Gordon, E., Rawlinson, K., Dabhade, N., Reed, E. & C. Dunn. (2023). Assessing quality performance outcomes and the relationship with RFI and PCI processes: a general contractor case study. *Proceedings of the 31st Annual Conference of the International Group for Lean Construction (IGLC31),* 412–422. doi.org/10.24928/2023/0175

ASSESSING QUALITY PERFORMANCE OUTCOMES & THE RELATIONSHIP WITH RFI AND PCI PROCESSES: A GENERAL CONTRACTOR CASE STUDY

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ABSTRACT

This paper is the third in the series, taking a cross-discipline view of project performance to investigate and understand the potential correlation between system inputs and outputs. In the 2021 paper "The Impact of Implementing a System Approach to Quality: A General Contractor Case Study," the authors compared project performance outcomes and team cultural assessments for 11 projects that had implemented a Systems Approach to Quality (SAQ), the Intervention group, against a similar set of projects that had implemented a compliance-based approach to quality, the Control group. This paper continues to investigate the project performance outputs for these two groups and specifically looks at the Request for Information (RFI) and Potential Change Item (PCI) workflows. This case study considers if RFI and PCI metrics can be used to determine if better quality design contributed to better performance outcomes. Then it considers how RFI and PCI processes relate to SAQ implementation. The authors' findings suggest that applying SAQ resulted in project teams documenting RFIs sooner in the project lifecycle and experiencing faster closure rates compared to the Control group.

KEYWORDS

Systems Approach to Quality (SAQ), Request for Information (RFI), Potential Change Item (PCI), Change Order (CO), design quality, performance outcomes

INTRODUCTION

THE REWORK PROBLEM & DESIGN QUALITY

Rework is a known problem in the Construction Industry. This General Contractor (GC), with a current US $5.9B revenue, headquartered in California and working throughout the US, Europe, and Singapore, experienced unpredictable results when delivering their final product. Sometimes the GC delivered work to meet customer expectations; sometimes, the GC achieved zero defects at substantial completion; and other times, the GC spent a lot of time and money to close out open issues. Even when the GC met plan and specification requirements,

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sometimes the owner would say, “That was not what I was expecting. Tear it out and re-do it.” (Spencley et al., 2018).

Receiving accurate information promptly to plan and build the work has long been discussed as essential to preventing rework and growth of project costs (Hughes and Zack 2012). Design quality and preventing design errors and omissions are vital as they directly influence the overall performance of construction projects (Alarcon and Mardones 1998). A study performed on nine industrial projects found that design deviations averaged 78% of the total count of deviations. These were further sub-categorized, and “design changes for improvement (DCI) caused, on the average, the greatest number of deviations, 13.3%, followed by design changes in process (DCP), 10.9%, and design changes initiated by the owner (DCO), 9.9%, while 13.2% of the total number of deviations were classified as design changes of unknown origin (DCU)” (Buratie et al., 1992). Furthermore, design changes averaged 79% of the total costs for all changes and 9.5% of the entire project costs (Buratie et al., 1992).

Hughes and Zack (2013) attribute this lack of information to a shift away from a master builder that designed, planned, and executed the work. While project designs have become more technically complex, designs and building duration times have become condensed, leading to missing information on the design documents (Dougherty et al., 2012). Thus, the Request for Information (RFI) process became a tool for the construction industry to ask designers clarifying questions about the intent of the design and receive the information necessary to build what was expected. If impacts are associated with the RFI response provided, the general contractor submits the proposed scope, costs, and schedule impacts in the Change Order (CO) process (Dougherty et al., 2012).

Measuring the outputs of the RFI and CO processes has become standard metrics to evaluate how a project is performing. First, RFIs have been used to measure design quality (Tilley et al., 1997), a leading indicator of how projects will perform. In the ASCE study “Defining the Success Status of Construction Projects Based on Quantitative Performance Metrics Thresholds,” RFIs and Change Orders quantities were used to differentiate between successful and non-successful projects (Aboseif et al., 2022). Similarly, this GC uses the volume of RFIs a project experiences to signify if projects have unanticipated changes and potentially could not meet the existing contractual requirements. If the count of RFIs for a project increases above the weekly average the project has been experiencing, this is considered a warning that the design quality does not reflect the information the GC needs to build. However, one challenge with this approach is that these comparisons were all made without distinguishing between successful and unsuccessful projects (Aboseif et al., 2022).

THE RESEARCH QUESTION

In previous research, the authors identified that projects implementing a Systems Approach to Quality (SAQ) achieved better performance metrics across quality, safety, cost, change management, schedule, and collaborative culture, versus a similar set of projects that implemented an industry standard, compliance-based approach to quality, the Control group, (Gordon et al. 2021a). Through this current research, the authors continued to investigate the project workflows for these two groups and looked at the Request for Information (RFI) and Potential Change Item (PCI) workflows, which is a required and leading step to issuing a formal Change Order (CO) for this GC. The authors endeavoured to understand the following:

> Can the RFI and PCI process metrics collected by this GC support assessing if design quality contributed to the Intervention group achieving better project performance outcomes and more collaborative cultures?
>
> Are there discernible differences in outputs for standard communication workflows, the Request for Information (RFI) process, and the Potential Change Issue (PCI) process through the project lifecycles?

Can the outputs of these standard communication workflows be leading indicators of project performance and cultural outcomes of projects?

The hypothesis: SAQ projects which created systems to build from knowledge and information, understand and align objective expectations for deliverables, including design packages, would have fewer RFIs and less towards the end of the project as many details were worked out ahead of time. Also, the categorization of the change would help identify those associated with design quality. When the change occurred would be an indicator of how SAQ influenced information flow. The authors also planned to review how the groups documented schedule information in the PCIs to understand how implementing SAQ influenced teams' internal planning and communication. The authors sought to determine if project RFI workflows would provide evidence about project design quality.

This study is important as it assesses standard process outcomes between projects that implemented SAQ and experienced better performance outcomes versus a Control group. The findings of this study can help leaders create project performance process thresholds and identify when projects "are in trouble" and need help, such as a different strategy or support.

THEORETICAL FRAMEWORK

SYSTEMS APPROACH TO QUALITY (SAQ)

Bertelsen described construction projects not as linear and ordered but as complex and dynamic systems (Bertelsen 2003a; Bertelsen 2003b). Like Bertelsen, this GC recognized projects are complex and dynamic and desired reliable, consistent, and predictable outcomes for quality on their projects (Spencley et al., 2108). To solve the rework problem this GC faced, they developed a Systems Approach to Quality (SAQ) (Gordon et al., 2021a). Foundational to SAQ are the principles: identifying Points of Release (PoR), when work is released to the next phase, building from knowledge and information, understanding expectations, and Distinguishing Features of Work (DFOW) from each stakeholder's perspective, aligning expectations to measurable acceptance criteria for the work, tracking and visualizing leading indicators, and performing causal analysis when evaluated work does not meet the expectations of the deliverable (Gordon et al. 2021a). These principles are applied to the project strategy and across the projects' many workstreams of safety, quality, cost, planning, and change management to deliver the expected deliverable at each PoR.

PREVIOUS RESEARCH

This paper is the third in a series to assess projects that implemented SAQ, the Intervention group, versus a similar set of projects that implemented an industry standard, compliance-based approach to quality, the Control group. The first paper measured project performance outcomes between the two groups for cost, schedule, change management, safety, quality, and cultural outcomes using Quinn's Competing Values Framework (CVF) and found that those that implemented SAQ had better performance outcomes more aligned with company objectives (Gordon et al. 2021a). In follow-up research, Gordon et al., 2022 reviewed contract date relative to project duration and studied staffing and resourcing profiles between the project groups to understand if different inputs contributed to better performance outcomes (Gordon et al. 2022).

Through this previous research, the following was reported:

"Cost: The median value of cost growth for the Intervention group was 5% and 9% for the Control group. The median value of fee gain for the Intervention group was 4% and -35% for the Control group.

Schedule: The median value of schedule growth at mobilization for the Intervention group was 11% and 18% for the Control growth.

Change Management: The median value of contract changes was 5% for the Intervention group and 13% for the Control group.

Safety: The median value of incidents per $100M for the Intervention group is 1.5 and 1.9 for the Control group.

Quality: The median value of claims as a percentage of contract cost for the Intervention group was 0.14% and 0.87% for the Control group.

Project cultures: Using Quinn's Competing Values Framework (CVF), the Intervention group reported more collaborative cultures" (Gordon et al., 2021a).

Signing the contract, the Guaranteed Maximum Price (GMP) as a percent of project duration: The median value for the Intervention group was .09% and 19% for the Control group" (Gordon et al., 2022).

The median value for time coded to VDC resources was approximately 3x more for the Intervention projects (Gordon et al., 2022).

The Intervention projects also outsourced more project management work (Gordon et al., 2022).

LITERATURE REVIEW

The RFI and CO processes are standard processes in the construction industry and have been used to assess drawing quality and communication of construction projects. Tilley et al., 1997 concluded that evaluating the RFI workflow with the drawing register can indicate design and documentation quality and status of project performance and analyzing the number of RFIs relative to contract value and project schedule, and response times can be used to assess the severity of the issues (Tilley et al., 1997). Similarly, a 2021 Construction Industry Institute study stated: "'RFI/$M' is a shorthand metric for project communication and design quality. In general, more RFIs are a 'bad sign.'" Furthermore, several studies review project RFI metrics for the projects investigated (Tilley et al., 1997; Hughes et al., 2013; Construction Industry Institute, 2021). The Navigant Construct Forum studied a data set of 1,362 projects from all over the globe between 2001 and 2012. They documented the following:

There were 1,083,807 RFIs submitted on these projects, averaging 796 RFIs per project.

Average number of RFIs per million dollar is 9.9 for all projects.

First response was calculated at 6.4 days and a median response time of 9.7 days (Dougherty et al., 2012).

Aboseif et al., 2022 published criteria for success metrics for communication by using quantitative performance data from 96 projects:

RFI per $million less than or equal to 8.6

RFI processing time less than or equal to 7 calendar days

Fewer than .39 change orders per $million

Although the RFI process has waste and inefficiencies (Tilley et al., 1997, Alarcon and Mardones, 1998; Uusitalo et al., 2020), the RFI process is a standard communication process. In the literature review, the authors realized there is a gap in investigating what the RFI and PCI flow looks like through the project lifecycle.

RESEARCH METHODOLOGY

METHOD

To investigate their questions, the authors used the same project data set from the 2021 and 2022 case studies (Gordon et al., 2021a; Gordon et al., 2022). Eleven projects that implemented

SAQ and were within 90% of completion by January 2022 were chosen as part of the Intervention group. For each SAQ project, a project of similar contract size, geographical location, and core market, when available, that did not implement SAQ was chosen for the Control group. The authors again applied the design thinking and systems thinking concepts and tools from the Center for Innovation in the Design & Construction Industry's (CIDCI) online innovation lab (CIDCI 2022) (Gordon et al., 2022). The process involved six steps.

First, the authors further explored the problem statement using the "web of abstraction" tool to frame and re-frame the question. Next, the authors spoke with experts in operations, data analytics, project controls, and scheduling. The discussions revealed that the organization had dashboards to understand the number of RFIs project teams were experiencing each week compared to the project's current average. Additionally, one operations expert analyzed RFI-to-PCI ratios to help project teams forecast the amount of PCI work based on RFIs produced. Through the enterprise Operations Data model tool, the authors could observe the counts of RFIs, and PCIs related to data points, like the reason for and the type of assembly associated with the RFI and PCI. The scheduling subject matter expert identified, including the proposed time of work in the PCIs and whether the work can be done concurrently or will extend the critical path, is crucial information needed to forecast more reliable plans.

The third step involved reviewing the collected data and identifying the information needed to investigate the questions. During the study period, RFI and PCI information was collected in a centralized project management software platform. When project teams seek clarification or an interpretation of the contract drawings, an RFI is initiated in the software when the subject, created date, from, and to fields are entered. When additional details such as discipline, agency review required, questions, suggestions, potential schedule and cost, and relevant attachments are added, the RFI is submitted via the company's project management software to the appropriate project stakeholder and enters pending status. If the stakeholder's response requires additional time and money above the contracted baseline work, a Potential Change Item (PCI) with scope, cost, and schedule impacts is submitted via the project management system for owner approval. Once the required fields of Type of PCI (Owner, Category Transfer, or Original Budget Change), Description, Status, and Date Initiated are entered, the PCI is created. When the owner approves the PCI, a formal Owner Change Order (OCO) is submitted.

Next, the authors mapped the available information to the questions and brainstormed how to visualize and compare the groups' data. The authors planned to visualize and analyze the type of RFI categorization through the project lifecycle. However, since RFI categorization was an optional field, this data was not available for many of the projects. Similarly, the amount of time projected for the work was an optional PCI field, and this information was not always available. Thus, the authors focused on looking at the counts of RFIs and the value and count of PCI data through the project lifecycle to determine design quality. The authors developed visuals of the data and then analyzed it.

DATA COLLECTION

From the company's enterprise project management software platform for both the RFI and PCI workflows, the following data was exported for each RFI and PCI: date created, date information is requested, date submitted to project stakeholder, date response submitted, and date closed.

The RFI and PCI data were compiled and reviewed for each project by two different project duration views. The first view compiled the RFI and PCI data for 1) the time before signing the GMP and 2) after signing the GMP. In the previous study, the authors found a significant difference between when the Intervention and Control groups signed the GMP, .09% and 19% of project duration between mobilization and substantial completion, respectively (Gordon et al., 2022). Thus, the authors investigated if there were differences in the RFI and PCI patterns for these durations. Secondly, the authors normalized the information by standard project milestones: actual mobilization date and substantial completion (Gordon et al., 2022). The authors looked at the time before mobilization and called this period the pre-game quarter. Then for each project, the authors compiled standard durations for the project lifecycle by taking the time between the actual mobilization date and substantial completion date and dividing that into four equal durations that included: mobilization date to 25%, 25% to 50%, 50% to 75%, and 75% to substantial completion. Data for each project was reviewed in these five quarters and aggregated into each group, to compare group trends.

For RFIs and PCIs, the following metrics were calculated for each project and then for each group, Intervention, and Control by the two durations: 1) Total count, 2) percent of the total count, 3) average closure rate, 4) RFI/PCI per million 5) RFI per 1000 hours of staffing.

Table 2: Performance Metrics and Units of Measurements

Metric	Formula
RFIs/PCIs per \$million	$\frac{Total\ Count\ of\ RFIs/PCIs * 1{,}000{,}0000}{Contract\ Value}$
RFIs per 1,000 hours of GC Hours	$\frac{Total\ Count\ of\ RFIs * 1{,}000}{GC\ Hours}$

DATA FINDINGS

The following RFI and PCI performance metrics were calculated: 1) RFIs per million were 5.2 and 6.4, respectively, for the Intervention and Control groups; 2) RFIS per 1,000 hours of GC hours were calculated as 9.4 for the Intervention group and 11.8 for the Control; 3) PCIs per million were 4.1 and 5.6, respectively for the Intervention and Control groups.

Figure 1 compares the total GC hours for the Intervention group versus the Control group for each quarter of the project. The y-axis represents the count of staff hours reported in the GC's weekly billing submissions, and the x-axis represents the entire project lifecycle in the five quarters. The x-axis is standard for all the following graphs.

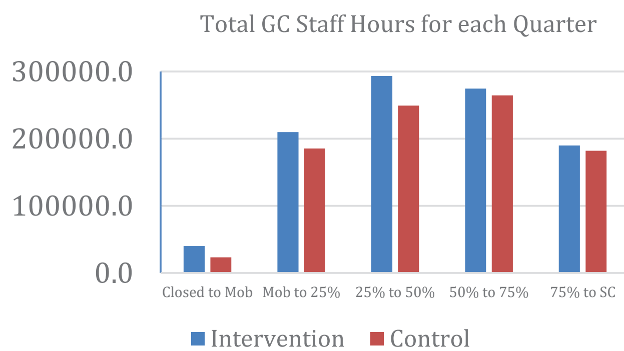

Figure 1: Count of total GC hours

Figure 1 shows that overall, the Intervention group reported 12% more staff hours than the Control group. In the pre-game quarter, before being on-site, the Intervention group had nearly double the staff hours as the Control. Box and whisker charts also revealed that the Intervention group had more variability in the count of hours staffed for their group of projects.

The graphs in Figure 2 show two views of the total RFI counts for the Intervention and Control groups. The left chart summarizes the count of RFIs for each duration in the project lifecycle, and the right graph plots the median values of the counts as a percentage of total counts for each duration.

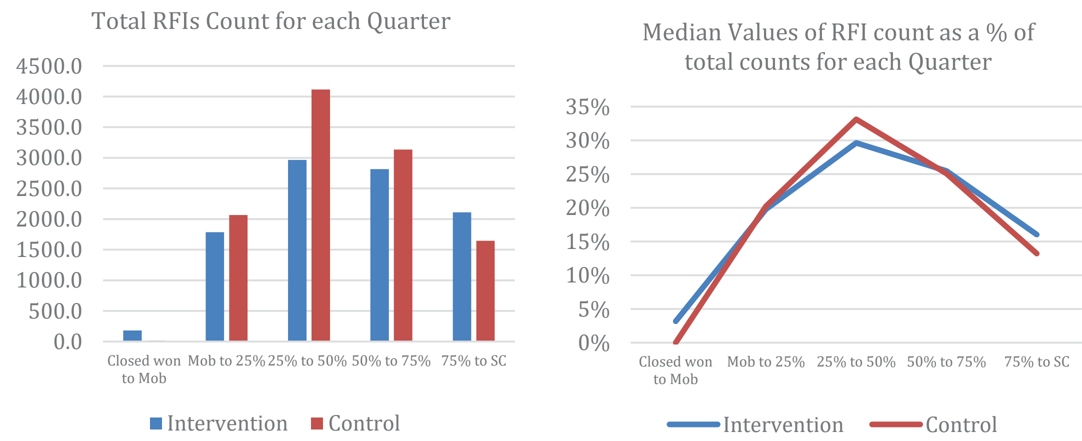

Figure 2: Total RFI counts and median value RFI count as a percentage of total counts.

Overall, the Control group submitted 10% more RFIs than the Intervention group. One significant difference is that the Intervention group reported 9.5x more RFIs than the Control projects before mobilization. In the three quarters after mobilization, the Control group had more RFIs. In the last quarter, the Intervention group submitted 25% more RFIs. For the graph on the right, the median values are similar for the percentage of total counts. The box and whisker analysis demonstrates that both groups had similar ranges and much variability for the four quarters after mobilization.

Figure 3 provides comparable PCI visualizations. The left graph summarizes the count of approved PCIs, and the right chart summarizes the median value of approved PCIs as a percentage of total approved counts for each of the five time periods.

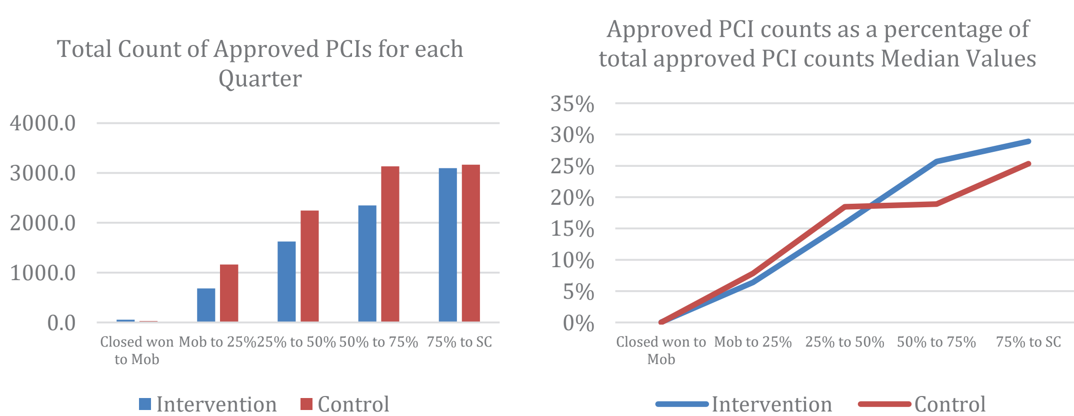

Figure 3: Count of approved PCIs and the median value of approved PCIs as a percentage of total approved PCI counts.

The left graph of Figure 3 shows that the Control group had more approved PCIs throughout the project lifecycle. This is expected as the previous research documented 8% more change than the Intervention group as a percentage of the overall contract value. The graph on the right shows that the Intervention group had more variability and a range of PCIs approved in the last two time periods of the project.

The RFI closure rate was calculated by subtracting the RFI date created from the date closed. Then, the average closure rate was found for each project in each duration, and the median value for each group, Intervention vs. the Control, was plotted as shown in Figure 4. The y-axis represents days in time, and the x-axis represents the normalized periods.

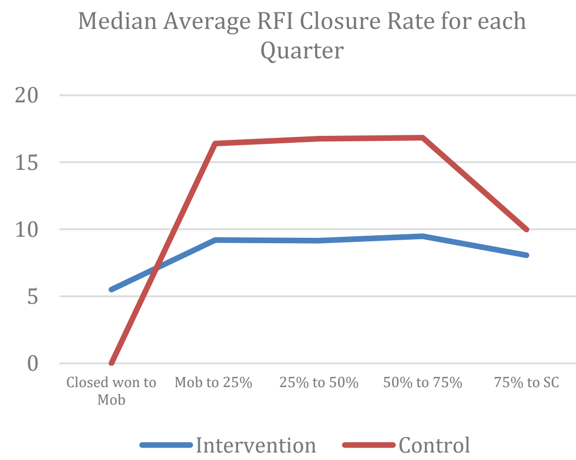

Figure 4: Median values for the average RFIs closure rate for the Intervention Group vs. Control group for the normalized periods.

From mobilization to 75% of the project duration after mobilization, the Control group's median average closure rate is 16 days. This is twice the Intervention group's median value, which was an 8-day closure rate during this period.

Figure 5, the left graph, shows the median PCI cost for each group during each of the five quarters. Previous research showed that the Control group experienced more change as a percentage of the total cost. For the Control group, the median value for PCI cost spikes after mobilization, and the box and whisker charts reveal that the second quarter experiences the most variability. For the Intervention group, the box and whisker charts show that the pre-game quarter, the quarter before mobilization, experiences the most variability in PCI costs. Figure 5, the right graph, shows the average PCI closure rate for each quarter. While the Intervention group's median value for closure rate steadily increases until the quarter before substantial completion, the median value for closure rate for the Control group is highest in 25% to 50% of the project after the GMP was signed.

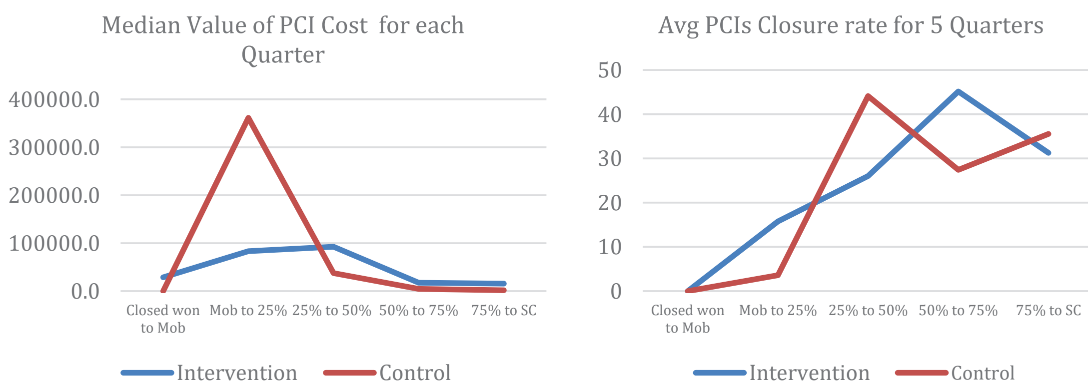

Figure 5: Plot of median values of the PCI cost for five quarters.

Limitations of the Data

Data limitations include 1) that this is only a case study of 22 projects; 2) the projects were either classified as having implemented SAQ based on conversations with the project team and their presentations at the organization's Monday Quality Calls forum (Gordon et al., 2021a) or not implemented; 3) Total counts of RFIs were based on RFIs with a created date and not a submitted date. The authors found a small percentage of RFIs that were created but not submitted; 4) When the contract required the project team to use a different project management software system, fields were used that coincided with the data collected in the GC's enterprise system; 5) The analysis does not distinguish between project delivery system; 6) The RFI and PCI analysis does not differentiate between the type of change requested – whether it was a clarification, error or omissions, an improvement, or change directive; 7) Category transfers were included as PCI counts.

DISCUSSION

MEANING

The Intervention group, which consisted of projects that implemented SAQ, submitted more RFIs before mobilization. This suggests that implementing SAQ and formal documentation of early and essential design decisions could contribute to signing the contract sooner, which allows the GC to focus on the execution of the work and better performance outcomes. Both groups had roughly the same median values of RFIs created before and after GMP, approximately 20% and 80%, respectively. However, the Intervention group's median value for signing the GMP was within 1% of mobilization, 18% sooner than the Control group. This suggests that the RFI and PCI work needed by mobilization for a project to have reliable outcomes can be determined and used to measure how projects are trending. The Intervention group, with twice as much stuff as the Control, also asked more questions earlier in the project lifecycle, suggesting implementing SAQ and staffing, and not design quality was a key to contributing to better performance outcomes.

The median value for the closure rate of RFIs for the Intervention group after mobilization for three quarters, while the project was in construction was 8 days. The Control group's median value for this same time was 16 days. The Intervention group received information in the project earlier and faster than the Control. This experience could contribute to the Intervention group's results on Quinn's CVF, where they ranked higher on collaboration than the Control group Control that more collaboration would lead to even more success (Gordon et al., 2021a).

Also, the timeframe when projects experienced Potential Change Items (PCIs) differed. The Intervention group experienced a lot more variability in the pre-game quarter before mobilization, while the Control group experienced more variability in the quarter following mobilization. This suggests that the Intervention group, applying the principles of SAQ, was better able to adapt and communicate and resolve changes with stakeholders earlier in the project and agree to the GMP sooner. Also, the large PCI numbers the Control group forecasted after mobilization could have contributed to the delays in signing the GMP.

The data also showed that the Control group had created 54% more total PCIs. The Control created nearly 3x as many PCIs as the Intervention group in quarter three, 50%-75% between mobilization and substantial completion. However, only a third of those created PCIs turned to approved status. The elimination or rejection of created PCIs could account for the Control group's lower average closure rate compared to the Intervention group during this period. This also demonstrates the additional workload the Control group was experiencing with fewer staff.

IMPLICATIONS

This study demonstrates how normalizing views of cross-discipline information in relation to project lifecycle can provide more insight into leading indicators or early system outputs that could alert the GC's organization to how a project's performance is trending and when intervention is needed. The work is also important as it demonstrates how GCs can leverage their enterprise data to intermediate benchmark project deliverable outputs that produce known outcomes.

CONCLUSION

Knowledge Gained by Participants, and Value for Practitioners

The authors learned from this case study that RFIs documented before mobilization can be a leading indicator of project performance success and collaborative cultures. The GMP will also likely be signed earlier in the project lifecycle. Additionally, more PCIs in the pre-game quarter is another leading indicator of project success and suggests that the organization look at PCI value in relation to the mobilization date to understand how projects are trending. The RFI closure rate significantly differed between the groups suggesting this is a critical lagging indicator demonstrating that a project is experiencing issues.

When the authors compared their case study findings for RFIs per million and closure rates against reported industry metrics, they found some differences. Hughes et al., 2013 research indicated that 9.9 RFIs per million is typical for projects, and Absoeif et al., 2022 stated that 8.6 RFIs per million was a successful project threshold. In this case study, both Intervention and Control groups had median values below that criteria, 5.2 and 6.4, respectively. This finding highlighted for the authors the importance of performing these studies and broadening them with their organization's data to understand representative benchmarks.

Finally, normalizing views of the organizational data to standard project milestones and taking a cross-disciplinary view of the data is essential for a more holistic understanding of what projects are experiencing. From this work, the following are early indicators for a successful project: the percent of total estimated staffing hours spent in planning before mobilization, the number of RFIs based on estimated project value that should be submitted before mobilization, and the planned duration for GMP approval needs to be by mobilization.

Further Research

While it is generally accepted that lower RFI counts equate to better quality design (Construction Industry Institute, 2021), this would suggest the Intervention group had more complete, clear, and concise information to build from. However, more investigation is needed to answer this question. In implementing SAQ, the teams' focus on understanding and aligning expectations for processes of engagement, communication, and for information needed to build could have contributed to fewer RFIs as well. This project group also documented 3x more VDC resources, likely facilitating increased communication and understanding. A social network analysis of the project groups could also be performed to analyze if there are patterns for how stakeholder knowledge intersects with the social network to create a better-quality design. Additionally, the type of change requested in the RFI should be analyzed to categorize the reasons for the change and assess design quality. The authors would also like to investigate the types of PCI changes each project group is experiencing and how proposed schedule information is documented to understand if any internal communication and planning patterns exist that could inform project performance trends.

For further research, the authors also aspire to explore the interactions and workflows for understanding and aligning stakeholder wants, needs, and project expectations and how the workflows and processes differ between the groups. The authors want to investigate how these project system outputs are visible in the organization's enterprise system data. This knowledge can be used to determine additional leading indicators of project performance trends.

Furthermore, the authors suggest broadening this study and previous papers from 2021 and 2022 to apply multivariable statistics to create statistical thresholds for project performance outcomes, cultural outcomes, staffing and resourcing profiles, and standard process outputs. For benchmarking, the authors would like to explore these views based on project type, customer accounts, design partners, project delivery system, and other project characteristics that would inform the GC's execution strategy.

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