). Figure 2 below, collaboration scores for case study B are presented on the y-axis in the 24 meetings (shown as Mtg) on the x-axis.

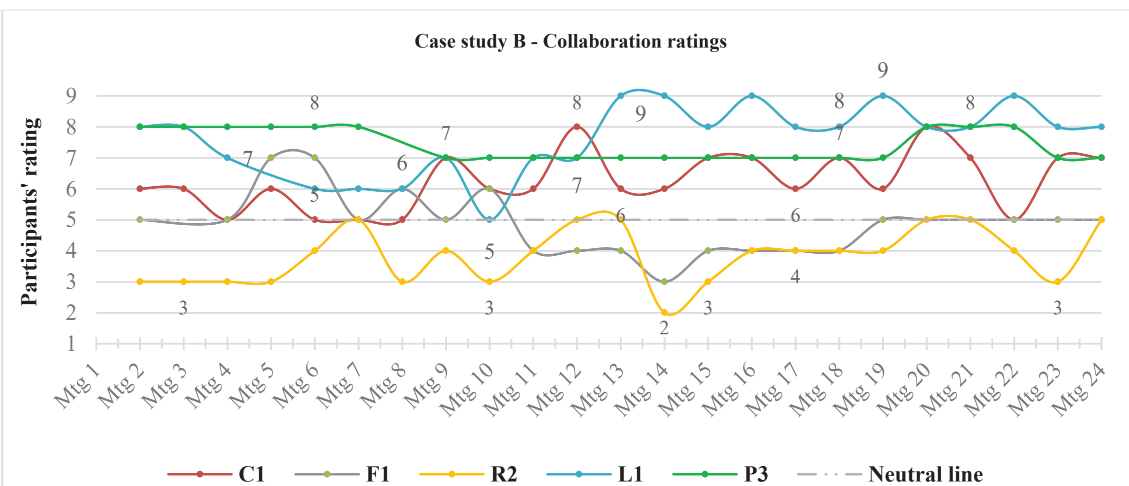

Figure 2: Case study B – Collaboration ratings by meeting

The observation of no consensus among participants about their collaborative experiences existed also in case study B due to the significant divergence between the ratings. Participants' ratings were widely scattered across the neutral line (rating of 5 points), with the most frequent ratings being 7 (22%), 8 (19%) and 5 (17%). For example, all architect ratings (R2) were below the neutral line, indicating a continuous dissatisfaction with the collaborative experience. In early meetings, the scope of the design was not clear due to the discrepancy in the design documentation, as participants had different versions of the tender documents. Thus, the proposed design solution did not match the design intent, which led to led to confrontation discussions, design changes to match the design intent, and delays in developing the design as quoted in the subsequent interview: *“They (subcontractors) don’t seem to be listening to our views, like how many times we explained our view on the lower connection of reading rooms, we removed the louvres and its structure, but they keep asking or acting as if it is still there, it’s frustrating” [R2, rating of 3 for meeting 5].*

A slightly different rating pattern is seen in the facade consultant ratings (F1) because the ratings were above the neutral line at the initial meetings and then continue to be below the neutral line (rating of 5 points) indicating dissatisfaction at many meetings. The façade consultant was also confused about the scope of the design due to its impact on the structural system design as quoted in the interview: *“The scope, yea, if everyone was clear on that it would be much simpler; we will know who is doing what… but that’s taken us since April basically till now (July) to understand that because no one declared it openly… I keep asking questions and every time I ask a question; I find something new” [F1, rating of 5 for meeting 7].* Furthermore, both the architects and the façade consultant were concerned about the insufficient fundamental information on the structural system given in the meetings, but the subcontractor preferred not to go into detailed engineering calculations before agreeing on the design principles. These conflicting views created confrontation in the design discussions because the designers were trying to work out a practical design solution with the subcontractor as F1 quoted: *“They (subcontractor) don’t want to say too much because the more you say the more you get feedback on… once they engaged the steel contractor, they will progress their shop drawings, which means that the steel guy would start his shop drawings and will have a note on his drawing that says need to confirm connection if they didn’t tell us what that is beforehand” [F1, rating of 3 for meeting 14].*

The contractor project engineer (C1) had constant positive collaboration scores above the neutral line. However, the scores were closer to the natural line in the first 8 meetings, as he had a different view of the changes in the design scope due to budget limits as quoted: *'It is not as per their [referring to the architects] drawings, but we had to let it be based on something because if we were behind, and we would not have a building” [C1, rating of 5 for meeting 4].'* The process of refining the design continued to occur to investigate other ways to reduce the cost, which required further design changes and consequently more reviews. The main contractor (C1) was dissatisfied with these excessive reviews because the design was not progressing as scheduled as quoted: *“We just got 12 very different façade types that have constantly changed, we should be sticking to the design not just keep changing and changing… we don’t know where the beam is and it is still changing, today the wind beam is changed again!” [C1, rating of 5 for meeting 8].*

The client’s (L1) ratings were positive in general with all ratings above the neutral line showing an overall satisfaction with the collaborative experience despite the tough discussions between designers and contractors in the meetings as quoted in the subsequent interview: *“I gave a rate of 7 because at the end they [referring to the subcontractor] agreed to look at the design again and that is what matters to me” [L1, rating of 7 for meeting 4].*

Despite the design challenges, the subcontractor’s (P3) ratings were also positive throughout the meetings at 7 or 8 indicating continuous satisfaction with the collaboration experience due to the concept of early participation in design decisions and being part of the team, as quoted in the interview: “*Yea, my ratings were much higher because we had a lot of coordination on something like this, where in previous projects many decisions were already made before we got involved so we also do not have a say in deciding how the project progresses” [P3, rating of 8 for meeting 5].*

As negotiations and consistent disagreement between participants continued to occur, an organisational decision involving the client and the main contractor was taken after meeting 8 including changing some of the meetings to be a design workshop as a mitigation plan for the delays encountered. A total of six design-focused workshops were held to replace weekly meetings 9, 11, 12, 16, 18 and 19 to better understand the technical concerns directly from the subcontractor's staff who were documenting the design drawings. The collaboration ratings of the participants began to be somewhat consistent after these workshops because the subcontractor team gave detailed feedback that made architects more informed about design restrictions and offered proper design solutions at the meetings, as quoted by the architect and the principal contractor: *'The workshops definitely are more constructive because it is much easier to get things done and decisions made and to work through details rather than having a formal meeting atmosphere and going through a lot of stuff that is not always super critical to what we are doing at the moment' [R2, rating of 5 for meeting 13]. "The workshops are more collaborative … generally because the group is not as big… plus the actual draftsmen work and try and get this resolved sort of coming with real problems and architects a bit more receptive and get things to work" [C1, rating of 8 for meeting 12].*

DISCUSSION

To address the research question, the study found that participants had different views of their collaboration and focused on different phases of collaboration when explaining their ratings. The client prioritised outcomes, subcontractors focused on antecedents, and the main contractor, architects, and facade consultant focused on processes. In the bespoke design case study, there was a greater variance in ratings, with dissatisfaction expressed by those focused on the collaboration's processes.

The client's delivery manager (L1) rated collaboration based on the outcomes achieved rather than the processes in both case studies. The findings support the study conducted by Tzortzopoulos, Kagioglou & Koskela (2020) which highlighted the client's concerns about preserving value during the handover of design responsibilities from architects to subcontractors. In both case studies, the subcontractors expressed satisfaction with their collaboration experience, albeit for different reasons tied to team formation and early involvement in design decision-making. These results are consistent with the existing lean construction literature, which recommends involving subcontractors early on in the design process to provide constructability feedback, enabling designers to make well-informed decisions regarding proposed solutions (Denerolle 2013; Raviv, Shapira & Sacks 2022). Despite the fact that the subcontractors displayed behaviours associated with providing constructability feedback, both attributed their high collaboration ratings to collaboration antecedents. There could be a couple of potential reasons for such practices. Firstly, it is plausible that the subcontractors may not be accustomed to expressing their views on actual working practices. Secondly, the lack of managerial attention towards cultivating a fair working environment where all participants have an equal opportunity to voice their opinions on working practices could be a contributing factor. (Eynon 2013; Winch 2009).

The interviews revealed that the R2, F1, and C1 scores were more focused on the collaboration processes than the outcomes. The high collaboration scores of the senior architect (R2) were related to elaborate feedback backed up by a breakdown of the cost of the design components. These practices led to adopting of practical design solutions and elevating the sense of mutual accountability where all participants shared the responsibility of meeting the design deliverables timeframe. Aligned with Dietrich et al. (2010), these findings provide insights into the knowledge creation process (interaction activities of feedback, brainstorming, and innovation) that are specific to the design discussions. The findings also support Denerolle's (2013) approach of fostering interdisciplinary collaboration through weekly meetings. Although design refinements are common in construction projects due to the highly iterative nature of the design process (Eynon 2013), they were seen by C1 as unnecessary coordination tasks which align with the well-established lean concept of process waste in the design phase that needs to be minimised (Tzortzopoulos, Kagioglou & Koskela 2020). These findings support the need for a planning management approach that is capable of handling the normal design changes in the detailed design phase (Kalsaas, Rullestad & Thorud 2020).

Practices associated with low ratings emerged in case study B because of the dissatisfaction of the architects (R2) and façade consultant (F1) with the practices of lack of transparency and providing inadequate design information combined with minimal cost justification which resulted in a call for mitigation actions to reduce confrontation. These findings demonstrate how goal misalignment at initial meetings led to unhealthy communication behaviours and poor decision quality (Manata et al. 2020; Suprapto, Bakker & Mooi 2015). Although Suprapto et al. (2015) point to the lack of willingness of senior management to be involved in improving team building and interpersonal relationships between participants at the project level, the findings of this study do not support this view, as the workshop decision was made by the senior representative of the client (L1). The diversity of participants involved in the detailed design meetings resulted in different interpretations or ways to frame the problems that existed in their discussions. The inter-organisational practice-based perspective explains such situations of participants failing to align their views and reaching a frame break stage (Gray 1989) , where the problems at the micro level were amplified in scope and time at the macro level (cross-organisational level) (Gray & Purdy 2018). This led to seeking mitigation actions to ease the tension between participants and reduce confrontation and avoid further problems associated with variations or claims for delay in construction projects (Walker, Davis & Stevenson 2017).

These findings suggest that collaboration needs a more tailored management approach based on understanding collaboration as a process that leads to outcomes, and requires regular monitoring of behavioural actions and differing frames when a problem occurs. Managers could remind participants that different interpretations of a problem do not mean by definition that they are opposing views and that their underlying concerns are initially intertwined and need their interdependence to solve the problem (Gray 1989; Gray & Purdy 2018). These different frames of the same problem can enhance creativity and innovation if well managed. More importantly, if participants began to lose their momentum, interventions can be introduced to address the reasons for collaboration inertia and help participants restore their efforts.

CONCLUSION

This paper examines collaboration as a perception-based phenomenon based on the opinions of participants on their collaboration at design meetings of construction projects. Analysis of the ratings of the participants reveals differences in the ways in which people from different organisations viewed collaboration. Two collaboration paths were identified from the analysis of ratings and interviews. A smooth path was achieved through detailed feedback to raise the awareness of technical constraints and sharing cost information to collectively make informed design decisions. The lack of transparency and inadequate design information led to a disruptive collaboration path. The practices of differing frames for addressing technical problems were resolved by an intervention to improve collaboration performance. Theoretically, the findings contribute to the growing literature on the need for better interdisciplinary collaboration in the construction industry to improve performance and provide useful insights into design management. Adopting the inter-organisational perspective provides a new lens to analyse interdisciplinary collaboration perceptions and reveal the practices that influence collaboration practices in construction projects, which can be further explored in future research.

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