Value analysis of early trade partners involvement in the design of construction projects

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Abstract

The positive impact of the early involvement of key project participants on the performance of construction projects is widely acknowledged. However, early involvement is hindered by fragmentation. The process and methods of early involvement of the construction team are also lacking. Current research on design and construction participants integration focuses on the general contractor, sidelining the value of trade partners, who perform more than 80% of the construction scope. To fill these gaps, this study outlines the value of early trade copartners' involvement in the design process. A critical narrative review of literature and documented case studies from integrated projects are used to identify current practices and gaps in early trade contractor involvement. The findings suggest that although it is acknowledged that trade partners have the highest influence on the design when involved at the early design stage, in practice there is inconsistency on when trade partners are engaged. Engagement is based on a reactive approach. It is also evident that earlier involvement of trades can result to better design output, systems selection, constructible systems design, and minimal design errors and omissions. This paper defines an early trade partner involvement outline based on the stages of design, deliverables, and responsibilities of trade partners during the design. The outline can inform owners and the design teams on anticipated input and output from trade contractors at a given point in the design process, and the benefits of such activities.

Keywords: Integrated design, early contractor involvement, subcontractors, design assist, horizontal fragmentation

1. Introduction

Fragmentation in design and construction processes and teams contributes to design failures, reoccurring cost overruns, delays, and quality concerns in construction projects. Design-bid-build (DBB) is associated with the highest degree of this fragmentation (Ahmed & El-Sayegh, 2020; Franz et al., 2020). DBB divides the design and construction participants, promoting an adversarial working environment (Elsayegh & El-adaway, 2021). This fragmented model fails to fulfill the value construction clients anticipate from their projects, necessitating the need for value-based delivery models that integrate participants (Choi et al., 2019) and processes (Khouja et al., 2021). Alternative delivery methods focus on the inclusion of downstream participants earlier in the project (Ahmed & El-Sayegh, 2020). Research has demonstrated that this early involvement of the construction team is a key determinant of team integration, which enhances project performance (Franz & Leicht, 2016). However, the early involvement of construction participants in the design phase is still hindered by existing organizational and industry practices (Khouja et al., 2021).

Research on the process, methods, and value of early involvement of the construction team in the design process is still scarce. This raises a limitation to owners' and designers' ability to identify the missed opportunity from early construction team input on the design (Elsayegh & El-Adaway, 2021). As part of the construction team, trade contractors perform highly specialized construction tasks (Franz et al., 2013), accounting for more than 80% of the construction scope. They acquire task-related knowledge that can inform design decisions (Gil et al., 2001). However, existing design-construction integration studies focus on general contractors, leaving out trade contractors. Recent construction engineering management scholars have acknowledged the need for trade contractors in the design process.

Trade contractors offer value to construction clients through refinement of the design based on specialty construction knowledge (Choi et al., 2019; Costa et al., 2019; Ferstad et al., 2023). However, several gaps regarding the early involvement of trade contractors have emerged. First, the appropriate timing of involvement is unclear. Second, the specific contributions to design and the responsibilities of trade contractors in the design process are unclearly defined yet it has been established that vague responsibilities and handoffs can negatively impact team integration which in turn impacts project output (Elsayegh & El-adaway, 2021). This study therefore aims to define a process for early trade contractors' involvement in the design process of construction projects. The findings illustrate the contribution of trade partners across the design process to inform owners and design teams on the benefits of early involvement of trade partners.

2. Research Process and Methods

This study was conducted as part of Institutional Review Board (IRB) approved research on the early involvement of trade contractors across project deliveries. The study adopts a multimethod approach in data collection and analysis to enhance the credibility of the study findings (Anguera et al., 2018; Creswell & Poth, 2017). Secondary data was collected from related literature and documented case study projects. An in-depth outline of the data collection process, analysis and discussion of findings contributes to high levels of rigor within the study (Cypress, 2017). The next sub-sections lay out the data collection and analysis methods followed to generate the findings of this study.

Review of secondary data

To identify the current practices in early trade partners design involvement, the authors conducted a critical narrative review of existing publications from peer reviewed journals, white papers, technical reports, and conference papers (Sukhera, 2022), primarily from the American society of civil engineers (ASCE) database, the lean construction journal (LCJ), the international group for lean construction (IGLC) conference series and science direct database. Additionally, case study projects were identified from the databases of construction industry organizations specialized in design and integrated project delivery. Case studies allow for in-depth analysis of a problem, and documentation of the actual real-world situations, making these cases a reliable source of information on the current practice in early trade partners involvement (Yin, 2018). They provided clarity on why trade partners are involved and at what point in the design. The analyzed case studies included those that have been documented by the Integrated Project Delivery Alliance (IPDA), the American Institute of Architects (AIA), and the Lean Construction Institute (LCI) (AIA et al., 2012; IPDA & LCI, 2016) and the Design-Build Institute of America (DBIA). The study included only empirical case studies reported through technical white papers published by these industry organizations and not projects documented in journals, conference papers, or other

grey literature. The cases included were selected based on their consideration and discussion of the aspect of early involvement of trade contractors in the design process. Thus, it is worth noting that case studies in the DBIA database were excluded from the analysis since they focused on the cost and schedule performance of the projects and less on the design team participants. Twenty-two cases with early trade contractor involvement were selected from the highlighted sources.

Data Analysis

An analysis of the content in peer reviewed literature allowed for identification of the gaps in current literature on early trade partner involvement. Content analysis was also used to identify the main ideas from the secondary case study sources. The reoccurring ideas in the case studies were grouped into main themes and patterns identified across all the cases to categorize the ideas under the common themes (Bahnson & Berdanier, 2023). The categories of identified themes on trade contractors' involvement included the timing of engagement, the benefits or value of their engagement, the deliverables, the responsibilities, and their selection process as discussed in the results section.

3. Results

Research progress on early trade contractor involvement in the construction industry

Researchers and practitioners acknowledge that construction industry clients are not financially benefiting from a fragmented approach to project delivery since siloed delivery negatively impacts on cost, schedule, and delivery speed of projects (Choi et al., 2019). Integrated delivery approaches, otherwise known as alternative delivery systems, such as design build (DB) and construction manager at risk (CMAR) perform better than the fragmented design-bid-build (DBB) (Franz et al., 2020). Seminal research on the alternative delivery methods assessed the impact of process integration on project cost, time, and quality performance (Konchar & Sanvido, 1998). Lean project delivery system has also been incorporated in project delivery to improve project delivery using the alternative project delivery (Vaagen & Ballard, 2021). Subsequent research currently focusses on team integration (Choi et al., 2019; B. W. Franz & Leicht, 2016) and integration of design and construction processes (Hanna, 2016; Kahvandi et al., 2017; Khouja et al., 2021), to improve project performance beyond cost, time, and quality (Ahmed & El-Sayegh, 2020). Although team integration has been termed critical in improving project performance (B. Franz et al., 2017) and customer satisfaction (Choi et al., 2019), bridging the existing gap in discipline fragmentation remains challenging (AIA, 2007; Aquere et al., 2013).

A ubiquitous finding from the studies on integration of disciplines forming the project team points to the influential role of the timing of construction team involvement (B. W. Franz & Leicht, 2016; Laurent & Leicht, 2019; Ling et al., 2020). However, the implementation of early involvement of construction participants in the design phase is still hindered by existing organizational and industry practices (Khouja et al., 2021). Most studies on early involvement acknowledge the need for general contractor or construction manager engagement in design. These studies present the benefits (Rahmani, 2021; Sodal et al., 2014) , challenges (Farrell & Sunindijo, 2022) , roles and responsibilities (Diab et al., 2020; Memic et al., 2023) , timing of involvement (Pulaski & Horman, 2005; van der Walt et al., 2019) and suitable delivery methods for contractor engagement in preconstruction (Graff & de la Garza, 2022; Malvik et al., 2021) . They also highlight how contractors' design involvement can be applied in specialized or complex construction projects (Ferme et al., 2018; Finnie et al., 2018). However, recent construction

management practitioners have acknowledged the need for trade contractors and other downstream stakeholders in the design process (Ferstad et al., 2023). Trade contractors perform specialized construction tasks (Franz et al., 2013), accounting for more than 80% of the budget. They acquire task-related knowledge that has been singled out as crucial in improving design (Gil et al., 2001). Trade contractors' contribution in design given their knowledge of construction means and methods, and process demands cannot be sidelined (Choi et al., 2019; Costa et al., 2019; Ferstad et al., 2023).

Researchers, albeit few, have explored this emerging need to utilize trade contractors' construction knowledge in the design process. This knowledge often exists in forms that can only be dispensed through direct engagement of trade partners with the designers (Gil et al., 2001). Current research in this area has focused on demonstrating the contribution of trade contractors on complex systems designs (de Graaf et al., 2023; B. W. Franz et al., 2013), different models of trades design involvement (Kelly, 2014; Migliaccio et al., 2022), and benefits of this involvement in exploring the technical attributes of clients' value (Ferstad et al., 2023). Based on this synthesis of literature, several gaps emerge in early trade involvement. First, the selection of these trades for participation in the design process is still unclear. Second, the specific responsibilities and deliverables of trade partners at different stages of the design process have also not been clearly defined. The information on the handoffs from trade partners at the end of each design stage is also limited. Lastly, the knowledge, skills and abilities that trades acquire from past construction projects that impact on their ability to positively influence the design outcomes have not been sufficiently explored, even though current selection is highly based on experiences. There is therefore still a need for additional research on trade partners' involvement in the preconstruction phase of projects.

Practical application of early trade partner involvement in construction projects

Twenty-two secondary case studies were reviewed to highlight current practice in the early involvement of trade partners. These documented case studies included in the analysis ranged from 7,000 sq. ft. to 878,000 sq. ft. in floor area with project upfront costs of up to $1,500 million designed within 55 months as summarized in table 1.

Table 1: Summary of reviewed case studies

Criteria	Project characteristics
Range of projects costs	Lowest cost: $0.5 million, highest cost: $1,500 million
Range of projects sizes	Smallest: 7,000 sq. ft., largest: 878,000 sq. ft.
Design timelines	Shortest: 4 months, longest: 55 months
Key trades engaged early	Mechanical, electrical, plumbing, fire protection, framing, steel, concrete, and façade
Trades included in multiparty contract	41%
Trades included in the core team	50%

Unlike the general contractor who is involved simultaneously as the architect or immediately after the design commences, there is still no consensus on the best timing for engaging trade contractors. Current practice exhibits inconsistencies on timing of involvement, with significant variation across projects from pre-design to criteria design, detailed design, and implementation documents as summarized in table 2. The key trades engaged early in the design process include the mechanical and plumbing, electrical, fire protection, façade, and structural systems. Reflecting on the outcome of the process, some project team members from these case

studies acknowledged the missed opportunities of not engaging the trades earlier than they did in the project design.

Setting up a contracting approach bears significant impact on the extent of participation in decision making within the project teams. 50% of the trade involved within the analyzed projects were not part of the multiparty contract that bound the owner, general contractor, and the architect, which limited their ability to fully contribute to the design process. Other trade contractors highlighted significant bureaucratic structures that limited the weight of their input on the design. This concern came up in projects with several levels of decision-making including a project executive team (PET), project management team (PMT) or core team and project implementation team (PIT). Efficient decision-making was evident in projects where the project implementation team was given significant influence over the design solutions proposed. The participants from these projects therefore expressed the need to balance trade engagement and efficient decision-making process with less bureaucracies (IPDA & LCI, 2016). Table 2 summarizes the areas of consideration when setting up a project for implementation of early trade partners involvement based on the documented case studies.

Table 2: Aspects of trade partner involvement across design stages

	Design stages				
Criteria	Conceptual design	Criteria design	Detailed design	Implementation documents	stage not specified
Stage of trade involvement	32%	14%	0%	9%	45%
Timing of involvement (No. of projects)	0% design: 5 Up to 25% design: 2	25% design: 2 Up to 50% design: 1	Up to 75% design: 0	75% design: 2	0 to 100% design: 10
Contract (% of projects)	23% party to the contract	4.5% party to the contract	0%	4.5% party to the contract	9% party to the contract
Involvement in the core team (% of projects)	18% part of the core team	4.5% part of the core team	0%	4.5% part of the core team	23% part of the core team
Decision making mandate	Core team and Owner advisory team based on Value matrix with owner's goals	IPD team but with a top-down decision making (PET TO PMT to PIT)	Not outlined	Core teams but to a limit of $ 50,000 value	Core team makes major decisions. SMT, PMT, PIT make smaller decisions at different levels.

The selection process of trade contractors in the case studies was majorly based on experience with similar scope of projects and ability to work in integrated teams. Projects that brought in the trade partners as early as conceptual design emphasized collaboration. However, the mechanism of evaluating the collaborative capability within the trades entities and personnel were not provided.

Table 3: Trade partners selection criteria and responsibilities in the design process

Criteria	Design stages				
	Conceptual design	Criteria design	Detailed design	Implementation documents	stage not specified
Selection process	Previous experience. Past relationship. Ability to engage in collaborative teams. Budget. Profit margin. Experience with lean and IPD. Innovative capacity.	Technical qualification. Experience of Key personnel. Collaborative ability. Past relationship with the core team. Price of bids.	No projects mentioned.	Best value – experience and expertise	Evaluation based on Site visits. Organizational structure. Lean experience. Team culture. Innovative capacity. Collaborative attitude/culture. Support for IPD. Conceptual cost.

The case studies outline the benefits that the design team obtains by engaging the trade contractors early in the project based on the tasks or responsibilities they perform during the design process. Trade contractors with a significant scope of work are often engaged in the pre-construction phase. Their involvement is based on arising needs of the design team; a reactive approach that limits ability to optimize the design aspects that have significant impacts on construction. Responsibilities of trades depend on the point at which they are engaged in the design process, indicated by the traditional design percentages milestones. It is worth noting that for most of the projects, 45%, the timing of the trade contractor involvement is not stated. The level of influence on design as the design timeline progresses is based on the cost of design influence curve as summarized in Fig. 1.

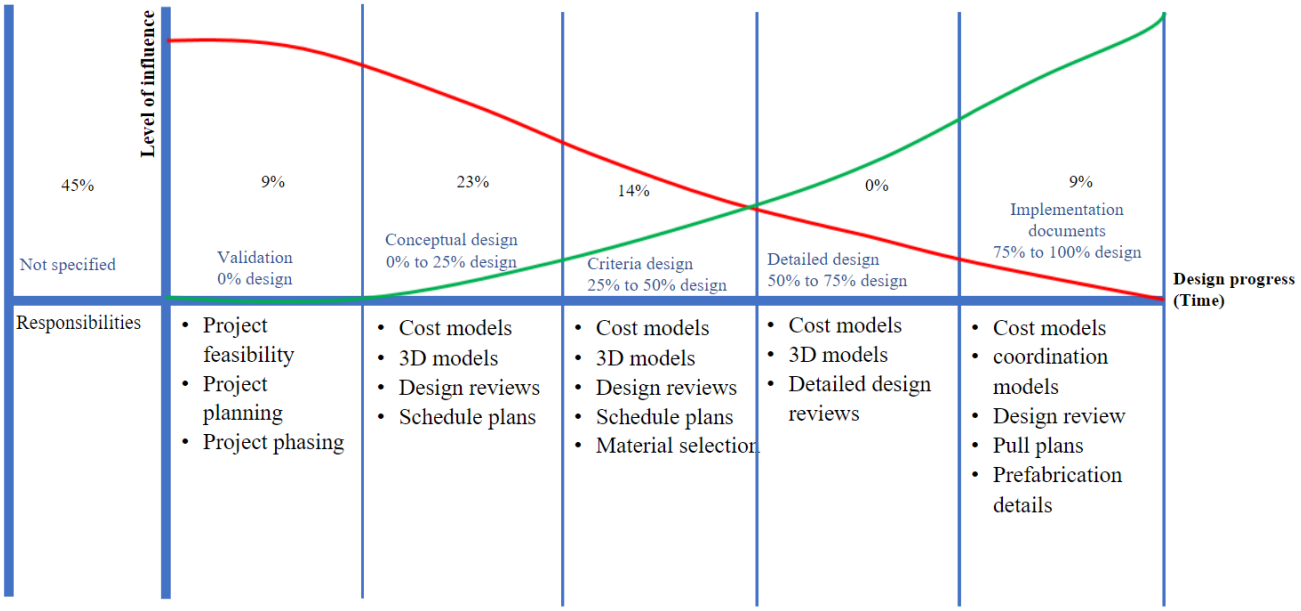

Figure 1: Outline of early trade partner involvement in projects with integrated design

4. Discussion

The overall findings suggest that early trade contractor involvement can result in positive outcomes during the design process, and significant efficiencies during the construction phase, as identified in previous studies (de Graaf et al., 2023; B. W. Franz et al., 2013; Gil et al., 2001) and discussed in the subsequent sub-section.

Categories of trade contractors involved early

Integrated projects rely on key stakeholders, although the point at which these stakeholders are brought into the project differs. Designers have found it beneficial to have trades with significant scope early in the design process as they provide innovative solutions that lead to cost and time savings (AIA et al., 2012). These projects, as evidenced in the case studies analysis, often engage the façade, mechanical, electrical, plumbing, fire protection, and structural trades early. The owners, designers, and general contractors allude to the large scope of work, system complexities, and interdependencies of systems as driving factors for selecting the trades for early engagement. In some instances, the framing trade contractors are also engaged early due to scope complexities and the magnitude of their scope (University of Minnesota et al., 2016).

Value at different design stages

The extensive definition of a project's value depends on the ability of the project team to translate the client's needs into tangible design solutions. To fully explore the cost or schedule implications of these design solutions, trade contractors provide valuable input on the feasibility of the proposed solution at the initial planning stage. The inputs prevent the team from proceeding with infeasible system or design alternatives. As the team progresses to the conceptual design stage, trade partners design the production plan and track the resulting cost and schedule changes through their detailed understanding of the installation processes. Continuous tracking ensures the project team is well informed for meeting the set targets, therefore eliminating solutions that exceed the budget, negative iterations in design aimed at reducing scope, or delaying decisions that may extend the project timeline (Johansen et al., 2021). The trades simultaneously develop and share strategies to optimize the schedule within the desired timeline (Ferstad et al., 2023).

Responsibilities in design

The designs developed by architects and engineers impact on construction methods adapted by the trade contractors during construction. In case the designs fail to accommodate the method of construction, significant design alterations arise during construction, wasting significant time and resources. Having the trade contractors refine the designs across all the stages based on construction needs eliminates these potential design errors, omissions and ambiguity that might be transferred to the construction stage. It also prevents the owner from incurring additional costs on design changes and reworks. By developing construction details, the trades reduce duplication of efforts in having both the designer and the trades generate construction details.

In the feasibility stage of IPD construction projects, the trade contractors have been, in some instances, engaged in validating the owner's business case as it relates to their scope of work. Owing to the extensive level of specialization in construction processes, the trade contractors have also proven to be invaluable in reviewing designs developed from the conceptual stage to the end of the design development process. The reviews are accompanied by cost models and estimates based on the level of the design. These inputs help owners and designers to determine the

constructability and alignment of design with construction needs. Trade contractors can be involved either as design-assist contractors for specific trade (Kelly, 2014), in other instances, trades serve as the designers of record. In addition to design development and design reviews, trade contractors inform the project team on construction aspects that might influence the feasibility of the proposed project based on factors such as location, site characteristics, or facility type.

As the design progresses, the trade partners generate cost estimates and schedules to ensure the design remains within the cost targets and can be implemented within the stated time frame. Upon the development of detailed systems information, trade contractors contribute to the detailed design stage by developing system and fabrication models for their scope of work and coordinating these with other trade partners to eliminate overlaps, clashes, or errors in the initial designs. The models are further developed during the construction detailing stage to capture all the aspects of the construction required for prefabrication and construction onsite. In projects with energy performance targets, the trade subcontractors are responsible for advising on energy-efficient alternatives and informing on detailed equipment selection data, including their cost, labor requirements, construction space, and sequencing requirements, and in some instances, generate designs for the selected options. Models serve as a potential point of handoff and collaborative engagement to plan responsibilities, share information, and transition from conceptual to fabrication level of detail as trades take greater responsibilities in later design stages.

Limitations in early trade contractors design involvement

Even with resources and documents that focus on tangible case studies or requirements, the value and responsibility of trade contractors in the design phase are vague, resulting in the possibility of being overlooked. The responsibilities, including the engaging in model detailing, production plans that inform cost and schedule impacts of the trades, have also been generalized, failing to connect the specific value intended at each stage with input required to support the fulfillment of the responsibilities. Selection of trades is typically based on their experience with similar project or previous relationship with the owner, architect, or the general contractor and supplemented with the value of bids, expertise, technical competencies, key personnel, and ability to work in a collaborative project environment. The knowledge and skills expected to achieve the ‘experience’ that is analyzed in these selection criteria is not explicit. Owners and design team members therefore lack a clear point of reference on which knowledge areas, skills or abilities are likely to translate to successful design influence by the trade contractors.

Although the industry is trying to adopt and promote early involvement of trade contractors in the design process, practitioners expressed existence of bottlenecks such as regulatory limitations, and project contracting mechanisms that limit the uptake of early trade partner involvement. Legal stipulations, for instance the quoted Pennsylvania separation Act, limit the construction teams from being involved in the design process by mandating competitive bidding and awarding the project to the lowest responsible bidders. In this case, the trades become hesitant in engaging in the design process as this does not guarantee the award of the construction scope of the project.

Industry practices such as the dominant design-bid-build mentality contribute to significantly lower inclusion of trade partners early in the process as it separates the design and construction. Another emerging challenge was the lack of processes and guidelines for early engagement of trade has also been identified as a hinderance to the progress of this practice. These

challenges uncover further areas that research needs to address to support involvement of trade contractors in the design process.

5. Implications for practice and scholarship

It is evident that the design team and owner engage trade contractors early when the scope of work at risk is large or the systems present complexities that require specialized knowledge that trade contractors acquire from hands-on construction experience. In such instances, the value of early engagement becomes apparent. The designers and owners acknowledge that trade contractors add value to the design process by refining designs from the conceptual stage to the detailed construction detailing, providing input on construction process considerations that need to be included in the design. They also provide insights on alternatives that can save the team costs, reduce construction durations, reduce energy demands, achieve sustainability targets, or easily comply with regulatory requirements based on their extensive knowledge of different product options. The ability of these trades to efficiently generate the cost implications of each design decision helps the project designers adhere to project targets without compromising on the quality and client's desired values. If sufficient planning for early engagement is not defined beforehand, project teams end up taking a reactive involvement approach, resulting in missed opportunities to benefit from these values.

However, even with resources and documents that focus on tangible case studies or requirements, the value and responsibilities for trade contractors in the design phase are vague, resulting in the possibility of being overlooked by the owner and designers. The responsibilities, including the design deliverables for the trades, have also been generalized, failing to connect the value intended at each stage with input required to support the fulfilment of the responsibilities. Owners and the design teams therefore lack a point of reference on which knowledge areas, skills or abilities are likely to translate to successful design influence by the trade contractors. These identified inconsistencies require further analysis.

Currently, the value of having trades early in the project is still vaguely defined, while their responsibilities and deliverables are presented in a generic manner. These areas present an opportunity for future research. As part of future work, a trade contractor design involvement process model for defining the value of early trade contractors' engagement will be developed.

6. Conclusion

Aligning design efforts with construction needs can support better design outcomes and enhance design efficiency and productivity during construction. However, research on how to involve the construction team early in the design process, specifically trade contractors, is scarce. This study started to identify the value of early trade contractors' involvement and the gaps in current research and practice. The key trades involved, the timing of engagement, some broad responsibilities, and tasks these trades work towards in collaboration with the owners, designers, and general contractors were identified. Secondary case studies, peer-reviewed publications, and industry design process guides were synthesized to identify the value of early involvement of trades. It is evident that the design team and owner engage trade contractors early when the scope of work at risk is large or the systems present complexities that require specialized knowledge that trade contractors acquire from hands-on construction experience. However, rarely are these attributes clear and apparent across the project team regarding when and how to engage trade contractors.

When engaged early, trade contractors can help refine designs from the conceptual stage to the detailed construction detailing, providing input on construction process considerations that need to be included in the design. They provide insights on alternatives that can save the team costs, reduce construction durations, reduce energy demands, achieve sustainability targets, or comply with regulatory requirements based on their knowledge of systems and product options. The ability of these trades to more accurately generate the costs associated with each design decision helps the project designers to adhere to project targets without compromising on the quality and the client's desired values. However, if the planning for early engagement is not defined beforehand, the team takes a reactive approach, resulting in missed opportunities. Currently, the value of having trades early in the project is still vaguely defined, while their responsibilities and deliverables are presented in a generic manner. This study presents the trades' responsibilities, and deliverables during early involvement and aligns these with design stages to guide in definition of the process of engaging trade contractors in the project. As part of future work, a trade contractor design involvement process model for defining the value of early trade contractors' engagement will be developed.

7. References

Ahmed, S., & El-Sayegh, S. (2020). Critical Review of the Evolution of Project Delivery Methods in the Construction Industry. *Buildings*, *11*(1), 11. https://doi.org/10.3390/buildings11010011

AIA, AIA Minnesota, & University of Minnesota. (2012). *IPD Case Studies. New version*.

Anguera, M. T., Blanco-Villaseñor, A., Losada, J. L., Sánchez-Algarra, P., & Onwuegbuzie, A. J. (2018). Revisiting the difference between mixed methods and multimethods: Is it all in the name? *Quality and Quantity*, *52*(6), 2757–2770. https://doi.org/10.1007/s11135-018-0700-2

Bahnson, M., & Berdanier, C. G. P. (2023). *A Qualitative Methods Primer: A Resource to Assist Engineering Education Scholars in Mentoring Traditionally Trained Engineering Faculty to Educational Research a Qualitative Methods Primer: A Resource to Assist Engineering Education Scholars in Mentoring Traditionally Trained Engineering Faculty to Educational Research*.

Choi, J., Yun, S., Leite, F., & Mulva, S. P. (2019). Team Integration and Owner Satisfaction: Comparing Integrated Project Delivery with Construction Management at Risk in Health Care Projects. *Journal of Management in Engineering*, *35*(1). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000654

Costa, F., Denis Granja, A., Fregola, A., Picchi, F., & Portioli Staudacher, A. (2019). Understanding the Relative Importance of Barriers to Improving the Customer–Supplier Relationship within Construction Supply Chains Using DEMATEL Technique. *Journal of Management in Engineering*, *35*(3). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000680

de Graaf, R., Pater, R., & Voordijk, H. (2023). Level of sub-contracting design responsibilities in design and construct civil engineering bridge projects. *Frontiers in Engineering and Built Environment*, *3*(3), 192–205. https://doi.org/10.1108/FEBE-12-2022-0045

Diab, M., Gebken, R. J., & Mehany, M. S. H. (2020). Strategies to Leverage Contractor Experience. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *12*(3). https://doi.org/10.1061/(ASCE)LA.1943-4170.0000396

Elsayegh, A., & El-adaway, I. H. (2021). Holistic Study and Analysis of Factors Affecting Collaborative Planning in Construction. *Journal of Construction Engineering and Management*, *147*(4). https://doi.org/10.1061/(ASCE)CO.1943-7862.0002031

Ferstad, H. K., Engebø, A., Slette, P. A., & Lædre, O. (2023). *Strategic Partnering Between Client, Contractor, and Subcontractor*. 1674–1685. https://doi.org/10.24928/2023/0155

Franz, B., Molenaar, K. R., & Roberts, B. A. M. (2020). Revisiting Project Delivery System Performance from 1998 to 2018. *Journal of Construction Engineering and Management*, *146*(9). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001896

Franz, B. W., & Leicht, R. M. (2016). An alternative classification of project delivery methods used in the United States building construction industry. *Construction Management and Economics*, *34*(3), 160–173. https://doi.org/10.1080/01446193.2016.1183800

Franz, B. W., Leicht, R. M., & Riley, D. R. (2013). Project Impacts of Specialty Mechanical Contractor Design Involvement in the Health Care Industry: Comparative Case Study. *Journal of Construction Engineering and Management*, *139*(9), 1091–1097. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000723

Gil, N., Tommelein, I. D., Kirkendall, R. L., & Ballard, G. (2001). Leveraging specialty-contractor knowledge in design-build organizations. *Engineering, Construction and Architectural Management*, *8*(5/6), 355–367. https://doi.org/10.1108/eb021196

IPDA, & LCI. (2016). *MOTIVATION AND MEANS: How and Why IPD and Lean Lead to Success*.

Johansen, A., Engbo, A., Torp, O., & Kalsaas, B. T. (2021). Development of target cost - By the owner or together with Contractors - Target Value Design. *Procedia Computer Science*, *181*, 1171–1178. https://doi.org/10.1016/j.procs.2021.01.314

Kelly, D. (2014). Examination of Design-Assist Subcontracting. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *6*(3). https://doi.org/10.1061/(ASCE)LA.1943-4170.0000143

Khouja, A., Lehoux, N., Cimon, Y., & Cloutier, C. (2021). Collaborative Interorganizational Relationships in a Project-Based Industry. *Buildings*, *11*(11), 502. https://doi.org/10.3390/buildings11110502

Stephane Denerolle. (2013). *The application of Target Value Design to the design phase of 3 hospital projects*.

Sukhera, J. (2022). Narrative Reviews: Flexible, Rigorous, and Practical. *Journal of Graduate Medical Education*, *14*(4), 414–417. https://doi.org/10.4300/JGME-D-22-00480.1

University of Minnesota, IPDA, & LCI. (2016). *MOTIVATION AND MEANS: How and Why IPD and Lean Lead to Success*.

Yin, R. K. (2018). *Case Study Research and Applications. Design and Methods* (6th ed.). SAGE Publications, Inc.