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ASSESSING QUALITY PERFORMANCE OUTCOMES AND THE RELATIONSHIP WITH STAFFING: A GENERAL CONTRACTOR CASE STUDY

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ABSTRACT

This paper describes a methodology for understanding how staffing projects may be assessed and considers how it may relate to project team performance when project teams implement a Systems Approach to Quality (SAQ). This paper expands on the 2021 paper "The Impact of Implementing a System Approach to Quality: A General Contractor Case Study" where the authors compared project performance outcomes and team cultural assessments for 11 projects that had implemented SAQ, the Intervention group, to a similar set of projects that had continued with a specification compliance -based approach to quality, the Control group. This study reflects organizational learning in a continuous improvement process and helps clarify distinguishing features of staffing for this General Contractor. The authors findings suggest that applying SAQ can help sustain a project team through the phases of ever-changing project life cycles and contribute to more reliable outcomes when staff is engaged earlier in the project and supported with Virtual Design and Construction (VDC) and outside project management resources.

KEYWORDS

Organizational change, quality, data, staffing, impact

INTRODUCTION

This is the fourth paper in a study series to document and study one US based General Contractor's (GC) quality approach focused on achieving "zero errors, zero defects, zero rework and zero surprises" (Spencley et al. 2018). This GC's quality approach required the organization and project teams to shift from assuming stakeholder expectations and only tracking lagging indicator issues to focusing on setting up systems and routines that prompt collaboration to define measurable acceptance criteria with tracking, to act on these leading indicators (Spencley et al. 2018, Gordon et al 2021a).

Projects consist of complex networks that can be influenced by many different factors (Bertelsen 2003a; Bertelsen 2003b; Bertelsen et. al 2005). This Systems Approach to

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Quality (SAQ) also accepts that construction projects are complex and dynamic (Gordon et. al 2021a). 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 SAQ, the Intervention group, to a similar set of projects that had continued with a compliance specification-based approach to quality, the Control group. The projects that had implemented this GC's SAQ had significantly better outcomes for cost growth, fee gain, schedule growth at mobilization, change percent duration, value of percent changes and the value of claims as percentage of contract cost (Gordon et al. 2021a). In this new paper the authors wanted to understand if project staffing and resourcing had any distinguishing differences between the two groups.

Staffing of projects is important to this GC because project records indicate that project teams have historically identified staffing as a top three reason for project fee loss. More recently, staffing has been named as the second leading cause of fee loss for open projects. Understanding how staffing influences project performance outcomes is important work for this industry. However, a review of the IGLC database showed that actual staffing data and correlations to project performance has not been explored. This study is foundational work for other staffing and resourcing studies. Furthermore, this work has created new organizational tools that the GC can use to understand and influence project workflows.

To align on terminology, the authors consider staffing to be the labor hours associated with personnel assigned to the project to administer construction management and planning activities, commonly considered general conditions. In contrast, resourcing is related to the corporate workgroup support. This GC has a strategy enabling project delivery through corporate workgroups gathering and sharing knowledge with projects. The workgroups develop methods that the project teams apply by developing their own routines and processes. Resourcing is also used to describe engagement of the organization's subsidiary companies to support project management and deliverables.

In this practice-oriented paper, the authors first discuss the complexity of construction projects and staffing to describe the foundation for the methodology. In this complex environment, the authors explore and analyze the questions:

- Did the projects that implemented a Systems Approach to Quality have different staffing profiles compared to Control projects?
- Did projects in each group have the same staffing hours and staffing roles at the same times in the project lifecycle?
- Were there discernable differences in staff experience between the groups?

Then, through the rest of the paper, the authors describe their methodology to investigate answers to these questions, qualify the limitations of the data, review the findings from their analysis, discuss the findings, and finally present a conclusion for future workflow and further research.

CONSTRUCTION PROJECTS

A COMPLEX & DYNAMIC PROCESS

Many of Bertelsen's IGLC papers have demonstrated how the construction process is not a linear, ordered process, but rather "exists on the edge of chaos" and should be viewed through a complex system perspective (Bertelsen 2003a). In his work, Bertelsen reviewed the construction production system and the industry of construction against 14

characteristics of a complex system described in The Philosophy of Complexity by Lucas (Bertelsen 2003b; Lucas 2000). After comparing and discussing the construction process through this lens, Bertelsen concluded that construction projects should be seen as a "complex dynamic phenomenon" and management systems should reflect this understanding (Bertelsen 2003b). Projects can experience many different and ever-changing challenges. Since the construction industry's interwoven network is not completely transparent, one project's logistical issues, supply chain issues, and skilled labor shortages can be affected by other local on-going work and/or issues in other parts of the world. Also, each project's team is unique and forms a temporary organization which brings its own set of team characteristics and demands. Additionally, stakeholder indecision and changes can cause delays. And there is of course unexpected weather and natural phenomena that forces the project to adjust its course (Bertelsen 2003a; Bertelsen 2003b; Bertelsen et. al 2005).

STAFFING A COMPLEX AND DYNAMIC PROCESS

Recognizing that construction projects are complex and dynamic, a GC project's staff form a major cost center that determines project overheads and can influence project outcomes. "Appropriate allocation of supervisory staff for a project could ensure the successful administration of the management functions, such as planning, organizing, leading, and controlling throughout the construction stage, and thus could reduce unnecessary waste for resources and assure high productivity" (Leung et. al 2008).

An IGLC paper search with the keyword "resource" located 216 papers and "staff" found 28 papers. Many of the papers explored topics of knowledge management, profiles of lean staff, case studies of lean principles, and VDC and production planning concepts. A keyword search of "staffing" found 2 papers. One paper was a case study that analyzed actual project staffing records for different standardized prefabricated housing units in Hong Kong (Leung et. al 2008). This case also studies actual project staffing records collected by a GC and attempted to correlate staffing strategies to the scale of the project. However, a search of the IGLC database for project staffing and project performance did not produce any results.

A SYSTEMS APPROACH TO QUALITY

This GC's quality approach reflects Bertelsen's views and the understanding that construction projects and construction organizations are complex and dynamic. SAQ foundationally promotes the integration of identification of Distinguishing Features of Work and risk across all workflows, such as safety, quality, project, cost, and logistics, with all stakeholders to understand and align on acceptance criteria through each phase of work for the highest likelihood of achieving reliable outcomes. (Spencley et. al 2018; Gordon et. al 2021a). These principles can be applied to project workflows, as well as, how leaders approach and manage the work through their Business Unit or Region.

The authors have worked to understand how project teams and the organization has implemented SAQ over the past six years (Gordon et. al 2021b). During this time three of the authors were part of corporate workgroups that developed methods for projects and supported project implementation of SAQ. To learn from staffing and resourcing of these complex and dynamic projects, the authors applied the methodology below.

METHODOLOGY

DIVING INTO THE PROBLEM STATEMENT & MAPPING A PATH FORWARD

To understand the implications of SAQ on staffing and resourcing, the authors applied 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). The author's process included six steps. The first step involved framing and reframing the problem through use of a tool called "web of abstraction". The web of abstraction tool enables understanding problem statements found in many different, yet interlinked, problems and enabled the authors to explore multiple perspectives around understanding staffing and resourcing.

The authors then interviewed Subject Matter Experts (SMEs) within the company to gather knowledge and to understand: How are complex and dynamic projects currently staffed? How might we evaluate and plan for the cost of staffing? How might we understand how well people are integrating and implementing the systems? The SME included a regional operations leader, mechanical preconstruction leader, and business process analyst. The key beliefs that emerged from these interviews: 1) all project staff have an assigned role 2) the company tracks years in the construction industry and years at the organization 3) projects can be supported by external project management and technical resources 4) it is important to consider the contract value and duration of the project to help understand the context of staffing 5) a key characteristic of successful projects includes the project's ability to sign the contract in a timely manner 6) VDC represents a fully integrated Systems Approach to Quality.

After interviewing the SME, the third step involved imagining and designing ways to explore the questions. The fourth step involved locating data sources and mapping information to investigate the questions. Next, the authors prototyped the proposed data mapping through visualization tools. Finally, the data was analyzed.

PHASE 1: STAFFING & RESOURCING HOURS INVESTIGATION

To understand staffing and resourcing differences between the two groups of projects, the authors first compared the cost codes that staff documented in their weekly billing submissions and recorded in the enterprise labor tracking system. The resources used for staffing projects were either administrative hours or craft hours. Administrative hours describe the roles of management positions that typically work in the office to purchase, manage, and coordinate the project through responsive communication tools. Craft hours describe the roles of skilled and unskilled production execution positions that put construction work in place.

Next the administrative office hours were categorized by standard work roles: Project Accountant, Project Executive, Project Manager, and Project Engineer. And the administrative field hours were categorized by standard work roles: Superintendent, Assistant Superintendent, and Foreman. Lastly, the administrative roles were identified by organizational discipline workgroups: RISQ – Risk, Insurance, Safety and Quality resources; PSPP – Production, Scheduling, and Production Planning resources; VDC – Virtual Design & Construction resources; MEP – Mechanical, Electrical, and Plumbing resources, and SPW – administrative and craft resources dedicated to Self-Performed Work (SPW) functions and outputs. For each SAQ project, this breakdown of GC hours was reviewed and compared to its counterpart in the Control project group.

To assess this information for projects, the authors used the organization's integrated operations data application. The application was designed by the second author on a data

visualization platform for operational leaders in the organization. The application assembles data from the many different software tools project teams use and relates the information by project lifecycle, core market, geography, customer, and other project attributes. It provides views of project information across measures of safety, quality, cost and schedule, objective indicators of project performance. The tool also provides relatable information from project timecard entries summarized by date and cost code.

To compare the differences between the Intervention and the Control group of projects, the hours were compared between two standard project milestones, actual mobilization, and actual substantial completion project dates. The actual mobilization date is the date the project team "mobilizes on-site," and actual substantial completion date is the date "when the Work or designated portion thereof is sufficiently complete in accordance with the contract documents so that the owner can occupy or utilize the work for its intended use" (DPR 2018). These standard milestones are routinely collected from project teams through a monthly status reporting process.

New coding was built into the operations data application that allowed filtering of GC staff time by 1) administrative or craft and then by 2) roles and workgroup categorization. The data was then exported to a spreadsheet application where it was further analyzed.

To compare project hours, all project timelines were divided into four quarters: 1) actual mobilization date – 25% of the project timeline; 2) 25% – 50% of the project timeline; 3) 50% – 75% of project timeline; and 4) 75% – actual substantial completion date. For each project, the dates associated with each project milestone were computed. The project's staff hours were allocated to the appropriate quarters. Then, the percentage of staff hours spent for each quarter out of the total staff hours was calculated. This information was also broken out for each workgroup to understand the subject matter expert (SME) resourcing. This enabled the authors to view the data as 1) count of hours 2) as a percentage of total hours for the project for GC administrative & sub-tier filtering. This data, for each group, was also represented in box and whisker charts. These findings are compiled in Figure 2.

PHASE 2: ADDITIONAL STAFFING CHARACTERISTICS INVESTIGATION

To understand more characteristics about the GC's staff, the authors tallied the numbers of each role on the projects. To study the experience of the staff, the authors compiled time in industry and time at this GC in years. The authors wanted to look at the experience of those that had a reasonable level of influence on project systems and routine behavior, "Majority Staffing." Therefore, the authors looked at the individual who recorded the most hours spent on the project, and the experience of the staff that had spent at least half that amount. Staff data was analyzed from the standard project pursuit workflow system where staff experience is represented by both years of recent experience at the GC and in the industry. Through the integrated operations data tool, the authors understood staff roles and assignments for each project. Then, the category, role, and experience level for each staff was compiled for review. The findings of this investigation are summarized in Table 1.

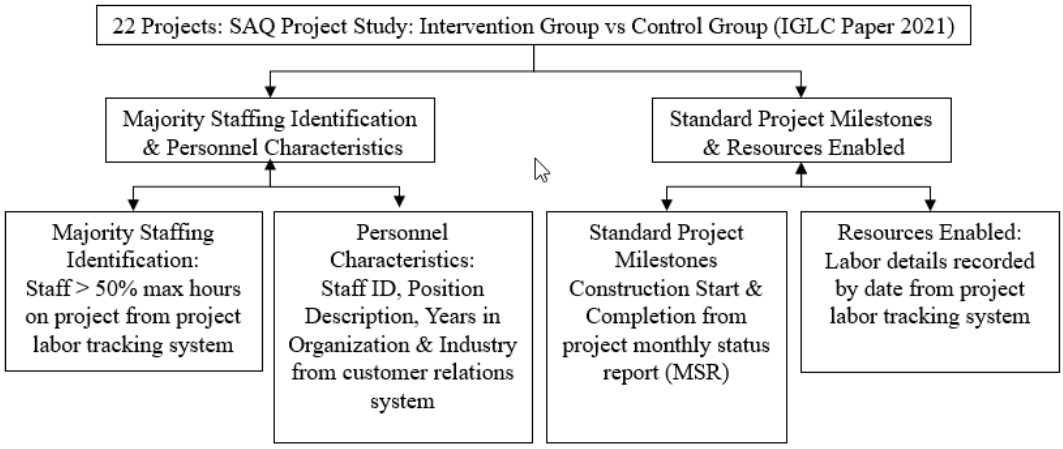
The SME interviews had highlighted three additional data points to investigate: 1) the date the Guaranteed Maximum Price (GMP) was signed 2) the project's use of VDC and 3) outsourcing of project management resources. This GC has a subsidiary company in India that focuses on providing "services and solutions to the Construction industry in the area of Virtual Design and Construction (VDC), Project Controls management,

Accounting and Software Development" (vConstruct 2021). The findings of this investigation are summarized in Table 1.

LOCATING AND MAPPING DATA SOURCES TO INVESTIGATE QUESTIONS

Analyzing the data consisted of understanding project workflow and understanding potential workgroup resourcing, project key roles and understanding standardized project milestones tracked across all projects organizationally and understanding of the organizational data workflows. Figure 1 shows the information mapped by this data study.

Figure 1: Variables mapped to data sources.



LIMITATIONS OF THIS DATA

The projects in the SAQ Intervention group all demonstrated, through discussions and sharing at a company-wide meeting called the "Monday Quality Calls", how they implemented the principles of a SAQ and their results (Gordon et al.2021b). Each SAQ project was matched with a project of similar contract size, in the same core market, completed or within 90% of completion in the last five years and when possible, in the same geographic region (Gordon et. al 2021a) The limitations of these data sets are: 1) it is a small sampling of projects, and a case study; 2) the projects are classified as having implemented or not implemented SAQ; 3) the data on staffing comes directly from the GC's platforms and the reporting from project teams. The project teams can categorize staffing based on what the customers expect staffing categories to be versus actual project needs and the individual's actual role designation in the company; 4) Not all data for each characteristic was available; 5) The data collected for administrative staffing hours is based on a forty-hour work week and is not reflective of total hour effort. The GC's administrative staff often spends more than forty hours per week working on the project; 7) contractual distinctions between projects was not studied; 6) the staffing experience data does not recognize a specialized experience or expertise of individual staff members.

DATA FINDINGS

PROJECT PERFORMANCE METRICS & STAFFING HOURS

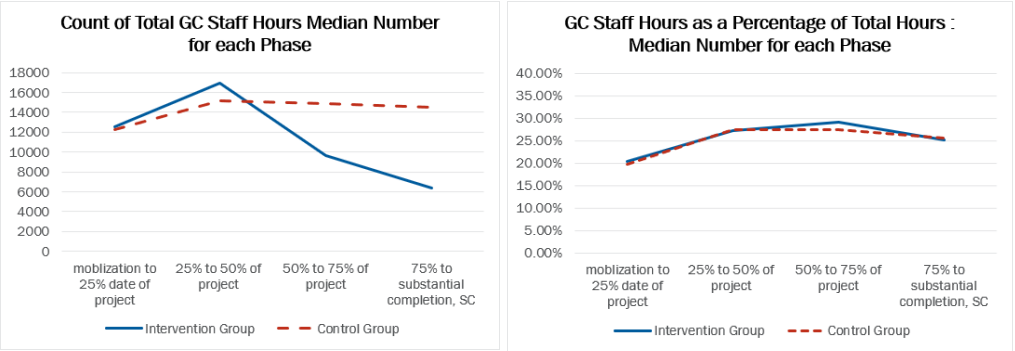
Through previous research, the intervention and Control group performance metrics and cultures were assessed. The IGLC paper "The Impact of Implementing a System Approach to Quality: A General Contractor Case Study" reported the following:

- Cost: The median value of cost growth for the Intervention group was 1% and 9% for the Control group. The median value of fee gain for the Intervention group was 4% and -29% for the Control group.
- Schedule: The median value of schedule growth at mobilization for Intervention group was 11% and 18% for the Control growth.
- Change Management: The median value of contract changes was 1% for Intervention group and 18% for the Control group.
- Safety: The median value of incidents per $100M for the Intervention group is 1 and 0.8 for the Control group.
- Quality: The median value of value of claims as a percentage of contract cost for Intervention group was 0.14% and 0.87% for Control group.
- Project cultures: Using Quinn's Competing Values Framework (CVF), the Intervention group reported more collaborative cultures (Gordon et. al 2021a).

For this study, the authors also analyzed the date the contract and Guaranteed Maximum Price (GMP) was agreed to and signed by all parties. Signing the GMP is a key Point of Release (PoR), when work is released to the next phase of the project to be built upon. Signing the GMP demonstrates alignment of contractual terms and conditions, a fundamental execution of SAQ principles. For GMP signed date as % of project duration, the Intervention group median value was signed at 0.9% of project duration, close to the project mobilization date. The Control group's median value was 19% of project duration, nearly 80% through the first quarter of the project.

Figure 2 summarizes the data observed from the time entries for project staffing and resourcing for the Intervention and Control groups. The x-axis represents the four quarters of the project. The first graph plots, for each of the project quarters, the median value of total staff hours for each group. The second graph plots the median value of staff hours for each quarter of the project as a percentage of the total hours.

Figure 2: Project Staff Hours Over Time Graphs.



For the two project groups, three views of the count of total staff hours were compared: 1) comparing counts of total hours by quarter 2) plotting the median values for each quarter shown in Figure 2, left graph and 3) through bar and whisker charts for quarter. Although the Intervention group had better outcomes for cost, schedule, change management, quality (Gordon et. al 2021a) and alignment on contractual terms, the Intervention group reported 10% more total staff hours. In reviewing the count of hours by quarters, the first and second quarter the Intervention group had 13% and 18% more hours. In the third and fourth quarters, the Intervention group reported 4% more hours. The plot of medians in the left graph shows greater differences between the group's

median values in the third and fourth quarters demonstrating this wider range of variability in count of hours for the Intervention group. The bar and whisker charts also show that the Intervention group had wider variability of total staff hours for all project quarters, while the ranges for the Control group were much tighter.

The right graph shows that the median values for the percentage of total hours spent during each quarter is similar for both groups. However, graphical analysis shows the Intervention group experienced more variability for staff hours as a percentage of the total hours in the second and fourth quarters of the project, suggesting staff and resources were allocated as required to adjust to project needs. In the left graph, the Intervention group spent a higher median of hours in the second quarter only and achieved lower median resource demands in the third and fourth quarters, also suggesting that their implementation of SAQ, and more time spent in the second quarters, enabled greater alignment on product deliverables.

These observations demonstrate that there was more variation in staffing in the SAQ, Intervention projects. The authors believe this is due to the complex nature of the projects and in recognizing the risks, these projects were allocated needed resources. Since the median value of the GMP for the Intervention group was signed within 1% of actual mobilization, and the median value of GMP signing was 19% of project duration for the Control group, this demonstrates that the SAQ GC teams were able to get alignment on conditions of engagement sooner, resulting in fewer distractions for the project teams. The Intervention group also reported more collaborative cultures (Gordon et. al 2021a).

ADDITIONAL STAFF AND PROJECT CHARACTERISTICS

Table 1 shows the additional staff characteristics and resourcing for each project that were explored. The table shows the median number for each group for each characteristic.

Table 1: Additional Characteristics Compared between Project Groups.

Staffing Characteristic	Metric	Median	
		Intervention group	Control group
Staff hours per week	Total staff hours / Duration in weeks	509	495
Staff hours per $M contract	Total staff hours / Contract Value	441	573
Count of Staff	Office (Project Executive, Manager, Engineer, Accountant)	8	9
	Field (Superintendent, Foreman)	10	16
Experience of Staff	Office staff years in Industry	14	18
	Office staff years at DPR	8	9
	Field staff years in Industry	22	20
	Field years at DPR	6	7
VDC Hours	VDC hours as % of total staff hours	2.0%	0.5%
SPW Hours	SPW hours as % of total staff & SPW hours	15%	14%
Project Management Outsourced contracts	contracts as a percentage of total contract value	0.08%	0.0%
	Total cost of outsourced contracts in dollars	$61,539	$0

When comparing average staff hours per week, both groups had similar median values. In comparison, for average staff hours per contract costs, the Control group had a higher median value and more variability in range, likely due to the increased project durations.

While the Intervention group and Control group had a 10% difference in total staff hours, and similar average staff hours per week, the Control group had 28% more total staff count. The median value for the count of field staff was 63% higher for the Control group, suggesting the field had more staff turnover. The authors believe the higher amount of change and change management the Control projects experienced during construction led to more staff turnover.

Overall, there was a negligible difference in the median values of experience of staff measured as years in the industry and years at the GC organization. This suggests that staffing experience was not an influential factor for this study.

The authors also noted two significant differences in resourcing 1) the use of VDC and 2) the use of external project management services. The SAQ projects, Intervention group, had a larger total and range of VDC usage. These projects had developed processes and routines for collaborating with project stakeholders with visualization. Thus, demonstrating one form of systemizing of measurable collaboration. Team members from the GC surveyed through Quinn's CVF in previous research also rated their projects as more collaborative, suggesting that the use of VDC was an important factor that contributed to this culture. In review of the data, the authors found that for projects under $150M there was very little time coded to VDC. On a deeper dive into the time entry data, the authors found that VDC time entry for an Intervention project under $150M was coded to project engineer's time. Also, both groups of projects had similar use of SPW to suggest SPW was not a factor in project outcomes for these data sets.

While the contract values of the projects were similar, and the Intervention group's total count of staff hours was 10% more, the Intervention group also contracted with more external project management support resources. This is interesting as the Control group projects were experiencing more changes (Gordon et. al 2021a). The Intervention group, aligned on contractual terms sooner, experienced less change management and contracted with more external project management support resources. This shows that there was aligned and agreed upon project management workflows with all stakeholders that allowed for work to be outsourced to free up the project team's time to focus on other aspects of construction.

CONCLUSION

NEW INSIGHTS

From this study of 22 projects representing nearly $4B of contract revenue, the authors observed that the projects that applied SAQ achieved GMP sooner, experienced less change in contract value, higher fees, were closer to forecasted schedule milestones, had less claims, fewer staff turnover and experienced more collaborative cultures. This suggests the timeframe in which projects achieve acceptance of GMP is a leading indicator of project outcomes and can be tracked to aid the organization's strategy of staffing and resourcing projects. This study also suggests the timeframe of achieving GMP acceptance is also a leading indicator of project culture experienced by the GC.

Furthermore, the authors observed the Intervention group had a higher count of hours during the first and second quarters and had less percentage of their total hours in the

fourth quarter. This suggests Intervention projects spent more time adjusting and responding to challenges earlier in the project.

The other key staffing and resourcing differences between the groups included: 1) systemization of measurable collaboration, evidenced by the increased use of VDC in the Intervention group. VDC is a vital quality tool as it provides visualization of project needs and requirements to assist communication and alignment amongst stakeholders; 2) the higher use of project management outsourcing which also demonstrates systemized and standardized project workflows. This suggests, developing standard workflows for VDC and project management for outsourcing, are two key characteristics that support success of complex and dynamic projects for this GC.

Still, the authors' takeaways are that there is not a simple staffing formula that guarantees reliable performance metric outcomes, and an expanded study is needed. The authors acknowledge that a GC data model designed to provide key data across various related platforms used by different workgroups, using normalized and standardized perspectives, is instrumental in doing staffing studies at organizational scale with reduced effort. The authors recommend an integrated data model that represents project lifecycle workflows based on work being released from phase of the project lifecycle to the next, will better utilize real-time data for analysis and evaluation. Integrated enterprise dataflow tools improved processing speed, reflection and learning whenever it was available. Visualization of GC data can create baselines to compare actual workflows.

With this experience, the authors recommend that an integrated operations data portal include all major systems. Finding common connections across these enterprise systems helps to clarify expectations amongst project team members, especially during transfers of information and deliverables. Integrating data conversations may also help different workgroups at the corporate level of the organization discuss the data they are collecting. These views may help them to consider how their data might benefit other workgroups, to further support project teams.

FURTHER RESEARCH

For further research, the authors suggest analysis of the outsourced project management processes relative to the project lifecycle to understand the differences in the project processes and daily routines that enabled measurable collaboration. The authors also suggest using a similar lens to review trade partner commitment trends and project cash flow to illustrate distinctions between the two project groups and the measurable collaboration associated with work authorizations, and billing and payment practices.

Furthermore, the authors would also like to explore how to utilize AI and machine learning to perform real time assessments on forecasted and actual staffing compared to organizational benchmarks observed in other similar projects considering the unique sets – by customer, by type of building, by contract value, and by location – to name a few. This would aid more informed decisions around present and future staffing using objective criteria and past performance benchmarks.

Widening the study within the organization and performing multivariable statistic techniques to gain further insights, the authors suggest added benefit from collaboration with other GC organizations applying the principles of SAQ to explore other staffing and resourcing characteristics related to core market, type of building, and decision-making maturity of customer, project team measurable collaboration skills, SAQ implementation experience, previous experience of the team working together and the social network that supported the SAQ implementation.

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