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Project Owner Satisfaction Forecasting through Longitudinal Monitoring of Project Team Attributes

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Abstract

Applying project team success to forecast a building project's outcomes is challenging due to the presence of a large number of variables in building's owner goals, program types, and project team composition. However, studying the dynamic interactions of team integration with the project outcomes, which can be represented by owner satisfaction, provides evidence of a meaningful relationship between the success of a project with regard to budget, quality, and schedule. Herein, the association of team integration and group cohesion with the success of project outcomes in terms of owner satisfaction is studied. This purpose was accomplished through regularly gathered information from project teams throughout the project design and construction, followed by the one-time after-completion survey of building owners to understand how and why snapshots of team interactions or dynamics lead to satisfaction perceived by owners. For the seven completed projects with different integration levels, building outcome was measured by owner satisfaction as a proxy for project success. The findings reveal that better team integration can lead to higher owner satisfaction, suggesting teams that are regularly rated high on factors related to strong team culture, such as, "clarity of role" and, "project manager leadership," are also likely to be rated higher by owners for successful building outcomes. Additionally, projects with more consistent responses across survey categories are more likely to be rated highly by owners. This finding creates an opportunity for planning and managing teams. For those project teams who have been consistent and rated higher in their survey responses, we can expect higher levels of team integration, group cohesion, and, ultimately, owner satisfaction with the overall building results. Consequently, this study offers the potential for in-progress team dynamics measures to help forecast owners' perceptions of their project outcomes.

Keywords:

Project Team Integration, Forecasting Success Outcomes, Owner Satisfaction.

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INTRODUCTION

The fragmentation of project delivery methods has been consistently cited as one of the main challenges in developing high-performance outcomes in construction projects (Ibrahim et al., 2011). The traditional approach fails to encourage integration and communication among project team members to overcome this fragmentation (Ahmed and El-Sayegh, 2021) and further leads to adversarial relationships among the parties (Meng, 2012). This potential for confrontational behavior causes project participants to pursue transfer risks to others rather than manage them directly (Forgues and Koskela, 2009). As a result, the fragmented process and passing of risk associated with traditional agreements negatively affect team dynamics (Asadian and Leicht, 2022), resulting in mistrust and a lack of transparency among project participants. In the ensuing "blame culture," team members try to minimize their level of exposure to poor performance instead of working together in the light of trust, cooperation, and collaboration (Baiden et al., 2006).

Because fragmentation is such an important yet difficult challenge, the industry has sought to improve its performance and efficiency by introducing new ideas, along with various improvement tools and methods. The introduction of more integrative delivery methods, such as Design-Build (DB) and Integrated Project Delivery (IPD), has shifted the construction industry towards more collaborative approaches. To this end, team integration has been suggested as a driving factor of the industry's necessary changes to become more successful in numerous studies (Baiden and Price, 2011; Franz et al., 2017; Ibrahim et al., 2011; Koolwijk et al., 2018; Laurent and Leicht, 2019). As a result, the concept of "team integration" in the construction industry, which has been adopted primarily to improve project delivery processes (Baiden et al., 2003; Jørgensen and Emmitt, 2009), has gained attention in recent years.

The impact of team integration on project outcomes can be studied from various perspectives, such as project performance indicators, including time, cost, quality, safety, and client satisfaction. According to Demirkesen and Ozorhon (2017), a major portion of existing research studies has previously portrayed the critical role of effective integration in project management research. However, they highlighted that these studies lack a thorough understanding of the relationship between integration and project performance, which can result in project management failures. In a similar vein, Kelly and Ilozor (2020) pointed out that a limited number of articles examine the relationship between integration and project performance outcomes. Despite this, studies have been conducted in the construction sector evaluating the performance of projects utilizing a more collaborative and integrated style of delivering a project. For example, El Asmar et al. (2013) assessed that IPD projects provide statistically significant improvements in 14 metrics across six performance areas, including quality, schedule, project changes, stakeholders communication, environmental, and financial performance.

In one of the comprehensive studies in this domain, Franz et al. (2017) showed how team integration is linked with the success of project outcomes for budget, quality, and schedule. The study demonstrated that the selected project delivery method significantly affected team integration and group cohesion, ultimately showing empirical impacts on project performance. Expanding on Konchar and Sanvido's (1998) early project delivery work, this research showed that the project delivery decisions influence how the team interacts in terms of collaborative processes, information sharing, including the use of BIM, and developing effective, cohesive teams. Furthermore, their findings revealed that owners perceived their turnover experience and building system quality as being higher for cohesive teams.

Similarly, Barutha et al. (2018) evaluated the industrial project's performance when more collaboration and integration strategies were adopted. Their study findings revealed that as the degree of collaboration and integration increases, the project performance increases directly by minimizing uncertainties about project outcomes. Thus, they suggested that more collaborative and integrated delivery methods lead to higher certainty of overall project performance on industrial projects, increasing the likelihood of meeting stakeholder business objectives.

Despite studies focusing on the impact of team dynamics, namely collaboration and integration, on project outcomes, such as cost, schedule, and design quality (Kelly and Ilozor, 2020), tangible examples of how team integration is related to the owners' perception and satisfaction are limited. For instance, to our knowledge, Choi et al. (2019) are one of few researchers who specifically investigated how project delivery methods and team integration affect the owner's perception of project outcomes. They examined the difference in team integration in the two alternative project delivery methods, IPD and construction management at risk (CMR), using 17 healthcare projects. This study further supports the notion that higher team integration can be achieved by IPD, compared to CMR, leading to higher owner satisfaction with project outcomes. However, although they adopted owner satisfaction as the indicator of project outcomes, they conducted their analysis based on the after-completion data for selected projects. Hence, monitoring the team characteristics related to the project outcomes while the project is progressing seems to be a missing point in this realm. This data collection strategy can be seen in most project delivery studies. They have concentrated on one-time observation at the end of the project or following completion to capture the project outcome data, such as cost or schedule details.

It can be observed that even though previous studies suggest a relationship between project team attributes and owner satisfaction, the in-progress monitoring of team performance is yet to be demonstrated. It is possible that project participants from successful projects recall team interactions as being more collaborative or positive than they were, in the moment. This indicates that monitoring teams' performance as they occur would provide a more accurate understanding of how a team interacts. Moreover, the quality of team interactions may provide an early indication of (i.e., a leading indicator) the project's performance, which can be helpful

in ensuring that desired outcomes would be achieved by the project completion. As a step towards filling this gap, the present study investigates the relationship of team integration with the success of project outcomes for owner satisfaction through regularly gathered information from project teams *during* the process of design and construction of projects, in addition to the one-time survey of building owners after project completion. The authors are of the opinion that both in-progress and after-completion studies of a project team are complementary activities that can bring valuable data that begins to show how team indicators during the project relate to overall satisfaction perceived by owners. Eventually, the research proposed that examining the relationships and interactions of team integration can be used to forecast owner satisfaction.

LITERATURE REVIEW

To address the need for in-progress versus post-completion assessment of project teams, we begin with the fragmented nature of traditional project delivery systems as a root cause of disaggregation among involved parties. Following this, integration as a collaborative relationship leading to enhanced outcomes is studied. Based on the analysis of both the traditional and the collaborative approaches within the existing literature, success indicators of project outcomes are identified to address the gaps of previous studies regarding efforts to empirically link in-progress team performance data with overall project success, specifically owner satisfaction.

Fragmentation of the construction industry

A typical construction project brings several different organizations together to form "the construction team," which is responsible for different phases of the project, such as design and construction (Alshawi and Faraj, 2002). Consequently, the team may prefer to focus on their organizational goals rather than their collective ability to work together effectively, resulting in the fragmentation in the construction project participants (Baiden et al., 2006). In other words, poor collaboration, inherent in traditional contracts, often leads to distrust and conflicts in project teams resulting in poor project performance (Dewulf and Kadefors, 2012). In this circumstance, different teams may not be able to work together as an integrated entity to deliver projects effectively.

The inability of project participants to work together often results in poor performance and product quality (Evbuomwan and Anumba, 1998). Project cost overruns are among other consequences of poor integration (El Asmar et al., 2009). The low degree of integration between design and production functions is also a significant factor limiting innovation and advancing technology in construction projects (Nam and Tatum, 1992). Arditi et al. (2002) further identified that failure of integration between project teams in the early phases could lead to planning problems, delays, and disputes during the construction process, harming the overall project outcomes.

The "Integrating construction resources and technology into engineering report" (1982)

enumerated some barriers that prevent integration, such as:

- owners' resistance because they assume extra costs would be required;
- traditional roles of construction personnel not familiar with working in the design office;
- reluctance of architects and engineers to accept constructability input,
- lack of qualified personnel, training programs, and incentives; and,
- lack of awareness of the potential benefits.

To move from these challenges toward more collaborative interactions, integrated approaches have been introduced to the industry. In contrast to the design-bid-build (DBB) project delivery, the design phase is no longer treated as a separate activity from the construction phase. Instead, a construction project is viewed as a collaborative venture involving several different organizations in the form of ‘‘the construction project team’’ responsible for the project’s design and construction that aims at achieving the common objective of delivering a project (Forgues and Koskela, 2009).

One of the prominent examples of this kind of relational contract in the U.S. is Integrated Project Delivery (IPD), whose main objective is to increase the likelihood of success by promoting trust, cooperation, and teamwork and reducing waste, inefficiency, and adversarial relationship (Leicht et al., 2015). Among several IPD principles identified from the previous literature, multi-party contracts, shared risk and rewards, early involvement of key participants, collaborative decision-making and control, and jointly developed goals have contributed towards the better developing of integrated teams (Ahmed and El-Sayegh, 2021; Ghassemi and Becerik-Gerber, 2011). Alignment of the parties' interests with the success of the project helps build trust, align risk and reward through mutually agreed scopes, and improve transparency which has been linked to both improved trust within the team (Pishdad-Bozorgi and Beliveau, 2016) and noticeably improved project outcomes (Cheng and Johnson, 2016).

According to Choi et al. (2019), researchers have reported successful project outcomes derived from IPD projects, recognizing IPD as a delivery method to overcome problems in the construction industry, such as adversarial relationships, inefficiency, fragmentation, and lack of trust. Cooperative and collaborative approaches, such as the integration found in IPD, can bring successful project outcomes through building the team and the culture of integration. In the following sections, the dynamic interaction of team integration and project success is studied.

Team integration and collaborative interaction

Two terms, “team” and “group,” are often applied interchangeably in the construction domain (Fisher and Hunter, 1997). Some scholars differ in their opinions about their common characteristics, such as membership, norms, and cohesion, the distinction between both terms is often unclear (Nawi et al., 2011). In support of this statement, Baiden et al. (2006) argued that

bringing people together would not necessarily ensure they would function well as a team.

In the critical literature review conducted by Nawi and his colleagues in 2011 regarding the concept of team integration in industrialized building systems (IBS), "group" was defined as a "collection of individually skilled people put together for a purpose, and members share information to reinforce individual performance towards achieving their goals, and thus their performance is usually a function of what its members achieve individually" (Nawi et al., 2011). Having tasked with a specific and clear purpose and a common goal, the group then develops into a "team" (Higgs et al., 2005). Therefore, it can be concluded that a team can be simply considered as a group with some additional attributes, specifically: interdependency in their tasks, shared responsibility for outcomes, being seen by others as an intact social entity embedded in one or larger social systems, and managing their relationships across organizational boundaries (Nawi et al., 2011). Correspondingly, Katzenbach and Smith (2015) described a "True Team" as a small group of people who have complementary skills and are committed to a common purpose and performance goals. They also commit to an approach for which they hold themselves mutually accountable. Within the three aspects of accountability, commitment, and skills, they emphasized five crucial elements for teams: (1) complementary skills; (2) commitment; (3) specific goals and meaningful purpose; (4) common approach; and (5) mutual accountability (Katzenbach and Smith 2015).

A process for gathering the collective strength of all the team members together so that team members' efforts surpass individual or group efforts is required to achieve the success of the project. In this respect, the word "integration" has been widely employed to describe the concept of freely exchanging information in the construction process between different participants, bringing a collaborative work environment culture (Laurent and Leicht, 2019). Several researchers proposed various definitions for integration; each concentrates on a different aspect of this concept. For instance, Baiden and Price (2011) defined team integration as a condition in which different organizations with different goals and cultures merge to shape a single cohesive and mutually supporting unit with the collaborative alignment of processes and cultures. On the other hand, Koolwijk et al. (2018) referred to integration as practices, such as the shared use of a building information model or using a shared office, performed at a project level and allow face-to-face communication.

Critical indicators of team integration from the literature review are summarized in Table 1. Based on the common aspects of previous studies, it can be argued that the culture of trust and respect without any blame, focusing on single goals and objectives, communication and smooth flow of information, mutually beneficial goals, collective understanding, having equal opportunity for project inputs, and seamless operation with no defined organizational boundaries are the most frequently used indicators in the construction industry, which are identified by the gray rows in Table 1.

Table 1: Indicators of team integration

Indicators	(Nam and Tatum 1992)	(Love et al. 1998)	(Moore et al. 1999)	(Dainty et al. 2001)	(Anumba et al. 2002)	(Baiden et al. 2003)	(Bromley et al. 2003)	(Baiden et al. 2006)	(Forgues and Koskela 2009)	(Cheng et al. 2010)	(Ibrahim et al. 2011)	(Korkmaz et al. 2013)	(Koolwijk et al. 2018)	Frequency of Use
Seamless operation	x	x						x	x		x			5
Communication		x		x						x	x	x	x	6
Sharing Information			x				x	x		x	x		x	6
Trust and respect	x		x	x				x	x	x	x		x	8
Collective understanding	x	x						x	x		x		x	6
Commitment from top management				x							x	x		3
No blame culture				x			x	x			x			4
Team flexibility						x		x			x			3
Owner involvement and leadership	x													1
Maintaining long-term business relationship	x												x	2
Having a single focus and objective		x	x			x	x	x	x			x		7
Mutually beneficial outcomes		x		x	x	x		x					x	6
Accuracy in predicting time and cost					x	x		x						3
Creation of co-located team							x	x		x			x	4
Equal opportunity for project inputs		x	x			x	x	x						5
Innovation and improvement									x					1
Integrated ICT systems		x								x			x	3

As Table 1 highlights, in one of the first research efforts in this area, Nam and Tatum (1992) listed means of integration in the U.S. construction industry in three main categories: Organizational Integration, Contractual Integration, and Information Integration. They stated that while organizational integration of design and production functions physically in one organizational boundary under joint leadership, contractual integration works between different organizations for a relatively short time to achieve a high-level goal defined within the project team. The Design-Build approach can be called an example of organizational integration with the advantage of offering close cooperation between design and construction. Furthermore, information integration is applied within both organizations as well as across organizations to enhance coordination and efficiency.

Jafaari and Manivong (1999) and Austin et al. (2002) considered integration as merging different disciplines with different goals, needs, and cultures into a cohesive and mutually supporting unit to undertake a single task. This means that different company processes, as well as organizational cultures, have to be aligned collaboratively with the objective of improving team culture and professional attitudes (Dainty et al., 2001). In one of the most comprehensive works conducted in this area, Baiden and colleagues investigated the extent of integration achieved by award-winning construction project teams (Baiden et al., 2006). They explored the practices within teams that lead to full integration, partial

integration, or fragmented working. Based on their literature review, the indicators for a fully integrated construction team were introduced as follows:

- Having a single focus and objectives for the project,
- Operates without boundaries among the various organization members,
- Works towards mutually beneficial outcomes by sharing achievements throughout the team,
- Predicts time and cost estimates more accurately through gathering collective expertise,
- Shares information freely among its members,
- Provides a flexible member composition that is capable of responding to change,
- Sharing a new identity and is co-located, usually in a given common space,
- Offers its members equal opportunities to contribute to the delivery process,
- Operates in an atmosphere where relationships are based on trust and respect, and
- It has a ‘‘no blame’’ culture.

Nawi et al. (2011) defined integrative design development as bringing all multi-disciplinary teams and functional backgrounds together, working in a structured, consistent, and simultaneous approach to achieve a more efficient and high-performance project. To further reinforce this argument, Othman et al. (2016) stated that an integration culture is required to bring project delivery teams to work together in an effective manner. This team can claim that they accumulate multi-disciplinary skills and knowledge of team members together and remove the traditionally adversarial relationship in a way that improves the effectiveness of project delivery. This is the definition of integration applied for the purpose of this study.

Table 1 illustrates how previous studies have identified a variety of indicators for team integration. However, we should point out that the indicators identified in these studies can be classified into two main categories, formative and reflective. In reflective models, the construct cannot be directly measured; rather, indicators are used as a substitute. This type of indicator involves variables that are believed to be affected by the construct in question (thus making them "reflective" of the construct), such as in the study conducted by Franz et al. (2017). As a result, causality passes from the construct to the indicator. Alternatively, if we consider formative indicators, as summarized in Table 1, the construct can be represented by some linear combination of indicators (thus "forming" it). The causality goes from indicators to constructs in these cases. Since, in the present study, we want to investigate the possible relationship between team integration and owner satisfaction, formative indicators seem more appropriate to examine causality between team performance and project success, namely owner satisfaction.

It should be noted that integration could bring benefits such as cost and schedule reduction, improve the design and construction relationship, optimizing design details and sequence to meet construction's needs, incorporating construction technology and innovation into the design, developing work-simplifying methods, and minimizing labor-

intensive designs (Nam & Tatum, 1992). In this context, previous research studies have shown that team integration has significant potential for considerable project performance improvements (Baiden and Price, 2011), and researchers have shown successful project outcomes derived from integration in the literature (Azhar et al., 2015; El Asmar et al., 2016; Manata et al., 2018). However, despite these studies, the links between team integration and project outcomes, specifically focus on owner perception and satisfaction, have received less attention. Previous studies mainly emphasized quantifiable result-oriented measures to assess project performance, including actual/planned cost and schedule, rework cost, and change (Choi et al., 2019). It is while that owner satisfaction with project outcomes is also a critical criterion of project success. Through literature review, to the best of our knowledge, the study conducted by Choi et al. (2019) is the only research that specifically investigated how project delivery methods and team integration affect the owner perception of project outcomes. This study examined the links between team integration and satisfaction perceived by owners with reference to project delivery methods focusing on health care projects. The findings highlighted that higher team integration achieved by IPD leads to higher owner satisfaction with project outcomes. However, while Choi et al.'s study concentrated on the relationship between team integration and owner satisfaction, the investigation was conducted through a post hoc study of completed projects, like most project delivery studies that have concentrated on one-time observation at the end of the project in order to capture the project outcome. None sample a pool of teams, compare the project integration, and then study the resulting successes or difficulties from the owner's perspective.

Success factors of project outcomes

The definition of a successful project has attracted a great deal of attention among scholars from the very beginning of emerging project management principles. Early research efforts identified the triple measurement set of cost, time, and quality as the project success benchmarks (Jaafari and Manivong, 1999). Based on this attitude, a project is considered successful if it can be completed within the estimated budget and initially scheduled time frame while meeting the expected quality. Whereas the application of these tangible assets as success criteria in both research and practice is justified by their relative simplicity, they do not capture the full picture of project results (Lehtiranta et al., 2012). This tridimensional measurement of hard outcomes has been suggested to be too simplistic in the context of evolving industries as it ignores the importance of soft outcomes, such as owner satisfaction, employee development, and employee satisfaction (Hackman and Lorsch, 1987). Several dimensions of project success, such as long-term business success, learning, meeting the scope defined, team satisfaction, safety, and absence of legal claims, have been introduced (Chan and Chan 2004; Sanvido et al. 1992). Considering these performance criteria in evaluating project outcomes can provide a better assessment of project success. It should be noted that there have been studies on the interrelationship of these factors (Ibrahim et al., 2011). As an illustration, completing a project within the defined scope and budget by applying proper

cost management skills would contribute to the owner's satisfaction.

Among all these indicators, the relationship of people management, like project team factors, has needed a more in-depth examination of project success drivers (Pinto, 2002). Despite the importance of assessing the project outcomes based on soft factors, the literature reveals that there are significant gaps in this area. Scott-Young and Samson (2008) discussed that there are few quantitative research studies of the impact project team management practices have on project performance. They also stated that the remarkable proportion of previous studies is more inclined toward only a limited number of project team-related success factors, necessitating the development of more comprehensive team models to prioritize the relative importance of team-related success factors (Scott-Young and Samson, 2008). Research conducted by Franz et al. (2017) confirmed this argument by describing practices, such as design charrettes, colocation, and joint development of project goals, as having an influence on project success.

Previous studies shed light on the fact that the owner's satisfaction has always played a pivotal role in assessing project success. Jugdev and Muller (2005) contend that the academic literature has been increasingly incorporating client satisfaction as a variable in determining project success for over four decades, both at the end of a project and during a product's lifecycle. Therefore, from a holistic perspective, client satisfaction and project success are closely related. According to Lehtiranta et al. (2012), a common way to measure success based on overall goals is to quantify client satisfaction. In the same fashion, when assessing project management's success and identifying areas of concern, El-Sheikh and Pryke (2010) equate client satisfaction essentially as synonymous with project success. Correspondingly, Griffis and Bates (2006) expressed that the owner, who is considered the ultimate decision-making authority, is more likely to have an objective perception of the organizational performance of a project compared to other parties (e.g., contractors or suppliers). In addition, the project cannot be considered an achievement if the owner is not pleased with the final product's performance. As a result, this study focuses on the team integration impact against a wide range of assessment criteria for evaluating the owner's overall satisfaction. Six areas proposed by Konchar and Sanvido (1998) and confirmed by Franz and Leicht (2016) to define the degree to which the facility met the expected requirements of the owner are used for this purpose (Konchar & Sanvido, 1998) as follows:

- **Turnover quality measures**
  - difficulty of facility startup,
  - number and magnitude of callbacks, and
  - operation and maintenance cost
- **System quality measures**
  - performance of the envelope, roof, structure, and foundation;
  - performance of the interior space and layout; and
  - performance of environmental systems

These indicators are employed for the purpose of the study, through which the overall level of owner satisfaction related to

the design and construction process could be evaluated. The multi-disciplinary search of both the team characteristics, such as integration and project success factor literature, formed the basis for data collection in support of the research evaluating team dynamics and project outcomes. The review has further shown a lack of research linking team health or related factors based on in-progress monitoring to project outcomes. To further explore these, it was necessary to identify instruments that would effectively capture the data about the performance of teams and their composition concerning the level of the owner's satisfaction.

RESEARCH APPROACH

This study aims to explore the relationship between team integration *during* project design and construction with project outcomes, focusing on the owner's satisfaction. To address this goal, the study approach couples two methods. First, the in-progress evaluation of selected projects related to the team characteristics was conducted with the aid of team health surveys. For this purpose, a longitudinal approach was employed to address the research question to investigate team integration during the project progress. In addition to these data, owners' satisfaction, building on the questionnaire results, was collected to identify the impact of team integration on project outcomes.

Data Collection Procedure

Essentially, longitudinal research measures the same variables repeatedly over time in the same population at recurring intervals. Due to their ability to trace patterns of change over time, longitudinal data are particularly useful and necessary for causal studies of individual behavior, providing a true picture of cause and effect. As social processes have become increasingly complex, longitudinal data is essential for establishing temporal order, measuring changes, and making more informed causal interpretations (Rajulton 2001). For this reason, longitudinal data seemed appropriate for the purpose of this study to capture the dynamic nature of team performance. To this end, snapshots of project performance during the project provide longitudinal data for in-progress monitoring of team characteristics for each project. The in-progress monitoring scenario would allow the research to track projects in real-time and make appropriate adjustments along the way. It is also helpful in capturing the dynamic nature of the variables, namely team performance (Ployhart and Vandenberg, 2010). Simultaneously, the questionnaire from Franz et al. (2017) was selected to capture relevant information on the project owners' perceptions of quality at the completion of each project. Using the combination of these two methods assist the authors in collecting empirical data during the progress of building projects, in addition to owners' satisfaction data from completed projects.

In the mixed-method approach of this research methodology, Qualtrics Survey Software was used as a tool to conduct online behavioral research. As Barnhoorn et al. (2015) stated, this tool facilitates data collection so that the high numbers of participants be tested at a low cost and in a short amount of time. The user-friendly interface of Qualtrics is also another factor that made it a good option for this research.

The projects selected to collect empirical data were identified through two large firms: one architecture/planning and one general contractor. The two firms had several projects in common, and the selection of projects for the study was limited to overlapping projects. The decision to limit data collection to projects from these two firms was made to control the impact of some influential factors, such as organizational structure and company culture, on the final result. It is evident that these factors can affect the project outcomes in various dimensions; hence, by maintaining consistent firms for all cases, we could be more confident that any effects observed would have a limited influence by these outside cultural factors on the study findings.

At the beginning of the research, 23 projects were initially chosen from a range of geographic locations, project types, and sizes. All of these projects were located in different areas within the U.S. As demonstrated in Figure 1, the sample was geographically diversified and did not focus on any single region of the country.

Figure 1: Project locations

Construction start time in a fourteen-month window (from April 2014 to June 2015) was a common factor across projects, ensuring information could be gathered in a limited range of time and over similar project stages. Projects were all building projects drawn from a range of market sectors, including justice/ civic, higher education, health care, sports, hospitality, and corporate.

As shown in Figure 2, from the 23 projects that were initially chosen, a sub-group of 17 completed projects that collect some in-progress data forms the initial data set in this study, with a subset of 7 projects where the owners completed surveys about their satisfaction. These seven projects, which include both in-progress data and after-completion owner satisfaction survey data, formed the final data set for the study's analysis. These seven selected projects are summarized in Table 2.

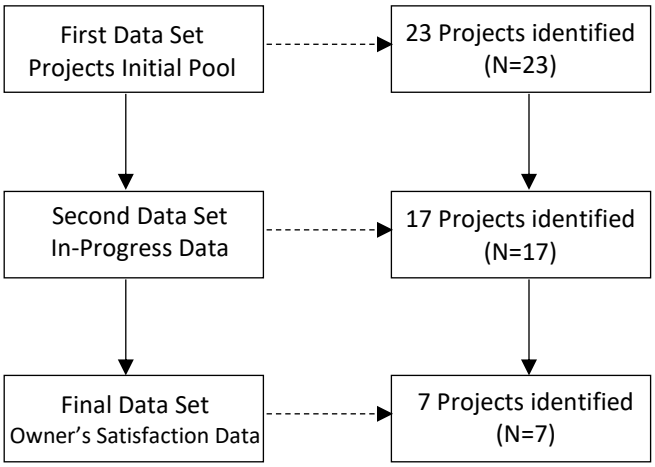


Figure 2: Three stages for project selection

Table 2: Case studies

Project ID	Project Information			Organization	Class
	Project Location (State)	Funding source	% New Construction	Type of contract	Level of Integration*
C02	Minnesota	Public	77%	CMR	II
C03	Arizona	Public	100%	CMR	II
C07	Nebraska	Public	100%	CMR	II
C09	Oregon	Public	100%	CMR	II
C11	Kansas	Public	40%	CMR	II
C13	Wyoming	Public	100%	CMR	II
C10	Minnesota	Public	100%	DB	V

*Class is based upon Franz et al. (2016) definitions and categorizations of integration based upon project delivery method decisions.

As can be seen in Table 2, all of these projects were publicly funded. The majority of contracts used are construction management at risk, with only one design-build contract among them. An alternative classification of project delivery methods (Figure 3) proposed by Franz and Leicht (2016) was employed to classify the project teams into five classes of integration based upon their project delivery

methods, the timing of construction manager involvement, the timing of trade contractor selection, payment terms, and the selection processes used for the construction manager and trade contractors.

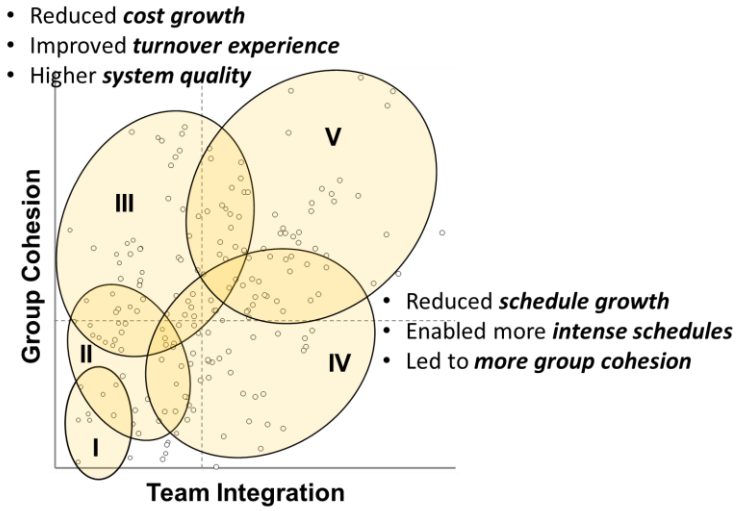


Figure 3: Team classification (Graphic from Maximizing Success)

Only one of the projects fell into Class V, and the other six were all Class II. Based on this research study, Class II projects follow a project delivery strategy that reduces the pool of bidders competing for the project based on their qualifications. The owner consistently used separate contracts for design and construction services, always hiring the builder and specialty trades after the Schematic Design phase. As a result of this contracting approach, this class has the highest probability of prequalification for the builder and specialty trades before selection. The selection criteria are predominantly cost-based, making lump sum contract terms the most common for the builder. The Class V project generally uses a single responsibility contract, contracting with the builder during the Schematic Design or earlier. A prequalification step reduced the pools of both the builder and specialty trades during procurement, and each was selected primarily on qualification-based criteria with an open book, reimbursable contract through the design phase.

Having classified each project, both dependent and independent variables were identified from the literature and applied in this work. The dependent variables are project outcomes that reflect the measured performance or success of the project based on the owner's perception. The independent variables are those factors, such as team characteristics and behavior, which can change between projects and impact performance outcomes. Independent variables will be used to identify the scale of changes in dependent variables (e.g., quality and owner satisfaction). The questionnaire was taken from a team performance study conducted by Franz et al. (2017) in the "Owner's Guide to Maximizing Success in Integrated Projects" research and consisted of eleven sections. However, the focus of this research was on project quality, team characteristics and behavior. All questions were rated on a 6-degree Likert scale in which six (6) was high, and one (1) was low.

The participants of this survey were selected from both the design team and the

construction team. Both teams' engagement is an essential element for the survey, where reaching unbiased (post hoc evaluation) results is the goal. Due to the differences in the nature of the work conducted within design and construction disciplines, considering only one of their viewpoints to structure the findings may skew the research. It can be argued that each of these teams comprises individuals with diverse backgrounds resulting in a unique set of requirements they wish to achieve. As a result, the design team, including architects and engineers, and the construction team (General Contractor), including the project managers (PM) and superintendents, were selected for the study. No trade partners participated in the survey. Surveys were distributed to each project manager to further distribute to the design and construction team members. At a minimum, this included members from the architecture and general contracting firms, as well as design consultants. The survey respondents fluctuated over the course of the project phases, but the project manager and core team members were consistent recipients of the surveys. The project response distributions among the seven projects under study can be found in Table 3.

Table 3. Total number of responses for each project

Project	Total # of Responses
C02	61
C03	35
C07	16
C09	24
C11	72
C13	40
C10	91

In summary, the respondents were generally engineers, architects, and contractors involved in the survey. Their viewpoints were collected at a minimum of five times throughout the project to investigate the design and construction teams' characteristics over the project progression. The numbers of responses participating in each of these five surveys were not the same, fluctuating from 16 to 91 respondents (Table 3).

When the projects were complete, the project manager for either the design or construction team filled out a wrap-up survey about the project outcomes, with follow-up to the client for confirmation and quality ratings. Since all surveyed projects were public projects, the owner representatives were the ones who filled out the quality rating, not the end-users. The wrap-up survey was identical to the survey used in Maximizing Success data collection process. As described before, the research tracked data from 17 projects; however, for ten projects, owner satisfaction data was not available, making the final data set seven projects for this research study. Owner satisfaction is measured by the question, “Rate your overall satisfaction with the design and construction process (1= not satisfied, 6= exceeded expectations).” The project's classification allows for a comparison between the two types: Class II, which typically enables low levels of team integration and low group cohesion, and Class V, which supports high levels of team integration and high group cohesion.

RESULTS AND DISCUSSIONS

In-progress Survey

During the projects’ progress and at recurring time intervals, the survey questions were

Table 4: Average values of survey questions for each project during the project progress

Project	Class	# of Responses	Schedule	Clarity of Role	Fun	Cohesiveness	Leadership	Design tools & resources	Communication within the office	Communication outside the office	Weekly team meetings	Standard Deviation
C02	II	61	3.56	4.43	3.36	3.54	3.98	4.18	4.03	3.41	3.95	0.37
C03	II	35	3.37	3.46	2.86	3.09	3.14	3.14	3.40	2.63	2.33	0.38
C07	II	16	4.69	4.50	4.56	4.38	4.50	4.56	4.50	4.38	4.33	0.11
C09	II	24	4.58	4.58	3.92	4.17	4.13	4.33	4.46	3.88	4.63	0.29
C11	II	72	4.21	4.47	3.75	3.76	4.11	3.88	3.89	3.58	4.19	0.28
C13	II	40	4.43	4.00	3.60	3.78	3.93	3.70	4.03	3.93	3.30	0.31
C10	IV	91	4.33	4.59	3.93	4.12	4.14	4.15	4.05	3.95	3.98	0.21

emailed to project team members, asking them to rate their experience about the following questions: clarity of schedule, clarity of role, fun, cohesiveness, leadership, design tools and resources being used within the team, communication with project team members within the office and outside the office, and weekly team meetings and clarity of tasks. To understand team performance over the project life span, the averages for in-progress questions captured during the project were calculated (Table 4). The final column lists each row's Standard Deviation (SD) as an indicator of how much the answers varied for each project. This allows us to consider team performance for each project as a single quantity, making it easier to compare various data from different projects under the study, based on the fact that consistency among survey answers would be an indicator of having a more stable team during the project progress. The coloring of the cells indicates the higher (darker red) values for the questions, while the lower values are highlighted with darker blue shading compared to the other projects.

Owner Quality outcomes- After Completion Survey

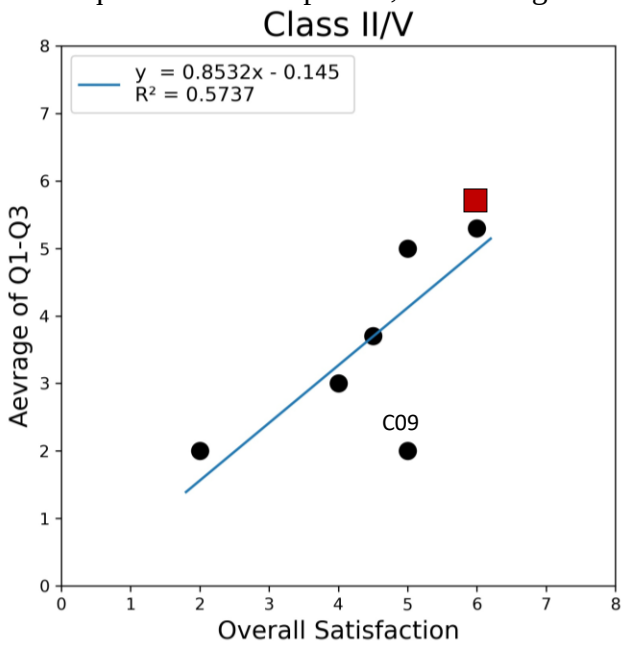
After completing each project, the owner's satisfaction was collected using the same questions from the original empirical study, where the lead point of contact from the owner organization rated the project according to the following questions (Table 5) and gave an overall rating.

Table 5: Key indicators of the overall owner's satisfaction for each project

Owner satisfaction indicators	**C07**	**C09**	**C13**	**C03**	**C02**	**C11**	**C10**
Difficulty of facility start up	4	5	2	5	2	1	1
Number and magnitude of callbacks	3	5	2	5	5	2	2
Operation and maintenance costs	3	5	2	5	5	2	1
Envelope, roof, structure, foundation	5	5	6	5	6	6	4
Interior finishes	5	5	6	4	4	5	6
Environmental systems (lights, HVAC)	5	5	5	4	5	5	5
Exterior aesthetic (style, proportion)	5	5	6	4	5	5	6
Interior environment (mood, feel, image)	5	6	6	5	4	5	6
Rate your overall satisfaction with the design and construction process	**4.5**	**5**	**5**	**2**	**4**	**6**	**6**

The data shown in the C09 project's client response is considered inconsistent. The high overall rating with indications of problems (high ratings for the difficulty in startup, high number/magnitude of callbacks, and higher operation and maintenance costs) mixed with the high satisfaction and high subsystem ratings suggests that the individual that completed the survey may not have read the questions carefully, though it is possible they were satisfied despite having difficulties in the turnover process.

The plot in Figure 4 is the average of the first three questions' responses, relating specifically to the handover process listed in Table 5, as a function of overall satisfaction for all seven projects. A positive slope on the correlation trend is to be expected, as higher satisfaction should be associated with higher scores on those questions indicating fewer challenges encountered in the turnover. To demonstrate the relationship more intuitively, reverse coding was employed in plotting the questions related to turnover satisfaction. In that case, lower ratings of operations costs, for example, indicate higher quality. The one exception is project C09, with a satisfaction score of 5 and an average of 2.



Questions 1-3:

Difficulty of facility startup

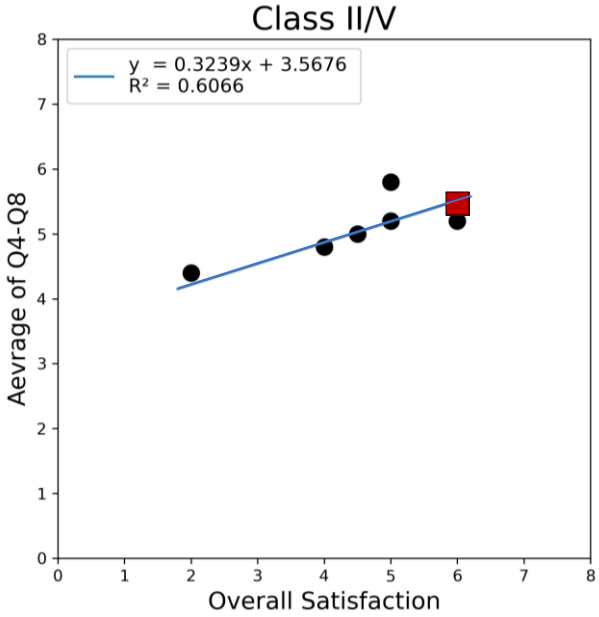
Number and magnitude of callbacks

Operation and maintenance costs

Figure 4: Relationship between averages of Q1-Q3 and overall satisfaction (Circle markers are Class II; square marker is Class V)

We can also plot the averages of Questions 4-8 on project system quality as a function of overall satisfaction. Questions 4-8 relate to the owner's satisfaction with specific subsystems or elements of the completed facility. These are positively framed questions, with higher scores indicating a higher performance in terms of quality or meeting design expectations. The relationship shows that overall satisfaction

increases as the average of the five questions increases (Figure 5). It should be noted, however, that the averages are all relatively high



Questions 4-8:

Envelope, roof, structure, foundation

Interior finishes

Environmental systems (lights, HVAC)

Exterior aesthetic (style, proportion)

Interior environment (mood, feel, image)

Figure 5: Relationship between the averages of Q4-Q8 and overall satisfaction (Circle markers are Class II; square marker is Class V)

Comparing in-progress data of team performance (Table 4) with after-completion data of owners' satisfaction (Table 5) implies that responses are consistent as overall owner satisfaction increases (Figure 6). In other words, when team members rate their performance with consistently higher values over the project design and construction period (which can be considered an indicator of a more stable team), the owner's satisfaction is higher for a given project. However, using the standard deviation, consistency must account for both the ratings across the project's progression and the array of respondents to the survey. Thus, while project C07 seemingly has the highest consistency, it also has the lowest response rate (n=16) among all the projects shown.

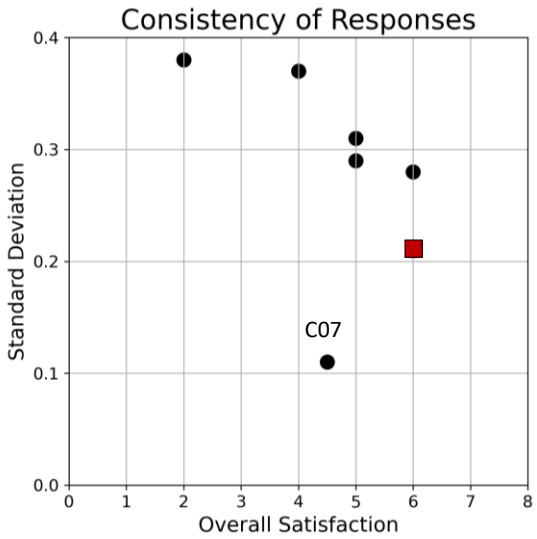


Figure 6: Consistency of responses (Circle markers are Class II; square marker is Class V)

Furthermore, Table 6 lists the correlation between owner satisfaction and the average rating for each of the survey items, ordered from high to low, together with the results of the regression model. The larger the slope, the higher the predicted difference in the average owner satisfaction score between the low and high scores of the survey item.

Table 6: Descriptive Statistics of the in-progress survey responses

Survey Item	Corr	Slope	Intercept	R2
Clarity of role	0.794	2.609	-6.550	0.630
Leadership strength from PM	0.748	2.472	-5.222	0.559
Weekly team meetings and clarity of tasks	0.722	1.286	-0.267	0.521
Communication with team members outside the office	0.709	1.761	-1.833	0.502
Schedule	0.702	1.903	-3.286	0.492
Cohesiveness	0.689	2.176	-3.698	0.475
Fun	0.629	1.634	-1.422	0.396
Design tools and resources being used within the team	0.547	1.602	-1.752	0.299
Communication with team members within the office	0.521	1.942	-3.224	0.272

For each survey item, the correlation between owner satisfaction and the average data can be plotted to show the relationship between these parameters. For example, Figure 7 shows the data and the regression line (slope: 2.6089; intercept: -6.5501; and R^2: 0.6303) for owner satisfaction as a function of clarity of role averages (first item in Table 6). While roles are typically consistent in firms, each project creates a unique organizational context – thus, the exact functions and responsibilities of roles may shift from project to project. Since the category "clarity of role" has the most significant slope,

improvements in that category suggest a greater impact based on the project team's perception that clarifying their role is an essential element within the team.

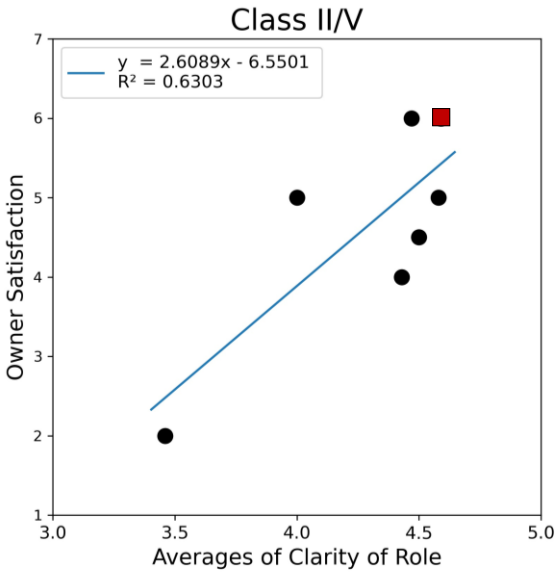


Figure 7: Example of the correlation between owner satisfaction and one of the team performance indicators, clarity of role (Circle markers are Class II; square marker is Class V)

As explained before, longitudinal data is suitable for making more informed causal interpretations of team behaviors over a time period. Therefore, a time-based survey was conducted for each project to capture the in-progress status. In this regard, we have time-series data from the projects, and each response is time stamped. The questions used for this time-based survey are magnitude of change, frequency of ups and downs, and how often above ratings are average or below average. We can count the number of unique time stamps where responses were given by the project (Table 7; third column). The univariate statistics for the time series for which owner satisfaction (OS) is also available in this Table.

Table 7: Descriptive Statistics and Number of Unique Times for the time series with Class and OS

Project	Class	Unique Times (count)	MIN	MAX	MEDIAN	VAR	OS
C02	II	30	2.33	4.33	3.44	0.24	4.00
C03	II	24	1.56	4.22	2.67	0.27	2.00
C07	II	12	2.78	4.44	4.44	0.28	4.50
C09	II	22	2.89	4.44	3.72	0.18	5.00
C10	V	59	3.22	4.44	3.67	0.09	6.00
C11	II	37	2.78	4.44	3.51	0.16	6.00
C13	II	34	2.11	4.44	3.56	0.27	5.00

In order to demonstrate time-based survey analysis, three projects of C03, C10, and C11 were selected as the three projects with more variability within the data across the two classes. Thus, we can generate a time series of survey responses for each of the eleven survey questions. If more than one response was received at a given time point, the scores were averaged (Figure 8).

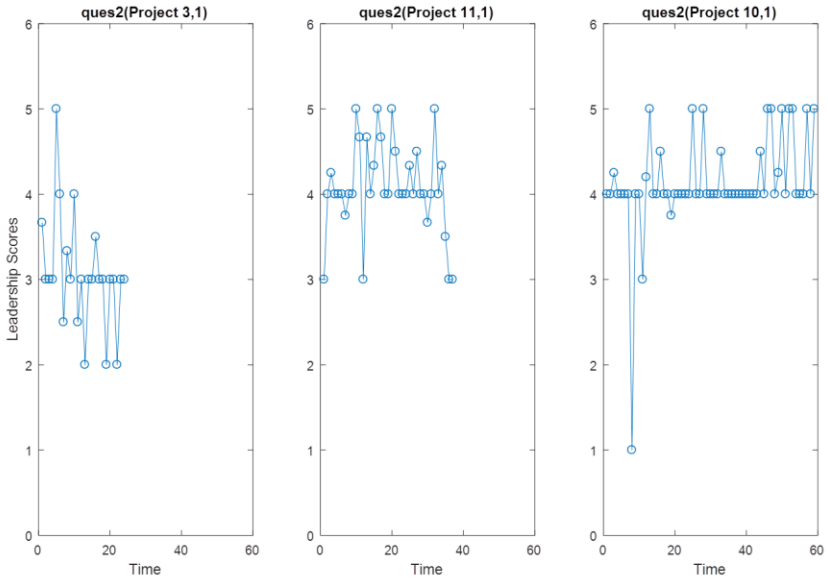


Figure 8: Time series of leadership scores. Time is discretized.

We calculate the mean across eight categories of team health survey responses: fun, cohesiveness, role, schedule, leadership, resources, communication within, and communication without. The environment and weekly categories did not have sufficient

time-series data. This is shown in Figure 9 for the three projects. The orange markers (not scores) indicate the project's phase; those data points correspond with the project phase (3=Design Documentation; 4=Construction; 5=Post Occupancy Evaluation). Almost all data are from the Construction phase.

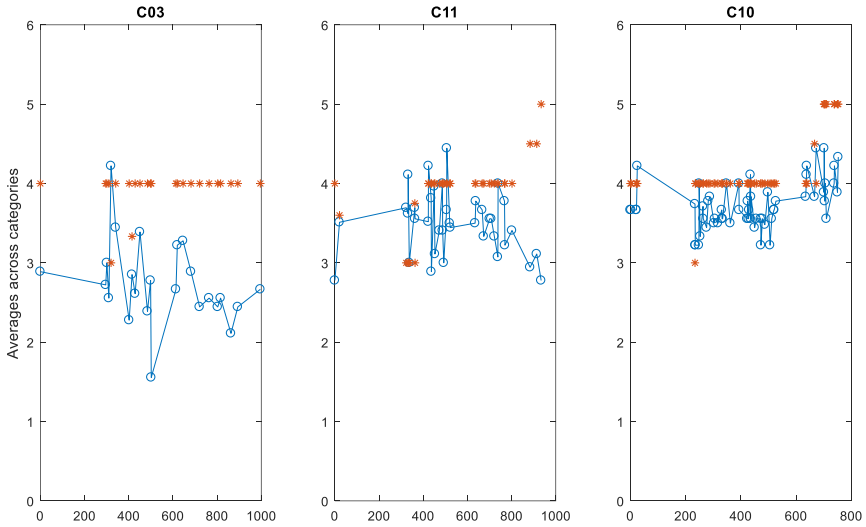


Figure 9: Time series for the average survey scores across all questions with sufficient data. Time is in days; the orange * indicates phase (3 – Design, 4 – Construction, 5 – Post Occupancy Evaluation).

As previously shown in Table 4, standard deviations were calculated for each project, and they vary across these seven projects. The standard deviation of the Category V project (C 10) is lower than the standard deviations of the Category II projects with the same owner satisfaction score (C 11). To better compare the diversity of the findings based on the standard deviation, the coefficient of variation can be used as a unitless indicator. The coefficient of variation is the ratio of the standard deviation to the mean. Therefore, it is a measure of variability relative to the mean. As owner satisfaction increases, the coefficient of variation of the Category II projects decreases. The relationship between CV and owner satisfaction can be seen in Fig. 10.

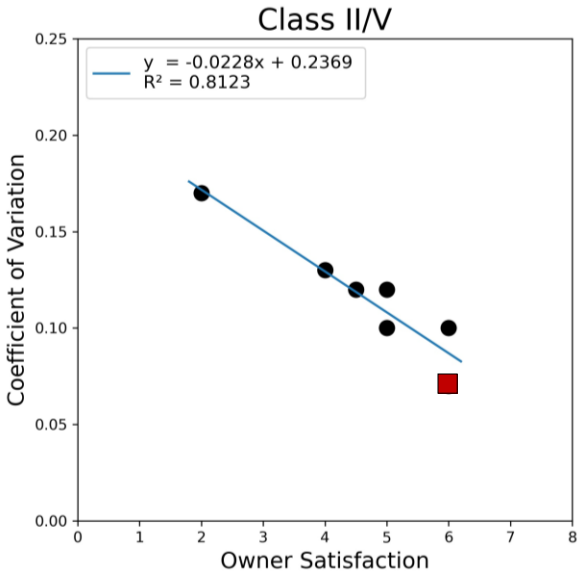


Figure 10: Coefficient of Variation (CV) as a function of owner satisfaction

(Circle markers are Class II; square marker is Class V)

Predictive Modeling

As we explained before, team characteristics and behavior can be considered early indicators of project performance in terms of owner satisfaction. However, since in this study, the variable in question is a composite measure representing team characteristics, which includes factors such as clarity of roles and leadership, the CV is used as an indicator of the variability or dispersion of these team characteristics over time. CV, as a standardized, unitless measure allows to compare variability between disparate characteristics. By examining the dispersion of team characteristics over time, we aim to capture the extent to which a team's performance and behaviors exhibit consistency or stability. To this end, the linear regression model was developed (Figure 11), which yields an equation that can be used to predict owner satisfaction for Category II projects.

As depicted in Figure 11, higher levels of consistency or stability within these team characteristics may contribute to more predictable and satisfactory outcomes for the owners. Therefore, we suggest that team characteristics, as reflected by the CV, serve as a leading indicator of owner satisfaction.

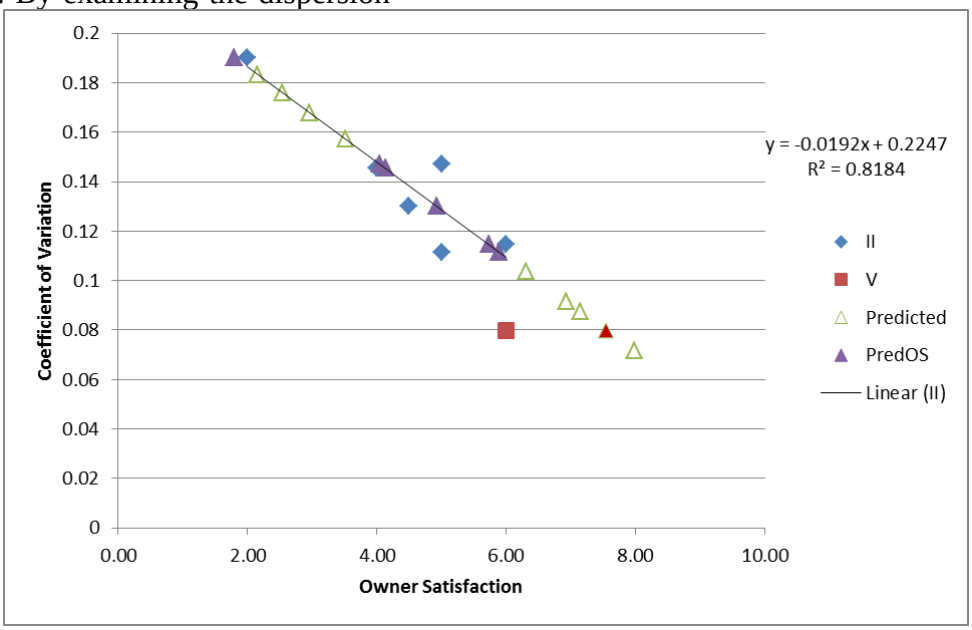


Figure 11: Owner satisfaction can be predicted by CV

To test the model for the sample projects of the research study with class II, predicted owner satisfaction can be compared to the actual amount of OS collected through questionnaires. The findings can be seen in Table 8.

Table 8. Owner Satisfaction Predicted

Project	CV	OS	OS-Predicted
C 02	0.13	4.00	4.14
C 03	0.17	2.00	1.80

C 07	0.12	4.50	4.94
C 09	0.10	5.00	5.90
C 11	0.10	6.00	5.73
C 13	0.12	5.00	4.04

Although the predicted amounts of owner satisfaction are relatively close to the actual data, it should be noted that due to the limitation of data, validating the accuracy of

the predictive model cannot be tested for the study data set. Nevertheless, this study tried to conceptually show that the regression model can be used to forecast the project's owner satisfaction based on the time series data of team performance and behaviors as leading indicators.

DISCUSSION

The results from the analysis of Owner's Satisfaction (OS) ratings with both rated quality outcomes as well as system quality indicates that OS serves as an invaluable proxy for assessing the overall quality of the project facility construction. These results corroborate prior findings reported by Kärnä et al. (2009) when they proposed a tested model and framework to describe the factors influencing customer satisfaction in the construction industry. They suggested that client satisfaction is affected by the project performance assessment concerning three comparisons: the quality of the building, the client's expectations, the quality of the construction process and the experiences that have emerged during the process. This study's findings also illustrate that when owners rate their experience higher with both the construction process (Q1-Q3) and the building quality (Q4-Q8), their overall satisfaction is higher.

As previously explained, two categories of informative and reflective models can be employed to discuss team integration indicators. In this study, using reflective indicators of team integration (Table 1), such as leadership and communication, we tried to determine how integrated the team is and use this construct to further understand how well the project outcomes would be in terms of owner satisfaction. Notably, low variation amongst these indicators suggests that teams that are all on the same page about how well the project is progressing tend to perform better for achieving owner satisfaction. As such, using the CV for the prediction regression model suggests that teams with more consistency across team characteristics over the project time tend to achieve higher owner satisfaction. This is in close alignment with the findings of the study conducted by Choi et al. (2019), as they showed that the greater levels of team integration in the IPD projects were highly correlated with those of owner satisfaction with project outcomes compared to those in the CMR projects..

Further, building upon the empirical results of the team cohesion factor from Franz et al. (2017), the OS rating should have a strong relationship to the quality performance across projects. As such, it provides an invaluable reference for comparing the in-progress metrics to understand the link between team integration throughout the longitudinal project lifecycle and the overall project outcomes.

The results from the coefficient of variation analysis for the in-progress survey data further suggest that team health assessments could be invaluable in forecasting the

achievement of owner satisfaction. The consistent use of Class II delivery strategy, public owners, and control of the lead design and construction participants shows that the collaborative efforts within the project team with similar delivery methods are one of the distinguishing factors for delivering better project quality and satisfaction to the owner. The explicit factors, like the clarity of roles, which one might assume to be clearly defined within and across projects, indicate the need for fundamental project management tasks, like developing clear roles and responsibilities and communicating basic processes, which are of notable importance in our fragmented industry, which has been widely emphasized by previous studies (Mohd Nawi et al., 2014). Developing and executing these well and in an effort to build a collaborative team, despite contractual limitations, contributes to better project success for meeting the owners' needs.

Further, capturing input from the team regarding how well the project team is functioning in terms of leadership, cohesiveness, and communication, among others, may serve as an early predictor of success in meeting expectations, specifically owner satisfaction. Often, the team's 'health' and their functioning for collaborative purposes are left as abstract notions or not actively monitored in the same fashion as project documents or cost and schedule controls. As Chan and Chan (2004) noted, quantifiable measures computed by result-oriented measures have been mainly used for performance assessment, which includes actual/planned cost and schedule, rework cost, and change. This is not to say that project delivery decisions are not important, as already well documented. As indicated by the data from the Class V project, the project with a noticeably more integrated delivery strategy stood out in terms of the team's health as well as the owner's satisfaction. The link between delivery and procurement decisions to the functioning of the project team has been commonly suggested; however, this study demonstrates the consistently high rating of team health longitudinally during a project lifecycle correlated to improved outcomes, specifically owner satisfaction.

CONCLUSION

Team integration and group cohesion in association with the success of project outcomes in terms of owner satisfaction are investigated in this study. Through in-progress information of seven projects gathered from project teams, including both the design team as well as the construction team, in-progress data was captured and comparatively analyzed in addition to the one-time after-completion survey of building owners. The snapshots of team interactions or dynamics help to understand and predict project success, specifically owner satisfaction.

The findings revealed that:

- Owners' overall satisfaction is considered to be an effective indicator of assessing project success. Herein, collected data suggested that where ratings of influential factors of the project success, such as ratings of the turnover process, are higher, the owner satisfaction for outcomes is also observed to be higher, as shown in Table 5.

- Projects with high ratings and more consistent responses (which are recognized by lower standard deviation and CV values) across survey categories are more likely to be rated highly by owners to meet their satisfaction.

- Team efforts to build collaboration and cohesion lead to better project outcomes. Where factors related to strong team culture, such as "clarity of role" and "project manager leadership," are rated higher by the team, the owner's satisfaction with outcomes is also higher. This study also shows that for social factors such as fun or communication, the level of the elements may not be predictive. Still, the trajectory and consistency could be informative of the need for intervention in cases where the team health is lower rated.

- Lastly, our results further support previous findings that project delivery decisions pursuing more integrated approaches enable greater ability to build a team and meet owner expectations. Hence, it can be argued that for those project teams who have a higher level of integration and group cohesion, owner satisfaction with the overall building results should be higher. The comparison of data for project teams that fall into the Class II (low on team integration and cohesion) with one that was Class V (high on integration and cohesion) supports this claim. This last finding creates an opportunity for better monitoring and forecasting of project success.

Regarding the limitation of this study, it can be noted that time series data focused on some of the factors related to group cohesiveness as a group's resistance to disruptive forces, such as clarity of role and leadership. Other factors did not have sufficient information for time series, and these included: fun, clarity of schedule, resources, communication within the team, and communication outside the team. To better analyze team performance, sufficient information for these factors needs to be gathered for time series.

While our sample size of seven projects is too small to draw many definitive conclusions on the ability to forecast success based upon the survey of team members, we believe the consistent time-based data collection from project teams can yield valuable insights. Despite all the challenges involved in conducting longitudinal work (including the continuity of the research team), there are many advantages. These include establishing meaningful metrics, tracking information over time, and understanding the impact of turnover of key staff on the project teams due to teams' attrition as personnel changes or changes in commitment to the project participation. With such information on project team dynamics, there are potential pathways to plan, track, and forecast building outcome success.

The findings of this study can help researchers and practitioners understand how project team characteristics, such as the level of team integration, along with their consistency over the project progress, influence owner satisfaction in construction projects. Therefore, understanding the relationships between team integration and owner satisfaction concerning the project outcomes will make project members more aware of how their interactions during the

project design and execution are associated with their project performance and success. The next step of this research study would be expanded to explore a large data set that allows in-depth data analysis comparing the impact of different team performances on owner satisfaction. A larger data set would allow drawing a meaningful conclusion about the accuracy of the prediction model in forecasting owner satisfaction based on team behaviors.

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