QUALITY FUNCTION DEPLOYMENT IN DESIGN/BUILD PROJECTS

By Low Sui Pheng¹ and Larry Yeap²

ABSTRACT: In the manufacturing sector, companies have successfully applied concurrent engineering tools, including Quality Function Deployment (QFD) to determine customers’ needs for the design at its early stages of development. However, despite its success stories in other industries, QFD has been applied only sparingly in the construction industry. The design/build (D/B) contractor, who bears both design and construction responsibilities, would find the QFD methodology useful. This paper examines the awareness and applicability of QFD methodology in D/B contracts. The research looks into the benefits, relevance, and problems in the application of QFD in D/B contracts. A qualitative approach in the form of in-depth interviews with experienced contractors involved in D/B contracts was carried out. The results suggest that, generally, D/B contractors could appreciate the merits of the QFD system. However, the decisions for implementation of QFD by the contractors were subjected to the “push” and “pull” factors that may vary from one organization to another.

INTRODUCTION

Quality Function Deployment (QFD) is a quality improvement technique that deals with quality problems from the outset of the product design and development stage and assures that customers’ requirements are accurately translated into appropriate technical requirements and actions (Low 1998). The emphasis on “voice of the customer” is the key to QFD (Low 1998; Kamara et al. 1999). This makes good sense in the construction industry, as every construction project is unique. Each building is custom-made to meet the requirements and needs of the client. As the construction industry matures, the ability to understand and translate the needs of the client into a finished building or product is fast becoming a prerequisite for the long-term viability of a company. As so aptly put forth by Preece et al. (1998), “rewards go to those who can best understand customer needs, and deliver the greatest value to their target clients.”

QFD in the construction industry has gained a whole new meaning and importance with the increasing trend to adopt project procurement using the design/build (D/B) method (McLellan 1994). As the company or organization assumes full responsibility and carries sole liability for both design and construction in a D/B contract, the ability to identify and respond to the client’s need at every critical stage of product or service development will have a vast impact on the final delivery, QFD, which identifies the client’s needs and then links the features of the product and services with the needs, sorts and ranks the needs, and examines the impact of satisfying them, therefore fits the bill perfectly.

QFD is a set of planning and communication routines that focuses and coordinates skills within an organization to design and construct facilities that satisfy the client’s needs and requirements (Ahmed and Kangari 1996). It is a form of concurrent engineering tool (Low 1998) that has been successfully applied in the manufacturing sector (Garvin 1988; Daetz et al. 1989) in the United States and Japan (Kogure and Akao 1983; Hauser and Clausing 1988). There is, however, little evidence of QFD implementation in the construction industry (Ahmed and Kangari 1996; Low 1998) until recently (Gargione 1999). Nevertheless, interest in this area has been growing and there exists a steady stream, albeit small in number, of literature that can assist in the understanding and application of the concept to the construction sector.

HISTORY AND STRUCTURE OF QFD

QFD was conceived in Japan in the late 1960s during an era when Japanese industries broke from their post-World War II mode of product development through imitation and copying and moved to product development based on originality. QFD was born in this environment as a method or concept for new product development under the umbrella of Total Quality Control (Akao 1997). Akao (1997), the founding father of QFD, explained that it was during this time that the Japanese automobile industry went through a critical stage of rapid development, out of which the seeds for QFD were conceived.

The QFD House of Quality is the tool that drives this process, using a matrix that relates customer wants to alternative designs and compares the alternative designs so that engineering and quality efforts can be concentrated on the most important and valuable characteristics. The term “House” is used because the original QFD tool used looks similar to a house with several rooms and a roof. The matrix in the QFD House of Quality relates a list of things that the customer wants to the design “Hows” (i.e., services that satisfy cus-

¹Assoc. Prof. and Vice Dean, School of Des. and Environment, Nat. Univ. of Singapore, 4 Architecture Dr., Singapore 117566.

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FIG. 1. Basic House of Quality
customer wants). The various elements that made up a basic House of Quality are shown in Fig. 1. These elements are

- Customer requirements and rating of importance: This room contains the list of customer wants and the voice of the customer.
- Counterpart/quality characteristics: This upper room lists the design Hows and the voice of the design engineer or architect.
- Relationship matrix: This middle room consists of a group of cells that indicate the strength of the relationships between customer wants and proposed design Hows.
- Correlation matrix: This is the roof of the house, which also consists of a group of cells. There is one cell for each pair of design Hows.
- Marketing information and customer perception: This is the planning matrix where the importance rating, competitive analysis, target value, amount of scale-up necessary, and sales points are listed.
- Technical assessment and target values. This bottom room consists of the prioritized manufacturer’s requirements, which identify the requirements that are most critical for success as well as the degree of technical difficulty to achieve them (Bossert 1991).

APPLICATION OF QFD IN CONSTRUCTION

In its basic form, QFD uses a series of 2D matrices to identify and evaluate the one-on-one relationships between sets of inputs and potential responses to those inputs. As the inputs (e.g., in-product/service-based QFD and the customer requirements), referred to as theWhats, are cross-checked against the related design and production response elements, referred to as the Hows, both the existence and the strengths of correlations are assessed by the QFD team and are numerically or graphically documented. These charts may be deployed from one stage to another to accomplish the customer’s requirements.

Akao (1990, 1997) reported that QFD was most often used in the automotive, electronics, and aerospace industries. It was found that the application of QFD was higher in the United States than in Japan. The companies that had used QFD said that they used it to attain “better design,” “better customer satisfaction,” “as a tool for cross-functional communication,” and to “shorten product cycle time.” It was noted that, although companies in Japan had used QFD to improve product quality based on an existing model, companies in the United States had used QFD in the manufacturing and engineering of new products.

The applications of QFD in construction were noted to be in different ways. The following are some examples of the varied applications of QFD as reported by Gargione (1999). Mallon and Mulligan (1993) used QFD on a hypothetical renovation of a personal computer workroom. Armacost et al. (1994) applied QFD to integrate customers’ requirements in an industrialized housing component, a manufactured exterior structural wall panel. Serpell and Wagner (1997) used QFD to determine preferences in the design characteristics of the internal layout of a building apartment. QFD was also applied to construction (Houvila et al. 1997) involving different participants working together in three construction projects: a structural design firm and two contractors.

Worked Example

A hypothetical personal computer workroom facility-upgrading project at University A1 is considered. The goals of the study are to decide if improvements are desirable or even needed and to focus on the elements for improvements. The entire application is divided into a number of steps and three figures.

First, customer requirements or needs are listed, as shown in Fig. 2. Customers would be students who are routine users of the computer workroom, maintenance staff, security personnel, and university administration. Assume that the most important customer (i.e., the users) identified their needs to be as follows:

$$\begin{array}{c|c|c|c|c|c|c|c|c}
\text{Customer Requirements} & \text{High-tech} & \text{Extra} & \text{Light Control} & \text{Competitor X} & \text{Competitor X} & \text{Competitor Plan} & \text{Sales Point} & \text{Absolute Weight} & \text{Demanded Weight} \\
\text{Security} & 5 & 9 & 3 & 4 & 5 & 4 & 5 & 1.25 & 1.2 & 7.5 & 23.6 \\
\text{Unlimited Access} & 4 & 9 & 9 & 2 & 4 & 2 & 4 & 2.00 & 1.5 & 12.0 & 38.1 \\
\text{Sufficient Lighting} & 3 & 9 & 1 & 4 & 3 & 4 & 4.00 & 1.0 & 12.0 & 38.1 \\
\hline
\text{Total} & 176 & 131 & 108 & 415 & 42.5 & 31.6 & 26.0 & 100 & \\
\text{Current Status} & 1 & 1 & 1 & & & & & & \\
\text{Competitor X} & 4 & 5 & & & & & & & \\
\text{Competitor Y} & 2 & 3 & & & & & & & \\
\text{Target Value} & 5 & 4 & 3 & & & & & & \\
\end{array}$$

FIG. 2. Voice of Customer
• Unlimited access to the workroom
• Sufficient lighting
• Security

Once the three needs are identified, they are then evaluated in order of importance by assigning them numbers from 1 to 5—5 being the most important and 1 the least important. Assume the customer group assigns the following values by consensus:

- Security: 5 (most important)
- Unlimited access: 4
- Sufficient lighting: 3 (least important)

Second, the customer group is asked to evaluate how close to the optimum the present workroom is, compared to each of their defined needs. Again, assume the following values are assigned:

- Security: 4 (closest to optimum)
- Unlimited access: 2
- Sufficient lighting: 1 (farthest from optimum)

Third, consider the competition. Say the competition was identified to be Competitor X, the computer workroom of University A2, and Competitor Y, a public-access computer workroom within the neighborhood community library.

The evaluation of Competitors X and Y is undertaken by surveying the customer group who has knowledge, however limited, of these two competitors. Assume that the results are as follows:

**Competitor X**
- Security: 5
- Unlimited access: 4
- Sufficient lighting: 4

**Competitor Y**
- Security: 4
- Unlimited access: 2
- Sufficient lighting: 3

Fourth, once the current status and competition are evaluated, the plan for improvement can be decided. The objective is to enhance the quality and status of the incumbent computer workroom to a level on par with the best competitor. However, there may be times when this is not feasible because of time and economic constraints, etc. If there were to be development or changes down the road that give rise to reasons not to pursue the original goal, then the initial evaluation can be revisited and the plan modified. The plan resulting from developing quality that equals Competitor X is therefore

- Security: 5
- Unlimited access: 4
- Sufficient lighting: 4

Fifth, define the sales point or market value of the computer workroom. Here only three values are used. These are

- 1.5 (the highest)
- 1.2 (next highest)
- 1.0 (the lowest)

The market value of the workroom relates to whether this computer workroom facility contributes to student improvement and whether it serves as a student attraction within the university. For the purpose of this example, the sales point of the workroom is deemed to be a contributing factor toward student improvement in computer literacy. Assume the following sales points are given:

- Security: 1.2
- Unlimited access: 1.5 (greatest market value)
- Sufficient lighting: 1 (least market value)

At this point, Fig. 2 can now be completed. Note that the demanded weight is a product that has taken into account all the factors involved.

Initially, security was assigned the highest rate of importance, No. 5. However, after the analysis, security had the lowest absolute weight and demanded weight among the three customer needs. This is because its current status is closest to the optimum and a sales point of 1.2 (which is not the highest) is given.

The next step is to determine how each customer requirement will be accomplished. As shown in Fig. 3, the methods for meeting customer needs are kept as simple as possible, relative to the customers involved in the discussion. A cross-functional group involving all likely customers of the computer workshop facility should be used. In this way, different views from all departments can be gathered. For example, the administrative personnel will be likely to focus on the general aspects of attaining unlimited access. They may propose constructing an external entrance that does not require entry into other areas of the building for after-hours office access. The security people may discuss having card-key access or automatic time-locking devices for the doors. The students will want a security arrangement that is user-friendly and hassle free. And the list goes on.

Discussion should be kept realistic but, at the same time, creative and imaginative. Consider each customer’s need in a hypothetical vacuum and deliberately ignore other customer requirements at this time. Limitations that arise would be resolved in due course in the QFD process.

Assume the following changes are suggested. For security, the quality characteristic is a high-tech security access system. For unlimited access, an added exterior door is the quality characteristic. For sufficient lighting, it is individual light control for every station. These quality characteristics are entered into the interim matrix, as shown in Fig. 3, to evaluate the correlation with each customer requirement. Three levels of correlation are used

- Strong correlation: 9
- Some correlation: 3
- Possible correlation: 1
The space is left blank if no relationship is determined.

Now that Part I (Quality Characteristics) and Part II (Voice of the Customer) of the matrix are in place, these can be put together to determine their correlation values (Fig. 4). Each level of correlation (whether 1, 3, or 9) is multiplied by the corresponding absolute weight of the customer requirement. For example, the high-tech access systems' strong correlation of 9 is multiplied by security's absolute weight of 7.5 to give a correlation value of 67.5. This calculation is carried for each correlation entered.

These correlation values are then totaled and converted to percentage weights. (Note that the numbers are rounded up to whole numbers for simplicity). The final step is to evaluate the current status of the incumbent computer workroom and the status of the competitors' workrooms with respect to quality characteristics. As before, a scale of 1–5 is used. Because none of these quality characteristics are present in the existing facility, they are all assigned a low value of 1.

For Competitor X, assume that a card-key access system and an exterior door are present. Values of 4 and 5 are given to these two quality characteristics, respectively. Assume Competitor Y does not have a highly sophisticated security system but individual light controls are provided at each workstation. Values of 2 and 3 respectively are given.

<table>
<thead>
<tr>
<th>Customer Requirements</th>
<th>Rate of Importance</th>
<th>Current Status</th>
<th>Competitor X</th>
<th>Competitor Y</th>
<th>Company Plan</th>
<th>Ratio of Improvement</th>
<th>Sales Point</th>
<th>Absolute Weight</th>
<th>Demanded Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5.00</td>
<td>1.2</td>
<td>7.5</td>
<td>23.8</td>
</tr>
<tr>
<td>Unlimited Access</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2.00</td>
<td>1.5</td>
<td>12.0</td>
<td>38.1</td>
</tr>
<tr>
<td>Sufficient Lighting</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4.00</td>
<td>1.0</td>
<td>12.0</td>
<td>38.1</td>
</tr>
</tbody>
</table>

\[
\text{Total} = 31.5 \times 100
\]

\[
\text{Ratio of Improvement} = \frac{\text{Plan}}{\text{Current Status}}
\]

\[
\text{Absolute Weight} = \text{Rate of Importance} \times \text{Ratio of Improvement} \times \text{Sales Point}
\]

\[
\text{Demanded Weight} = \frac{\text{Item Absolute Weight}}{\text{Total Absolute Weight}} \times 100
\]

FIG. 4. Integrating Quality Characteristics and Voice of Customer

FIG. 5. Applying QFD in the Manufacturing-D/B Process
With the rest of the Voice of the Customer matrix completed, the target value (or “action plan”) for each defined quality characteristic can now be established. In this example, the quality characteristics’ percentage weights are used to prioritize them (i.e., value 5 for high-tech access, 4 for adding extra door, and 3 for individual light controls).

In this worked example, the “correlation matrix” or the “roof” of the house is omitted to keep things simple. Hence it can be seen that, from a nominal listing of customer needs, an order is established to guide the design. Primary objectives have been ordered as a result of this QFD evaluation.

The application of QFD in the manufacturing-D/B process can be divided into four phases, as illustrated in Fig. 5:

- Programming, which covers customers’ requirements for the building and design objectives
- Design, which covers the design objectives and construction drawings
- Production, which covers construction drawings and production plans
- Construction, which covers the production plans and construction phases (Houvila et al. 1997)

Based on the above description, it can be seen that QFD is a structured and disciplined process that provides a means to identify and carry the voice of the customer through each stage of product or service development and implementation (Marsh et al. 1991). The phases shown in Fig. 5 are applicable for both the manufacturing and the D/B process. In both instances, customer’s requirements are phased to filter through the processes from project inception to completion. This is unlike the “traditional” construction process, where customers’ requirements are sidelined because design is separated from production.

OBJECTIVES AND METHODOLOGY OF STUDY

In the traditional procurement method, where each professional or consultant is supposed to be solely responsible for his or her scope of work, client requirements have been assumed to be met with the production of construction drawings or individual services by the professional or consultant. This takes place in the absence of a systematic setting of bench marks or rationalizing and prioritizing of the customer’s needs. The voice of the customer is generally lost in the process. Whereas the traditional procurement method has been found to be in need of QFD techniques (Londe et al. 1997), a D/B contractor that bears both design and construction responsibilities, and thus requires greater cross-functional communication, may find the QFD methodology to be even more useful. This eventually may translate into decreased customer dissatisfaction and costly reworks.

In view of the issues stated above, the objectives of this present study are

- To assess the awareness of QFD methodology in D/B contracts
- To highlight the benefits of QFD and its relevance in D/B contracts
- To identify any problems or issues peculiar to D/B contracts in the application of QFD

This research looks at the awareness and applicability of QFD in D/B contracts. It intends to make a comparative study with the findings reported by Chia (1999) on a similar topic carried out using architects and engineers working on general construction contracts.

QFD is a relatively new concept to the construction industry. This paper therefore uses a qualitative approach in assessing the awareness and applicability of the QFD system in the design process of D/B contracts. This approach is supported by in-depth interviews conducted with experienced contractors typically involved with D/B contracts.

The interviews are semistructured in nature. During the course of the interviews, the interviewees were introduced to the concept of QFD and its merits and achievements, in particular, in the manufacturing industry. Key concepts and values of QFD were explained in detail. The potential applications of QFD in construction were also discussed with the interviewees to impress upon them the prospect of its implementation as well as to ascertain their response to this system. To achieve the above, a set of questionnaires was developed as a guide for the interviewees in tackling the various aspects of QFD introduced to them. A complete set of the questions can be found in Yeap (2000). An important part of the questionnaire, which focuses on the practicality and constraints in QFD implementation, is shown in the appendix. The data collected from these interviews were then analyzed qualitatively to achieve the objectives of this paper.

The in-depth interviews were conducted with 15 contractors in early 2000 in Singapore. The contractors selected for the interviews had been involved in D/B projects in the last decade. The interview sessions often lasted between 1 and 2 h. The interview was conducted in an informal manner to create a positive and relaxed atmosphere where the interviewees were encouraged to present their ideas and comments freely. This often led to discussions that went beyond the questions asked. However, such extensions were found to be useful in ascertaining the disposition of the respondents toward the topic of the study.

PROFILE OF RESPONDENTS

The group of 15 contractors selected for the interview are actively involved in D/B projects. These contractors specialize in building services such as plumbing and sanitary services, air-conditioning and mechanical ventilation services, fire protection systems, and electrical systems. The respondents typically hold a managerial post in their organization and are very experienced in their respective fields. Apart from holding a responsible office, some of these respondents are graduate engineers and professional engineers in their respective fields. In general, the experience of the respondents ranges from 6 to 20 years.

As frequent participants in D/B contracts, the respondents are well versed with the requirements and responsibilities associated with such works. They command a thorough understanding of the design and construction responsibilities as well as the authority requirements entailed in D/B projects. As such, a reasonable level of confidence and coherence in their responses is assured.

AWARENESS OF QFD

The survey revealed that only 1 out of the 15 respondents (approximately 7% of the sample size) has heard of QFD. These results were consistent with the findings shown in the survey conducted by Chia (1999), where it was reported that the awareness of QFD among professionals, mainly architects and engineers, was approximately 10% of the sample size. This figure is extremely low and confirms the lack of awareness of QFD in the construction industry. In this regard, the findings provide an indication of the awareness of QFD within the construction industry as a whole. This opinion is justified as the combination of the surveys covers major players of the industry, namely, professionals or consultants as well as contractors, and had revealed consistent results.

The findings of the current survey generally concurs with
the observations made in the United States, where it was found that QFD is not a recognized or requested tool in the practices of government, institutions, nonindustrial corporations, and other private clients (Oswald and Burati 1993). Thus, the awareness of QFD and its benefits is limited among the primary players of the industry—namely, architects and engineers.

In fact, the respondent who claimed to have heard of QFD is a professional engineer himself. It was interesting to note that his exposure to QFD came about while sharing his experience on the implementation of ISO 9000 with a Japanese contractor. According to the Japanese contractor, implementation of ISO 9000 is not common in Japan. One of the more popular quality management systems prevailing there is the QFD system. In this regard, potential research into the implementation of QFD in the construction arena in Japan is warranted.

CUSTOMER SATISFACTION

Among the following factors posed to the respondents to be ranked in order of priority, it was generally found that customer satisfaction was ranked as the most important component in a D/B project. Cost considerations was ranked second, followed by authority requirements, quality, and contract duration.

These observations follow closely the market practice in D/B projects, where the prospect of clinching a contract rests on the ability of the contractor’s proposal to deliver and match the needs of the customer at the most competitive cost.

Whereas almost 70% of the respondents rated customer satisfaction as their core objective, it was noted that the remaining 30% claimed that customer satisfaction was only fairly important. This group of respondents had unanimously rated cost as the top priority, followed by authority requirements.

An analysis of the survey results showed that, within this group of respondents who compromised customer satisfaction, they claimed that from experience they knew that the customer, on many occasions, could be persuaded to accept and appreciate alternative proposals that are competitive in cost and that design is able to satisfy current regulations. Notably, the respondents in this category include contractors in the electrical, plumbing, and sanitary trades. Although the above observation seems to reflect that an emphasis or focus on customer satisfaction could be correlated to a particular building trade, further rationalization of this assumption could not find any truth in this implication. Instead, what attracted attention was that the contractors under this category are not ISO 9000 certified. Comments such as “our company is still managed very much in the Chinese management style, where our core objective is to carry out the works to make profit” reinforce the findings of the questionnaire. Indeed, this philosophy was prominent in their responses to the survey where the emphasis on quality was lacking and ranged from “fair” to “least important.”

On the other extreme, respondents who prioritized customer satisfaction stated that this was the management policy of their office. Some of these respondents were saying that “satisfying the customer is the core value of our company and has been made the company policy in our ISO 9000 system.”

The above responses imply the need for a rationalized approach to enhance the focus on customer satisfaction to D/B contractors. Although ISO 9000 had aided in aligning the construction industry on this premise, QFD offers a systemized platform in achieving this objective. QFD sufficiently facilitates the procedure and structure through the utilization of matrices in translating the voice of the customer to design parameters and downstream deployment of such quality characteristics and functions throughout all phases of the construction process.

PROFESSIONAL ETHICS

The nature of D/B contracts requires the participants to take on dual responsibility both in the design and in the construction of the proposed facility. In this regard, the requirement for design services to be included as part of the work scope in the contract emphasizes the need for discipline and professionalism by the contractors in executing their works. This intrinsic nature of D/B contracts frequently poses a great burden upon the contractor to fulfill his obligation to satisfy the customer’s needs while maintaining professionalism.

Almost 80% of the respondents have indicated clearly that professional ethics preside over customer satisfaction. Some examples of the opinions expressed are as follows:

- “We have an obligation to deliver a proposal that not only serves the needs of the client but one which must be technically sound and complies with regulations.”
- “Professional responsibility cannot be compromised. If this code is breached in order to satisfy the customer, the design solution would not be sound. Eventually the customer would stand to lose, as they would ultimately inherit the development and its entire infrastructures.”
- “It is very important to impress upon the customer that the service they get comes with professionalism and integrity. This will bear a long-term business relationship, which outweighs compromising responsibility to satisfy customer requirements.”

The remaining 20% of the respondents said that customer satisfaction is definitely more important than professional ethics. Comments such as the following were recorded:

- “Actually both are equally important. However, if the customer insists on his preference, say, on a system design, I would follow his instruction but highlight the shortcomings of his preference and the advantages of my design. If he persists, he would take responsibility for his decision.”
- “It’s on a case-by-case basis. If the requirements do not breach authority regulations, I would go along with the client’s instructions.”

QFD would serve well in this regard to provide a platform that systematically identifies design parameters in relation to customer requirements as well as provide clear understanding of conflicting design objectives in the early stages of the design process. Early identification of conflicting objectives would pave the way to better understanding and clarity of responsibility.

NEED FOR QUALITY

Several of the core values of QFD were included in the questionnaire to ascertain the responses of the contractors to these items. The analysis of the findings is presented below.

All the respondents, with the exception of one, had confirmed the absence of a standard or systemized procedure in their offices to carry out proper documentation of customer requirements and the conversion of these requirements to design objectives. Although most recognized that proper documentation of customer requirements was an important contribution to improving the quality of design, further investigation revealed that most respondents emphasized that the use of such documentation serves more as a tool for contractual agreement and referencing rather than for identifying design objectives.
In fact, all respondents indicated that the task of identifying design objectives and parameters was largely based on past experience. It was noted that the identification of design objectives based on this method was believed to be sufficient in meeting client requirements.

The survey revealed that almost all respondents rated proper documentation of the design solution to be equally as important as proper documentation of customer requirements. It was explained that proper documentation of the design solution is important for purposes of tracing of records, for example, on design assumptions used in deriving the solution. It was noted that this portion of the works generally had been fairly well covered either through requirements set in the ISO 9000 system or through in-house procedures. However, none of the respondents had expressed the need for integrating the two processes.

In addressing this matter, the survey revealed that an equal number of respondents ranked managing conformity of customer requirements to be as important as managing conformity of design solutions. Arguments in support of either case were valid and rational. This led to the deduction that, as long as there is an absence of a quality system that would provide the means to integrate the two subjects, differentiating between a design solution based on customer requirements versus another based on “perceived design objectives” would not be conclusive. As observed above, practitioners would not be able to identify and appreciate the merits of integrating customer requirements and assigning the appropriate design solutions. In this respect, QFD would serve well to fill this void and provide the construction industry with a system that yields better quality design.

Although there seems to be a need for further refinement and improvement to documenting a client’s requirements, a majority of the respondents actually indicated that there is no short-term planning to put in place a system to address this need. However, despite the lack of a systematic procedure to carry out the above tasks, all the respondents had expressed confidence in developing a design solution that closely meets the client’s requirements.

It is evident from the above that there is a need for a quality management system to provide a platform for an organized system or process to enhance the conformity of design objectives to meet customer requirements. The application of QFD in this aspect would indeed help to fill the absence of such a quality assurance process. This assumption found much support from the respondents who expressed keenness in adopting the QFD methodology.

ADD VALUE TO DESIGN

The ability to add value to the design is one of the keys to a successful D/B proposal. To achieve this, the contractor may require more than just intuition. Creativity and innovation, most often than not, were looked upon as one of the main considerations of value-added input to the project (Chia 1999). The research by Chia (1999) reported that architects stressed great importance and pride in contributing “novel” solutions to design proposals and would take extra efforts to produce a design that is unique or different from others. Some architects, as reported in the above research, would turn down a potential business deal if they were forced to follow some “crowd’s design.” The above findings prod one to further rationalize whether such innovations would, in fact, meet the client’s requirements. Of course, this amounts to forcing the client to accept a design solution that is self-gratifying.

In view of the above observations, a similar question was posed in the questionnaire, to ascertain the responses from contractors in respect to value-added design. The survey revealed a mixed response from the interviewees. Half the respondents emphasized that customer satisfaction can be compromised. They would adapt the design proposal to conform with customer’s instructions, although these may lead to an inferior design. On the other extreme, the remaining half of the respondents insisted that a good design should not be compromised.

Respondents who lobbied for customer satisfaction were quoted as saying: “No point having a good design if the customer is not happy with it. Eventually it would not be accepted. So just do what the customer wants as long as the system complies with authority requirements.” Another respondent claimed, “I would adhere to the instructions of the customer so long as the design serves its function and does not breach regulatory requirements.”

On the other extreme, one of the respondents who lobbied in support of value-added designs was quoted as saying: “A value-added design is more important because it would yield less complaints, provide better function, and the customer would eventually be happy. So far, I have no problem in convincing my clients on my proposals.” Another respondent was quoted as saying: “If the design is not up to the mark, the inadequacies would show sooner or later and the customer ultimately suffers. This shall be highlighted. If the customer still persists on his requirements, I am prepared to walk away from the deal to prove the worthiness of my proposal.”

It would appear from the above observations that the D/B contractors generally do not hold so fervently to their design initiatives as compared to architects. This is partly due to the nature of the work itself. In the case of the architects, the design solution is largely based on creativity, art, and innovation. Although there is in place a technical framework for governance of design, the architect is often given a free hand in his design. In the case of the D/B contractors, however, the design solutions are mainly technical in nature and, to a large extent, limit extensive departure from regulatory requirements. As such, it would seem that the design solutions contributed by the contractors would place less emphasis on self-gratification when compared to the architects. Nevertheless, in either situation, QFD can play a pivotal role in supporting effective innovation and strategy by providing a benchmark for all parties to focus on what matters to the customer and not what is nice to have.

ENHANCED CUSTOMER SATISFACTION

The studies showed that most respondents believed in-depth discussion with the customer is the most effective method for enhancing customer satisfaction in the design process. This process enhances the communication between parties and provides the means to derive a good understanding of the customer’s needs and requirements. One respondent exclaimed that “knowing the role and position of the client in his organization would help me understand his background and gauge the accuracy of his brief . . . this in turn would improve the channel of communication, thus deriving an accurate brief.”

Although the above strategy possesses its merits, all the respondents concurred on the importance of carrying out cross-functional communication during the design process. One of the respondents was quoted as saying that “in a design-and-build environment, communication and brainstorming among the design team is a prerequisite to good understanding of the client’s needs and paves the way to a common strategy in providing a good design.” One of the respondents reported that the cross communication culture is part and parcel of the company management policy. In-house project reviews attended by the project manager, quantity surveyor, architect, structural engineer, and construction manager were often conducted to rationalize the strategy to be adopted for a potential project.
It appears from the above that client participation and cross-functional communication were generally found to be the more significant elements in enhancing customer satisfaction in the design process. This observation reinforces the “holistic view” presented by Winch et al. (1998), which perceived quality to include quality of realization (through customer interaction) and quality of specification (achieved through the translation of customer requirements to technical specifications).

**IMPLEMENTATION: CLIENT’S INFLUENCE**

Generally, the implementation of QFD in the construction industry concerns mainly three major participants, namely, client, contractor, and building authority. The influence of each of these participants on QFD shall be discussed in the following sections.

One of the common problems encountered in the design process is to obtain an accurate client’s brief. A majority of the interviewees have in one way or another expressed difficulties in carrying out this task because of the characteristics of the client. The following quotations from the respondents help exemplify this point:

- “You’ll be lucky to find a client who knows exactly what he wants.”
- “Clients always assume that you can read their minds and look startled when your drawings show otherwise.”
- “Getting an accurate customer requirement is always difficult. You need very experienced people on both ends, one to provide accurate instructions and the other to correctly comprehend and pen the actual needs.”
- “It is not too difficult to note down the requirements, but it is getting the commitment from the client that is difficult. Sometimes discussions turn out like business evaluations rather than a technical one.”
- “When you get a client who is not knowledgeable in the building industry, be prepared to visit him frequently. He will tell you his actual ideas when you show him the finished plans.”

Understanding these behavioral patterns is essential in formulating the client’s requirements, as it prompts the party creating the design brief on areas to prod and uncover from the customer. Essentially, this would lead to higher customer satisfaction. QFD is able to provide the facility and the means as an up-to-date technology for in-depth understanding of customer requirements through structured and comprehensive methods of prioritizing, reviewing, and conflict resolution of customer requirements.

A minority (about 20%) of the respondents have had pleasant encounters with clients. Some even said that the customers were usually accurate in their demands and had a good eye for design. This observation is not surprising. As the employment of professionals (such as architects, engineers, and project managers) to represent the client in construction projects is becoming a popular practice in the industry, the quality of specifications and the design brief, among the other elements in the construction contract, were found to have improved. The ability of these professionals to administer and communicate customer requirements more accurately would complement the inherent potentials of QFD and improve customer satisfaction through better quality in design.

The significance of the client’s influence on time, cost, and quality parameters in the D/B project is unquestionable. This is shown in two parameters surveyed in this study. The influence of the client on cost and time was found to be consistent with common understanding in the industry. Typically, as represented by all the respondents, should more time be given for the design process, fine-tuning of the design proposal and refinement of customer requirements to achieve a competitive cost could improve the quality of the design. In reality, however, most D/B contracts are given very short periods for completion and “fast tracking” is assumed to be second nature. Such constraints impose a great burden on the implementation of QFD. Notably, this problem may only be resolved through “educating the client” on the importance of an adequate time frame for the design process. In this instance, QFD would be an important tool to be used to raise the awareness of clients about the intricacies and complexities inherent in construction projects.

With regards to cost control by the client, it was concluded that the common practice would have adverse implications for QFD. Where such a cost limitation is exercised, there would be mounting pressure on the D/B contractor to be more watchful in cost allocations and budget. This “ripple effect” may eventually stifle the involvement of various individuals critical in implementing QFD.

**IMPLEMENTATION: D/B CONTRACTOR’S INFLUENCE**

Typically, in a D/B contract, the contractor would be the party responsible for implementing and evaluating the effectiveness of QFD. To achieve this, the contractor needs to provide resource allocation in the form of staff training and staff time required for the implementation of the QFD process. The survey showed that approximately 80% of the respondents concurred that QFD is a system to improve the quality of design; hence, investment in this system is justifiable.

Contrary to the above, however, the remaining 20% of the respondents claimed that the QFD process is too complicated and seems to demand too much of staff commitment. The time spent implementing QFD would be carried out at the expense of other business opportunities.

Another significant issue highlighted by many of the respondents relates to the strategic implementation of QFD. Many claimed that, because of the novelty of the subject in the industry, a “wait-and-see” approach for the implementation of QFD would be recommended. Some respondents said that they do not aspire to be pioneers in implementing QFD and recommended that the larger players in the industry, such as international contractors, undertake this responsibility. According to the respondents, the implementation of QFD by others would weed out potential difficulties for application of this system at such an early stage in the construction industry. This strategy would also enable them to observe the effectiveness of QFD on other contractors and hence provide for a better understanding of the system.

**IMPLEMENTATION: OTHER INFLUENCES**

Many of the respondents believed that the implementation of QFD would not materialize if this responsibility hinges upon the contractor’s own initiative. Instead the involvement of the local government in imposing compulsory implementation of such a management system is necessary, as in the case of ISO 9000.

Another major problem faced in the implementation of QFD is due to the formulation of large and complex matrices to take into account the complex and unique requirements inherent in construction projects. In this regard, the sheer amount of elements and activities of the project requires sophisticated computer programs to be used in rationalizing the matrix analysis. Such systems would incur large capital cost investments in the software as well as hardware for the computers. In addition, given the lack of resources and computer knowledge in most contracting organizations, it was believed that government organizations in touch with the construction industry should first take the lead in spearheading QFD for construction projects.

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CONCLUSIONS

The implementation of QFD is largely dependent on the influence of three main parties, namely, client, D/B contractor, and local government. Although the scope of this study does not provide a conclusive coverage of all the issues and influences of these parties on the implementation of QFD, it has reviewed some of the more pertinent issues.

The studies carried out had indicated that one of the constraints in implementing QFD was on account of the client himself. The research had confirmed that the inability of the client to communicate his requirements often would result in a poor understanding of the actual needs. This, in turn, would result in an inaccurate understanding of requirements by the contractor that eventually caused the design proposal to be abandoned or reworked.

Additionally, the client’s influence on setting the budget and duration for the contract would affect the quality of the deliverables (namely, the “design proposal” or the “constructed facility”). It was noted from the above interviews that the allocation of a greater profit margin and longer construction period by the client would enable the contractor to improve design quality through a refinement of the design proposal, with appropriate staffing. It was believed that this understanding and awareness from the client could be enhanced through the implementation of QFD, where the intricacies and complexities of executing a quality design are systematically and comprehensively documented for review.

This study had shown that, generally, the D/B contractors could appreciate the merits of the QFD system. However, the decisions for implementation of QFD by the contractors were subjected to the “push” and “pull” factors that may vary from one organization to another. The “pull” factors (such as self-actualization needs inherent in the contractor’s organization) to command better quality services or better business opportunities with clients who appreciate “quality” services provides the initiative on the part of the contractor to implement QFD. On the other hand, the “push” factors (such as compulsory implementation of QFD imposed by the local government) forces the contractor to embrace QFD.

Nevertheless, because of the novelty of this system, many respondents had believed that the larger contractors, or even government organizations, should spearhead the implementation of QFD. Not only would larger organizations have better resources (in terms of staff training and a budget for purchasing the necessary software and hardware) and management policies to carry out the comprehensive implementation of QFD, the achievements by large organizations are generally more easily acceptable as the industry standard, compared to similar achievements by a smaller construction company. In this regard, pilot experimental projects can initially be proposed to disseminate knowledge on the technique and to expose project personnel to the intricacies of QFD.

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