CRITICAL SUCCESS FACTORS OF A BUILDING DESIGN TEAM

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Abstract

The success of a building design team is achieved as a result of a combination of multiple events/factors and interactions, and has a great impact on the quality of the building construction process. While most of previous studies have focused on quality of the construction process, the success of a design team has not been completely investigated. This paper presents the critical factors that impact the success of a building design team and describes an assessment tool to measure the successful performance of the design team with respect to the critical factors. The development of the assessment tool employs the concept of quality function deployment (QFD), a technique to measure the service quality of an organization.

Keywords: Critical success factors, building design, team performance assessment, quality function deployment, and building design quality.

1. Introduction

A building design team includes architects, engineers, estimators, administrators and technical drafters. The performance of the building design team refers to the degree to which the outputs produced by the team meet the customer's expectations, objectives, and standards. The team performance can be evaluated by means of both the outputs (i.e. construction documents) produced by the group or team as a whole, as well as the contribution of individual team members to the success of the team. The team performance or the team design effectiveness has a great impact on the success of the overall building construction process. Therefore, it is necessary to measure the performance of a design team so that appropriate actions will be taken to improve the quality of future construction documents. Most of the previous studies, e.g. [1], [2], [3], [4], and [5], have aimed at identifying the factors affecting the quality of the construction process rather than the design team performance. For example, Sanvido et. al. [1] defined the critical factors that lead to project success and provided a forecasting tool to enable parties to rapidly assess the possibility of a successful project from their viewpoint. The authors identified a set of conditions or factors that, when thoroughly and completely satisfied on a project, ensures the successful completion of the facility. However, the impact of the building design team performance on the success of the construction project was not examined.

According to the previous studies, the success of a building design team is achieved as a result of a combination of multiple events/factors and interactions. Certain factors are more critical to team success than others. These factors are called critical team success factors and can be used to measure the team performance. The objective of the current research is to identify the critical factors that lead to team success and provide an assessment tool to enable project participants to quickly determine the team performance index indicating the strength as well as the weakness of the design team.

2. Research tasks

The current study aims at developing an assessment tool to help the leader of a building design team quickly determine the level of the team service performance and in turn establish appropriate actions to be taken for improvements and success in future projects. The development of the assessment tool employs the concept of quality function deployment (QFD) that is a technique to measure the service quality of an organization.

QFD, also known as the House of Quality, is defined as a structured methodology and mathematical tool used to identify and quantify customers' requirements and translate them into key critical parameters that in turn help a company to prioritize actions to improve their product or service to meet customers' expectations [6]. In other words, QFD is used for translating the 'voice of customer' through the various phases of project or service planning, designing, and manufacturing into a final product. The elements of a QFD model (refer to Figure 1) include information contained in a Data Matrix and two Process Matrices (one for calculation of maximum level of performance (Max LP) and the other for calculation of actual level of performance (Actual LP). In a typical QFD application, a company creates and analyzes the Data Matrix linking customer needs or expectations to a set of product or service design metrics that the company can then measure and control. Information contained in the rows and columns of these matrices will be explained in the following section. The QFD process described in [7], [8], and [9] has been adopted and modified to develop the process of measuring the level of service performance of a building design team. Basically, the process involves two major steps as presented below.

2.1 Collecting data

A survey questionnaire was developed to collect data necessary for calculating the level of service performance with respect to the expected outcomes of a building design team. The questionnaire was randomly sent to 125 AEC (Architecture Engineering and Construction) firms across the country. The rate of response to the survey was 18 out of 125 firms. Senior personnel or design team leaders of the AEC firms were explicitly requested to respond to the questionnaire. The information collected from the questionnaire was divided into three sections. The first section was designed to collect information about the relative importance of the factors indicating customer satisfaction to be used in 'House of Quality' calculations. This data group contained the questions to rate the importance of 10 critical success factors with respect to customer expectations or satisfaction, which were identified as a result of an extensive literature review. Table 1 provides a brief description of these 10 factors (A-J). These factors were listed in Column 1 of the Data Matrix and Column 4 of the Process

Matrices 1 and 2. The rating was based on a scale 1 to 5, where 1 means 'not significant' and 5 'extremely important'. The importance values assigned by the respondents were then normalized and presented in Column 5 and 5' of the Process Matrices 1 and 2 (see Figure 1).

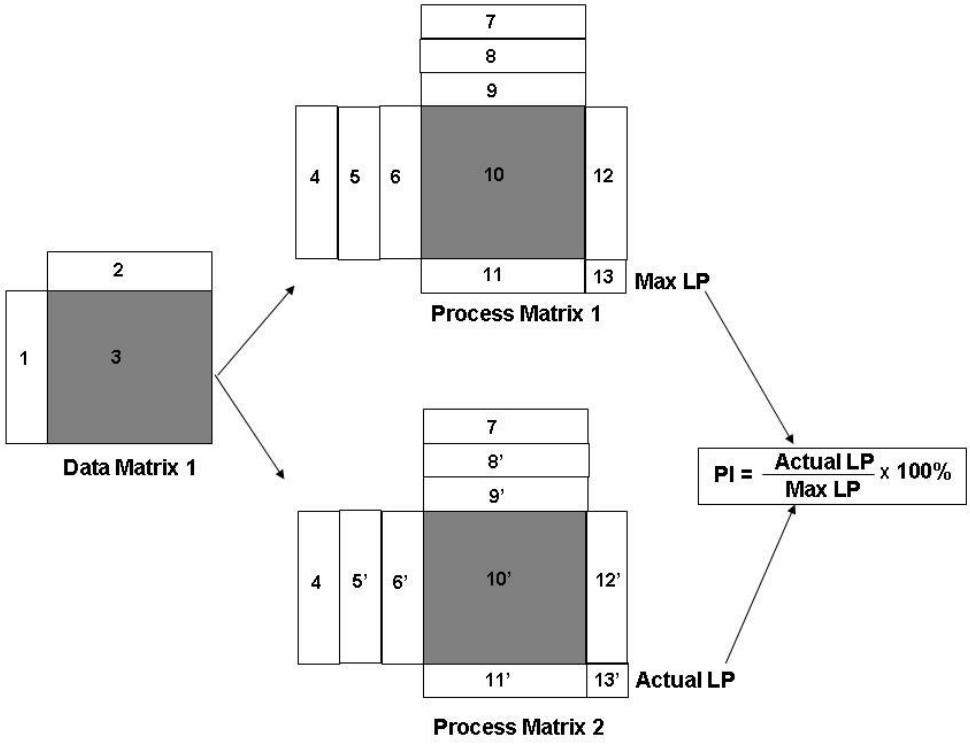

Figure 1: The QFD Assessment Model

The second section of the survey questionnaire was designed to collect information about the significance of the factors most affecting the design team performance including resource availability, work experience, quality management, project characteristics, and constraints; which were presented in Row 2 of the Data Matrix and Row 7 of the Process Matrices 1 and 2. A brief description of these factors (K-O) is provided in Table 2. The respondents to this survey were requested to rate the significance of these factors based on a scale 1 to 5, where 1 represents 'not significant', and 5 represents 'extremely significant'. The rating values obtained from the respondents were then normalized and presented in Rows 8 and 8' of the process matrices 1 and 2 respectively.

The third section of the survey questionnaire includes the questions to ask for information about the strength of relationships between the customer expectations and design team performance factors. This information is obtained from professional designers on a scale of 0 to 5, where 0 represents 'no relationship' and 5 'perfect relationship'. The rating was then averaged and recorded in Matrix 3 of the Data Matrix (refer to Figure 1).

Table 1: Customer Satisfaction Factors

Notation	Factors	Description
A	Understanding the client	The ability to understand the specific needs of the owner. Customer satisfaction is driven by the ability to define customer needs and requirements, which help to maintain the design and project success.
B	Communication	The ability to disseminate information about the process of the project and to listen to the owner.
C	Project manager qualifications	The project manager experience and his ability to work effectively with the design team.
D	Accuracy	The ability to provide the right service at the first time with minimum amount of rework and the extent to which the service complies with owner's requirements.
E	Timeliness	The variation in the completion time of the contract compared to the scheduled date, including milestones.
F	Completeness	The number and value of the items on the 'things-to-do' list upon completion of the contract.
G	Accessibility and convenience	The ease with which the contracting service is obtained from the design firm and approachability of the design firm for any problem.
H	Consistency and dependability	The degree of quality to which the design firm provides the same level of service performance to all clients at different times and the design team performance to several projects.
I	Responsiveness	The ability to react to the problems encountered during the project.
J	Courtesy	The degree of respect, politeness, consideration and kindness of the design firm and office personnel.

It is noted that Columns 6 and 6' of the Process Matrices 1 and 2 contain the data about the expected and actual status respectively of the customer satisfactions. Also, Rows 9 and 9' display the expected and actual status respectively of the team performance. The data contained in these columns (6 and 6') and rows (9 and 9') will be collected from a particular design project to measure the successful performance of the design team, as presented in the following section "Calculating the team performance index".

2.2 Calculating the team performance index

Refer to Figure 1, the information contained in the Data Matrix and the two Process Matrices were used to calculate the performance index (PI) of the building design team. The overall PI is defined as the ratio of the actual level of performance (Actual LP) to the

maximum level of performance (Max LP). The Max LP and Actual LP were determined using information contained in the Process Matrices 1 and 2 respectively and will be explained below.

Table 2: Design Team Performance Factors

Notation	Factors	Description
K	Resource availability	This factor refers to the availability of computer aided design tools (e.g. CAD software, hardware), work place environment, (e.g. Interior design-lighting-temperature-space), and money/time needed for the project
L	Work experience	This factor refers to professional experience and skills of project managers, designers, and draftpersons
M	Quality management	The ability of the design team to manage the quality of design projects using different management tools such as rewarding/recognizing policies, effective communication, good decision-making, quick problem solving, and total quality management implementation.
N	Project characteristics	This factor refers to accessibility of project resources/information, understanding of the project functional requirements, application of procurement and tendering methods, complexity of the project, and types of the project (e.g. commercial, residential, or heavy construction).
O	Constraints	This factor refers to experience/specialization of the client, regulations of unions, and social characters of individual members of the design team.

In the Process Matrix 1 (refer to Figure 1), the data in Column 5 represents the normalized important weights for the expected outcomes of the design team (i.e. customer expectations/needs) such that their summation must equal to 1; Column 6 contains data about the expected status of the customer service objectives under perfect conditions (i.e. they all score a maximum 5); Row 8 represents normalized important weights for team performance factors such that their summation must be equal to 1; Row 9 displays the expected status of team performance factors under perfect conditions, i.e. they all score a maximum 5; Matrix 10 (the shaded area) contains the point scores that were calculated by using the following equation:

$$S_{ij} = ½ *[(W_i \text{ x } PW_i) + (H_j \text{ x } PH_j)]*SR_{ij} \qquad \text{Eqn. (1)}$$

Where:

S_{ij} = point score for the cell in row i and column j of Matrix 8

PW_i = the status of the customer expectations factor in row i

PH_j = the status of the team performance factor in column j

W_i = the normalized weight of importance of the customer expectations factor in row i

H_j = the normalized weight of importance of the team performance factor in column j

SR_{ij} = the strength of the relationships between the customer expectation factor in row i and the team performance factor in column j, which is obtained from Matrix 3 of the Data Matrix

Row 11 of the process matrix 1 (Figure 1) contains the maximum level of performance (Max LP_j) with respect to a team performance factor (K-O). Max LP_j is the sum of all point scores in the same column j of Matrix 10. Similarly, the sum of all the point scores in the same row i of Matrix 10 gives the maximum level of performance (Max LP_i) with respect to the customer expectations factor corresponding to that row and these Max LPj are displayed in Column 11 of the Process Matrix 1. Finally, the overall max level of performance (Max LP) for the whole team under perfect conditions is determined by adding all these Max LP_i or Max LP_j, which is presented in Cell 13 of the Process Matrix 1.

In the Process Matrix 2 (refer to Figure 1), Column 6' represents the status of customer satisfactions with respect to the customer expectations under actual conditions in a particular design project; Row 9' represents the status of team performance factors under actual conditions. The satisfaction status was rated on a scale of 1 to 5, where 5 represents 'extremely satisfied' and 1 'not satisfied'. Matrix 10' represents the point scores (S_{ij}) that were computed using Eqn. (1) where values for the terms specified in the equation were obtained from the data in Matrix 3 of the Data Matrix, columns 5', 6', and rows 8', 9' of the Process Matrix 2. Row 11' and Column 12' of the Process Matrix 2 contain the actual level of performance for each customer expectation factor and team performance factor respectively. Cell 13' shows the actual level of team performance (Actual LP) under actual conditions.

Finally, the overall team performance index for the design team is determined as follows:

$$\text{Performance Index (PI)} = (\text{Actual LP}/\text{Max LP}) \times 100\%$$

3. Results and discussions

Figure 2 represents the Data Matrix that contains the data collected through the survey questionnaire reported from design team leaders, senior design professionals, and project owners. Specifically, the information in the second column (Importance Weight of Customer Expectations Factors) was obtained by means of the survey reported from project owners; the second row (Importance Weight of Design Team Performance Factors), from design team leaders; and the shaded matrix, from senior design professionals. The importance weights (W) reported from project owners (refer to second column in Figure 2) indicates that they are more concerned about the factors 'Understanding the Client' (W = 4.8), 'Communication' and 'Responsiveness' (W = 4.4) (i.e. 'customer expectations' categories A, B, and I). The lowest importance weight for the customer needs or

expectations is 3.4 for the category F (Completeness). Regarding the design team performance factors, the surveyed senior design professionals consider the factors of 'Work Experience' and the 'Project Characteristics' as the most important factors for a successful team as they were highly ranked as 4.13 and 4.1 respectively in the weights. The shaded matrix in Figure 2 contains the numerical values representing the strength of the relationships between the design team performance factors and the customer expectations/needs. The value in each cell of the shaded matrix was obtained from senior professional designers (i.e. independent assessors) on a scale of 0 to 5, where 0 represents 'no relationship' and 5 'perfect relationship'. This information indicates that the design team performance factor L (Work Experience) and the 'customer expectations' category E (Timeliness) has a close relationship with a strength value of 4.67. Also, the factors 'Quality Management' and 'Project Manager Qualification' have a close relationship (4.60). The 'customer needs' category G (Accessibility /Convenience) has a close relationship (4.60) with the design team performance factor 'Project Characteristics'.

		Design Team Performance Factors					**Sum**
		K (Resource Availability)	**L** (Work Experience)	**M** (Quality Management)	**N** (Project Characteristics)	**O** (Constraints)	
Customer Expectations	Importance Weight	3.97	4.13	3.96	4.1	3.25	
A (Understanding the Client)	4.8	2.33	3.33	3.20	4.00	3.50	16.36
B (Communcation)	4.4	4.00	3.67	4.20	2.80	2.75	17.42
C (PM Qualifications)	4.3	2.67	4.00	4.60	4.40	3.00	18.67
D (Accuracy)	3.7	3.00	4.33	3.80	4.00	2.25	17.38
E (Timeliness)	3.9	3.33	4.67	3.60	4.40	2.50	18.5
F (Completeness)	3.4	3.33	4.33	3.40	4.20	2.50	17.76
G (Accessibility/Convenience)	4.1	3.00	4.33	3.60	4.60	2.50	18.03
H (Consistencey/Dependability)	4.2	3.00	4.00	3.40	4.00	2.25	16.65
I (Responsiveness)	4.4	2.67	4.00	3.40	4.40	2.50	16.97
J (Courtesy)	3.9	2.33	3.33	3.20	2.40	2.75	14.01
Sum =		29.66	39.99	36.40	39.20	26.50	171.75

Figure 2: The Data Matrix

To compute the maximum level of team performance, the performance status in each and every factor is assumed to be a perfect 5. The results from calculations of the maximum levels of team performance are presented in the Process Matrix 1 (Figure 3). The point scores for intersections between 'customer expectations' factors and design team performance factors were calculated using Eqn. (1). Below is an example of calculation of the point score for intersection between factor A 'Understanding the Client' and factor K 'Resource Availability'.

$$S_{11} = ½ *[(0.12 \times 5.0) + (0.14 \times 5.0)]*2.33 \quad = 1.51$$

It is noted that the importance weights have been normalized and their summation should be equal to 1. Another observation is the factor 'Project Characteristics' with a high importance weight of 0.27 and a large sum of relationship strengths 39.20 from the Data Matrix (Figure 2) requires the highest expected level of performance (36.27) as shown in the last row of the Process Matrix 1 – Figure 3. The factor 'PM Qualifications' that has a very close relationship with all the design team performance factors (i.e. the highest sum of relationship strengths = 18.67 in the row for category C of the Data Matrix – Figure 2) also requires the largest expected levels of performance (14.46) as shown in the last column of the Process Matrix 1 – Figure 3.

			Design Team Performance Factors					
			K (Resource Availability)	**L** (Work Experience)	**M** (Quality Management)	**N** (Project Characteristics)	**O** (Constraints)	**Max. level of team performance (Max. LP_i)**
Customer Expectations	Importance Weight		0.14	0.17	0.26	0.27	0.16	
		Expected Status	5	5	5	5	5	
A (Understanding the Client)	0.12	5	1.51	2.41	3.04	3.90	2.45	13.32
B (Communcation)	0.11	5	2.50	2.57	3.89	2.66	1.86	13.47
C (PM Qualifications)	0.10	5	1.60	2.70	4.14	4.07	1.95	14.46
D (Accuracy)	0.09	5	1.73	2.81	3.33	3.60	1.41	12.87
E (Timeliness)	0.10	5	2.00	3.15	3.24	4.07	1.63	14.09
F (Completeness)	0.08	5	1.83	2.71	2.89	3.68	1.50	12.60
G (Accessibility/Convenience)	0.10	5	1.80	2.92	3.24	4.26	1.63	13.84
H (Consistencey/Dependability)	0.10	5	1.80	2.70	3.06	3.70	1.46	12.72
I (Responsiveness)	0.11	5	1.67	2.80	3.15	4.18	1.69	13.48
J (Courtesy)	0.09	5	1.34	2.16	2.80	2.16	1.72	10.18
Max. level of team performance (LP_i)			17.78	26.94	32.77	36.27	17.28	**131.04**

Figure 3: The Process Matrix 1 – Max Level of Team Performance

Figure 4 represents the Process Matrix 2 to calculate the actual level of team performance in which the actual status of the design team performance factors (recorded in the status row) was rated by design team leaders and the actual status of customer expectations was rated by project owners and recorded in the status column of the Process Matrix 2. Once the actual information for a design project has been known, the actual level of team performance is calculated as 120.42, as shown in the bottom right corner cell in the Process Matrix 2 (Figure 4). It is noticed that the design team performance factor N (Project Characteristics) that has the highest importance weight (0.27) results in the largest actual level of team performance (33.81) as shown in the last row of the Process Matrix 2 (Figure 4). However, the factor C (PM Qualifications) is has the highest actual level of team performance (13.38) although its importance weight (0.10) is lower than that of the factor

A (Understanding the Client). This can be explained by the fact that the factor 'PM Qualifications' has greater interrelationships with all the team performance factors than the factor 'Understanding the Client' (i.e. the sum of its relationship strengths is the largest = 18.36 as shown in the Data Matrix – Figure 2).

			Design Team Performance Factors					
			K (Resource Availability)	**L** (Work Experience)	**M** (Quality Management)	**N** (Project Characteristics)	**O** (Constraints)	**Actual level of team performance (LP_a)**
Customer Expectations	Importance Weight		0.14	0.17	0.26	0.27	0.16	
		Actual Status	4.67	5.00	4.00	4.60	4.25	
A (Understanding the Client)	0.12	5	1.46	2.41	2.62	3.68	2.24	12.42
B (Communcation)	0.11	5	2.41	2.57	3.34	2.51	1.69	12.52
C (PM Qualifications)	0.10	5	1.54	2.70	3.54	3.83	1.77	13.38
D (Accuracy)	0.09	4	1.52	2.62	2.66	3.20	1.17	11.17
E (Timeliness)	0.10	5	1.92	3.15	2.77	3.83	1.48	13.15
F (Completeness)	0.08	4	1.62	2.53	2.31	3.28	1.25	11.00
G (Accessibility/Convenience)	0.10	5	1.73	2.92	2.77	4.01	1.48	12.91
H (Consistencey/Dependability)	0.10	5	1.73	2.70	2.62	3.48	1.33	11.86
I (Responsiveness)	0.11	5	1.61	2.80	2.70	3.94	1.54	12.59
J (Courtesy)	0.09	5	1.29	2.16	2.38	2.03	1.55	9.42
Actual level of team performance (LP_t)			16.83	26.58	27.73	33.81	15.49	**120.42**

Figure 4: The Process Matrix 2 – Actual Level of Team Performance

The last step taken in the assessment process is to determine the team performance index (PI). For this particular architectural-engineering project, the PI is obtained as follows:

$$PI = (\text{Actual LP/Max LP})x100\% = (120.42/131.04)x100\% = 92\%$$

It is obvious that the desirable design team performance index should be as close to 100% as possible. The design team performance index can tell the design team leader how well the team as a whole was functioning. Additionally, with this assessment tool, customer expectations and design team performance factors can be individually evaluated to determine areas of strength or weakness so that appropriate actions should be taken to improve the team performance quality. For example, for the team performance factor M (Quality Management), the maximum level of performance and the actual level of performance are found as 32.77 (from the Process Matrix 1 – Figure 3) and 27.73 (from Process Matrix 2 – Figure 4) respectively. As a result, the team performance index for this factor M is 27.73/32.77 or 84.6%, which indicates a need for improvement on the quality management of the team. Based on these performance indexes, the weakness of the design

team may fall in the factors D, F, M, and O as their performance indexes are the lowest ones. In summary, the team performance index is of value to the team leader in the sense that the team leader can use it to compare the team performance with respect to different customer expectations or team performance factors as well as in different design projects and take appropriate measures to maximize the performance of the design team in future projects.

4. Conclusion

This study has investigated the significance or importance weight of various factors that most affect the success of a building design team. These factors were divided into two major groups: customer expectations factors (A-J) and team performance factors (K-O). A survey questionnaire was developed to collection data about the importance weights and interrelationships between these two groups of factors. Based on the concept of Quality Function Deployment, a mathematic model to measure service quality of an organization, these data were recorded in a matrix format and then used to calculate the level of performance (i.e. performance index) of the design team. The performance index indicates how well the design team functioned in a particular project; thus, enabling team leaders to identify the weakness of the team as well as the actions that need to be taken for improving the overall team performance.

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