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A/E Design Team Performance Evaluation

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The performance of a building design team refers to the degree to which the outputs produced by the team meet the customer's expectations, objectives, and standards, which in turn has a great impact on the quality of the building construction process. Whilst most of the previous studies have focused on the quality of the construction process, the performance of the design team has not been completely investigated. It has been found that improving the quality of design effort outputs would play a crucial role on the quality of the construction process. This paper presents the major factors that impact the success of a building design team in terms of the team's performance and how to assess the performance of the team, and it also identifies projects owners' expectations with regard to team performance 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.

Key Words: Team Performance, Performance Index, Quality Function Deployment

Introduction

A building design team includes architects, engineers, estimators, administrators and technical drafters. 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 (Becker, 2000). These factors are called critical team success factors and can be used to measure the team performance. The team performance can be evaluated by means of both the outputs (i.e. construction documents) produced by the group or the 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 (Cohen and Bailey, 1997). 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. Sanvido et. al., 1992) have aimed at identifying the factors affecting the quality of the construction process rather than the design 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 and identify the weakness of the design team.

Relevant Previous Studies

Investigation of the critical factors affecting the success of a construction project has attracted the interest of many researchers and practitioners. Sanvido et. al. (1992) 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. Becker (2000) identified the three most critical success factors of a building design team, which are team members belief in each other, understanding how power works in and around the team, and mutual committment to a set of values or a shared purpose. Also, out of these three success factors, a number of behaviors emerge that ensure results, satisfaction and learning. Chan et. al. (2004) identified a number of variables influencing the success of project implementation, which can be grouped into five main categories: project-related factors (e.g. type, nature, size, complexity of project), project management actions (e.g. communication system, control mechanism, feedback capabilities, planning effort, developing an appropriate organization structure, implementing an affective quality assurance program, control of subcontractors' workers, and overall managerial actions), project procedures (e.g. procurement method and tendering method),

human-related factors (e.g. clients' characteristics, skills, business size, management, experiences, and team leader skills) , and external environment (e.g. economic, social, political, physical, industrial relations environment, and technology advanced).

The performance of a design team can be evaluated in terms of quality of the team's outputs, effectiveness, and productivity. Quality is defined as the degree to which the project and its components meet the owner's expectations, objectives, standards, and intended purpose, determined by measuring conformity of the project to the plans, specifications and applicable standards (McAtee, 2000). The criteria suited for an initial evaluation of design effectiveness include accuracy of design documents, usability of design documents, cost of design effort, constructability of design, economy of design, performance against schedule, and ease of start-up. Riggs, J. L. (1985) organized the criteria, the weights, the performance scale, the performance index within an objective matrix that can be used to evaluate the project productivity. The criteria define what is to be measured. The weights determine the relative importance of the criteria to each other and to the overall objective of the measurement. The performance scale compares the measured value of the criterion to the standard or selected benchmark value. Using these three components, the performance index, is calculated and the result is used to indicate and track performance.

The various dimensions of design team performance identified in the previous studies ranged from general conceptual guidelines to more specific aspects. It is noticed that the various factors contribute differently to the results of these studies. As a result, it is worth measuring the importance of these factors as well as determining the interrelations amongst themselves in order to better understand their influence of the success of a building design team: the major subject of the current research.

Research Tasks

The current study aims to develop an assessment tool to help the leader of a design team to quickly determine the level of the team service performance and in turn to 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 (Hoyle, 1998). 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 (LP) and another for calculation of actual LP).

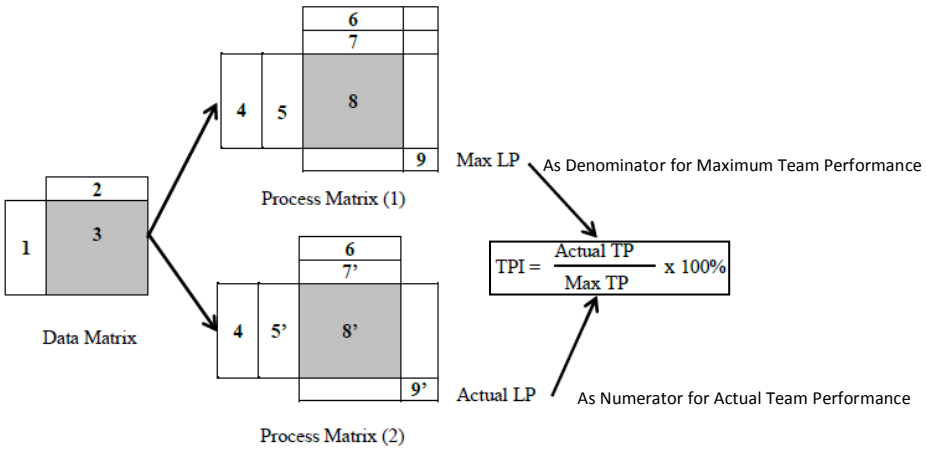

Figure 1: The QFD Assessment Model

In a typical QFD application, a company creates and analyzes the data matrix linking customer needs or requirements to a set of product or service design metrics that the company can then measure and control. The QFD process described in (Akao, 1990; Akao et. al., 1994; Arditi and Lee, 2003; Yang 2003) 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 five major steps as follows:

Developing survey questionnaire
Completing information in the data matrix
Creating the process matrix to calculate the Max LP
Creating the process matrix to calculate the Actual LP
Computing the overall performance index

a) Developing survey questionnaire: 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 satisfaction, which were identified as a result of an extensive literature review. Authors identified the chosen factors for customer satisfaction and design team performance based on the frequency of listing them in previous research studies and the authors' background and experiences. Table 1 provides a brief description of these 10 factors. The rating was based on a scale of 1 to 5, where 1 means 'not important' and 5 'extremely important'.

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 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.

The importance values assigned by the respondents were then normalized and presented in Column 4 of the process matrices (see Figure 1).

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. A brief description of these factors is provided in Table 2. The respondents to this survey were requested to rate the significance of these factors based on a scale of 1 to 5, where 1 represents 'not significant', and 5 represents 'extremely significant'.

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 draft persons
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.

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.

b) Completing information in the data matrix:
In the data matrix (refer to Figure 1), the data includes information in column 1, row 2, and matrix 3, as explained below.

Column 1 (in Figure 1 – Data matrix): contains ten factors (A through J) representing customer expectations (the WHATs), as described in Table 1.

Row 2 (in Figure 1 – Data matrix): includes five critical factors that most impact the performance of a design team (the HOWs). Brief descriptions of these team performance factors are provided in Table 2. The relative importance of the team performance factors were reported on a scale of 1 to 5, where 1 represents 'not significant' and 10 'extremely significant'.

Matrix 3 (in Figure 1 – Data matrix): represents the strength of the relationships between the design team performance factors (Row 2) and the customer expectations/needs (Column 1). This information is obtained on a scale of 0 to 5, where 0 represents 'no relationship' and 5 'perfect relationship'.

c) Creating the process matrix to calculate maximum level of team performance (Max LP):
The data to be collected are organized in a data matrix. It contains information about owner's needs or requirements (the WHATs), the significant factors that impact the performance of the design team (the HOWs), and the strength of their interrelationships.

d) Creating the process matrix to calculate actual level of team performance (Actual LP):
The information contained in the data matrix will be used to create a process matrix (Figure 1) in which the data in column 2 and row 2 represent the normalized importance

e) Determining the overall performance index for the design team:
The team performance index of the building design team can be obtained from the following equation:

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$$\text{Team Performance Index (TPI)} = \frac{\text{Actual TP}}{\text{Max TP}} \times 100\%$$

The team performance index is of value to the design leader who can use it to compare team performance in different projects and take measures to maximize team performance in future projects.

Results and Discussions

Table 3 represents the data matrix (Step b in the Research Tasks section) that contains the data collected through the survey questionnaire reported from design team leaders, senior design professionals, and project owners. Specifically, the information in column 2 (Importance Weight of Customer Expectations Factors-IW) was obtained by means of the survey reported from project owners; row 2 (Importance Weight of Design Team Performance Factors), from design team leaders; and matrix 3 (the shaded area), from senior design professionals.

Table 3: The Data Matrix

		Design Team Performance Factors					
		K (Resource Availability)	**L** (Work Experience)	**M** (Quality Management)	**N** (Project Characteristics)	**O** (Constraints)	**Sum**
Customer Expectations	Importance Weight	3.97	4.13	3.96	4.10	3.26	
A (Understanding the Client)	4.8	2.33	3.33	3.20	4.00	3.50	16.36
B (Communication)	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	18.50
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 (Consistency/ 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**

The importance weights (IW) reported from project owners (refer to column 2 of the data matrix – Table 3) indicate that they are more concerned about the factors 'Understanding the Client' (IW = 4.8), 'Communication' and 'Responsiveness' (IW = 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 matrix 3 of the data matrix – Table 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 matrix 3 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) have 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'

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category G (Accessibility /Convenience) has a close relationship (4.60) with the design team performance factor 'Project Characteristics'.

To compute the maximum level of team performance (Step c), 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 (Table 4). The point scores for intersections between 'customer expectations' factors and design team performance factors were calculated in accordance with the concept of Quality Function Deployment method that the reader can refer to (Akao, 1990 and Akao et. al., 1994) for further information.

Table 4: The Process Matrix 1 – Max Level of Team Performance

			Design Team Performance Factors					
Customer Expectations			**K** (Resource Availability)	**L** (Work Experience)	**M** (Quality Management)	**N** (Project Characteristics)	**O** (Constraints)	**Maximum level of performance (LP_{Max})**
	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 (Communication)	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 (Consistency/ 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
Maximum level of team performance (LP_{Max})			17.78	26.94	32.77	36.27	17.28	**131.04**

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 (Table 3) has the highest impact on design team performance (36.27) as shown in the last row of the Process Matrix 1 – Table 4. The factor 'PM Qualifications' 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 – Table 3) also has the largest expected impact on design team performance (14.46) as shown, by projects' owners, in the last column of the Process Matrix 1 – Table 4.

Table 5 represents the process matrix 2 to calculate the actual level of team performance (Step d in the Research Tasks Section) 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 through design team leaders 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 (Table 5). 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 (Table 3). However, the factor C (PM Qualifications) has the highest actual level of team performance (13.38) although its importance weight (0.10) is lower than that of 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 – Table 3).

Table 5: The Process Matrix 2 – Actual Level of Team Performance

			Design Team Performance Factors					
			K (Resource Availability)	**L** (Work Experience)	**M** (Quality Management)	**N** (Project Characteristics)	**O** (Constraints)	**Actual level of performance (LP_{Actual})**
Customer Expectations	Importance Weight		0.14	0.17	0.26	0.27	0.16	
		Actual Status	4.67	5	4	4.60	2.25	
A (Understanding the Client)	0.12	5	1.46	2.41	2.62	3.68	2.24	12.42
B (Communication)	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 (Consistency/ 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_{Actual})			16.83	26.58	27.73	33.81	15.49	**120.42**

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

Team Performance Index (TPI) = Actual LP/Max LP = 120.42/131.04 = 92%

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 can 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 – Table 4) and 27.73 (from Process Matrix 2 – Table 5) 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 quality management of team. Similarly, for the customer expectations regarding accuracy (category D), the maximum level of performance and the actual level of performance are found as 12.87 (from the Process Matrix 1 – Table 4) and 11.17 (from Process Matrix 2 – Table 5) respectively; hence, the team performance index for this factor is 11.17/12.87 or 86.82%.

Based on these performance indexes, the weakness of the design team may fall in the factors D, F, K, and O as their performance indexes are the lowest ones. In addition, these performance indexes indicate that the design team would be more successful if the team leader could improve the team performance regarding 'Quality Management' and 'Accuracy' as these factors have the lowest performance indexes. 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 the appropriate measures to maximize the performance of the design team in future projects.

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Conclusions

A number of factors are combined to determine the success of a building design team. There is an urgent need for a workable and efficient procurement to improve practices in future building projects. This research identifies, analyzes, and categorizes various critical success factors which impact a building design team's performance and their significance. This research also assigns the team performance factors' effectiveness in regard to owners and senior experienced professional's perceptions. It has investigated the interrelation and the weighted importance for all effectiveness and team performance factors. In the context of building design team performance, quality function deployment has been tested to be a great statistical tool to analyze this data. This tool has been successfully used not only to find the importance of the factors, but also to calculate a performance index for a team in a project. This tool will enable any firm or design team leader to assign the objectives and the requirements for any potential future project. Furthermore, calculations by the team leader would be helpful to find the level of team performance (performance index). By following the procedures which have been discussed previously, it would be very effective to evaluate any design team and calculate its performance level (index).The data from process matrices is analyzed in different ways of interpretation which would be very useful to find out the different interrelations between all factors and their impacts on design team performance. It is also important to interpret the interrelation between the owners' expectation and the design team performance factors according to calculated scores and indexes in order to improve the understanding of customer requirements by design team leaders to produce better quality design effort outputs.

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