QUANTIFYING THE IMPACT OF NON-TRADITIONAL STAKEHOLDER INVOLVEMENT ON PROJECT QUALITY

Rizwan Assainar[1] and Mounir El Asmar[2]

ABSTRACT

The traditional approach of stakeholders' involvement in architecture, engineering, and construction (AEC) projects typically consists of the architect or engineer's (A/E) involvement in the design phase, and the general contractor or construction manager's (GC or CM) and subcontractors' involvement in the construction phase. Previous research emphasizes the need for the involvement of the GC/CM in the design phase and focuses less on the A/E's participation in the construction phase. This study evaluates the impact on project quality performance of both (1) the GC or CM and subcontractor's involvement in the design phase, and (2) the A/E's involvement in the construction phase. This type of involvement is termed the "non-traditional approach" in the paper. Relevant literature was analyzed, and a data collection instrument was developed and utilized in detailed interviews to gather information on different stakeholders' involvement, as well as quantity performance scores from more than 30 recently completed complex institutional construction projects in the United States. Univariate analyses, such as t-tests and Mann-Whitney-Wilcoxon tests, were performed to evaluate stakeholders' involvement impact on project quality performance. The preliminary findings indicate that non-traditional stakeholder involvement is linked to statistically significant improvements in project quality. The AEC industry can utilize this information as a guide for decision makers, assisting them to select the appropriate level of involvement of various stakeholders at different phases of a project.

KEYWORDS

Integrated Project Delivery, People, Quality.

INTRODUCTION

The rising need for fast-track construction projects with increasing complexity has ultimately resulted in the development of alternate project delivery methods that supplement traditional sequential project delivery in a successful attempt to improve project performance. Though new delivery systems have been studied and their superior performance documented from a high level perspective, the impact of specific characteristics of these systems has not been investigated fully. For instance,

[1] Graduate Student, Construction Management Program, School of Sustainable Engineering and the Built Environment, Arizona State University, P.O. Box 870204, Tempe, AZ 85287-0204; Phone: (480) 703-1538; E-mail: rassaina@asu.edu.

[2] Assistant Professor, School of Sustainable Engineering and the Built Environment, Arizona State University, P.O. Box 870204, Tempe, AZ 85287-0204; Phone: (480) 727-9023; E-mail: asmar@asu.edu.

the involvement magnitude of key stakeholders in different phases of Architecture, Engineering and Construction (AEC) projects has not been studied in detail and quantified.

The traditional approach of stakeholders' involvement in AEC projects is typically focused on the architects and engineers' (A/E) involvement in the design phase; and the general contractors or construction managers (GC or CM) and subcontractors' involvement in the construction phase. In the past two decades, the new and more collaborative delivery methods contributed to reducing this separation of stakeholder in favor of more integrated types of involvements. Specifically, there has been more emphasis on the early involvement of contractors in the design phase, and to a smaller extent the A/E's involvement in the construction phase. The builders' involvement in the planning and design phases can help guide the design with respect to schedule constraints and early cost estimates, as well as providing constructability analyses through a fundamental understanding of the construction means and methods. Similarly, designers' involvement in the construction phase can help maintain facility quality while possibly decreasing the project duration because of their extensive knowledge of the design. Their involvement also is important to make decisions that help the project move smoothly and to make sure the owners receive an adequate facility that fulfills their needs.

This paper assesses how each stakeholder's specific involvement, and its magnitude, in different phases of an AEC project can impact the project's quality. The paper quantitatively studies how (1) the involvement of A/E in the construction phase, and (2) builders in the design phase, are ultimately affecting project quality performance. First, the paper reviews and analyzes the relevant literature on stakeholders' involvement, through looking at both quantitative qualitative studies. Then the paper will discuss the objectives and methodology of the study, before finally presenting the preliminary results and a discussion of the findings.

LITERATURE REVIEW

The literature review addresses two complementary sections. The first covers previous studies that presented quantitative analyses, while the second consisted of more qualitative studies including case studies and opinion-based questionnaire data. Both sets of prior work are valid and complement one another to provide an adequate point of departure for this paper.

QUANTITATIVE STUDIES

Song et al. (2009) identified contractors' inputs during early design stages and illustrated the impact on construction schedule performance through an industrial case study and a simulation model. The industrial case study and model developed was based on a pipe spool fabrication and construction process. The levels of involvement of the fabrication contractor at different stages of the design and construction stages are used as scenarios. The categorization was based on the contract agreement and consisted of four scenarios: (1) Fabricator involvement starting at the fabrication and assembly stage; (2) Fabricator involvement starting at the Detail Design (DD) stage; (3) Fabricator involvement starting at the Engineering Design Specification (EDS) stage; and (4) Fabricator involvement starting at the Design Basis Memorandum (DBM) stage. The actual project is similar to Scenario 1 above, and the other scenarios were modeled by estimating frequency data with the help of the actual suppliers in order to estimate realistic data. Scenario 1 was used as the baseline, and Scenario 2 results showed a project duration reduction of 3.4% and a 1.4% reduction of man-hours used. Scenario 3 showed a reduction of 7.7% and 3.6% in project duration and man-hours, respectively; and finally Scenario 4 resulted in project duration and man-hours reductions of 12% and 5.5%, respectively. Commonly observed benefits of early contractor involvement revolve around improved knowledge transfer and include improved drawing quality, material supply, and information flow. However, the scope of the study was limited to (A) being based on a simulation model for a single project, and (B) measuring only the impact on schedule performance, while the resulting project quality performance is not measured. Robert et al. (2012) recently studied early contractor involvement (ECI) in Northern Ireland and showed cost reductions through implementing early contractor involvement. The surveyed project costs ranged from £10.4 million to £268 million, with an average project cost of £123.7 million. When compared with the target costs for the early contractor involvement schemes, an average savings of £1.3 million was calculated per scheme. The following findings were also noticed when early contractor involvement was observed: 92.86% of ECI projects were delivered on time, and 85.71% of ECI projects were delivered to the required quality.

QUALITATIVE STUDIES

There are a limited number of quantitative studies investigating the early involvement of contractors based on empirical project data. However, numerous studies present in-depth insights by surveying experienced practitioners. For example, Gil et al. (2000) conducted a three-phase survey study. In the first phase, 18 lead designers, design managers, and construction managers were interviewed; in the second, 12 individuals working in MEP construction firms were interviewed, ranging from labor managers to vice-presidents. In the third phase, seven practitioners were interviewed to represent owner organizations. The authors conclude that if specialty contractors are involved early during design, the duration and cost are reduced and they can contribute in multiple ways to the project by developing creative solutions while also offering their knowledge of space considerations for construction processes, their knowledge of fabrication and construction capabilities, and their knowledge of supplier lead times and reliability. Gil et al. (2000) also found that early communication between specialty contractors and designers can help designers and owners more accurately estimate the cost of design alternatives thus increasing the quality. More recently, Van Valkenburg et al. (2008) completed case studies and concluded that early involvement of contractors shows promising results and its success depends on the timing and manner of involvement, along with a clear definition of each stakeholder's proper role. Additionally, Mohamad et al. (2010) propose that through contractors' early involvement during the design stage, combined with the use of the value management methodology as a decision-making tool, better optimization of construction cost can be achieved, thus promoting more efficient and effective constructability. The authors suggest that this further transfers the design decision to the professional consultants solving technical problems, which require the combined effort of the multi-disciplinary team. According to Scheepbouwer et al. (2011), owners and contractors agree that early contractor involvement helps improve project quality and cost control, but designers argued that any time savings will be negated due to increased collaboration and negotiation between the parties. Rahmani et al. (2012) discusses early contractor involvement as a way to promote innovation, facilitate value management and value engineering, minimize claims and reduce time and cost of projects. The survey conducted by Rahmani et al. (2012) mentions the following benefits resulting from the early involvement of contractors in the design phase: opportunity for better relationships, effectiveness of contractor's input to design, better risk management, overall improved project delivery, efficient resource utilization, improved contract administration, and *improvement in project quality*. This last item is the subject of the current paper, which aims to validate and quantify the resulting improvement in quality due to stakeholders' non-traditional involvement.

PROBLEM STATEMENT AND METHODOLOGY

The review of literature mostly focused on the early involvement of contractors in the design phase. Unfortunately, the body of literature on the involvement of A/E in the construction phase is relatively shallow. Several studies were based on surveys and opinions of project personnel, and few studies focused on empirical project data. The literature review illustrates that the studies have focused mostly on cost and schedule metrics and some studies showed improvements in these two areas, while most other studies showed there is a potential improvement in several other areas (including project quality) expected from early contractor involvement. This paper will validate and quantify the resulting improvement in quality due to stakeholders' non-traditional involvement to complement the existing literature on schedule and cost performance. The paper also will add to the body of literature the quality impact of the A/E involvement in construction.

This research aims to quantitatively understand how nontraditional involvement of stakeholders impacts project quality performance. The nontraditional involvement of stakeholders is defined as the early involvement of GC or CM and subcontractors in the design phase, and the involvement of A/E in the construction phase. The paper also statistically analyzes the impact of colocation of key project stakeholders on construction quality performance. The objective of this paper is to quantify the impact of various stakeholders' involvement in AEC projects based on data collected from recently completed projects followed by an analysis of quality performance. The paper will empirically analyze data from projects with varying levels of stakeholder involvement at different phases of the project.

The methodology for this study encompasses three distinct stages. *Stage A* was the assessment of literature and industry practices presented earlier, that helped lay the ground for the rest of the study. *Stage A* also included the identification of important input and output variables, serving as a solid basis for the survey development. *Stage B* was the data collection phase and included three steps: survey development; industry data collection; and pilot testing. As a part of survey development, The GC or CM were asked to rate the as-built quality of project systems which includes: foundation, structure, interior finishes, exterior enclosure, roofing, mechanical systems, electrical systems, site and so forth. The ratings were subcategorized into: Economy, Standard, High, Premium, and High Efficiency Premium on a scale of 1 through 5 respectively. The resulting project data from 35 completed complex institutional projects were verified and readied for analysis. The last stage of this research, *Stage C*, builds on the previous two and consisted of analyzing the data collected then discussing quality performance results. The data collected were statistically analyzed to test whether early involvement of GC or CM and subcontractors in design, and A/E in construction, lead to superior quality performance. The analysis was accomplished in three steps:

(1) Categorizing the projects falling in each involvement category;

(2) Testing for normality on all datasets using quantile-to-quantile plots (Q-Q plots) and categorizing into distributions where the normality assumption holds, and those where is does not;

(3) Conducting two-sided t-tests where the dataset is normally distributed and Mann-Whitney Wilcoxon (MWW) tests where the dataset is non-normally distributed. Since the decision regarding which test to use is based on Q-Q plots, which are used to approximate whether the distribution can be assumed normal, the authors conducted a comprehensive assessment by considering both tests in the analysis and analyzing any differences in the resulting p-values. Further, in the "preliminary results and discussion" section both test results are discussed.

The variables were categorized into: (1) "No Involvement," (2) "Little Involvement," (3) "Some Involvement," (4) "High Involvement," and (5) "Very High Involvement" of stakeholders in each category. The list of involvement variables (inputs) considered includes:

- The GC or CM familiarity with the owners' objectives and expectations firsthand (directly from the owner);
- The A/E support during the construction phase;
- The involvement GC or CM in the design and preplanning phases;
- The subcontractor or specialty contractor involvement in the design and preplanning phases;
- The use of co-location, a collaborative method where project participants conduct their day-to-day work in the same physical space; otherwise known as the "Big Room."

PRELIMINARY RESULTS AND DISCUSSION

In this section the impact of different stakeholders' involvement on quality performance is quantitatively investigated. As discussed earlier, univariate analyses were performed on the collected project data to study the various involvement variables and test their impact on quality performance. Any significant differences in performance are highlighted based on p-values obtained from t-tests and MWW tests. If these tests show a p-value smaller than 0.05 then there is a statistically significant performance difference between (1) the projects where key stakeholders exhibited heavy non-traditional involvement (A/E in construction; GC or CM and subcontractors in design) and (2) those where key stakeholders were not heavily involved.

Boxplots of the data are presented. A boxplot is a nonparametric graphical summary of data, displaying the sample minimum, lower quartile, median, upper quartile, and maximum. The median value is represented by a thick black line, dividing the data set in half, and the box represents the 50% of the data around the median, whereas the remaining 50% of the data are divided equally above and below the box. Boxplots give a visual representation of the dataset and provide insights regarding the distribution of the data (El Asmar et al. 2013). Figure 1 shows the boxplots of *as-built quality* on the y-axis, and different involvement variables on the x-axes. The median and range from boxplots in the upper left corner makes it clear that the GC or CM's familiarity with the owner's objectives and expectations firsthand shows an increase in the quality of the built facility. Further, the t-test and MWW test on the extent of the GC or CM familiarity with the owner's objectives show statistical significance with p-values of 0.025 and 0.037, respectively, confirming a possible relationship between project quality and GC or CM familiarity with the owner's objectives firsthand.

The upper right corner of Figure 1 shows the A/E support during the construction phase. Here again, the median and ranges in the boxplots show an increase in quality when the A/E are very supportive during the construction phase. The t-test and MWW test illustrate a likely increase in the quality of the project with p-values 0.036 and 0.049 respectively. These values are statistically significant at the 0.05 level.

Further, high involvement of the GC or CM in design illustrates a greater project quality as compared to little involvement of the GC or CM in the design phase (see the center portion of Figure 1). The t-test and MWW test for involvement of GC or CM in design confirms the potential benefit in quality increase, with p-values of 0.00037 and 0.001, respectively.

The lower left corner of Figure 1 shows the involvement of key subcontractors in the design phase. The plots illustrate a greater project quality when subcontractors are involved, as compared to when there is little involvement in the design phase. The t-test and MWW test confirm this likely increase in the quality of the project with p-values 0.005 and 0.009 respectively. As with previous results, these values are statistically significant at the 0.05 level used for this study.

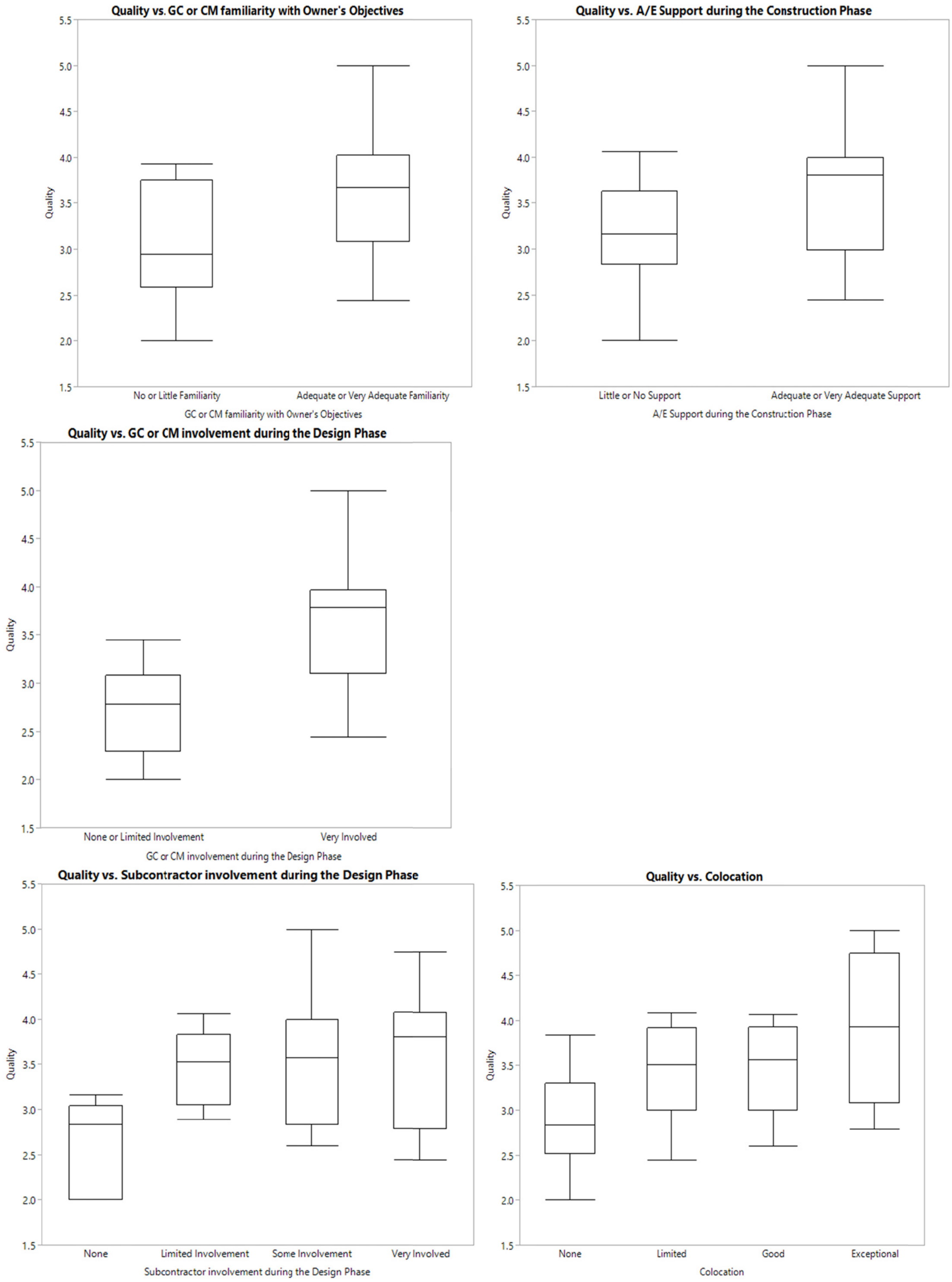

Figure 1: Project Quality versus Stakeholder Involvement

Finally, the lower right corner of Figure 1 shows the co-location of the key project stakeholders and its impact on project quality. The trends of the medians and the ranges show an increase in co-location of stakeholders is associated with higher project quality. The statistical tests show p-values of 0.025 and 0.049, confirming the statistical significance at the 0.05 level.

CONCLUSION

This study offers insights on the impact of different *stakeholders'* involvement on project quality. Most studies in the literature focused on the two performance metrics of cost and schedule; this paper added the facility quality dimension of performance. The preliminary results show that the as-built quality of the facility increased significantly when the project exhibited early GC or CM involvement in design, GC or CM familiarity firsthand with the owner's objectives, early involvement of subcontractors in design, high A/E support in construction, and use of colocation. The results of this study specifically stem from more than 30 complex vertical construction projects. The next step in this research will include studying the relationships between stakeholder involvement and additional performance metrics, including: cost growth, delivery speed, change orders, requests for information, and safety performance. This research study offers a contribution to the construction engineering and management literature and to the AEC industry by demonstrating quantifiable quality performance benefits with different types and levels of involvement of project stakeholders. The information provided in this paper can be used as a guide for project decision makers, assisting them to adopt different levels of involvement for stakeholders across the design and construction phases of AEC projects.

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