Using Quality Function Deployment to Plan Curricula in Higher Education

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ABSTRACT

The purpose of the present study is to apply the principles of QFD (and specifically HOQ) to the question of curriculum development in institutions of higher education. A key strategic tool of quality function deployment (QFD) is the house of quality (HOQ). The HOQ is a conceptual map that provides the means for inter-functional planning and communication. It is used to plan and design new or improved products and services. The present paper utilises the methodology of HOQ in the context of an institution of higher education in Taiwan to investigate the relationship between: (i) the needs of students and potential employers; and (ii) the strategy of an educational department in response to those needs. The study finds that potential employers are concerned about students’ professional ethics, professional certifications, and the ability to learn; and that students want to take an examination for job certification and wish to secure an occupation. The study also finds that the college department should concentrate on the teaching of required professional courses, elective professional courses, computer courses, and livelihood educations. The study demonstrates the applicability of HOQ methodology to the planning of curricula in the higher-education sector. Educational organisations can refer to this study to ascertain the needs of their own students and employers, and to plan curriculum programs accordingly.

INTRODUCTION

In the late 1960s, Akao and Mizuno (1967) introduced the concept of quality function deployment (QFD), but it did not emerge as a viable methodology until 1972 when it was applied at the Kobe shipyards in Japan. Subsequently, several companies used QFD as a strategic quality-management system for the delivery of products and services (Akao, 2007; Han et al., 2001; Heizer & Render, 2006; Mazur, 1993; QFD Institute, 2007). Although QFD has not become especially popular as a design technique for new products and services it is an appropriate methodology for this purpose for organisations of any size, and King (1989) has reported several case studies of QFD implementation in the United States of America. Similarly, Prasad (1998) has noted that many companies have experimented with QFD ideas for design purposes and have realised significant benefits.

QFD enables organisations to focus on the critical characteristics of a new or existing product or service from the various perspectives of: (i) the customer; (ii) the company; and (iii) technological requirements. Indeed, QFD essentially transforms the needs of the customer (the voice of the customer’, or ‘VOC’) into appropriate engineering characteristics of a product or an appropriate strategy for customer services. Moreover, QFD prioritises such product/service characteristics while simultaneously setting targets for product or service development. In short, QFD is a customer-driven approach to quality planning and development.

An important component of QFD is the ‘house of quality’ (‘HOQ’)—so called because of its schematic resemblance to the outline of a house. The HOQ is a graphic tool for defining the relationship
between customer desires and the capabilities of a product or service. It does this by utilising a planning matrix to correlate customer desires (or ‘wants’) with how a firm is going to meet those ‘wants’ (Han et al., 2001; Karsak et al., 2002; Sanford, 2005; Walden, 2003). The HOQ thus has several simultaneous objectives: (i) to meet customer requirements more effectively; (ii) to increase organisational capabilities; and (iii) to maximise organisational goals.

Although many organisations have used QFD (including HOQ) for design and quality control of products and services for external consumption, few organisations have utilised HOQ for designing internal processes and job training. It is the contention of the present paper that HOQ has significant potential in this regard. In particular, institutions of higher education (such as colleges and universities) could use HOQ to plan courses and curricula. As competition within the higher-education sector becomes more intense, educational organisations must pay closer attention to the concerns of their customers (students and employers) in planning their courses and curricula. If they do not do so, universities and colleges will experience diminishing student enrolments and their graduates will have fewer employment opportunities.

The purpose of the present study is, therefore, to apply the principles of QFD (and specifically HOQ) to the question of curriculum development in institutions of higher education. In other words, the study aims to identify: (i) the voice of the customers’ (VOC); (ii) the voice of the organisation’s (VOO); (iii) the relationships between VOC and VOO; (iv) the priorities for organisational strategy; and (v) the priorities of customers’ needs. Using these findings, it is the contention of the present paper that institutions of higher education can plan their curricula more effectively and thus improve the quality of the educational services they offer.

**THEORETICAL BACKGROUND**

QFD is a philosophy for quality assurance (Mizuno & Akao, 1993), not merely a series of steps to follow. A comprehensive and applicable QFD system must reflect technology, reliability, and cost consideration (Akao, 1990).

**Structure of House of Quality**

The so-called house of quality’ (HOQ) is illustrated in Figure 1. As shown in the diagram, the HOQ consists of six areas (Halong et al., 2000; Tang & Paoli, 2004): the foundation of the ‘house’ is formed by the priority order of organisational strategy; the main part of the ‘house’ is represented by the relationship matrix of customer needs and product features; the porches of the ‘house’ are represented by the VOC and the priority order of customers’ needs; the mezzanine of the ‘house’ is formed by the VOO; and the roof of the ‘house’ is formed by the technical or strategic correlation matrix.

Details of the elements of the HOQ (as applied to an institution of higher education) are shown in Figure 2. The elements of HOQ, as illustrated in Figures 1 and 2 are described in more detail below.

**Voice of customer (‘WHATS’).** The VOC is also known as ‘customers’ needs’, ‘customers’ requirements’ or ‘demanded quality’ (Harshman, et al., 2005; Griffin & Hauser, 1993; Luthar, & Karri, 2005; Mazur, 1993; Prasad, 1998). For most enterprises, the VOC is, in essence, the market requirement. In this part of the HOQ, customers are listened to, and a list of customer needs and expectations is created.

**Voice of organisation (‘HOWs’).** The VOO is also known as ‘design requirements’, ‘product technical requirements’, ‘product features’, ‘engineering characteristics’, or ‘quality characteristics’ (Han et al., 2001; Mazur, 1993; Prasad, 1998). The ‘HOWs’ thus constitute the organisational strategy whereby
a set of ‘WHATs’ can be realised. Using this list of ‘HOWS’, an organisation can measure and control quality to ensure that the ‘WHATs’ are satisfied. That is the organization needs to organize a co-leadership team (QFD team) to plan design requirements in order to fulfil the voice of customer (Chen, 2006).

**Figure 1: Structure of House of Quality (HOQ)**

**Relationship matrix.** The relationship matrix indicates the relationships between the VOC and the VOO (Karsak et al., 2002; Mazur, 1993). These relationships can be represented in numbers or symbols. In Figure 2, the rectangular area of rows and the columns depicts the relationships between the ‘WHATs’ and the ‘HOWs’. Relationships within this matrix are usually defined as ‘strong’, ‘moderate’, ‘weak’, or ‘none’ (with ratings of 9, 3, 1, and 0 or blank respectively).

**Correlation matrix.** The correlation matrix matches the VOO (or sometimes the VOC) with product technical requirements (Karsak et al., 2002; Mazur, 1993; Shin et al., 2002). This is an important feature of the HOQ because a given strategy could be redundant and might not add much value to customer wants. Correlation can be positive, zero, or negative (Shin et al., 2002). If two HOWs help each other meet the target value, they are rated as positive (that is: 9, 3, or 1); if meeting one HOW target value makes it more difficult (or impossible) to meet another target value, these two HOWs are rated as negative (that is: –9, –3, or –1).

**Priority order of customer needs.** Customers are surveyed for their needs, and the needs are calculated using digitised scales to find a final rank order (Mazur, 1993; Walden, 2003). In Figure 2, the columns labelled $Ja$ to $Jg$ represent evaluations of customers’ needs in terms of: (i) degree of importance of customers’ needs; (ii) planned level; (iii) improvement ratio; (iv) satisfactory points; (v) absolute grades; and (vi) relative grades.

**Priority order of organisation strategy.** The results will reveal overall priorities for the product or strategy technical requirements and additional goals. In Figure 2, the rows labelled $Kh$ to $Ks$ represent evaluations of organisational strategy in terms of: (i) degree of difficulty in implementing strategy; (ii)
planned level; (iii) improvement ratio; (iv) satisfactory points; (v) absolute grades; and (vi) relative grades.

**Figure 2: Detail of HOQ**

Use of HOQ

Because most successful enterprises attach importance to customer satisfaction, the priority order of customers’ needs should be obtained by HOQ techniques. Based on these needs, the organisation can then plan an appropriate strategy and designs to satisfy its customers. To ascertain this priority order, the QFD team should refer to survey data of customers’ needs and decide the degree of importance of customers’ needs, the planned level, and the satisfactory points; the team then calculates the improvement ratio, the absolute grades, and the relative grades (that is, columns J to Jg in Figure 2).

In response to these customers’ needs, the QFD team should set a strategy for organisation to implement technical items and improve service quality to satisfy customers (Gonzalez et al., 2004). In doing so, it is obviously important to ascertain the priority of technical items. The data are obtained through market evaluation and research. The purpose is to quantify the solution parameters into achievable ranges, thereby creating a criterion for assessing success and avoiding unreasonable decision-making (Chen, 2006). When calculating relative grades, the relationship matrix \( R_{KJ} \) indicates how much each VOO affects customers’ needs.
The QFD team then evaluates an organisational strategy, the degree of difficulty in implementing the strategy, the planned level, and satisfactory points; the team then calculates the rows of improvement ratio, absolute grade, and relative grade of strategy (that is, rows labelled $K_h$ to $K_s$ in Figure 2). In summary, to serve customers more effectively, the organization should attach importance to the priority order of customers’ needs and the priority order of organisational strategy.

**METHODOLOGY**

Before the QFD team builds a HOQ, a survey sheet of the items that constitute the VOC should be designed. Using this survey, the weights of customers’ needs can be obtained and recorded. The steps involved in building a HOQ are as follows (Wang et al., 1998). The VOC items (‘WHATs’) are listed from $K_1$ to $K_8$, as shown in Figure 2. The QFD team notes the weights data from the survey ($1 \leq J_a \leq 5$), evaluates the degree of importance to customer needs ($1 \leq J_b \leq 10$), decides the target value ($1 \leq J_c \leq 5$), and evaluates satisfactory points ($1 \leq J_e \leq 1.5$). The items for the strategy of the organisation (‘HOWs’) are listed from $J_1$ to $J_8$, as shown in Figure 2. The QFD team evaluates the importance of organisational strategy ($1 \leq K_h \leq 5$), evaluates the degree of difficulty in implementing the strategy ($1 \leq K_i \leq 10$), decides the planned level or target value ($1 \leq K_m \leq 5$), and evaluates organisation satisfactory points ($1 \leq K_p \leq 1.5$).

The relationship matrix, $R_{K,J}$, between the ‘WHATs’ and the ‘HOWs’ is developed in meetings (strong relationship = 9, medium = 3, weak = 1, and no relationship = blank). The correlation matrix of the VOO is built and checked by the relationship matrix (Shin et al., 2002). The coefficients of correlation between organisational strategies are as follows: strong = 9, medium = 3, weak = 1, and no relationship = blank. The QFD team calculates the absolute grades and priority order of the organisational strategy and the customer needs.

In calculating the column or row vectors in Figure 2, the following procedure is followed: the column vector of improvement ratio $J_d$ is equal to $J_c$ divided by $J_a$; the column vector of absolute grades $J_f$ is equal to $J_b$ times $J_d$ times $J_e$; the row vector of improvement ratio $K_n$ is equal to $K_h$ divided by $K_m$; and the row vector of absolute grades $K_q$ is equal to $K_i$ times $K_n$ times $K_p$. The element value of column vector $g_K$ and the element value of row vector $s_J$ are:

$$g_K = \sum_{K=1}^{8} R_{K,J} \times K_q$$

$$s_J = \sum_{J=1}^{8} R_{K,J} \times J_f$$

Having computed the vectors $g$ and $s$, the organisation can then focus on the priority order of customers’ needs and implement its own organisational strategy in response (Fehlmann, 2005; Kim et al., 2005). The participants in the present study consisted of the following members of the Department of Business Administration (DBA) of a Taiwanese college: employers (43), alumni (120), undergraduates (205), and faculty members (15). The survey was conducted during the autumn and winter of 2006. The calculations were carried out using Excel and SPSS.
RESULTS

According to Shin et al. (2002), a common mistake in QFD is to perform analyses using an inconsistent HOQ chart—that is, a chart in which the information from the correlation matrix (roof matrix) is inconsistent with that from the relationship matrix. In Figure 3, if $HW_{J1}$ (‘HOWs’ column 1) and $HW_{J2}$ are related, which is manifested by a non-zero entry, $g_{J1,J2}$, in the cell is defined by $HW_{J1}$ and $HW_{J2}$ in the correlation matrix. The relationship coefficient of the cell $(K, J)$ in the relationship matrix, $R_{K,J}$, indicates the extent to which $HW_{Jx}$ affects the VOC. If there is relationship between $HW_{J1}$ and $HW_{J2}$ in the correlation matrix (roof matrix), it is expected that $R_{K,J1}$ in column $J1$ will show a similar pattern to $R_{K,J2}$ in column $J2$.

Consistency Check

The consistency of an HOQ chart can be evaluated by the following procedure:

1. Normalise the weighting scales in the relationship matrix, scaling $R_{K,J}$ to $f_{K,J}$. For example, in the case of a 1–3–9 weighting scale; the normalised weighting scale is 0.11–0.33–1.00.

2. Calculate the similarity coefficient ($SC$) between every pair of $HWs$ (‘HOWs’ column) having a non-zero relationship coefficient in the roof matrix. The SC is defined as:

$$ SC_{J1,J2} = 1 - \frac{\sum_{K=1}^{m} |f_{K,J1} - f_{K,J2}|}{m}, $$

where:

- $SC_{J1,J2}$: similarity coefficient between $HW_{J1}$ and $HW_{J2}$, (HOWs column)
- $f_{K,J}$: normalized relationship coefficient between WHATs and HOWs,
3. Calculate the consistency index ($CI$), which is defined as the statistical correlation between non-zero correlation coefficients ($g_{J_1J_2}$) in the roof matrix and the corresponding similarity coefficients $SC_{J_1J_2}$. If the information contained in the relationship and roof matrices is consistent, the $CI$ closes to 1.

4. Evaluate the $CI$ values. Conduct a statistical significance test on the $CI$ value. If the null hypothesis that $CI$ is less than or equal to zero is rejected, the HOQ chart is considered consistent and passes the consistency check. Otherwise it is necessary to investigate which part of the HOQ chart has caused the inconsistency (Shin et al., 2002).

Inconsistency Check
A sensitivity test can be conducted to identify the pairs of HWs that cause inconsistency, as follows:

1. Calculate the marginal difference in $CI$ as:

$$
*_CI_{J_1J_2} = CI_{J_1J_2} - CI
$$

where:

- $*_CI_{J_1J_2}$: marginal difference in $CI$, and
- $CI_{J_1J_2}$: $CI$ after dropping data related to HW$J_1$ and HW$J_2$.

2. Rank the pairs of HWs in descending order in terms of their marginal differences obtained in Equation 4. A pair of HMs having the highest marginal difference is considered to contribute the most to the inconsistency of the HOQ chart.

3. Identify the critical pairs of HWs causing the inconsistency. Adjust or drop the correlation matrix cells, $g_{J_1J_2}$, and relationship matrix cells, $R_{KJ}$.

4. Check the pairs of HWs to see whether there is inconsistency in the data related to the pairs of HWs identified in step 3.

Results of Consistency and Inconsistency Checks
The data in Figure 3 are checked as follows. The similarity coefficients, $SC_{J_1J_2}$, between every pair having a non-zero relationship coefficient in the roof matrix are calculated as shown in Table I.

<table>
<thead>
<tr>
<th></th>
<th>J1</th>
<th>J2</th>
<th>J3</th>
<th>J4</th>
<th>J5</th>
<th>J6</th>
<th>J7</th>
<th>J8</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J2</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J3</td>
<td>0.72</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J4</td>
<td>0.81</td>
<td>0.67</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J5</td>
<td>0.82</td>
<td>0.57</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J6</td>
<td>0.88</td>
<td>0.68</td>
<td>N/A</td>
<td>0.79</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J7</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.93</td>
<td>0.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J8</td>
<td>0.72</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.75</td>
<td>N/A</td>
<td>0.78</td>
<td></td>
</tr>
</tbody>
</table>

$m$: number of cells in which either $CM_{J_1}$ and $CM_{J_2}$ has a nonzero value, and $n$: number of WHATs.
The statistical correlation between the non-zero relationships in the roof matrix and the similarity coefficients in the relationship matrix \((CI)\) was calculated as 0.167, and its p-value was 0.521. Therefore, the HOQ chart in Figure 3 failed to pass the consistency check. The marginal differences in \(CI\) by dropping each pair of HWs were computed, as shown in Table II.

After adjusting correlation coefficients \((g_{Jx,Jy})\) and relationship coefficients \((R_{K,J})\), the resulting \(CI\) was 0.684 and its p-value was 0.002. Using new correlation coefficients and relationship coefficients, the consistent HOQ chart is shown in Figure 4. As shown in Figure 4, the priority order of customer’s needs was as follows:

1. (Row K 7) Employers want their employees to have professional ethics (135).
2. (Row K 5) Employers want their employees to have job certification (129).
3. (Row K 3) Students or learners want to take an examination for job certification (128).
4. (Row K 1) Students or learners want to have an occupation (125).
5. (Row K 8) Employers want their employees to have the ability to learn (101).
6. (Row K 6) Employers want their employees to have computer skills (97).
7. (Row K 2) Students or learners want to enter a higher school (87).
8. (Row K 4) Students or learners want to start an enterprise (70).

**Table II: Calculated marginal differences in \(CI\)s in descending order**

<table>
<thead>
<tr>
<th>(CI_{Jx,Jy} - CI = ^*CI_{Jx,Jy})</th>
<th>(CI_{Jx,Jy} - CI = ^*CI_{Jx,Jy})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CI(_{1,2})</strong></td>
<td>0.244</td>
</tr>
<tr>
<td><strong>CI(_{1,3})</strong></td>
<td>0.172</td>
</tr>
<tr>
<td><strong>CI(_{1,4})</strong></td>
<td>0.166</td>
</tr>
<tr>
<td><strong>CI(_{1,5})</strong></td>
<td>0.166</td>
</tr>
<tr>
<td><strong>CI(_{1,6})</strong></td>
<td>0.169</td>
</tr>
<tr>
<td><strong>CI(_{1,7})</strong></td>
<td>0.149</td>
</tr>
<tr>
<td><strong>CI(_{2,3})</strong></td>
<td>0.103</td>
</tr>
<tr>
<td><strong>CI(_{2,4})</strong></td>
<td>0.18</td>
</tr>
<tr>
<td><strong>CI(_{2,5})</strong></td>
<td>0.083</td>
</tr>
<tr>
<td><strong>CI(_{2,6})</strong></td>
<td>0.131</td>
</tr>
<tr>
<td><strong>CI(_{3,4})</strong></td>
<td>0.113</td>
</tr>
<tr>
<td><strong>CI(_{4,6})</strong></td>
<td>0.186</td>
</tr>
<tr>
<td><strong>CI(_{5,6})</strong></td>
<td>0.166</td>
</tr>
<tr>
<td><strong>CI(_{5,7})</strong></td>
<td>0.296</td>
</tr>
<tr>
<td><strong>CI(_{5,8})</strong></td>
<td>0.164</td>
</tr>
<tr>
<td><strong>CI(_{5,9})</strong></td>
<td>0.204</td>
</tr>
<tr>
<td><strong>CI(_{7,8})</strong></td>
<td>0.166</td>
</tr>
<tr>
<td><strong>CI(_{5,10})</strong></td>
<td>0.296</td>
</tr>
<tr>
<td><strong>CI(_{5,11})</strong></td>
<td>0.204</td>
</tr>
<tr>
<td><strong>CI(_{7,8})</strong></td>
<td>0.166</td>
</tr>
</tbody>
</table>

The educational organization has to plan curriculum program in the priority order of the following.

1. (Column J2) The required professional courses include marketing management, human resources management, financial management, production and operation management, information management, and professional ethics (294).
2. (Column J3) Elective professional courses (that is, professional or job certification courses) (276).
(3) (Column J4) Computer courses, including management information systems, business software, and electronic commerce (188).

(4) (Column J8) Livelihood education (132).

(5) (Column J1) Background courses (economics, accounting, and statistics) (112).

(6) (Column J6) Foreign language courses (English and Japanese) (82).

(7) (Column J5) Comprehensive knowledge courses (53).

(8) (Column J7) Extracurricular activities (49).

The organisational strategy correlation matrix (roof matrix) revealed high degrees of correlation (marked 9) between: (i) background and foreign language courses; (ii) required professional and elective courses; and (iii) comprehensive knowledge and extracurricular activities. Moderate degrees of correlation are marked as ‘3’, and low degrees of correlation are marked as ‘1’. The QFD team can use these correlations to check the legitimacy and consistency of the relationship matrix.

**CONCLUSIONS**

Administrators of a modern educational institution need to see their college or university as an enterprise, with students and employers as its customers. In view of the ever-increasing competition that exists in the higher-education sector, administrators should be concerned to ensure that their educational enterprises meet the needs of their customers. The HOQ methodology helps them to achieve this. Based on the VOC (customers’ needs or ‘WHATS’), an educational organisation can plan its curriculum program (organisational strategy or ‘HOWs’) in response to the needs.

This study has used the HOQ methodology to establish that professional ethics, professional or job certifications, and the ability to learn are very important for students and potential employers. A higher-education institution should therefore concentrate on the teaching of compulsory professional courses (especially professional ethics courses), elective professional courses, and computer courses.

The findings are limited to the Department of Business Administration in a private Taiwanese college. However, other educational organisations can refer to the methodology of this study to ascertain the needs of their own students and employers, and to plan curriculum programs accordingly. In the future, educational organizations may utilize the series of houses of quality to deployed resources to achieve potential employers and students requirements.

**REFERENCES**


Note:  WHATS: voice of customer or customer's needs,  
ST: students or alumni  EP: employers  
HOWS: voice of organization or organization's strategy  

K 1: to get an occupation  J 1: background courses  
2: to enter a higher school  2: required professional courses  
3: to take an exam of job certification  3: elective professional courses  
4: to start an enterprise  4: computer courses  
5: having a job certification  5: comprehensive knowledge courses  
6: having the skills to use computer  6: foreign language courses  
7: having professional ethics  7: extracurricular activities  
8: having the ability to learn  8: livelihood education  
h : evaluation of organization strategy  a : evaluation of customer's needs  
i : degree of difficulty to implement strategy  b : degree of importance to customer's needs  
m : planned level  c : planned level or target value  
n : improvement ratio  d : improvement ratio  
p : satisfactory points  e : satisfactory points  
q : absolute grades  f : absolute grades  
s : relative grades  g : relative grades  
POOS: priority order of organization strategy  POCN: priority order of customer's needs  

Figure 4: Results of HOQ for Educational Organisation