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Application of Quality Function Deployment in new product and service development

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Department:

APPLICATION OF QUALITY FUNCTION DEPLOYMENT IN NEW PRODUCT AND SERVICE DEVELOPMENT

by

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PUBLICATION THESIS OPTION

This thesis consists of the following three articles that have been prepared in the format as specified by the respective journals to which they have been submitted:

Pages 2-30 are intended for submission to the Total Quality Management and Business Excellence journal and consist of the article – "*The Application of Quality Function Deployment to New Product Development.*"

Pages 31-75 are intended for submission to the Engineering Management Journal and consist of the article – "Analyzing Customer Requirements for the American Society of Engineering Management Using Quality Function Deployment."

Pages 76-111 are intended for submission to the Managing Service Quality journal and consist of the article – "*Analyzing Customer Requirements for the Career Center.*"

ABSTRACT

Quality Function Deployment (QFD) is a systematic process to integrate customer requirements into every aspect of the design and delivery of products and services. Understanding the customers wants or needs from a product or service is crucial to the successful design and development of new products and services. QFD is a system that utilizes customer demands to meet client missions by outlining what the customer wants in a service or product. QFD was used in this research to determine customer needs and thus to ensure that customer demands are met. This methodology is demonstrated using two case studies: Hydrogen Fuel Cell Vehicle (HFCV) and American Society for Engineering Management (ASEM). QFD was also integrated with SERVQUAL to present an effective methodology that was demonstrated in a Career Opportunities Center (COC) case study. The results included prioritized customer requirements, resource allocations and technical requirements. The QFD methodology presented in this study could serve as a powerful tool in the development of many new products/services.

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1. INTRODUCTION

Quality function deployment (QFD) method was first originated in Japan. QFD is used to select the design features of a product to satisfy the expressed needs and preferences of the customer as well as to prioritize those features and select the most important features for special attention later in the design process. The unique approach of QFD is its ability to integrate customer demands with the technical aspects of a service. It helps the cross-functional team to make the key tradeoffs between the customers' needs and the technical requirements so as to develop a high quality service or product. Hence, QFD is not only a methodological tool but also a universal concept that provides a means of translating customer requirements in each stage of product/service development.

Paper I presents a methodology that could be applied to any New Product Development (NPD) process or to improve existing products. This has been demonstrated by the application of the QFD methodology to the design of a Hydrogen Cell Fuel Vehicle (HFCV). Paper II presents a methodology that could be applied to the development of new services or to enhance the existing service processes. This methodology has been explained with the help of the American Society of Engineering Management (ASEM) case study. The integrated approach of QFD with SERVQUAL has been presented and demonstrated in Paper III using a Career Opportunities Center (COC) case study. Using QFD methodologies, customer requirements can be met effectively and efficiently. This study aims to contribute to the literature on the application of QFD as well as SEVQUAL methodologies in the product and service sectors. This study has demonstrated the detailed QFD methodology that could be applied to development of new products and services as

well as to improve the quality of the existing products and services. This research has also demonstrated how QFD could be integrated with SERVQUAL (a tool used to measure service quality) and apply this integrated methodology in the service sector.

PAPER I. THE APPLICATION OF QUALITY FUNCTION DEPLOYMENT TO NEW PRODUCT DEVELOPMENT

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ABSTRACT

Quality function deployment transforms customer requirements into technical design specifications by linking customers, marketers, engineers, competitors, and production methods. Quality function deployment integrates the voice of the customer into the design phase, producing better products with high levels of customer satisfaction. This paper examines the application of quality function deployment in the new product development process by using the production of a fuel-efficient vehicle as an example. An integrated team of marketers, design engineers, and business experts developed a House of Quality for the fuel-efficient vehicle that provided an insight into the customer preferences and the technical requirements that helped achieve desired results in the prototyping of a Hydrogen Fuel Cell Vehicle (HFCV).

Keywords: Quality Function Deployment (QFD), New Product Development (NPD), Voice of Customer (VOC), House of Quality (HOQ)

1. INTRODUCTION

In today's competitive market environment, organizations must focus on being first to market with cutting edge technology. Global competition forces organizations to develop innovative ideas to make their products competitive in the market. The ability to adapt to constant change is key for any successful business. With increasing globalization, all organizations must focus on customer satisfaction and needs, and they must remain open to discovery if they are to sustain their business. To ensure success in the competitive marketplace, organizations should adopt a new product development (NPD) process that delivers products based on customers needs. The tools and methods used in the development process determine product quality and thus demand attention. QFD is a system for translating consumer requirements into appropriate company requirements at each stage, from research and product development to engineering and manufacturing to marketing/sales and distribution (Fisher and Schutta, 2003).

Ultimately, QFD transforms customer requirements into technical design specifications that promote customer satisfaction. It links customers, marketers, engineers, competitors, and production methods. In addition, by facilitating the development of a detailed view of the complete design and manufacturing process, it can resolve problems in the early phases of design, thus drastically improving production. QFD is effective because it integrates the voice of the customer (VOC) into the design phase, producing better products with high levels of customer satisfaction. QFD consists of four phases: product planning, product design, process planning, and production planning. This paper examines the application of QFD in

NPD by using the production of a fuel-efficient vehicle as a case study. The final deliverable of this study is a house of quality (HOQ) that was constructed by integrating customer opinions gathered via a survey. This case study focused on the implementation of the first phase of QFD by the marketing team, which helped the design team with useful information for the development of HFCV.

2. LITERATURE REVIEW

2.1 QUALITY FUNCTION DEPLOYMENT

QFD is a planning process that translates customer needs into appropriate organizational requirements (Pawitra and Tan, 2003). Miguel (2009) indicates that the use of QFD is similar to the development of innovative products, but it is limited to additions of existing product lines, product repositioning, and product improvement. Miguel further states that outcomes may result in little, moderate, or great innovation, but not extreme innovation.

Maritan and Panizzolo (2009) proposed that when used in the strategic planning process, QFD maintains the integrity of the VOC and generates innovative strategies to achieve an organization's vision. They also argue that it leads directly to policy deployment for implementation and performance management.

Miguel and Carnevalli (2008) have reported that key steps in the implementation of QFD include the development of a level of quality control that allows the manufacture of products with specifications determined by QFD. They point out that the process receives support from upper management, facilitates training, implementation, and team building, limits the frequency and length of meetings, and creates a conceptual model.

2.2 VOICE OF THE CUSTOMER (VOC)

The Voice of the Customer is defined as the identification, structuring, and prioritization of customer needs (Griffin and Hauser, 1991). Customer needs are measured in terms of consequences, which are determined by asking customers

directly what they are looking for in a product or service. The VOC is obtained primarily by two methods, interviews or focus groups.

Griffin and Hauser (1991) suggest that interviews with 20-30 customers should identify 90% or more of the customer needs in a relatively homogeneous customer segment. Multiple analysts (4-6) should review the transcripts of the focus groups to identify group synergies. Product concepts are then created based on customer priorities.

The Kano model is a theory of product development and customer satisfaction. Kano et al. (1984) distinguish three types of service requirements that influence customer satisfaction in various ways: ''must be", ''one-dimensional'', and ''attractive'' quality requirements.

Must be requirements can be defined as the basic attributes of quality in terms of customer satisfaction. In other words, they are a necessary but insufficient condition for customer satisfaction (Busacca and Padula, 2005).

One-dimensional requirements are related to product performance; they create customer satisfaction when present and dissatisfaction when absent (Redfern and Davey, 2003). The higher the perceived service quality, the higher the customer's satisfaction and vice versa. One-dimensional requirements are both a necessary and sufficient condition for customer satisfaction (Busacca and Padula, 2005).

Attractive requirements can be defined as the service attributes that satisfy or even excite customers when present but do not dissatisfy when absent (Berger et al., 1993). Such attributes have the greatest influence on customer satisfaction with a given service (Matzler et al., 1996). They are a sufficient, but unnecessary condition for satisfaction (Busacca and Padula, 2005). Attractive attributes can be used as an

element of an aggressive marketing strategy to attract competitors' customers. QFD normally deals with satisfiers not delighters.

Zhao and Dholakia (2009) have reported that although one-dimensional (i.e., linear) relationships are common, other relationships between attribute-level performance and customer satisfaction also exist that change dynamically over time and with user experience.

2.3 THE HOUSE OF QUALITY (HOQ)

Olewnik and Lewis (2008) report that the HOQ is a popular design tool that supports information processing and decision making in the engineering design process. They note that for companies just implementing QFD and the HOQ, there is undoubtedly an improvement in information structure, flow, and direction. Their research determined that although HOQ offers conceptual support for the design process, quantitative conclusions based on HOQ are likely flawed since calculations of quantitative importance rely on a scale choice and designers will not likely be able to assess the true relationship between customer attributes (CA) and technical attributes (TA). Hauser and Clausing (1988) state that the principal benefit of the HOQ is increasing the quality focus of the organization. That is, the HOQ gets people within an organization thinking in the right directions and thinking together. Exhibit 1 depicts a standard HOQ.

QFD uses a set of interrelated matrix diagrams. The first matrix is the HOQ, which converts the customer needs into requirements that must be fulfilled throughout the supply chain. The starting point on the left of the house is the identification of basic customer needs, which constitute customer attributes. The next step is the

definition of the priority levels customers assign to these needs. These priorities are translated into numeric values that indicate relative importance. Customer ratings, shown on the right side of the house, enable benchmarking with competitor's products. The section just below the roof states the technical attributes used to meet the customer needs. The relationship between the customer and technical attributes constitutes the main body of the HOQ, called the relationship matrix. The correlation matrix defines the relationships among technical attributes; as represented by the roof of the HOQ. The bottom of the house evaluates the competition in terms of technical requirements and target values are defined in this matrix (Tan and Pawitra, 2001). The construction of each of the sections in the HOQ is discussed in the following sections. The different sections of the HOQ can be seen in Exhibit 1.

3. METHODOLOGY

This paper is organized as follows. First, a brief review of literature on QFD and related concepts are presented. Second, the methodology used in this research to perform the QFD analysis is described. Finally, the conclusions drawn from the research are discussed.

3.1 UNDERSTANDING CUSTOMER CHOICE DECISIONS

The application of QFD to NPD requires that the VOC be integrated into every stage of product planning to ensure customer satisfaction. This approach helps companies avoid the need for costly redesign. In the current competitive market, product success rate is vital for any customer-driven business. To achieve product success, companies must understand customer needs and desires. The first step toward understanding customer needs is to identify attributes and customer consequences. Attributes are defined as the physical or abstract characteristics of a product. They are objective, measurable, and reflect the producer's perspective. Consequences are a result of using attributes. Customers judge products based on their consequences, not their attributes. In other words, customers judge a product on its outcome, or affect of use on them. A product has many attributes, and each may have more than one consequence (Fisher and Schutta, 2003).

3.2 INTERVIEWS

The product that was being developed was a hydrogen fuel cell vehicle (HFCV) that was a plug-in hybrid. The vehicle's power source consists of a battery

and a hydrogen fuel cell. The first step in obtaining the VOC for this case study was to conduct interviews, which was used to derive a customer survey. The interviews were one-on-one conversations conducted with customers to determine their expectations from a vehicle. Thirty interviews were conducted; research has shown that this captures approximately 90% of customer concerns for the general customer base (Griffin and Hauser, 1991).

The interview questions included:

1. What do you look for when purchasing a vehicle?
2. What is your main need in a vehicle?
3. What is your main use for your car now?
4. What is important to you in your current vehicle?
5. What brands of vehicles are you currently familiar with?
6. What brands of environmentally friendly vehicles are you familiar with?
7. Of those vehicles, what do you know about them?
8. What is your opinion of environmentally friendly vehicles?
9. What would be your ideal environmentally friendly vehicle?
10. Name, age, and occupation?

The purpose of the interview process was not to ask each customer all ten questions, but to promote the customer to talk. When the subject stopped talking, the next question would get the conversation flowing again. To elicit consequences from a customer, the interviewer used a probing technique repeatedly by asking "why" to determine the attributes responsible for making a specific feature appealing to them. Seventeen customer consequences were developed from the interview data.

3.3 AFFINITY DIAGRAM

After the VOC had been gathered via the interview process, the collected data was organized using affinity diagrams. Affinity diagrams group the consequences gathered based on similarity to clarify customer input. The 17 consequences were grouped into six similar categories, and each category was given a title. The left side of the HOQ was completed with customer consequences and attributes. The affinity diagram is shown in Exhibit 2.

3.4 SURVEY

The next step was to obtain the importance rating and rankings of each consequence from the customer base. A survey was conducted of 104 customers regarding the relative importance of the 17 consequences. The reason behind this was to avoid misinterpretation of the customer's overall attitude or satisfaction towards the product that could lead to poor prediction of the customer's purchase behavior. Customers do not place equal importance on all consequences. Three vehicles were chosen for this purpose including a Toyota Prius (Vehicle A), a BMW 335 advanced diesel (Vehicle B), and the HFCV (Vehicle C). In addition, the survey respondent's current car was used to allow comparison. The identities of the three vehicles were not disclosed to the survey respondents. A brief description of each vehicle was provided, however, to allow them to make a nonbiased decision on ratings and rankings of each consequence, relative to each vehicle. Each respondent was asked to read the descriptions and provide rating and rankings for each vehicle.

The survey was conducted in two parts. First, he respondents were asked to identify the most important consequence to them and label it as "10". All other

consequences were to be assigned a value (rank) between 1 and 10, relative to the consequence labeled as most important. Therefore, some consequences may be just as important as the first consequence assigned a value of "10", and they too would be assigned a value of "10." Consequences that were almost as important as the first consequence assigned a value of "10" may be assigned values of "9" or below, relative to how important the customer felt they were in relation to the first "10" consequence. The mean of the rankings was calculated for the results of each consequence that constituted the importance column in Exhibit 3.

The second part of the survey involved rating each consequence as it applies to each of the four vehicles on a Likert scale from 1 to 5. The mean of the ratings was calculated for each consequence and noted in the rating column in Exhibit 3. The weighted rating values were obtained by multiplication of the importance (rank) and rating together. The weighted rating is a means of obtaining a comprehensive measure by evaluating both what is important to a customer and how well the customer thinks each product is doing on what is important to them. This is also used as a means to evaluate resource allocations, as if the customer base feels that a company is lacking on a consequences that they deem very important, more focus can be applied to improving this, which may ultimately improve market share. Conversely, if a customer-base feels that a product excels on consequences that are of no importance to them, resources can be directed away from these areas and applied to areas needing improvement. The survey's main purpose was to gather more specific information on potential customer desires and needs. The results of the survey are tabulated in Exhibit 3.

3.5 DEVELOPMENT OF TECHNICAL REQUIREMENTS

After the customer consequences were analyzed, the next step in the construction of the HOQ was the development of technical requirements. The technical requirements are the design specifications that satisfy customer needs. This aspect of QFD is directly in the organization's control, and focuses on designing specific, measurable design aspects that ensure the end product meets the customer wants and needs. The technical requirements are called the "how's" and are placed on the top of the house. Each consequence can have one or more technical requirement. Technical requirements must be within the control of the manufacturer. It must also be measurable to enable designers to determine if the customer's needs are fulfilled. Brainstorming among marketers and product designers was used to develop the technical requirements, along with various Internet sources for references to industry standards. Thirty technical requirements were developed and organized using tree diagrams. One of the seven management tools, the tree diagram is a hierarchical structure of ideas built from the top down using a logic and analytical thought process.

A customer design matrix log was then developed that created a product development log that provided a history of the design process. It contained the design concepts derived from the customer's voice and the corresponding technical requirements that were designed, their measurement units and values. The column "Measurement Units" in Exhibit 4 was placed at the bottom of the HOQ indicating how each technical requirement would be measured. Exhibit 4 shows the customer design matrix log.

3.6 RELATIONSHIP MATRIX

Once the customer consequences and the technical requirements were developed, a relationship matrix was constructed. The matrix defines the correlations between customer attributes and technical attributes as weak, moderate, or strong using a standard 9-3-1 scale. For this scale the following notations are used Strong (H) = 9, Moderate (M) = 3, and Small (S) = 1.

Each customer consequence was matched with each technical requirement. The relationship between them was then determined and placed in the relationship matrix that constitutes the center of the HOQ. This matrix identifies the technical requirements that satisfy most customer consequences and determines the appropriate investment of resources for each. The technical requirements that addressed the most customer consequences should be dealt into the design process to ensure a customer-approved product. Ideally in the QFD analysis, no more than 50% of the relationship matrix should be filled, and a random pattern should result (Fisher and Schutta, 2003). Relationships were determined here on the basis of research conducted using resources available on the Internet. Appendix A displays the relationship matrix developed for the HOQ.

3.7 PLANNING MATRIX (CUSTOMER COMPETITIVE ANALYSIS)

After completion of the relationship matrix, the focus of the project shifted to the construction of the planning matrix. This matrix defines how each customer consequence has been addressed by the competition. It provides market data, facilitates strategic goal setting for the new product, and permits prioritization of the customer desires and needs. It also compares the product to its key competitors. A

standard 5-point Likert scale was used. Each vehicle was represented by different symbol. A square symbol was used for the Toyota Prius, a circle for the BMW 335d, and a triangle for the HFCV. The ratings were based from the customer survey. Customers rated the three vehicles for each of the 17 customer consequences included in the planning matrix. Appendix A shows the planning matrix in the HOQ.

3.8 TECHNICAL CORRELATIONS

Following completion of the planning matrix, technical correlations were determined. These form the roof of the HOQ. The roof maps the relationships and interdependencies among the technical requirements. The analysis of which informs the development process, revealing the existence and nature of design bottlenecks. The relationships among technical requirements were plotted and given a value. Past experience and test data were used to complete the roof of the HOQ. Symbols are used to represent the strength of the relationship between the technical requirements and are assigned by the researcher. Appendix B shows the roof of the HOQ.

3.9 TECHNICAL MATRIX

Next, a technical matrix was constructed to form the foundation of the HOQ. This matrix addresses the direction of improvement, standard values, units of measurement, the relative importance of technical requirements, and technical evaluation.

The direction of improvement indicates the type of action needed to ensure that the technical requirements are sufficient to make the product competitive. For

each technical requirement, the direction of improvement was marked using the following symbols:

⬆ - Bigger, faster, heavier, more, or longer is better

⬇ - Smaller, shorter, lighter, slower, or less is better

● - Meeting a specific target is better

The customer design provides information regarding consequences, technical requirements, and their units and values. It contains design concepts derived from the VOC and detailed design considerations. The column "Measurement Units" in Exhibit 4 was placed at the bottom of the HOQ, indicating the units of measurement for each technical requirement.

The relative importance of each technical requirement was calculated by multiplying the value assigned to its relationship with a specific consequence (9, 3, or 1) multiplied by the importance of that consequence; the values of all consequences were then added to yield the final weight. These weights were placed in a row at the bottom of the HOQ. A final weight is a comprehensive measure that indicates the degree to which the specific technical requirement relates to the customer consequences.

The technical evaluation of the competition and the product to be developed is carried out by the engineering and technical staff who would design the product. The process establishes strategic goals for the product development process to ensure the satisfaction of the customer. For each technical requirement, the product was compared to its competitors and a technical evaluation was performed. Thus, the construction of the HOQ was completed. Appendix A shows the completed HOQ with the roof shown in Appendix B.

3.10 PRIORITIZING RESOURCE ALLOCATIONS

The collected information from the above methods helped in the development of strategic decisions, one of them being the allocation of resources. An importance-performance grid was developed to prioritize the usage of resources for improvement on the most critical customer benefits. The relative importance ratings were plotted on the vertical axis (importance) and the median importance rating on the horizontal axis (performance). Using the values from the column "Importance" from Exhibit 3, the median importance rating was found out to be 6.5. Consequences with rating higher than that of the median importance rating were placed above the horizontal line and the other below the median. After this decision was made, the focus shifted to the distribution of consequences on either the left or right side of the vertical line. For this purpose, the median was calculated for each consequence and if the mean brand rating was higher than that value it was placed on the right side of the vertical line otherwise on the left side. Using this grid, the level of priority was assigned to each consequence from the customers point of view. Exhibit 5 shows the importance-performance grid for Vehicle C (HFCV).

4. CONCLUSION

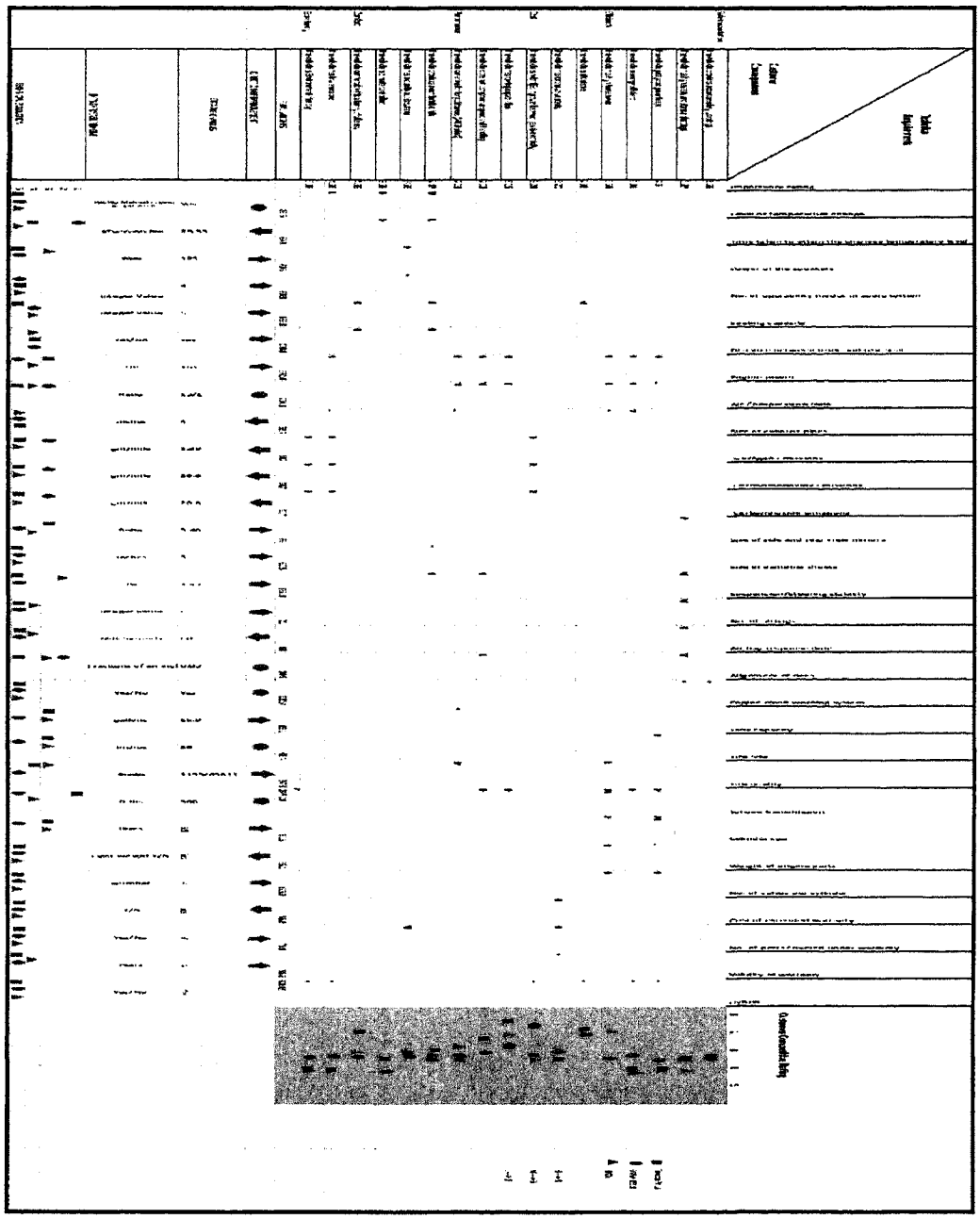
This study has illustrated how QFD could be applied to the production of a fuel-efficient vehicle (HFCV). The results showed that the first and utmost priority should be given to the following customer benefits: climate control, quality audio control, high safety and standard rating, long distance travel, high speed and handling, comfortable ride, good gas mileage, substantial horsepower, and affordable. These benefits are ones that must be accomplished in order to appeal the customers in the market. These consequences fit this priority list because they are of high importance to the customer, but have poor performance. The third priority benefits are energy efficiency, towing capability, extensive warranty, accurate safety warnings, and comfortably fits family of all sizes. These benefits are considered third priority because they are important to customers and are already performing well at current levels. The fourth priority benefits include low emissions, environment-friendly, and power split between electric and gas. These benefits are performed well and not of high importance, so no improvement needs to be made with these benefits currently. These results helped the design team of the HFCV by providing them with insight into customer's wants in a vehicle.

It is demonstrated that the QFD methodology could be applied in a new product development process. The recommendations made to the design team are proposals based on the results obtained by the application of QFD methodology to the HFCV. It helped the organization in developing a proprietary knowledge base about their customers and their needs and wants and allowing them to make the required changes in the early development stages that could lower the development costs and

increase profit levels. Although this study focused on the production of HFCV, the QFD methodology presented could serve as a powerful reference to the development of a new product of any kind. The authors hope that this study could attract more new product development teams and organizations to adopt QFD in the NPD process and develop better and successful products and achieve high customer satisfaction with increased profit levels.

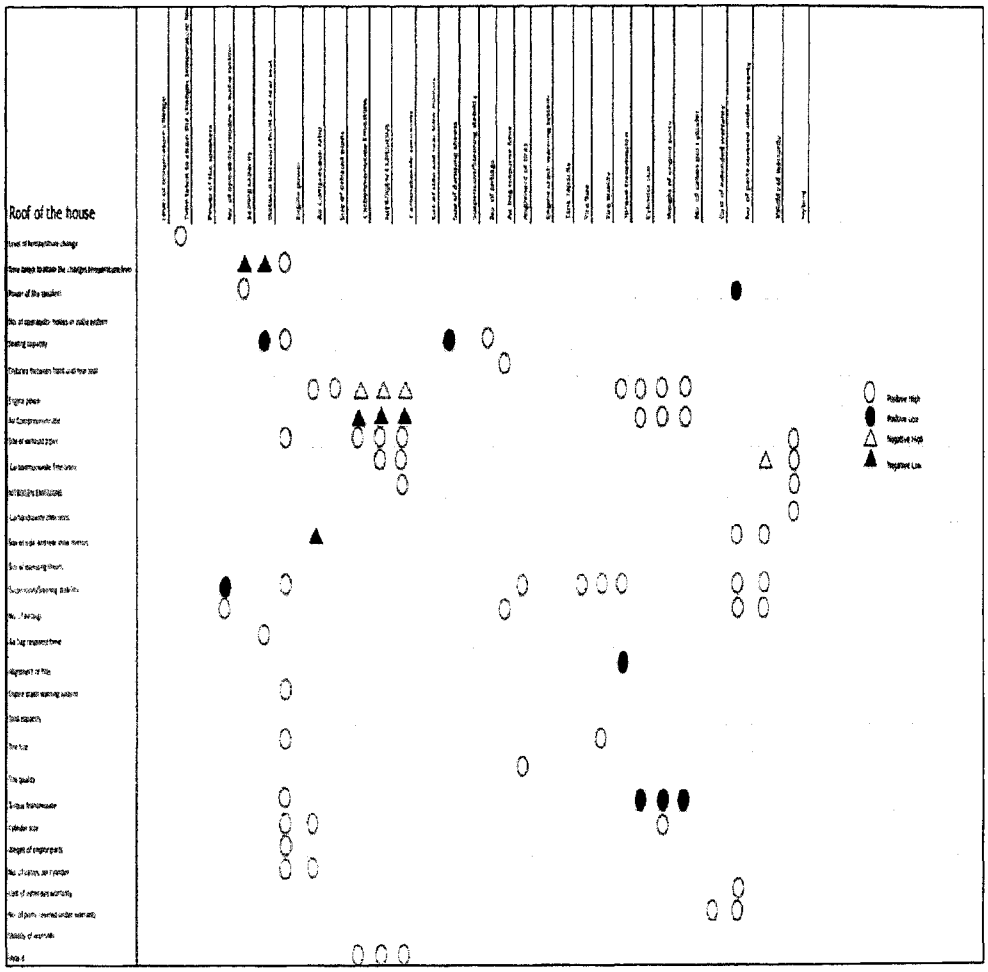
APPENDIX A

HOUSE OF QUALITY



APPENDIX B

ROOF OF HOUSE OF QUALITY



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EXHIBITS

Exhibit 1. HOQ Model (Cohen, 2007)

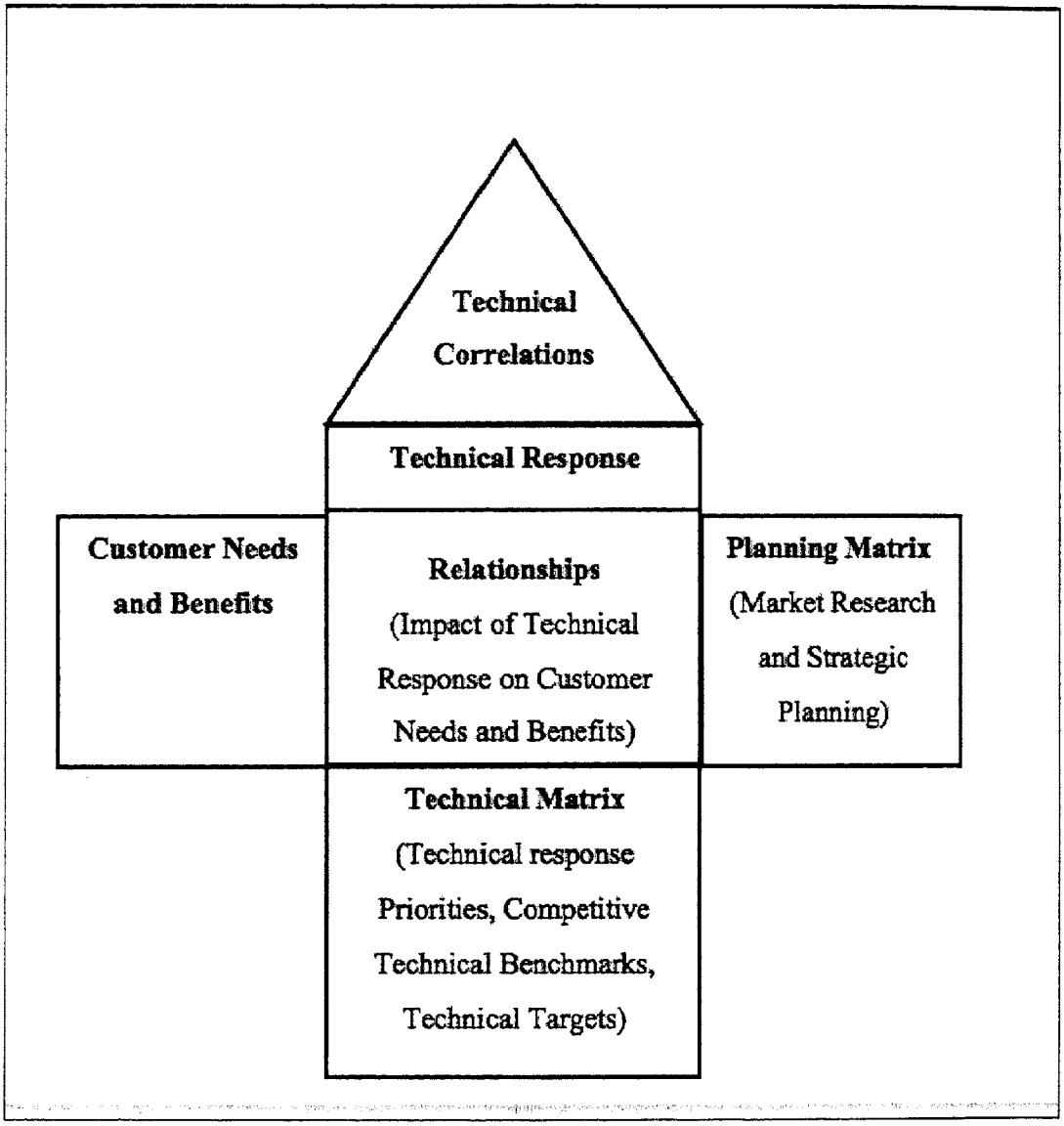


Exhibit 2. Affinity Diagram

Attributes	Consequences
Safety	The vehicle provides accurate safety warnings.
	The vehicle has high safety and standard ratings.
Efficiency	The vehicle gets good mileage.
	The vehicle is energy efficient.
	The vehicle has high horsepower.
Cost	The vehicle is affordable.
	The vehicle has an extensive warranty.
	The vehicle is a hybrid (i.e., it splits power between electric and gas).
Performance	The vehicle has towing capabilities.
	The vehicle does not compromise speed and handling.
	The vehicle can be driven for longer distances (>400 miles).
Comfort	The vehicle provides a comfortable ride.
	The vehicle has a quality audio system.
	The vehicle is climate controlled.
	The vehicle comfortably fits a sufficient number of people.
Eco-friendliness	The vehicle has low emissions.
	The vehicle is environmentally friendly.

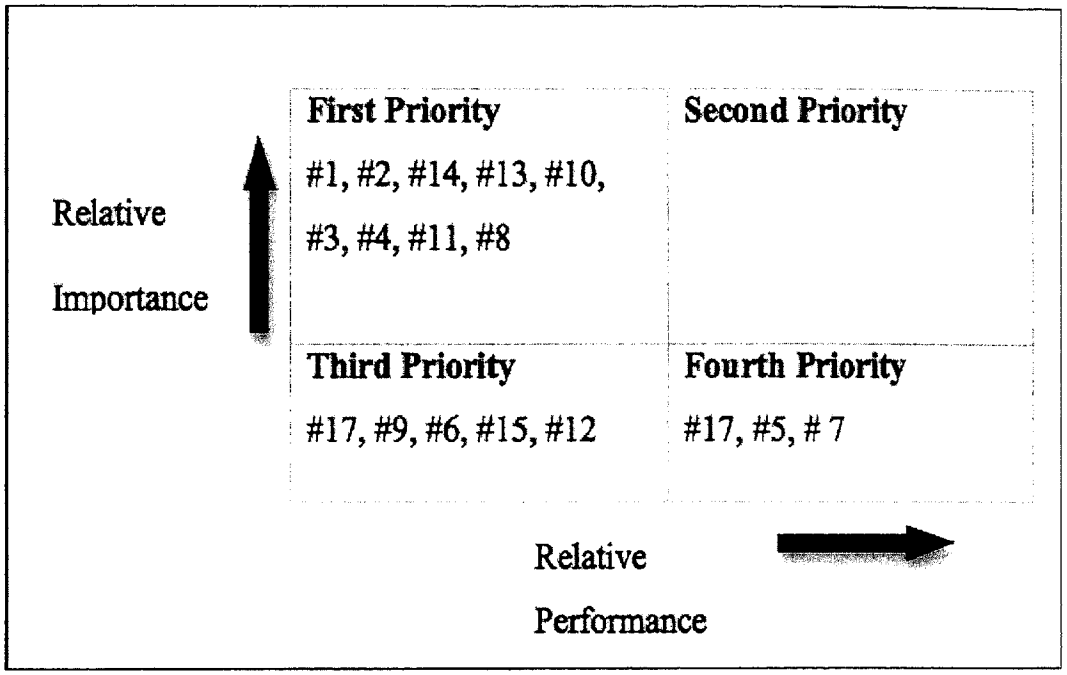
Exhibit 3. Importance Rating

			Vehicle A		Vehicle B		Vehicle C		Current Vehicle	
		Importance	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
1	This vehicle is climate controlled.	6.6	4.2	27.51	4.2	27.51	3.6	23.58	4.0	26.20
2	This vehicle has a quality audio system.	6.7	3.4	22.64	3.5	23.31	3.3	21.98	3.7	24.64
3	This vehicle provides a comfortable ride.	7.5	3.3	24.65	3.9	29.13	3.6	26.89	3.7	27.64
4	This vehicle gets good gas mileage.	7.6	4.4	33.44	3.9	29.64	4.4	33.44	3.3	25.08
5	This vehicle has low emissions.	4.7	4.2	19.57	3.5	16.31	4.4	20.50	2.9	13.51
6	This vehicle is energy efficient.	5.4	4.2	22.64	3.5	18.87	4.4	23.72	2.9	15.63
7	This vehicle is good for the environment.	5.1	4.1	20.87	3.6	18.32	4.3	21.89	2.8	14.25
8	This vehicle has a lot of horsepower.	6.5	2.3	15.04	3.8	24.85	2.9	18.97	3.0	19.62
9	This vehicle has towing capabilities.	5.2	1.9	9.79	3.1	15.97	2.5	12.88	2.7	13.91
10	This vehicle does not compromise speed and handling.	7.1	2.9	20.51	3.4	24.42	2.9	20.58	3.5	24.78
11	This vehicle is affordable.	8.0	3.7	29.77	2.5	19.87	2.3	18.03	3.7	29.77
12	This vehicle has an extensive warranty.	6.2	3.2	20.06	3.3	20.49	3.0	18.69	2.9	17.70
13	This vehicle can drive for long distances. (>400 miles)	7.1	3.7	26.67	3.6	25.60	3.0	21.68	3.7	26.52
14	This vehicle has a high safety and standard rating.	7.0	3.8	26.63	3.8	26.56	3.7	25.65	3.5	24.12
15	This vehicle provides accurate safety warnings.	5.7	3.6	20.51	3.7	21.13	3.6	20.51	3.5	19.78
16	The vehicle is a hybrid.(Split powers between electric and gas)	3.2	3.6	11.70	2.1	6.74	3.8	12.21	1.7	5.44
17	This vehicle comfortably fits a family of all sizes.	4.7	2.4	10.95	3.7	17.06	3.3	15.56	2.8	13.23
18	Overall, I am satisfied with this type of vehicle		3.2		3.6		3.4		3.9	
	SUM	104.07	62.15	362.93	62.74	365.77	62.39	356.76	58.16	341.82
	AVERAGE			3.49		3.51		3.43		3.28

Exhibit 4. Customer Design Matrix

No	Customer's Voice	Technical Requirements	Measurement	Measurement Units
1	Climate control	Level of temperature change	Boolean Value	Yes/No
		Time taken to attain the changed temperature	Time	Minutes/Seconds
2	Audio system	Power of speakers	Power	Watts
		No. of operability modes in an audio system	Number	Integer value
3	Comfort	Seating Capacity	Capacity	Integer value
		Distance between front and rear seat	Length	Inches
4	Fuel efficiency	Engine Power	Power	Horsepower
		Air compression ration	Volume	Cubic cms(cc)
		Size of exhaust pipes	Diameter	Inches
5	Environmental friendly	Lower Emissions (Nitrogen, Carbon- dioxide, Carbon-monoxide)	Weight/Distance	Grams/Km
		Hybrid	Boolean Value	Yes/No
6	Safety	Size of side & rear view mirror	Ratio	Ratio
		Size of damping sheets	Thickness	Inches
		Suspension/steering stability	Spring frequency	Cycles/minute (cpm)
		No. of airbags	Number	Integer value
		Air bag response time	Time	Seconds
		Alignment of tires	Toe-in (Distance)	Fractions of an inch
		Crash warning system	Boolean Value	Yes/No
7	Long distance travel	Tank capacity	Capacity	Gallons
		Tire quality	UTQG standards	Grades
8	Warranty	No. of parts covered under warranty	Number	Integer value
		Validity of warranty	Time	Years
		Cost of extended warranty	Boolean Value	Yes/No
9	Performance	Torque transmission	Force	Foot-pounds
		Cylinder size	Volume	Liters
		No. of valves/cylinder	Number	Integer value
		Weight of engine parts	Weight	Grams

Exhibit 5. Importance-Performance Grid. (The numbers in Exhibit 5 indicate the consequences from Exhibit 3)



II. ANALYZING CUSTOMER REQUIREMENTS FOR THE AMERICAN SOCIETY OF ENGINEERING MANAGEMENT USING QUALITY FUNCTION DEPLOYMENT

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ABSTRACT

Quality Function Deployment (QFD) is a systematic process to integrate customer requirements into every aspect of the design and delivery of products and services. Understanding the customers wants or needs from a product or service is crucial to the successful design and development of new products and services. QFD is a system that utilizes customer demands to meet client missions by outlining what the customer wants in a service or product. This paper intends to provide recommendations to the American Society of Engineering Management (ASEM) for service aspects to increase customer satisfaction and member benefits by the application of QFD.

Keywords: Quality Function Deployment (QFD), American Society of Engineering Management (ASEM), Voice of Customer (VOC), House of Quality (HOQ)

1. INTRODUCTION

In any service organization, poor quality can result in dissatisfaction among the members, which ultimately effects the organization's reputation and an additional cost involved to improve quality. Dissatisfaction of the members to a great extent or over a long enough time period may lead to a drop in the membership count of the organization. Various factors such as money, responsibility, quality, and time, if managed in an efficient manner, would lead to the successful functioning of the organization. It is crucial for any service organization to understand their customers' requirements and service expectations as they represent implicit performance standards used by the customers in the assessment of service quality. A significant relationship between the relative quality, as perceived by the customers, and the organization's profitability has been shown in the literature (Andronikidis *et al.*, 2009).

Twenty engineering managers from industry, education, and government founded the American Society of Engineering Management (ASEM) in 1979. It is one of the significant professional societies devoted to the science and art of engineering management. Engineering Management can be defined as the art and science of planning, organizing, and allocating resources in any kind of organization, and directing and controlling activities that include technical elements. Engineering Management is rapidly being recognized as a professional discipline. Engineering managers are distinguished from other managers by the fact that they possess both an ability to apply engineering principles and skills in organizing and directing technical projects and managing people in technical jobs.

Since the time of its establishment, ASEM has witnessed a considerable growth with approximately 747 members in 2007. ASEM offers numerous membership benefits including, but not limited to, the Engineering Management Journal (EMJ), newsletter, networking, annual conference, and student and professional chapters (https://www.netforumondemand.com/eweb/DynamicPage.aspx?Site=asem&WebCode=MBEN). However, in the last several years, membership has steadily declined. A survey of the members of ASEM, to understand their needs and requirements, has not been performed in many years. Therefore, a survey to assess customer requirements against ASEM's current service offerings was conducted in the fall of 2009.

This study presents results of a proposal submitted to, and accepted by, the American Society of Engineering Management's Executive Board to study ASEM using QFD and present the results for publication in the *Engineering Management Journal*. This study addressed a need to study the declining membership of ASEM and offer insights into potential improvements in the society's services. The study outlined the final deliverable as a survey analysis presented in a House of Quality (HOQ) format, which is a typical presentation of QFD results. The HOQ presents the results of a survey that was developed after "focus group" or "interview" conversations with key members of ASEM and then distributed to over 800 email addresses of current and past members. The survey was also reviewed by the Missouri S&T Institutional Review Board (IRB) prior to distribution to ensure all informed consent requirements were met. The HOQ also incorporates benchmarking of other similar organizations such that recommendations can be made on improvements regarding others' successes or failures.

From the survey conducted in this study, it was concluded that the expectations of the members were not currently being met by ASEM. Therefore, efforts should be made both by the volunteer members as well as the ASEM management to improve its quality and increase the members' satisfaction level. This paper is focused on the implementation of the first phase of quality function deployment (QFD) and making recommendations to improve the membership ratings as perceived by the members of ASEM. This paper is organized as follows. First, a brief review of literature on QFD and related concepts are presented. Second, the methodology used in this research to perform the QFD analysis is described. Third, the ASEM case study is presented. Finally, the conclusions drawn from the research are discussed.

2. LITERATURE REVIEW

QFD was developed by Yogi Akao in 1966 and was initially introduced in Japan in the late 1960s and early 1970s. QFD was first implemented in Mitsubishi's Kobe shipyard in 1972. Following QFD's introduction in Japan, it was then implemented primarily in manufacturing settings in the United States. Since then, it has been successfully used in many industries and various functional areas, including product development, quality management, customer needs analysis, product design, planning, engineering decision making, management, teamwork, timing, costing and other areas (Chan & Wu, 2002).

Following QFD's introduction in the manufacturing setting, QFD has also been gradually introduced into the service industry, including sector's such as banking, hotels, travel, healthcare, and education, which constitutes a significant and growing segment of the US economy. Nonetheless, the American customer satisfaction index (ACSI) scores for the service sector are still lower than those for manufacturing (ACSI, 2010). Given these circumstances, more attention is needed in the service industries to increase customer satisfaction.

3. BACKGROUND

This section of the paper will outline QFD and define some of its fundamental aspects, such as gathering the voice of the customer (VOC) and deriving the House of Quality (HOQ) from survey results.

The opportunities to apply QFD in service and business sectors are rapidly expanding. QFD has been used to enhance a wide range of service aspects in healthcare, chemical, and telecommunications industries as well as the typical product design applications. It is vital for companies to identify the exact needs of the customers and to measure their satisfaction to survive in the current competitive market. QFD focuses on designing in quality rather than inspecting in quality which reduces development times, lowers startup costs, and promotes the use of teams (Fisher and Schutta, 2003).

3.1 QUALITY FUNCTION DEPLOYMENT

QFD is a planning process that translates customer needs into appropriate company requirements at each stage, from research and product/service development to engineering, manufacturing, marketing/sales, and distribution (Pawitra and Tan, 2003). The quality function deployment method was first originated in Japan and is used to select the design features of a product to satisfy the expressed needs and preferences of the customer as well as to prioritize those features and select the most important for special attention further down the design process (Fisher and Schutta, 2003). Maritan and Panizzolo (2009) proposed that when used in the strategic planning process, QFD maintains the integrity of the VOC and generates innovative

strategies to achieve an organization's vision. They also argue that it leads directly to policy deployment for implementation and performance management. Overall, QFD is a service planning and development tool, that facilitates service providers with an organized way to assure quality and customer satisfaction while maintaining a sustainable competitive advantage (Akao, 1990). QFD aims at enhanced customer satisfaction, organizational integration of expressed customer wants and needs, and higher profit levels (Griffin, 1992).

QFD is a comprehensive quality system aimed specifically at satisfying the customer. It concentrates on maximizing customer satisfaction by seeking out both spoken and unspoken needs (Helper and Mazur, 2006). QFD displays the notation of customer orientation for designing products and services. Its purpose is to listen to the customer and translate their requirements back in any business process so that the end product or services will satisfy their needs and demands (Chan, et. al. 2006).

QFD differs from traditional quality systems that aim to minimize negative quality such as poor service; it maximizes positive quality that creates value and aims specifically at satisfying customer needs (Mazur, 1993). QFD provides an organized, systematic approach to bringing customer requirements into product and service design (Helper and Mazur, 2006). QFD focuses on delivering "value" by seeking out both spoken and unspoken customer requirements, translating them into actionable service features and communicating them throughout an organization (Mazur, 1993, 1997; Pun et al., 2000). It is driven by the "voice of the customer" and because of that, it helps service providers to address gaps between specific and holistic components of customer expectations and actual service experience. In addition, it helps managers to adopt a more customer-driven perspective, pointing out the

helps managers to adopt a more customer-driven perspective, pointing out the differences between what managers visualize as customer expectations and the actual customer expectations. It provides a way to more objectively address subjective needs yet demonstrates the belief in customer focus and employee involvement for every party involved in the supply chain.

QFD is developed by a cross-functional team and provides an interdepartmental means of communication that creates a common quality focus across all functions/operations in an organization (Stuart and Tax, 1996). The unique approach of QFD is its ability to integrate customer demands with the technical aspects of a service. It helps the cross-functional team make the key tradeoffs between the customers' needs and the technical requirements so as to develop a service of high quality. Hence, QFD is not only a methodological tool but also a concept that provides a means of translating customer requirements in each stage of service development (Chan and Wu, 2002).

3.2 VOICE OF THE CUSTOMER (VOC)

A critical aspect of a QFD analysis is gathering the voice of the customer to assess how a product or service measures against what the customer wants or expects. The voice of the customer is defined as the identification, structuring, and prioritization of customer needs (Griffin and Hauser, 1991). Customer needs are measured in terms of consequences, which are determined by asking customers directly what they are looking for in a product or service. Then, the customer consequences are assessed and knowledgeable professionals associated with the specific field of the product or services being assessed develop technical

made to meet the customer consequences developed from the VOC. For example, if a customer consequence was better fuel economy (associated with a vehicle), perhaps a technical requirement would be the fuel type or weight of the vehicle that would directly be associated with the customer consequence.

The VOC is obtained primarily by two methods, namely through interviews or focus groups, which are then used to develop a survey questionnaire to distribute to potential and/or existing customers. Griffin and Hauser (1991) suggest that interviews with 20-30 customers should identify 90% or more of the customer needs in a relatively homogeneous customer segment. Multiple analysts (4-6) should review the transcripts of the focus groups to identify group synergies. Once the interviews and/or focus groups are conducted, an affinity diagram can be used to group the similarities in responses from the participants to develop a questionnaire that addresses all the topics important to the participant. The survey then asks the participant to rate an existing product or service on a scale of 1 to 5 on how well they view the product or service performs on each customer consequence. The participant is also asked to weight how important each customer consequence is to them for the product or service. A weighted rating can then be obtained by multiplying the rating and weight assigned to each customer consequence so that prioritization can be assessed. For example, a customer consequence could be discovered to be very important to a participant, but they view the product or service as performing poorly. This consequence would have priority to address over a consequence that the participant viewed as having a high rating on performance yet it was not seen as important.

The next discussion refers to the House of Quality, which is the tool used for organizing the customer consequences and subsequent technical requirements developed to address those consequences.

3.3 HOUSE OF QUALITY (HOQ)

Olewnik and Lewis (2008) report that the HOQ is a design tool that supports information processing and decision making in the engineering design process. They note that for companies just implementing QFD and the HOQ, there is undoubtedly an improvement in information structure, flow, and direction. Hauser and Clausing (1988) state that the principal benefit of the HOQ is increasing the quality focus of the organization. That is, the HOQ gets people within an organization thinking in the right directions and thinking together.

QFD uses a set of interrelated matrix diagrams. The first matrix is the HOQ, which converts the customer consequences into technical requirements that must be fulfilled throughout the supply chain. The starting point on the left of the house is the identification of basic customer consequences. The next step is the definition of the priority levels that customers assign to these needs. These priorities are translated into numeric values that indicate relative importance, as discussed earlier. Customer ratings, shown on the right side of the house, enable benchmarking with competitors' services. The section just below the roof states the technical requirements used to meet the customer consequences. The relationship between the customer consequences and technical requirements constitutes the main body of the HOQ, called the relationship matrix. This matrix helps identify certain technical requirements that should be given priority if one addresses multiple customer

consequences. The correlation matrix defines the relationships among technical requirements, which is represented by the roof of the HOQ. The bottom of the house evaluates the competition in terms of technical requirements in which the target values are defined by the researcher in this matrix (Tan and Pawitra, 2001). The construction of each of the sections in the HOQ is discussed in the following sections. Exhibit 1 depicts a standard HOQ.

The following section of this paper will outline a standard generic methodology for conducting a QFD analysis, which includes obtaining the VOC and translating it into meaningful data using an HOQ.

4. METHODOLOGY

4.1 OVERALL QFD PROCESS

QFD involves the construction of one or more matrices, called quality tables, which ensure customer satisfaction and improved quality services at every level of the service development process. The House of Quality, one of the most commonly used matrices in the QFD methodology, was chosen for this study as it is a toolbox of decision matrices and the customer requirements and competitive benchmarks were utilized for decision-making (Andronikidis *et al.*, 2009).

This methodology presents the development of a survey to understand the customer consequences for a product's or service's potential, current, or past customers regarding its functions to these demographics, and translates these consequences using quality function deployment into technical requirements to improve service offerings. The final deliverable of this methodology is an HOQ that is constructed by integrating customer consequences gathered via a survey, developing technical requirements to address each customer consequence, benchmarking competitors on similar design structures, and comparing the product or service to its competitors and prioritizing actions based on customer wants and competitors' successes and/or failures. The step-by-step process for the development of the HOQ is discussed in detail in the following sections and then the conclusions drawn from the methodology are provided.

4.2 UNDERSTANDING CUSTOMER CHOICE DECISIONS: THE VOICE OF THE CUSTOMER

One of the essential strategies for successful functioning of any service organization is delivering superior service quality to their customers. Understanding what exactly the customer's needs and wants (voice of the customer) are is a key criterion in total quality management (Griffin and Hauser, 1991). The first step towards understanding customer needs is to identify attributes and customer consequences. Attributes are defined as the physical or abstract characteristics of a service process. They are objective, measurable, and reflect the service provider's perspective. Consequences are a result of using attributes; basically, an end result in what a customer "gets" from using a service or product. Customers judge services based on their consequences, not their attributes. In other words, customers judge a service on its outcome, or affect of use on them. A service has many attributes, and each may have more than one consequence (Fisher and Schutta, 2003).

To gather the VOC, researchers conduct focus groups or interviews with a select group of potential, existing, or past customers and ask them what is important to them in the service or product being offered. "Why" is asked numerous times until the respondent responds with the same answer each time. This is the fundamental customer consequence that the customer wants from using the service or product. These responses are grouped using an affinity diagram and used to develop a meaningful survey questionnaire that captures all things important to the customers. To ensure that the appropriate number of responses is gathered (90%), a standard sample size calculation can be performed.

4.3 DEVELOPMENT OF CUSTOMER CONSEQUENCES

During the survey, the respondents are asked to evaluate the particular product or service provider on each customer consequence on a standard 5 point Likert scale. The respondent is also asked to weight each consequence on how important it is to them on a 5 point Likert scale. These ratings and weightings will be multiplied to derive a weighted rating to encompass both the performance rating and the importance for each consequence. With this information, the researcher can determine which of the consequences are the most important and also the worst in performance and assign them as top priority. This will be discussed further in the upcoming methodology.

If respondents for other similar types of products or services are available, the same survey can gather data regarding customer consequences for those competitors. If respondents are not available, the researchers will use available data (i.e., website published information, annual reports, technical reports, financial statements) to determine which competitor being evaluated is "best" and assign it a value of "5". The researchers will also identify which competitor is "worst" at each consequence and sign them a value of "1". All competitors will be assigned a value relative to "best" and "worst" using researcher or industry expertise in the subject area. This information will be used to "benchmark" the product or service being directly evaluated by the researcher to see how they compare to similar competitors.

4.4 DEVELOPMENT OF TECHNICAL REQUIREMENTS

After the customer consequences are analyzed, the next step in the construction of the HOQ is the development of the technical requirements. The

technical requirements are the design specifications that satisfy customer consequences. These technical requirements are on the top of the HOQ and are referred to as the "how" of the HOQ. They describe "how" to meet the customer consequences and improve a product or service. The technical requirements must be within the control of the product or service provider and must be measurable (i.e., quantitative measurements, "yes/no"). Each customer consequence can have more than one technical requirement, and each technical requirement may fulfill the need of more than one customer consequence.

The development of technical requirements often requires expertise in the area regarding the service or product and requires creativity to develop. This area of the HOQ is the "thinking outside the box" aspect and there is no definite "right or wrong" answer. Any reasonable technical requirement should be considered. Often times ambiguous research and information collected from many sources (i.e., experts, websites, technical reports) may be used to spark brainstorming and creativity to develop technical requirements.

4.5 RELATIONSHIP MATRIX: THE BODY OF THE HOUSE OF QUALITY

Once the customer consequences are developed, survey results are gathered, and the technical requirements developed, a matrix to highlight relationships between the customer consequences and the technical requirements is constructed. This matrix is the "body" of the House of Quality. The matrix defines the correlations between the customer consequences and technical requirements as strong, moderate, or weak using a 9-3-1 scale. For this scale the following notations are used Strong (H) = 9, Moderate (M) = 3, and Weak (S) = 1. Each customer consequence was matched with

any applicable technical requirement; make note that relationships should not be forced; leaving a blank if no relationship is determined. Here again, this assignment of relationships requires the expertise of the researchers or industry members. Normally only the strongest relationships are specified leaving approximately 60-70% of the matrix blank (Griffin and Hauser, 1991). Although some indicate that ideally in the QFD analysis, no more than 50% of the relationship matrix should be filled, and a random pattern should result (Fisher and Schutta, 2003). This matrix identifies the technical requirements that satisfy most customer consequences. The technical requirements that address the most customer consequences should be a main priority in the design process to ensure a product or service that satisfies the stated customer expectations.

4.6 PLANNING MATRIX (CUSTOMER COMPETITIVE ANALYSIS)

After the completion of the relationship matrix, the focus of the analysis shifts to the construction of the planning matrix. The planning matrix defines how each customer consequence has been addressed by the competition. It provides market data, facilitates strategic goal setting for the new product, and permits comparison of the customer desires and needs. It also compares the service to its key competitors. For the competitive analysis, research should be conducted regarding similar products or services. Researchers may have to assert a level of expertise in drawing meaningful information from the information available, as many competitors will not openly aid their competition by providing market data and design specifications. The researchers will use available data (i.e., website published information, annual reports, technical reports, financial statements) to determine which competitor being evaluated

is "best" and assign it a value of "5". The researchers will also identify which competitor is "worst" at each consequence and sign them a value of "1". All competitors will be assigned a value relative to "best" and "worst" using researcher or industry expertise in the subject area. This information will be used to "benchmark" the product or service being directly evaluated by the researcher to see how they compare to similar competitors.

4.7 TECHNICAL CORRELATIONS

Following the completion of the relationship and planning matrices, the technical correlations are determined. These correlations are depicted in the roof of the HOQ. The roof maps the relationships and interdependencies among the technical requirements. The analysis of which informs the development process, revealing the existence and nature of service design bottlenecks. The relationships among technical requirements were plotted and given a value. Relationships among the technical requirements are important to evaluate, as one technical requirement could either aid or hinder the success of another crucial technical requirement in meeting customer consequences. Past experience and publicly available data (i.e., website information, technical reports, financial reports) can be used to complete the roof of the HOQ. Symbols are used to represent the strength of the relationship between the technical requirements and are assigned by the researcher.

4.8 TECHNICAL MATRIX

The last step in the formation of the HOQ is the foundation or bottom of the house. This foundation is referred to as the technical matrix. This matrix depicts the

values assigned by the researchers of the direction of improvement and/or standard values of each technical requirement needed to be competitive in the industry. Often times, if a numerical value cannot be absolutely determined, the researchers and/or industry experts use judgment based on expertise in the subject area to assign "targets." The direction of improvement indicates the type of action needed to ensure that the technical requirements are sufficient to make the service competitive for each entity evaluated. For example, if a technical requirement's target value is 5, and a service provider's mean for that requirement is 4, the direction of improvement would be up to aim for the higher target value.

4.9 PRIORITIZING RESOURCE ALLOCATIONS

The collected information from the above methods enables the development of strategic decisions, one of which is the allocation of resources. An importance-performance grid can be developed to prioritize the usage of resources to improve the most critical customer benefits. The mean importance ratings (gathered from the survey) can be plotted on the vertical axis (importance) and the mean customer competitive ratings (gathered from the survey) on the horizontal axis (performance). Using the importance rating values, the mean importance rating (for all consequences) should be calculated. The consequences with an importance rating higher than that of the mean importance rating should be placed above the horizontal line and those lower should be placed below this line. After these values are plotted, the focus can shift to the distribution of consequences on either the left or right side of the vertical line. For this purpose, the mean performance rating is used and labeled for the vertical axis. Each consequence with a lower mean should be plotted to the left of the axis,

and each consequence with a performance mean higher than the mean should be plotted to the right of the vertical axis. Using this importance/performance grid, the level of priority can be assigned to each consequence from the customer's point of view, and subsequently resource allocation decisions can be influenced. This grid helps greatly in utilizing the available resources to fulfill the required customer requirements rather than investing those resources in areas which do not appeal to the customer.

5. APPLICATION OF QFD TO THE AMERICAN SOCIETY OF ENGINEERING MANAGEMENT: A CASE STUDY

The following discussion presents the results of the QFD methodology previously discussed as applied to the American Society of Engineering Management. The study was designed to focus on the development of a survey to understand the customer requirements for ASEM current, past, and potential members and translate these requirements using quality function deployment into service offerings. The final deliverable of this study is a HOQ that was constructed by integrating customer opinions gathered via the survey. The step-by-step process for the development of the HOQ is discussed in detail in the following sections and then the conclusions drawn from this research are provided.

5.1 UNDERSTANDING CUSTOMER CHOICE DECISION

The first step towards understanding customer needs is to identify attributes and customer consequences. Attributes are defined as the physical or abstract characteristics of a service process. They are objective, measurable, and reflect the service provider's perspective. The main goal of applying QFD to ASEM was to identify how its members, both entirely as an organization and chapters locally, could be served in a better manner, including an increase in the number of members. Emphasis was placed on identifying the expectations of current members and the necessary measures to meet those expectations along with providing better service quality and features to members in the industry and student segments.

To gather the VOC, the researchers conducted interviews with a select group of "experts" regarding ASEM. These experts consisted of executive board members

and other members associated in the area for many years. From these interviews regarding perceived problems or opportunities with ASEM, a survey was developed to administer to potential, current, and past members of ASEM. The national ASEM administrator delivered the survey to approximately 800 email addresses. These addresses represent all of the email addresses on file for ASEM nationally. Using a standard sample size calculation (z=0.05, s=1.1, e=0.15), approximately 145 respondents are needed for a valid sample size. A total of 170 respondents participated in the survey, which is approximately a 21% response rate. Three main member types were targeted including student, academic, and industrial members. The number of members among the three different categories was: student (13), academic (69), and industry (84). The survey consisted of twelve evaluation questions based on quantitative responses to determine the level to which the organization is serving its members and the areas to target for improvement. The survey aided the members in expressing their thoughts on different aspects of the organization as well as to communicating their requirements for increased satisfaction levels.

5.2 DEVELOPMENT OF CUSTOMER CONSEQUENCES

After the successful deployment and receiving direct feedback from the national survey, the researchers focused on the development of the customer consequences which are the "what benefits our customers really want from our service." Twenty-four customer consequences were determined from the member responses obtained through the survey and were ultimately placed on the left side of the HOQ. To interpret and organize the survey result into customer consequences, the collected data was organized using affinity diagrams. Affinity diagrams group the

consequences gathered based on similarity to clarify customer input. The affinity diagram is shown in Exhibit 2. This column was arranged, prioritized, and benchmarked with other similar service organizations (such as the American Society of Mechanical Engineering). Twenty-four customer consequences were developed, and the level of "importance" for each of the 24 customer consequences was determined based on the number of members who felt that these requirements should be provided by ASEM currently and/or in the future. The respondents were also asked to evaluate how well ASEM was providing each consequence on a 5-point Likert scale, in other words, a "performance" rating. The "importance" and "performance" rating were then multiplied together to obtain a weighted rating to show which consequences were the priority. Exhibit 3 shows the importance rating for each of the customer consequences. The importance rating column was placed beside the customer consequences column to the left of the HOQ. The left side of the HOQ was completed with the customer consequences and importance ratings.

To gather benchmarking data regarding each consequence for similar service providers, the researchers used available data (i.e., website published information, annual reports, technical reports, financial statements) to determine which competitor being evaluated is "best" and assign it a value of "5". The researchers also identified which competitor is "worst" at each consequence and assigned them a value of "1". All competitors were assigned a value relative to "best" and "worst" using researcher or industry expertise in the subject area. This information was used to "benchmark" the product or service being directly evaluated by the researcher to see how they compare to similar competitors.

5.3 DEVELOPMENT OF TECHNICAL REQUIREMENTS

After the customer consequences were analyzed, the next step in the construction of the HOQ was the development of the technical requirements. The technical requirements are the design specifications that satisfy customer needs, which are also referred to as quality characteristics. Based on the ASEM members' customer consequences, various ways were developed to increase the quality of service offerings as well as future membership. The technical requirements are called the "how's" and are placed on the top of the house. They are the measurable implementations used to ensure all customer requirements are met. This aspect of QFD is directly in the organization's control and focuses on designing specific, measurable service design aspects that ensure the end service meets the customer wants and needs. Each customer consequence can have one or more technical requirement.

The development of technical requirements often requires expertise in the area regarding the service or product and requires creativity to develop. This area of the HOQ is the "thinking outside the box" aspect and there is no definite "right or wrong" answer. Any reasonable technical requirement should be considered. Often times ambiguous research and information collected from many sources (i.e., experts, websites, technical reports) may be used to spark brainstorming and creativity to develop technical requirements.

The competitive analysis, brainstorming, and publicly available information via the Internet were used to develop the technical requirements for ASEM. These provided references to industry standards and educational assumptions. Tree diagrams were then used to organize these technical requirements. One of the seven

management tools, the tree diagram is a hierarchical structure of ideas built from the top down using a logic and analytical thought process. A customer design matrix log was then developed as a service process development log to provide a history of the development process. It contained the design concepts derived from the customer's voice and the corresponding technical requirements that were designed, and their subsequent values. Exhibit 4 shows the customer design matrix in which nineteen technical requirements was developed.

5.4 RELATIONSHIP MATRIX

Once the customer consequences and the technical requirements were developed, a relationship matrix was constructed. The matrix defines the correlations between the customer attributes and technical attributes as strong, moderate, or weak using a standard 9-3-1 scale. For this scale the following notations are used Strong (H) = 9, Moderate (M) = 3, and Weak (S) = 1. Each customer consequence was matched with each technical requirement. The relationship between them was then determined and placed in the relationship matrix, which constitutes the center of the HOQ. A blank was left if there was no relationship between the customer consequence and technical requirement. Normally only the strongest relationships are specified leaving approximately 60-70% of the matrix blank (Griffin and Hauser, 1991). Although some indicate that ideally in the QFD analysis, no more than 50% of the relationship matrix should be filled, and a random pattern should result (Fisher and Schutta, 2003). This matrix identifies the technical requirements that satisfy most customer consequences. The technical requirements that addressed the most customer

consequences should be a main priority in the design process to ensure a customer-approved product or service. Exhibit 5 depicted the body of the HOQ for ASEM.

5.5 PLANNING MATRIX (CUSTOMER COMPETITIVE ANALYSIS)

After completion of the relationship matrix, the focus of the analysis shifted to the construction of the planning matrix. This matrix defines how each customer consequence has been addressed by the competition. It provides market data, facilitates strategic goal setting for the new product, and permits prioritization of the customer desires and needs. It also compares the service to its key competitors. For the competitive analysis, research was conducted on other local relevant professional societies and their membership benefits and offerings were compared to those of ASEM. The competitors were selected based on how close the field was to the Engineering Management profession. The competitors included the International Council on Systems Engineering (INCOSE), Institute of Industrial Engineers (IIE), American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronics Engineers (IEEE), and American Society for Quality (ASQ). Each of the six societies were judged against each of the twenty-four consequences on a scale of 1 to 5, using the same methodology as before where the best is assigned a "5" and the worst is assigned a "1" and all others are judged relative to those. Then the mean was calculated for each competitor and placed in the columns to the right of the HOQ. This analysis was done using Internet sources, other relevant information, and from the responses obtained from the survey administered by the researchers. Exhibit 3 also depicts the customer competitive ratings for all six societies. Each society was represented by different a symbol. A square symbol was used for ASEM, a triangle

symbol for INCOSE, a red colored circle for the IIE, a black colored circle for ASME, a diamond symbol for IEEE, and a parallelogram symbol for ASQ. All of the six societies were rated against each of the 24 customer consequences on a scale of 1 to 5, included in the planning matrix.

5.6 TECHNICAL CORRELATIONS

Following completion of the relationship matrix, the technical correlations were determined. These form the roof of the HOQ. The roof maps the relationships and interdependencies among the technical requirements. The analysis of which informs the development process, revealing the existence and nature of service design bottlenecks. The relationships among technical requirements were plotted and given a value. Relationships among technical requirements are important to evaluate, as one technical requirement could either aid or hinder the success of another crucial technical requirement in meeting customer consequences. Past experience of the researchers and publicly available data (i.e., websites, reports) were used to complete the roof of the HOQ. The symbols used to represent the level of the relationship between technical requirements are shown below. Exhibit 6 shows the roof of the HOQ.

5.7 TECHNICAL MATRIX

Next, a technical matrix was constructed to form the foundation of the HOQ. This matrix addresses the direction of improvement, standard values, final weights of technical requirements/quality characteristics, and technical evaluation. The direction of improvement indicates the type of action needed to ensure that the technical

requirements are sufficient to make the service competitive. The quality characteristics/technical requirements were analyzed and a standard/limit value was determined for each. The researchers established these values after evaluating other competitors' standards. The final weight of each technical requirement was calculated by multiplying the value assigned to its relationship with a specific consequence (9, 3, 1) by the importance of that consequence. The values of all consequences were then added to yield the final weight. These weights were placed in a row at the bottom of the HOQ. A final weight is a comprehensive measure that indicates the degree to which the specific technical requirement relates to the customer consequences, therefore outlining what requirements should be a priority.

5.8 PRIORITIZING RESOURCE ALLOCATIONS: THE IMPORTANCE / PERFORMANCE GRID

The collected information from the above methods enabled the development of strategic decisions, one of which is the allocation of resources. An importance-performance grid was developed to prioritize the usage of resources to improve the most critical customer benefits. The mean importance ratings were plotted on the vertical axis (importance) and the mean customer competitive ratings on the horizontal axis (performance). Using the importance rating values, the mean importance rating (for all consequences) was calculated as 3.9, which is shown in Exhibit 3. The consequences with an importance rating higher than that of the mean importance rating were placed above the horizontal line and those lower were placed below this line. After this decision was made, the focus shifted to the distribution of consequences on either the left or right side of the vertical line. For this purpose, the mean was calculated for rating values of ASEM as 3, which is also shown in Exhibit

3. For each consequence, if the customer competitive rating for ASEM was higher than that value it was placed on the right side of the vertical line otherwise on the left side. Using this grid, the level of prioity was assigned to each consequence from the customer point of view. Exhibit 7 shows the importance-performance grid developed for ASEM.

5.9 RESULTS AND DISCUSSION OF THE ASEM CASE STUDY

The results of this study showed that the first and utmost priority should be given to the following customer consequences: EM education updates, provide support for student activities, continually updated website, electronic communications, provide more online-based research, and increase society awareness. The consequences placed in the first priority indicate that they have a high importance but low performance and are to be accomplished first. Second priority should be given to the following consequences: training courses on latest developments, become a sponsoring society for ABET, career opportunities, opportunities to meet and network with colleagues and others in the profession, popular among colleagues, research and information updates, research publication outlet, electronic publications, and opportunities for members to voice opinions. These are consequences with low importance and low performance.

Based on these priorities, several recommendations were developed by the researchers. One major contribution would be that the website should be properly maintained and continually updated with the latest news. Also, e-mails should be sent to all the members frequently with important updates in the field of Engineering Management. In addition, separate sections should be allotted on the website to post

updates. A career opportunities development team should be established that would handle various career related issues such as encouraging more companies to post their job listings on the website, posting of member resumes online, organizing training workshops to provide members with information on resume/cover letter drafting, development of professional skills required, and career and educational guidance. Career fairs could also be organized twice a year to improve career opportunities. Online forums can be created for management as well as members to post their opinions and updates, share their knowledge, and increase their opportunities to network. Seminars and conferences should be organized on a regular basis to provide networking opportunities to the members as well as the exchange of information. An improvement in the e-resources available to the members is necessary. More journal papers, technical articles, and electronic publications should be available to the members and easily accessible. An online library should be created which serves as a repository for all articles, publications, and information that is updated on a regular basis. A member directory should be created containing information regarding all members that is updated regularly and available to all ASEM members.

Third priority should be given to the following customer consequences: continuing education programs, training courses on latest developments, assistance with resume/cover letter drafting, relationship with a professional mentor for career guidance, and scholarship opportunities. These are the consequences with high importance and high performance, indicating that these consequences are performing well. Fourth priority should be given to the following customer consequences: hands-on experience with software or other common workplace tools, technical articles and information related to your profession, and representation/advocacy for the

profession. These consequences are of low importance but high performance. They need not be addressed immediately.

An increase in the number of internship or co-op opportunities equips individuals with a real-time project experience and also leads to an increase in their abilities and knowledge base. Continuing education programs are beneficial to enhance personal and professional growth. Increasing the number of certificate programs offered, online courses in various fields, professional development courses, and individual courses depending on each individual's interests can provide more opportunities for programs of this type. The offering of specially designed workshops and training sessions to keep members abreast of current new developments in the industry leads to greater customer enthusiasm and satisfaction. This would provide ASEM members an edge over the rest of the individuals in the market. A customer service committee could be formed which would be responsible to deal with problems faced by the members and assist them with the required help in a timely manner. Creation of online forums to post their opinions, problems, or suggestions improves the member-management relationship. In addition, various programs could be organized accordingly to generate funds to help students who display need and merit. Scholarship opportunities could be improved by the creation of a trust for financial aid.

Examining the primary reason for joining ASEM according to the members, 33% of the respondents selected staying updated with the latest news in their field and 14% of the respondents selected having access to special benefits such as publications and educational programs. These areas need to be concentrated on as they are of the first and second highest priority to the members and their main purpose/expectation

from the organization should be fulfilled. In response to one survey item that asked the members about the degree to which their level of expectations were met in certain areas, 25% of the respondents stated that their level of expectations were not met at all in the area of website and electronic communication and 16% of the respondents selected representation/advocacy expectations were not met. These indicate the areas of high dissatisfaction among the members that need to be given special attention and improved. In terms of technical articles and information related to your profession, 40% of the respondents stated this was extremely important and 45% responded this was somewhat important. This indicates a strong desire among the members to have Engineering Management publications available through ASEM. In terms of subscriptions to professional publications that help you stay current on news and events, 52% of the respondents stated this was extremely important and 32% responded this was somewhat important. This indicates a strong desire among the members to have professional publications available through ASEM. From a survey item asking members which benefits are most important to them, the priority order could be concluded in terms of providing member benefits as: technical articles and information related to your profession (83%), events that allow you to network with fellow engineers (70%), subscriptions to professional publications which help you stay abreast of current events, research, and papers (64%), job listings of available positions (24%), hands-on experience working with software or other tools that will be common in the workplace (21%), a relationship with a professional "mentor" who can help you with career guidance (17%), and assistance with drafting your resume/cover letters (4%). The number in the parenthesis indicates the percentage of the respondents who selected that particular benefit. This indicates that the number of

technical articles and profession related information, networking opportunities, and subscriptions to professional publications should be increased to meet members' needs.

5.10 IMPLEMENTED RECOMMENDATIONS FROM THE STUDY

The results of the QFD study were presented to the ASEM Board of Directors. The research findings were utilized for improvement plans to increase member benefits. In particular, the findings were used in the redesign of the organization's website. The newly designed website includes links for current news, job postings, publications, education and training, member benefits, the Engineering Management honor society, and an online store, among others.

6. LIMITATIONS OF THE STUDY

The outcome of this study was significant, however, there were limitations associated with the methodology. The emails on record with ASEM represent students, academic professionals, and industry that were either present or past members of ASEM. A broader scope could have been obtained if the survey was sent to others outside of ASEM. However, as mentioned previously, it is difficult to gain access to competitor information, specifically competitor customer contact information.

7. AREAS OF FUTURE RESEARCH

While outside the scope of this research, an analysis of each population demographic individually would be useful to understand how ASEM could offer more targeted services for specific aspects of its user base. Hypothesis testing could be used to determine relationships between certain groups and specific services. ASEM might be able to improve their users' satisfaction by aiming specific services toward each demographic. Since the application of this QFD methodology was deemed successful for ASEM, it would be valuable to apply the methods to other similar service organizations to replicate its success.

8. CONCLUSIONS

This study has illustrated how QFD could be applied to the development/improvement of service benefits to meet the needs of ASEM as a service organization. The QFD methodology was successfully demonstrated as it applies to the development of new services. This analysis will enable the organization to develop a proprietary knowledge base about their customers and their needs and wants which will allow them to make the required changes to improve member benefits. Although this study focused on the improving the service process for the ASEM, the QFD methodology presented could serve as a powerful reference to the development of any new service process. The authors hope that this study could attract more service process development teams and organizations to adopt QFD in their development process to develop successful services and achieve high customer satisfaction with increased profit levels.

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EXHIBITS

Exhibit 1. HOQ Model (Cohen, 2007)

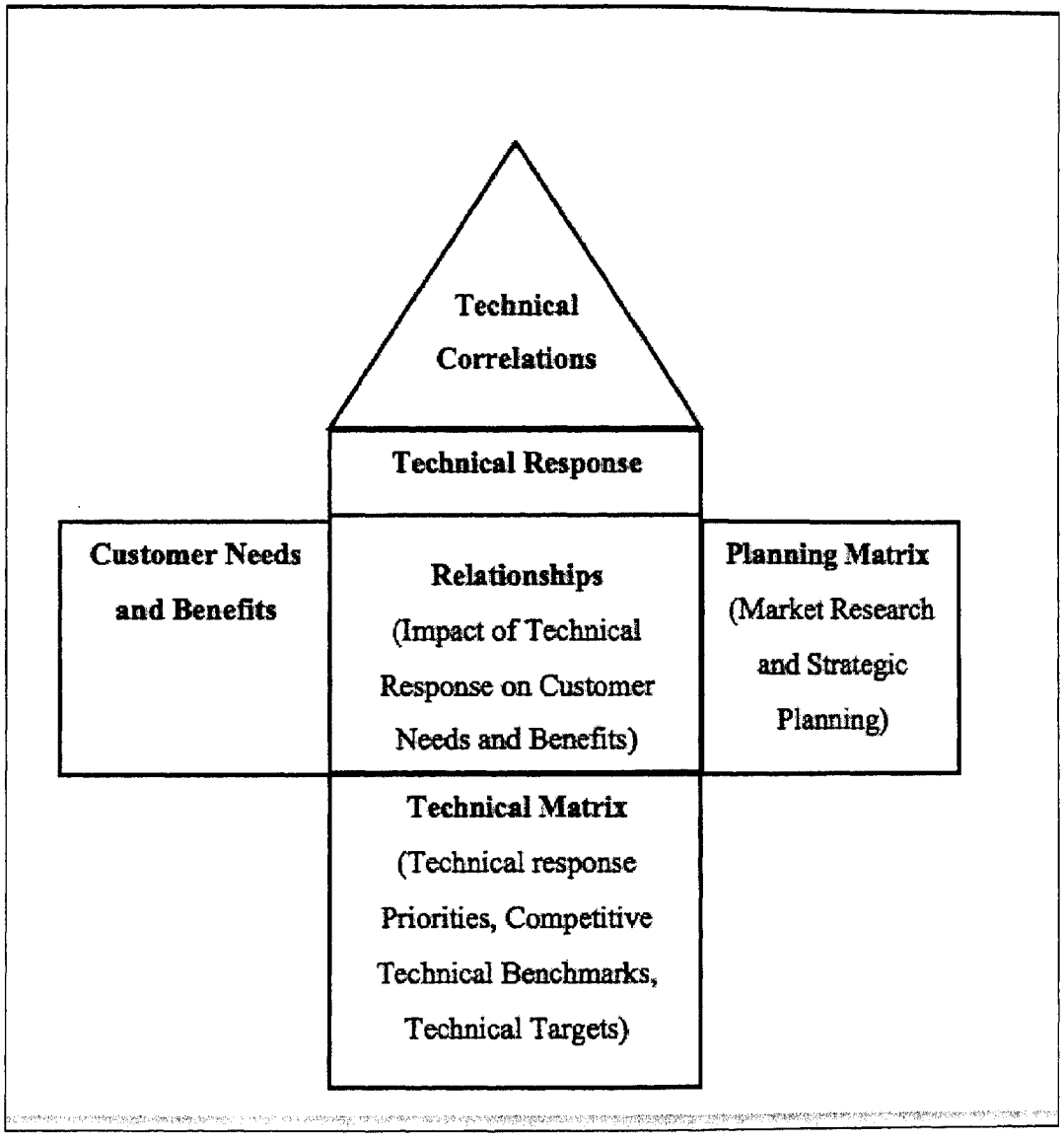


Exhibit 2. Affinity Diagram

Attributes	Consequences
Education	Continuing education programs
	Training courses on latest developments
	EM education updates
	Emphasis on curriculum & accreditation
	Scholarship opportunities
Professional growth	Hands on experience with software etc
	Assistance with resume/ cover letter drafting
	Career opportunities
	Relationship with mentor
	Opportunities to network
	Popular among colleagues
	Representation/advocacy
Research	Research & information update
	Research publication outlet
	Electronic publications
	Provide more online-based research
	Technical articles & info
Customer service	Opportunities to voice opinions
	Timely response to complaints
Extra features	Become a sponsoring society of the ABET
	Support for student activities
	Continually updates website
	Electronic communication
	Increase society awareness

Exhibit 3. Weighted Ratings (WR)

			INCOSE		IIE		ASEM	
		Importance Rating	Rating	WR	Rating	WR	Rating	WR
1	Continuing education programs	3	5	15	4	12	2.5	7.5
2	Hands on experience with software etc	3	3	9	1	3	3.9	11.7
3	Training courses on latest developments	3	3	9	2	6	2.5	7.5
4	EM education updates	4	4	16	3	12	2.7	10.8
5	Emphasis on curriculum & accreditation	4	3	12	2	8	3	12
6	Become a sponsoring society of the ABET	3.9	5	19.5	5	19.5	3	11.7
7	Assistance with resume/ cover letter drafting	3	1	3	1	3	2	6
8	Career opportunities	3.9	3	11.7	3	11.7	3.9	15.21
9	Relationship with the mentors	3	1	3	2	6	2.9	8.7
10	Opportunities to network	3.9	3	11.7	2	7.8	3.2	12.48
11	Popular among colleagues	3.9	3	11.7	2	7.8	3	11.7
12	Research & information update	4	3	13	2	8	4	16
13	Scholarship opportunities	3	2	6	4	12	2.5	7.5
14	Support for student activities	3.9	2	7.8	3	11.7	2.5	9.75
15	Continually updated website	4	3	12	3	12	2.7	10.8
16	Electronic communication	4	3	12	3	12	2.7	10.8
17	Research public outlet	4	3	12	3	12	3.8	15.2
18	Electronic publications	4	2	8	3	12	3.8	15.2
19	Provide more online-based research	4	4	16	3	12	2.7	10.8
20	Technical articles & info	2.2	4	8.8	3	6.6	4.1	9.02
21	Increase society awareness	3.9	1	3.9	1	3.9	2.7	10.53
22	Representation/advocacy	3	3	9	1	3	3	9
23	Opportunities to voice opinions	3.9	2	7.8	2	7.8	3	11.7
24	Timely response to complaints	3	2	6	3	9	2	6

Exhibit 3. Weighted Ratings (WR) [continued]

			IEEE		ASQ		ASME	
		Importance Rating	**Rating**	**WR**	**Rating**	**WR**	**Rating**	**WR**
1	Continuing education programs	3	5	15	5	15	5	15
2	Hands on experience with software etc	3	4	12	4	12	4	12
3	Training courses on latest developments	3	3	9	5	15	5	15
4	EM education updates	4	4	16	3	12	2	8
5	Emphasis on curriculum & accreditation	4	5	20	3	12	3	12
6	Become a sponsoring society of the ABET	3.9	5	19.5	3	11.7	5	19.5
7	Assistance with resume/ cover letter drafting	3	5	15	3	9	5	15
8	Career opportunities	3.9	5	19.5	4	15.6	4	15.6
9	Relationship with the mentors	3	5	15	1	3	4	12
10	Opportunities to network	3.9	5	19.5	5	19.5	4	15.6
11	Popular among colleagues	3.9	5	19.5	4	15.6	3	11.7
12	Research & information update	4	3	12	3	12	4	16
13	Scholarship opportunities	3	3	9	2	6	5	15
14	Support for student activities	3.9	3	11.7	3	11.7	5	19.5
15	Continually updated website	4	5	20	4	16	5	20
16	Electronic communication	4	5	20	3	12	4	16
17	Research public outlet	4	5	20	4	16	4	16
18	Electronic publications	4	5	20	4	16	4	16
19	Provide more online-based research	4	5	20	5	20	4	16
20	Technical articles & info	2.2	5	11	5	11	4	8.8
21	Increase society awareness	3.9	3	11.7	4	15.6	3	11.7
22	Representation/advocacy	3	4	12	5	15	4	12
23	Opportunities to voice opinions	3.9	3	11.7	4	15.6	3	11.7
24	Timely response to complaints	3	4	12	5	15	3	9
	Median	3.9						

Exhibit 4. Customer Design Matrix

No.	Customers voice	Technical Requirements	Val
1	Continuing education programs	Certificate programs	Nu
		Online Courses	Nu
2	Hands-on experience, working with S/W or other tools that will be common in workplace	Internship Opportunities	Nu mbe r
3	Training courses on latest developments	Individual Courses	Nu
		Customized training workshops	Nu mbe
4	EM education updates	Immediate e-mail updates	Y/N
		Monthly newsletter	Y/N
		Separate section for updates to be posted on the website	Y/N
5	Emphasis on curriculum and accreditation	Curriculum development team	Y/N
6	Career opportunities	Career opportunities development team	Y/N
		Host career fair	Y/N
		Posting of resumes online	Y/N
7	A relationship with a professional mentor who can help you with career guidance	Mailing/posting member directory information	Y/N
8	Opportunities to network	Seminars and conferences	Nu
		Online forums for networking & discussions	Y/N
9	Scholarship opportunities	Organizing fund raising programs	Nu mbe
		Establishing a trust for financial aid	Y/N
10	Provide more online based research	Provide e-library option on the website	Y/N
11	Timely response to complaints	Customer service committee	Y/N

Exhibit 5. Body of House of Quality

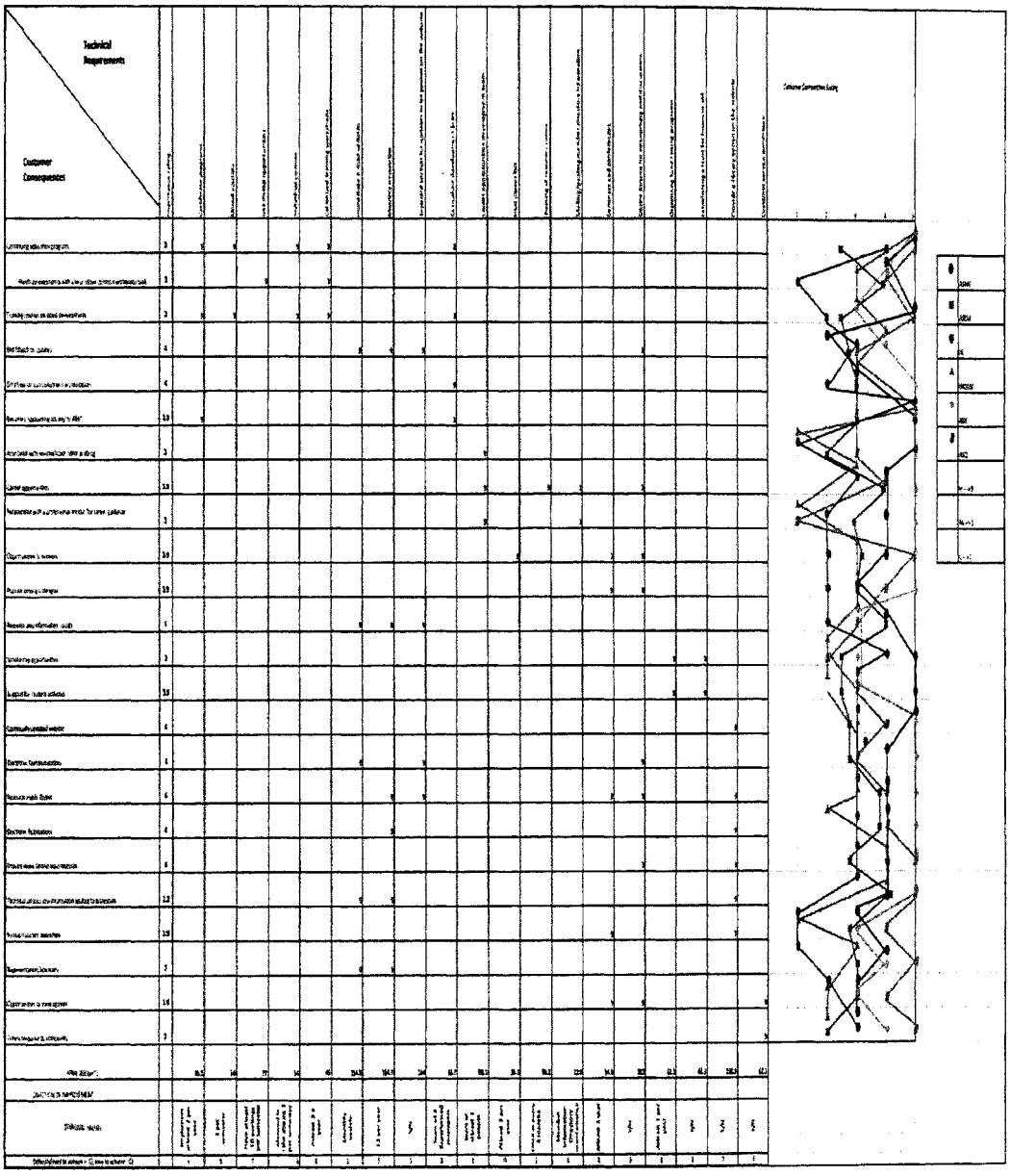


Exhibit 6. Roof of House of Quality

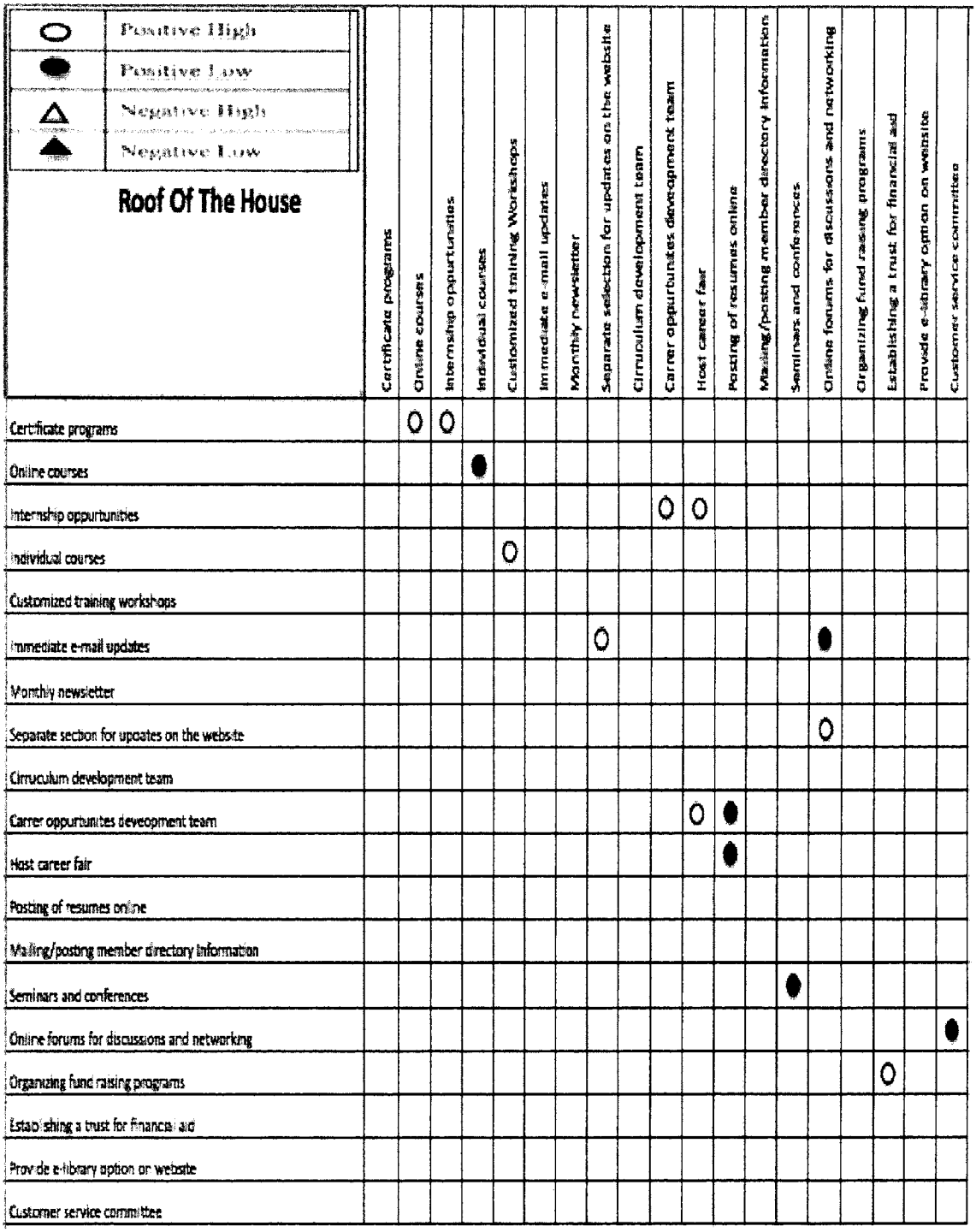
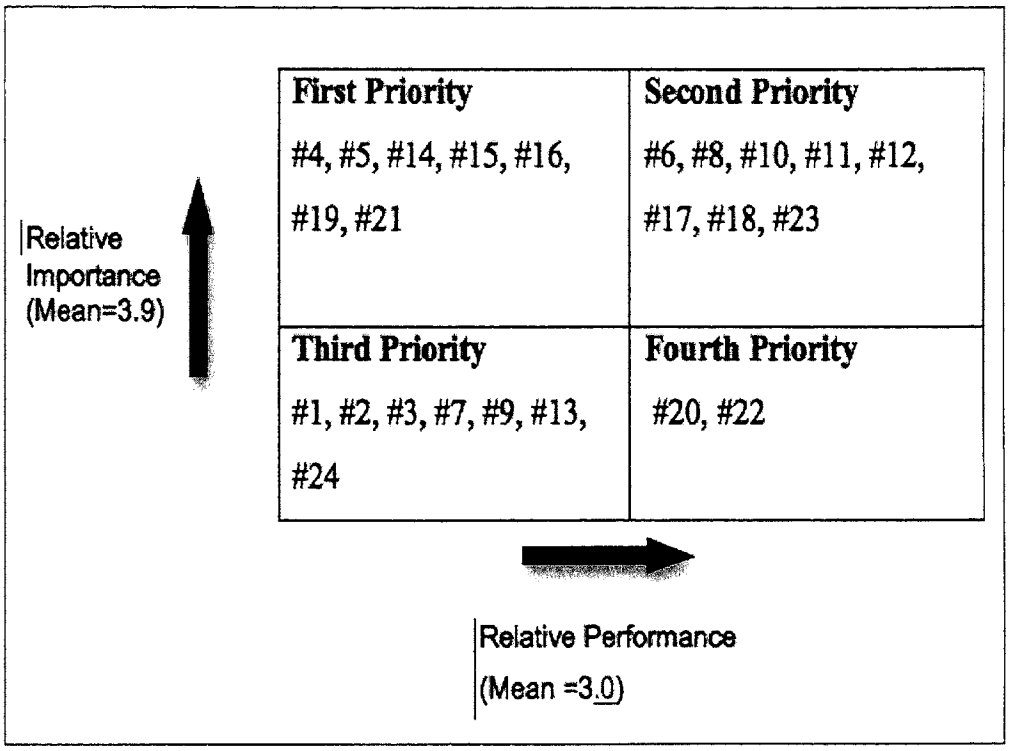


Exhibit 7. Importance-Performance Grid for ASEM
(The numbers in Exhibit 7 indicate the consequences number from Exhibit 3)



III. ANALYZING CUSTOMER REQUIREMENTS FOR A CAREER OPPORTUNITIES CENTER

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ABSTRACT

This paper integrates quality function deployment (QFD) and SERVQUAL to evaluate a university career opportunities center (COC) and recommends service standards to increase its benefits to students. QFD is a systematic process to integrate customer requirements into every aspect of the design and delivery of products and services. Understanding what customer desires or needs from a product or service is crucial to the successful design and development of new products and services. QFD was used here to determine customer needs and thus to ensure that customer demands are met. SERVQUAL was used to determine customer requirements, the first step in the construction of a house of quality. The first phase of QFD, product planning, provided the career opportunities center with the data and recommendations required to improve the quality of their services. This methodology could serve as a powerful tool in the development of any new service process.

Keywords: Quality Function Deployment (QFD), Career Opportunities Center (COC), Voice of Customer (VOC), House of Quality (HOQ), SERVQUAL, Service Quality

Paper Type – Case Study

1. INTRODUCTION

Opportunities to apply QFD in the service sectors are rapidly expanding. QFD has been used to enhance a wide range of services in the healthcare, chemical, and telecommunications industries and in customer support. It is vital for organizations to identify customer needs and track customer satisfaction. "The QFD process provides design-in-quality rather than inspected-in-quality which led to the reduced development time for the processes, lowered start up costs, promotion of the usage of teams" (Fisher and Schutta, 2003).

In any service organization, poor quality can result in dissatisfaction among the customers and ultimately affect the organization's reputation. Various factors are essential to the successful functioning of an organization; these include responsible operation, high quality, and efficient time management. A career opportunities center (COC) must understand student requirements and service expectations because these represent the implicit performance standards by which students judge the quality of service.

A university COC seeks to bridge the gap between students and employers. It equips students with the professional skills they need to find employment. The staff keeps the students regularly informed about various events such as the career fair, and it can help them make major career decisions. A COC should maintain high standards of quality and serve students efficiently. To do so, its staff must understand student needs and constantly monitor feedback to improve their performance.

"QFD is a service development process based on inter-functional teams (marketing, manufacturing, engineering, and R&D) who use a series of matrices,

which look like "houses," to deploy customer input throughout design, manufacturing, and service delivery," (Griffin and Hauser, 1991). As required by QFD this work constructed matrices, called "quality tables," that ensure customer satisfaction and improved service quality at every level of the service development process. The HOQ data was gathered after initial customer interviews were conducted and used to create and administer a survey instrument. The survey was developed to understand student requirements for the COC and the SERVQUAL method of data analysis was used to translate the survey results into specific services appropriate for constructing the HOQ. SERVQUAL is useful to evaluate and measure service quality based on five service constructs: reliability, assurance, tangibles, empathy and responsiveness (Furneaux, 2006).

Finally, this study constructed an HOQ by integrating customer opinions from the survey into organized output. This paper presents a step-by-step process for the development of an HOQ using SERVQUAL and offers some conclusions based on this research.

2. LITERATURE REVIEW

QFD has been widely implemented in the product sector; however, few papers concentrate on its application in the service sector. Coleman et al. (1997) applied SERVQUAL to measure the quality of the library services at Texas A&M University. They administered a survey among 200 people including faculty, staff, graduates, and undergraduates in the university. They performed a gap analysis and plotted graphs for each of the five SERVQUAL dimensions (reliability, assurance, tangibles, empathy, and responsiveness) depicting the gap levels. With the help of gap analysis, they concluded that reliability was ranked the highest and that the current library services only fulfilled the tangibles just above the average level. It was concluded that SERVQUAL helped to identify the customer perceptions of the existing and desired level of service quality and disclosed areas for improvement.

SERVQUAL was applied to Sao Paulo State University in Brazil to improve the quality of the higher education being provided (Oliveria and Ferreira, 2009). They intend to use SERVQUAL as a tool for service quality improvement in the higher education service sector. With the help of questionnaires and gap analysis, the overall average for the five dimensions of SERVQUAL was calculated as -0.852 that indicated a great scope for improvement in the higher education service. They recommended that the following areas had to be concentrated on: training programs for collaborators regarding technical and behavioral issues, revised service processes, and improving the infrastructure. They suggested that SERVQUAL is a potential tool to improve service processes by correcting the gap that is the difference between what the client expects and what the company actually delivers.

Ikiz et al. (2008) integrated QFD and SERVUAL methods to assess service quality in the hotel industry. In its initial stages, their study used SERVQUAL to measure customer expectations and perceptions and adopted a QFD process for the development of new services or the improvement of the existing services. A six-step hotel of quality model for hotel services along with a step-by-step process for its construction was proposed and described. For the HOQ concepts to be more applicable in the hospitality industry, these concepts were modified and defined in hotel jargons. SERVQUAL was used to obtain the customer needs in the HOQ.

Tyran and Ross (2006) applied SERVQUAL to identify the specific needs that an academic advising support system could fulfill. This study intended to improve the existing academic advising facility at Western Washington University (WWU). They modified the SERVQUAL dimensions and items according to their project requirement and administered a survey among 142 students of WWU. The survey results were analyzed using factor analysis and gap analysis and then prioritized. The study identified that students preferred an automated advising system to those of traditional advising systems.

Baki et al. (2008) integrated SERVQUAL and Kano's model into QFD and applied it to a case study of a cargo company in Turkey. This study applied SERVQUAL to identify the perceptions of the quality in the logistics services using Kano's model to categorize its strengths and weaknesses and incorporate them into QFD to improve the services. Five more attributes were added to the standard 22 attribute (obtained from five RATER dimensions: reliability, assurance, tangibles, empathy and responsiveness) SERVQUAL instrument that was used in the study by Baki et al. Based on the past research conducted, the two quality assurance tools

SERVQUAL and QFD were selected for to this case study on improving services provided by a career opportunities center (COC) at a university. This paper demonstrates how QFD could be integrated with SERVQUAL to be applied in the service sector.

3. BACKGROUND

3.1 QUALITY FUNCTION DEPLOYMENT (QFD)

QFD is a planning process that translates customer needs into appropriate organizational requirements (Pawitra and Tan, 2003). Maritan and Panizzolo (2009) proposed that, when used in the strategic planning process, QFD maintains the integrity of the voice of the customer (VOC) and generates innovative strategies to achieve an organization's vision. They have also argued that QFD can lead directly to beneficial changes in an organization's service policies.

QFD is a system that translates customer requirements into appropriate company requirements at each stage of the process, from research and product or service development to engineering and manufacturing to marketing, sales, and distribution. The QFD method was first developed in Japan, and it is used to select product design features that will best satisfy the expressed needs and preferences of the customer. It prioritizes those features and permits selection of the most important ones (Fisher and Schutta, 2003).

QFD is a comprehensive quality system aimed specifically at satisfying the customer. It maximizes customer satisfaction by identifying both spoken and unspoken needs (Helper and Mazur, 2006). QFD focuses specifically on the needs of the customer. It advocates listening to the customer and considering customer requirements in all business processes so that the end product or service will satisfy customer needs and demands. (Chan et al., 2006).

QFD provides an organized, systematic approach to the consideration of customer requirements in product and service design (Helper and Mazur, 2006). It

provides a means to objectively address the subjective needs of customers and provide both employee involvement and a focus on customers.

There is also certain opposition raised against QFD. Olewnik and Lewis (2008) proposed that the House of Quality tool offered by the QFD was limited to qualitative support but failed to provide valid quantitative support. It was stated that, "Quantitative conclusions are likely flawed since the quantitative importance calculations like the relative weight are independent of the type of quantitative scale used and it is unlikely that designers could assess the true relationship between the customer attributes and the technical attributes".

QFD is unique in its ability to integrate customer demands with the technical aspects of a service. It helps the cross-functional team to make key tradeoffs between the customers' needs and the service characteristics so as to develop a high quality service. Hence, QFD is not only a methodological tool but also one that can be applied universally to provide a means of considering customer requirements in each stage of service development (Chan and Wu, 2002).

The first stage in QFD is the identification of the customer needs. QFD is driven by the voice of the customer and thus helps service providers address gaps between specific components of customer expectations on one hand and actual service experiences on the other. In addition, it helps managers to adopt a more customer-driven approach, pointing out the differences between manager's perceptions, customer expectations, and actual customer expectations. VOC is discussed more in detail in the following section.

3.2 VOICE OF CUSTOMER (VOC)

VOC permits identification, structuring, and prioritization of customer needs (Griffin and Hauser, 1991). Customer needs are measured in terms of consequences, which are determined by asking customers directly what they are looking for in a product or service. The VOC is obtained primarily by two methods: interviews and focus groups. The interviews are one-on-one conversations conducted with customers to determine their expectations from a product or service.

Griffin and Hauser (1991) suggest that interviews with 20-30 customers should identify 90% or more of the customer needs, based on the beta-binomial model, in a relatively homogeneous customer segment. The purpose of the interview process was not to ask each customer all questions, but to promote the customer to talk. When the subject stopped talking, the next question would get the conversation flowing again. To elicit the consequences from a customer, the interviewer used a probing technique by repeatedly asking "why" to determine the reason responsible for making a specific feature appealing to them.

QFD facilitates organizations to minimize changes during the development process. It also enables them to make any necessary changes earlier in development that would result in cost cutting. This results in shorter developmental times, lower developmental costs, and greater profits. For successful implementation of QFD, it is vital to capture the VOC. After the collection of customer needs through interviews, the data needs to be analyzed. SERVQUAL is a data analysis tool that is elaborated in the following section.

3.3 SERVQUAL

Berry, Parasuraman, and Zeithaml developed SERVQUAL in mid eighties (Coleman et al., 1987). It is a service quality tool based on the customer's perceptions of and expected for performance. It measures service quality based on five service aspects (RATER): reliability - ability to perform service dependably and accurately, assurance - ability of staff to inspire confidence and trust, tangibles - physical facilities, equipment, staff appearance, etc., empathy - the extent to which caring individualized service is given and responsiveness: willingness to help and respond to customer needs (Furneaux, 2006).

Research conducted by Coleman et al. (1987) used SERVQUAL to measure library service quality and concluded that customers in general judge service quality based on five dimensions: reliability, responsiveness, assurance, empathy, and tangibles.

Initially, Parasuraman et al. (1985) proposed ten service quality attributes: reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding/knowing the customer, and tangibles. Later, they refined these to five dimensions: reliability, assurance, tangibles, empathy, and responsiveness (RATER). A number of theoretical and operational issues have been raised against SERVQUAL, in particular related to the validity of the RATER dimensions (Buttle, 1995). Some of these issues are: "Do consumers actually evaluate service quality in terms of expectations and perceptions? Do the five RATER dimensions incorporate the full range of service quality attributes? Do consumers incorporate 'outcome' evaluations into their assessments of service quality?"

The SERVQUAL questionnaire administered in the Oliveria et al. (2009) study consisted of two parts: one that measures client expectations in relation to a current service segment and the other that measures the client perceptions in relation to an ideal or a particular service company. With the help of SERVQUAL, customer satisfaction can be measured in terms of the difference, or gap, between the expected and perceived level of performance. This approach can be applied to any service organization to evaluate the standards of quality for the services provided. "Services are different from goods in many ways: they are intangible, require participation of the customer, simultaneous production and consumption" (Oliveira et al., 2009).

SERVQUAL is a reliable and valid scale used to measure the perceived and expected levels of performance in any service organizations and thus resulting in improved service offerings. SERVQUAL is most effective when administered periodically to monitor new trends in the service quality. By calculating the average of the differences between the scores on the questions that make up a given dimension, and by calculating an average across all dimensions, an organization's quality standards can be administered (Parasuraman et al., 1988).

SERVQUAL has also been used in the house of quality design process to evaluate customer satisfaction with an organization's services. It can be used to identify and analyze customer requirements and thus forms the first stage in the construction of an HOQ. As noted by Parasuraman et at. (1988), the SERVQUAL dimensions can be modified based on the requirements and needs of an organization to make them more relevant to the context in which they are used (Paryani et al., 2010).

The Kano model is a theory of product development and customer satisfaction. Kano et al. (1984) distinguish three types of service requirements that influence customer satisfaction in various ways: ''must be", ''one-dimensional'', and ''attractive'' quality requirements. Research conducted by Baki et al. (2008) concluded that the integration of SERVQUAL, the Kano model, and QFD could serve as an effective tool in assessing quality of services provided by an organization. The linearity assumption in SERVQUAL can be eliminated by integrating SERVQUAL with the Kano model and QFD to develop a way to satisfy customer needs, thus leading to increased customer satisfaction and higher profits.

Once the customer data obtained through the VOC is analyzed and organized by using SERVQUAL, it is incorporated into the HOQ in its initial stages. More discussion on HOQ is presented in the following section.

3.4 HOUSE OF QUALITY (HOQ)

Olewnik and Lewis (2008) reported that HOQ supports information processing and decision making in the engineering design process. They note that companies just implementing QFD and HOQ improve their information structure, flow, and direction. Hauser and Clausing (1988) state that the principal benefit of the HOQ is a closer focus on quality in an organization. That is, an HOQ encourages people within an organization to keep the appropriate goals in mind and to work together towards those goals.

QFD uses a set of interrelated matrix diagrams. The first matrix is the HOQ, which converts the customer needs into requirements that must be fulfilled throughout the supply chain. The starting point on the left of the house is the identification of

basic customer needs which constitute customer attributes. The next step is the definition of the priority levels to which customers assign these needs. These priorities are translated into numeric values that indicate relative importance. Customer ratings, shown on the right side of the house, facilitate benchmarking with competitors' services. The section just below the roof specifies the technical attributes used to meet the customer needs. The relationship between the customer and technical attributes constitutes the main body of the HOQ, called the relationship matrix. The correlation matrix defines the relationships among technical attributes as represented by the roof of the HOQ. The bottom of the house evaluates the competition in terms of service characteristics and target values are defined in this matrix (Tan and Pawitra, 2001). The methodology section in this paper discusses the detailed process regarding the construction of the HOQ. It describes how to construct each of the matrices that constitute the HOQ. The different matrices in the HOQ are shown in Exhibit 1.

4. GENERAL METHODOLOGY

4.1 UNDERSTANDING CUSTOMER CHOICE DECISIONS

Essential to the success of any service organization is the delivery of superior service to customers. Understanding customer needs and desires (i.e., the VOC) is key to total quality management (Griffin and Hauser, 1991). The first step toward understanding customer needs is to identify customer consequences. Customers judge services based on their consequences. In other words, customers judge a service on its outcome or its effect on them. The first phase in the construction of an HOQ is the identification of customer requirements. Published research by Ikiz et al. (2008) indicates that integration of SERVQUAL into QFD is an effective means to identify customer requirements; therefore, this method was applied in the case of the COC.

4.2 SERVQUAL DIMENSIONS

SERVQUAL was developed to measure the gap between the customers and service providers perception of service quality. Parasuraman et al. (1985) proposed ten service quality components initially that were later on modified into five RATER dimensions. A twenty-two-item instrument was developed for the RATER dimensions with either 4 or 5 items in each of the dimensions. The definitions of these dimensions and the number of items in each of them can be modified depending on the different types of service processes in which SERVQUAL was being applied. To gather the VOC, researchers conduct focus groups or interviews with a select group of potential, existing, or past customers and ask them what is important to them in the service or product being offered. "Why" is asked numerous times until the respondent responds with the same answer each time. This is the fundamental

customer consequence that the customer wants from using the service or product. These responses are grouped under the five RATER dimensions and used to develop a meaningful survey questionnaire that captures all things important to the customers. To ensure that the appropriate number of responses is gathered (90%), a standard sample size calculation can be performed.

4.3 SURVEY

A questionnaire is administered among the target set of customers to obtain the VOC. The survey is conducted in two parts. First, the respondents are asked to identify the most important consequence, assigning to each a rank from 1 to 10, with 10 indicating the highest level of importance. The mean rank is calculated for each customer requirement. To determine the quality of the COC service, respondents are also asked if they would recommend the service to peers. In the second part of the survey, respondents are asked to indicate the degree to which each of the consequences was true of an ideal COC (expected level of service quality – E) and of the specific university COC (perceived level of service quality – P) on a scale from 1 to 5, where 5 indicated strongly agree and 1 indicated strongly disagree. The mean ratings are calculated for each consequence. With the help of this survey, the VOC is captured. SERVQUAL is used to analyze the survey results.

4.4 GAP ANALYSIS USING SERVQUAL

After the VOC is captured, this data is analyzed using SERVQUAL by performing a gap analysis on each of the five RATER dimensions. Using the results of the gap analysis, the customer consequences are prioritized. For each customer

requirement, the perceived level (P) and expected level (E) of service are obtained from the survey data. The gap score (P-E) for each of the consequences, the average gap score for each of the dimensions, and the overall gap score are calculated. The five RATER dimensions are prioritized based on the value of the average gap scores; i.e. the dimension with the highest average gap score is the one given the highest priority for improvement.

First, the five RATER dimensions are organized based on the priority order. Next, the consequences within these dimensions are prioritized based on the gap scores calculated for each of the consequences. When two consequences have the same gap score, their mean importance ratings obtained from the survey results are used to determine their priority level. Using the gap scores and the importance ratings, the customer consequences are prioritized.

4.5 DEVELOPMENT OF SERVICE CHARACTERISTICS

Once customer consequences are analyzed the customer needs and benefits matrix is complete. The next matrix to be concentrated on in the construction of the HOQ is the technical response matrix. Each customer consequence can have one or more service characteristic(s) that constitute the technical response matrix. These characteristics are the design specifications that satisfy customer needs. The service characteristics are called the how's. These appear on top of the HOQ and are the measurable steps to ensure that all customer requirements are met. The service characteristics defined in QFD are within the organization's direct control. They focus on specific, measurable aspects of service. Various techniques could be used to develop the service characteristics. Following this, the developed service

characteristics need to be organized. Each of these measurable services characteristics are calculated along with their units of measurement and values.

4.6 RELATIONSHIP MATRIX

Once the customer consequences and the service characteristics are developed, a relationship matrix is constructed. The matrix defines the correlations between customer attributes and technical attributes as strong, moderate, or weak using a standard 9-3-1 scale. Normally, only the strongest relationships are specified, leaving approximately 60-70% of the matrix blank (Griffin and Hauser, 1991). The matrix identifies the service characteristics that satisfy most customer consequences and determines the appropriate investment of resources for each.

4.7 PLANNING MATRIX (CUSTOMER COMPETITIVE ANALYSIS)

After the completion of the relationship matrix, the next step is the construction of the planning matrix, which defines how each customer consequence is addressed by the competition. This matrix provides market data, facilitates strategic goal setting for the new service, and permits prioritization of customer desires and needs. In this methodology, which incorporated SERVQUAL into HOQ, the competitive analysis is performed between the current service process and the ideal service process. Different symbols are used for the current service process and the ideal service process. This analysis is plotted on the right side of the HOQ. The values required for this process are obtained from the survey data.

4.8 TECHNICAL CORRELATIONS

Following the completion of the planning matrix, technical correlations are determined. These form the roof of the HOQ. The roof maps the relationships and interdependencies among the service characteristics. The analysis of these characteristics informs the development process, revealing the existence and nature of service design bottlenecks.

4.9 TECHNICAL MATRIX

A technical matrix is constructed to form the foundation of the HOQ. This matrix addresses the direction of improvement, target values, the final weights of service and quality characteristics, and the level of difficulty to reach the target values. The direction of improvement indicates the type of action needed to ensure that the service characteristics are sufficient to make the service competitive. Final weights are a comprehensive measure that indicates the degree to which the specific service characteristic relates to the customer consequences. Target values are established with the help of the industry standard values. The level of difficulty indicates the difficulty level to reach the target values for each of the services attributes. All of this data is organized at the bottom of the HOQ and is useful in the technical analysis for the service process.

5. APPLICATION OF QFD AND SERVQUAL TO THE CAREER OPPORTUNITIES CENTER (COC): A CASE STUDY

The mentioned methodology has been applied to the COC at a university. Detailed steps are listed for the construction of the HOQ, with SERVQUAL being incorporated into QFD in this application. A step-by-step procedure for this case is discussed in this section.

5.1 SERVQUAL DIMENSIONS FOR THE COC

The main goal of applying QFD to a university COC was to identify how the COC could better serve students. This work sought to identify student expectations of the students and the measures necessary to meet them. Here, SERVQUAL was applied to identify the key customer needs and requirements. The modified five SERVQUAL dimensions are shown in Exhibit 2.

To make the dimensions more relevant to the COC, few SERVQUAL items were modified or removed based on the responses obtained through student interviews. A total of 15 customer requirements were identified. The adjusted SERVQUAL items along with their description are shown in Exhibit 3.

These SERVQUAL items are the customer consequences that were obtained by conducting face-to-face interviews with 30 students enrolled at the university of the COC being evaluated. The intention behind interviewing these students was to keep the conversation flowing. To elicit the consequences from a customer, the interviewer used a probing technique repeatedly by asking "why" to determine the reason responsible for making a specific aspect appealing to them. When the student stopped talking, the next question would get the conversation flowing again. These

interview responses were recorded and were used to develop a questionnaire that was administered among the students of the university of the COC being evaluated.

5.2 SURVEY CONDUCTED FOR THE COC

After a survey was developed using the responses recorded from the interviews, it was administered among 99 students of the same university that served as the primary source of information for this study. The survey asked the students to express their thoughts on various aspects of the COC and to indicate what changes would increase their satisfaction. Customers do not assign equal importance to all requirements. The survey was administered in two sections. First, the students were asked to identify the most important consequence, assigning to each a rank from 1 to 10, with 10 indicating the highest level of importance. The mean rank was calculated for each customer consequence. To determine the quality of the COC services, respondents were also asked if they would recommend the service to other students. In the second part of the survey, students were asked to indicate the degree to which each of the consequences was true of an ideal COC and of the specific university COC on a scale from 1 to 5, where 5 indicated strongly agree and 1 indicated strongly disagree. The mean ratings were calculated for each consequence as shown in Exhibit 4. The survey results obtained were analyzed using SERVQUAL by performing a gap analysis that is discussed in the following section. The questionnaire developed for this study is included in Appendix B. Exhibit 4 shows the survey results.

5.3 PRIORITIZING SERVQUAL DIMENSIONS FOR THE COC

The five SERVQUAL dimensions: reliability, assurance, tangibles, empathy, and responsiveness were prioritized based on the gap score calculated for each dimension. There were four items under reliability, three under assurance, two under tangibles, four under empathy, and two under responsiveness for the COC. For each customer requirement, the perceived level (P) and expected level (E) of service were obtained from the survey data. The difference (gap score) between them was calculated, as was the average gap score for each of the five dimensions. The five RATER dimensions for the COC were prioritized based on the value of the average gap scores; i.e. the dimension with the highest average gap score was the one given the highest priority for improvement. Empathy had the highest average gap score (-1.25), making it the highest priority. The dimensions were prioritized in the following order starting with the highest priority: reliability (-1.12), responsiveness, and assurance (-1.1), and tangibles (-0.95). Exhibit 5 shows the gap score for each of the five SERVQUAL dimensions.

Based on the gap scores calculated for each customer requirement, the importance ratings obtained from the survey data, and the priority level of each SERVQUAL dimension, the customer requirements were prioritized. When two consequences have the same gap score, their mean importance ratings obtained from the survey results could be used to determine their priority level.

The results showed that students identified the following requirements, listed in priority order from the highest to lowest:

1. I get a job that fits me
2. I have a job that I enjoy

3. I know what different jobs are available
4. I can work overseas
5. I get job offers
6. I get a job that pays well
7. I get opportunities with potential employers
8. I have my resume easily accessible to companies
9. I stand out to a potential employer
10. I am prepared for an interview
11. I am comfortable during an interview
12. I have interviewing experience
13. I get resume evaluation
14. I have a professional resume
15. I have a professional appearance for an interview

Exhibit 6 depicts the priority levels assigned to customer requirements.

5.4 DEVELOPMENT OF SERVICE CHARACTERISTICS FOR THE COC

After analyzing the survey results using SERVQUAL, the focus shifted to the development of service characteristics that are the design specifications that would satisfy customer needs. Each customer consequence can have one or more service characteristic. Various strategies were developed to reduce or eliminate low customer satisfaction and increase the quality of service. The service characteristics are called the how's. These characteristics appear on top of the HOQ and constitute the technical response matrix. They are the measurable steps to ensure that all customer requirements are met. The service characteristics defined in QFD are within

organization's direct control. These characteristics focus on specific, measurable aspects of service.

Brainstorming was used to develop the service characteristics using various Internet sources that provided references to industry standards. Tree diagrams were used to organize these service characteristics. Tree diagrams are hierarchical structures of ideas built from the top down using logic and analytical thought. A customer design matrix log was then developed to create a service process development log that provided a history of the development process. This log contained the design concepts derived from the VOC, along with the corresponding service characteristics and their values. Twenty service characteristics were developed which are listed in Appendix A.

Exhibit 7 depicts the customer design matrix.

5.5 RELATIONSHIP MATRIX FOR THE COC

Once the customer consequences and the service characteristics were developed, a relationship matrix was constructed. This matrix defines the correlations between customer attributes and technical attributes/service characteristics as weak, moderate, or strong using a standard 9-3-1 scale. For this scale the following notations are used: Strong (H) = 9, Moderate (M) = 3, and Weak (S) = 1. Each of the fifteen customer consequences were matched with each of the twenty service characteristics for the COC. The relationship between them was then determined and placed in the relationship matrix that constitutes the center of the HOQ. This matrix identifies the technical requirements that satisfy most customer consequences and determines the appropriate investment of resources for each. The technical requirements that

addressed the most customer consequences should be addressed in the design process to ensure a product that satisfies the stated customer expectations. Ideally in the QFD analysis, no more than 50% of the relationship matrix should be filled, and a random pattern should result (Fisher and Schutta, 2003). Relationships were determined here on the basis of research conducted using resources available on the Internet. Appendix A displays the relationship matrix developed as a part of the HOQ for the COC.

5.6 PLANNING MATRIX (CUSTOMER COMPETITIVE ANALYSIS) FOR THE COC

After completion of the relationship matrix, the focus of this study shifted to the construction of the planning matrix, which defines how each customer consequence has been addressed by the competition. This matrix provides market data, facilitates strategic goal setting for the new service, and permits prioritization of customer desires and needs. In this methodology, where SERVQUAL was incorporated into the HOQ, the competitive analysis is done between the current COC and an ideal COC. For the competitive analysis, a survey was conducted to determine the characteristics of an ideal COC, and this ideal COC was compared to the university COC. The survey respondents judged the ideal COC and the current COC against each of the fifteen consequences on a scale of 1 to 5, where "5" indicated strongly agree and "1" indicated strongly disagree. The mean for each consequence was calculated and placed in the columns to the right of the HOQ. A triangle was used for the ideal COC, and a square was used for the university COC. Appendix A shows the planning matrix in the HOQ.

5.7 TECHNICAL CORRELATIONS MATRIX FOR THE COC

Next, the technical correlations were determined after the completion of the planning matrix. These form the roof of the HOQ. The roof maps the relationships and interdependencies among the service characteristics. The analysis of these characteristics informs the development process, revealing the existence and nature of service design bottlenecks for the COC. The relationships among service characteristics were plotted and given a value. Past experience and test data were used to complete the roof of the HOQ. Appendix A shows the correlations developed for the roof of the HOQ for a COC.

Exhibit 8 indicates the symbols used to represent the level of the relationship among service characteristics developed for this case study.

5.8 TECHNICAL MATRIX FOR THE COC

A technical matrix was constructed to form the foundation of the HOQ. This matrix addresses the direction of improvement, target values, the final weights of service and quality characteristics, and the level of difficulty to reach the target values. The direction of improvement indicates the type of action needed to ensure that the service characteristics are sufficient to make the service competitive; this direction is indicated below the roof of the HOQ. For each service characteristic, the direction of improvement was marked using the following symbols:

▼ - Objective is to maximize

▲ - Objective is to minimize

x - Objective is to hit the target

The quality and service characteristics were analyzed and a standard or limit value was determined for each. These are the industry standard values. These values were established based on well-informed assumptions, and they are believed to be within reach for the university COC. The final weight of each service characteristic was calculated by multiplying the value assigned to its relationship with a specific consequence (9, 3, 1) multiplied by the importance of that consequence (obtained from the survey results); the values of all consequences were then added to yield the final weight, that is a comprehensive measure that indicates the degree to which the specific service characteristic relates to the customer consequences. These final weights are shown in a row along the bottom of the HOQ. The engineering and technical staff that would design the service process evaluates the level of difficulty involved in achieving each service characteristic. This evaluation becomes the basis for development of strategic goals for the development of the service process to ensure customer. The level of difficulty involved in reaching the target values for each service characteristic was determined on a scale of 0 (easy) to 10 (difficult). Thus, the HOQ was completed for a COC; it is shown in Appendix A. Twenty service characteristics were developed that would fulfill customer requirements. The service characteristics were prioritized based on their final weights that were calculated from the technical matrix as shown in Exhibit 9. Exhibit 9 depicts the priority levels of the service characteristics.

5.9 RESULTS AND DISCUSSION FOR THE COC

With the help of QFD and SERVQUAL methodologies, the SERVQUAL dimensions, customer consequences/requirements and the service characteristics were prioritized. The priority order of the five RATER dimensions based on their gap scores was determined as: empathy (-1.25) followed by reliability (-1.12), responsiveness, and assurance (-1.1), and tangibles (-0.95). The overall gap score for the five dimensions was -1.1 indicating a scope for improvement for a COC. Exhibit 10 depicts the gaps between expected & perceived service for the 5 SERVQUAL Dimensions.

A few of the customer requirements that ranked higher than the others were: I get a job that fits me, I have a job that I enjoy, I know what different jobs are available, I can work overseas, I get a job that pays well, and I get opportunities with potential employers. Establishing a team for career guidance and counseling team to provide students with individual attention and care would increase the performance of the COC. Hosting more career fairs with the participation of a large number of companies would provide students with more opportunities to interact with employers and to secure suitable jobs. Establishment of a resume evaluation team with sufficient staff would increase student confidence and help them face interviews. Conducting periodic workshops on writing resumes and cover letters, interviewing, and business ethics, and professionalism would increase student knowledge and improve their professional skills. Conducting frequent mock interviews would equip students with practical experience that could help them to perform better in interviews.

The service characteristics were also prioritized that helps the design team in development of better services and reducing the service development costs. The

number of mock interviews conducted received the highest priority along with number of staff appointed for conducting mock interviews, followed by the number of staff members on the career guidance and counseling team, the number of interview calls received, the number of staff members appointed for resume evaluation, the number of workshops conducted on setting up, and accessing online job accounts. Also important were expected salary amount, employer access to online resumes, number of workshops on interviewing and business ethics, the number of international companies participating in the career fair, and the number of formal outfits that could be rented. A focus on implementing these service characteristics in order of their priority would improve the function of the COC.

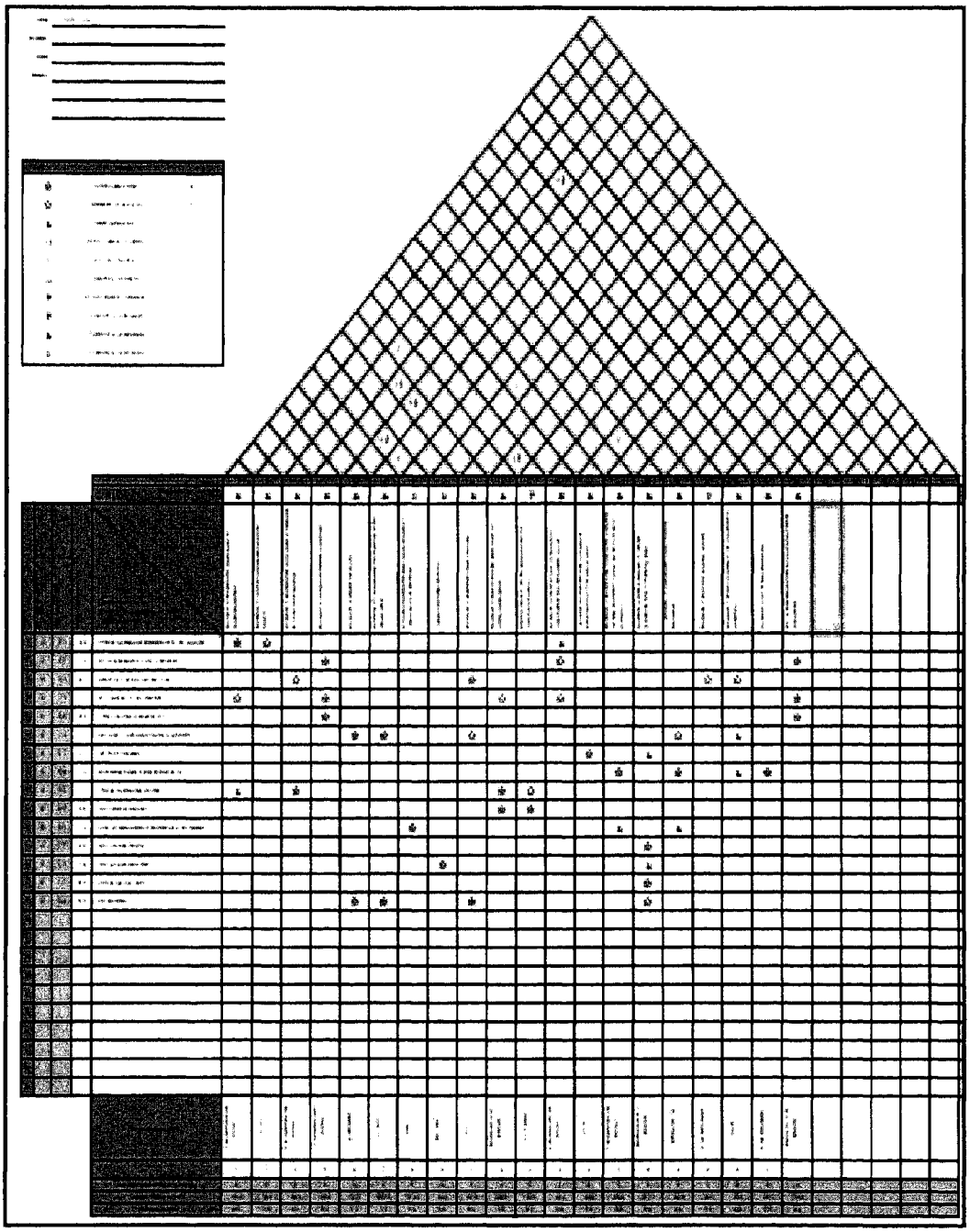
6. CONCLUSIONS

This study has illustrated how SERVQUAL and QFD can be applied to the development and improvement of COC services. Both methodologies were successfully applied in this case study focusing on improving the quality of the services provided by a university COC. With the data collected from the survey and calculations based on both QFD and SERVQUAL, the five SERVQUAL dimensions (reliability, assurance, tangibles, empathy and responsiveness) were defined, customer requirements identified, and the service characteristics developed to meet the customer requirements. These requirements were prioritized and they provided a basis for the improvement of COC service.

This research applied the QFD methodology in development of new services. It helped the COC develop a comprehensive knowledge base about student needs and desires allowing the COC to make required changes in the early development stages. Although this study focused on the improving the service development process for the COC, the QFD methodology presented in this study could assist in the development of any new service process. Ideally, this study will encourage more service process development teams and organizations to adopt QFD, to develop better and more successful services, and to achieve high customer satisfaction with increased profits for the service organization.

APPENDIX A

HOUSE OF QUALITY



APPENDIX B

PART A – SURVEY QUESTIONNAIRE

Find the benefit of using the Career Opportunities Center in the list below that is most important to you. Assign it 10 points. Then, assign from 0 to 10 points to the other benefits to indicate how important they are to you in comparison to the most important one. You may assign the same number of points to more than one benefit.

_____ I have a professional appearance for an interview

_____ I am comfortable during an interview

_____ I stand out to a potential employer

_____ I am prepared for an interview

_____ I have interviewing experience

_____ I get opportunities with potential employers

_____ I can work overseas

_____ I know what different jobs are available

_____ I have a professional résumé

_____ I get a résumé evaluation

_____ I have my résumé easily accessible to companies

_____ I get a job that fits me

_____ I get a job that pays well

_____ I have a job that I enjoy

_____ I get job offers

APPENDIX B

PART B – SURVEY QUESTIONNAIRE

Please rate how well the Missouri S&T Career Opportunities Center delivers each of these benefits when you use it. Circle the number below that best indicates how well you feel the MST COC satisfies each of the benefits. For comparison purposes, please rate your ideal career center on the same benefits. Use a scale of:

1= Strongly Disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly Agree

	MST COC	Ideal COC
I have a professional appearance for an interview	1 2 3 4 5	1 2 3 4 5
I am comfortable during an interview	1 2 3 4 5	1 2 3 4 5
I stand out to a potential employer	1 2 3 4 5	1 2 3 4 5
I am prepared for an interview	1 2 3 4 5	1 2 3 4 5
I have interviewing experience	1 2 3 4 5	1 2 3 4 5
I get opportunities with potential employers	1 2 3 4 5	1 2 3 4 5
I can work overseas	1 2 3 4 5	1 2 3 4 5
I know what different jobs are available	1 2 3 4 5	1 2 3 4 5
I have a professional résumé	1 2 3 4 5	1 2 3 4 5
I get a résumé evaluation	1 2 3 4 5	1 2 3 4 5
I have my résumé easily accessible to companies	1 2 3 4 5	1 2 3 4 5
I get a job that fits me	1 2 3 4 5	1 2 3 4 5
I get a job that pays well	1 2 3 4 5	1 2 3 4 5
I have a job that I enjoy	1 2 3 4 5	1 2 3 4 5
I get job offers	1 2 3 4 5	1 2 3 4 5
Would you recommend this service to your peers?	1 2 3 4 5	1 2 3 4 5

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EXHIBITS

Exhibit 1. HOQ Model (Cohen, 2007)

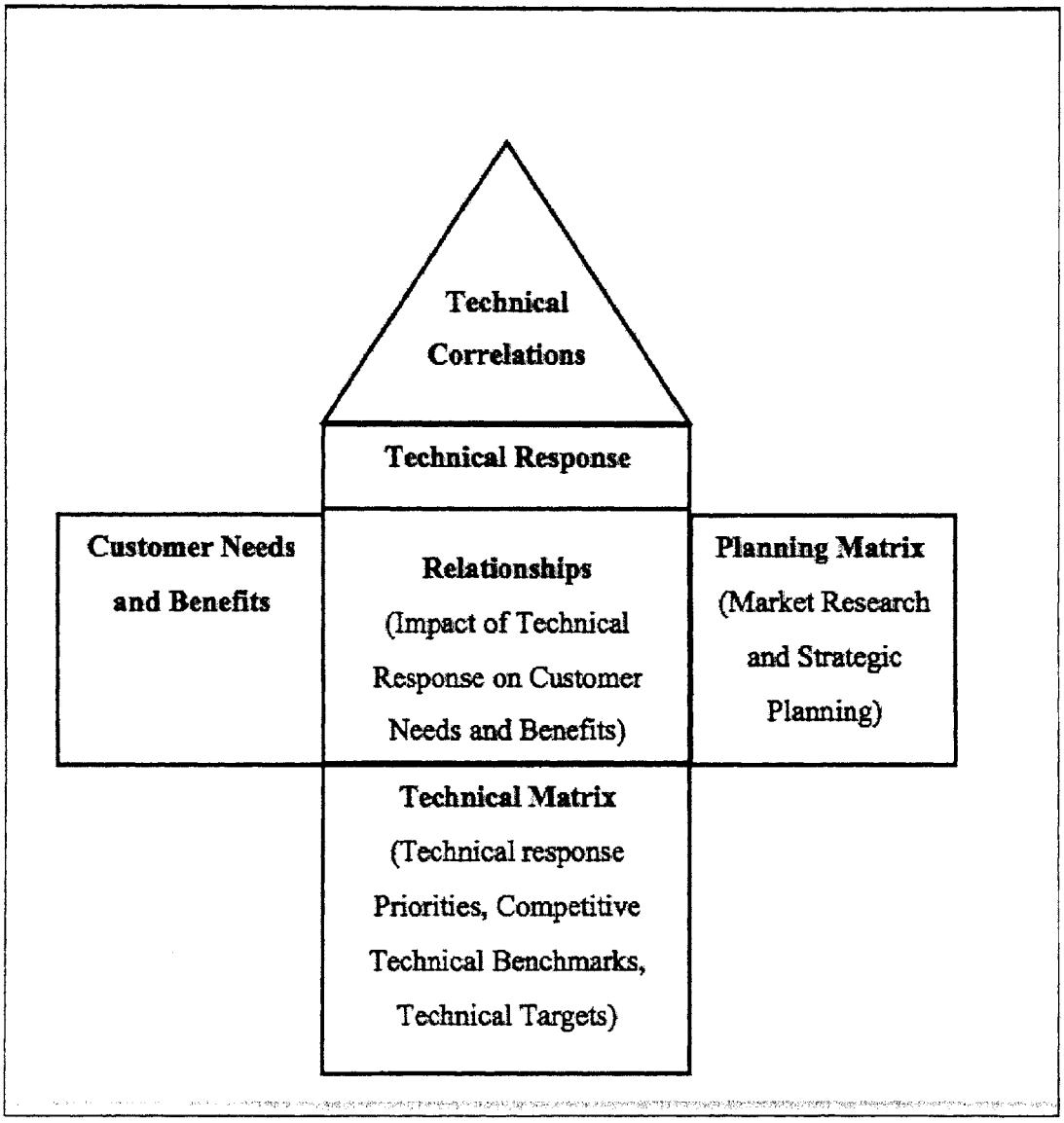


Exhibit 2. SERVQUAL: Five Dimensions

Dimensions	Description
Reliability	The ability of the COC staff to deliver the promised services dependably and precisely.
Assurance	Knowledge and courtesy of the COC staff and their ability to communicate trust and confidence in the students.
Tangibles	Physical aspects of the COC including the appearance of personnel and communication services.
Empathy	Ability to provide individualized attention and care by the COC staff to the students.
Responsiveness	Willingness of the COC staff to serve the students and provide them with prompt services.

Exhibit 3. SERVQUAL: Adjusted Items Description

Dimensions	Customer Requirements
Empathy	I get a job that fits me
	I have a job that I enjoy
	I know what different jobs are available
	I can work overseas
Reliability	I get job offers
	I get a job that pays well
	I get opportunities with potential employers
	I have my resume easily accessible to companies
Assurance	I stand out to a potential employer
	I am prepared for an interview
	I am comfortable during an interview
Responsiveness	I have interviewing experience
	I get a resume evaluation
Tangibles	I have a professional resume
	I have a professional appearance for an interview

Exhibit 4. Survey Results (Averages of all the ratings)

Customer Requirements	Importance Ratings	Current COC Rating	Ideal COC Rating
I have a professional appearance for an interview	6.8	3.6	4.5
I am comfortable during an interview	7.3	3.5	4.6
I stand out to a potential employer	8.1	3.5	4.7
I am prepared for an interview	7.7	3.5	4.5
I have interviewing experience	6.9	3.5	4.5
I get opportunities with potential employers	7.7	3.5	4.6
I can work overseas	3	2.5	3.7
I know what different jobs are available	7.7	3.5	4.6
I have a professional résumé	7.7	3.6	4.6
I get a résumé evaluation	6.6	3.4	4.5
I have my résumé easily accessible to companies	7.5	3.7	4.6
I get a job that fits me	8.4	3.3	4.7
I get a job that pays well	7.8	3.5	4.6
I have a job that I enjoy	8.4	3.3	4.6

Exhibit 5. Calculation of Unweighted SERVQUAL Scores

Dimension	No.	Customer Requirements	Expectation Score (E)	Perception Score (P)	Gap Score (P–E)	Average for Dimension
Tangibles	1	I have a professional appearance for an interview	4.5	3.6	-0.9	-0.95
	2	I have a professional resume	4.6	3.6	-1	
Reliability	3	I get opportunities with potential employers	4.6	3.5	-1.1	-1.12
	4	I have my resume easily accessible to companies	4.6	3.7	-0.9	
	5	I get a job that pays well	4.6	3.5	-1.1	
	6	I get job offers	4.7	3.3	-1.4	
Responsiveness	7	I get a resume evaluation	4.5	3.4	-1.1	-1.1
	8	I have interviewing experience	4.5	3.5	-1.1	
Assurance	9	I am comfortable during an interview	4.6	3.5	-1.1	-1.1
	10	I stand out to a potential employer	4.7	3.5	-1.2	
	11	I am prepared for an interview	4.5	3.5	-1	
Empathy	12	I can work overseas	3.7	2.5	-1.2	-1.25
	13	I know what different jobs are available	4.6	3.5	-1.1	[Overall Avg. SEVQUAL Score: -1.1]
	14	I get a job that fits me	4.7	3.3	-1.4	
	15	I have a job that I enjoy	4.6	3.3	-1.3	

Exhibit 6. Prioritizing Customer Requirements

Dimensions	Priority Level	Customer Requirements	Gap Score	Importance Rating
Empathy	1	I get a job that fits me	-1.4	8.4
	2	I have a job that I enjoy	-1.3	8.4
	3	I know what different jobs are available	-1.1	7.2
	4	I can work overseas	-1.2	3
Reliability	5	I get job offers	-1.4	8.5
	6	I get a job that pays well	-1.1	7.8
	7	I get opportunities with potential employers	-1.1	7.7
	8	I have my resume easily accessible to companies	-0.9	7.5
Assurance	9	I stand out to a potential employer	-1.2	8.1
	10	I am prepared for an interview	-1	7.7
	11	I am comfortable during an interview	-1.1	7.3
Responsiveness	12	I have interviewing experience	-1.1	6.9
	13	I get a resume evaluation	-1.1	6.6
Tangibles	14	I have a professional resume	-1	7.7
	15	I have a professional appearance for an interview	-0.9	6.8

Exhibit 7. Customer Design Matrix

Dimension	No.	Customer Requirements	Service Requirements	Measuring Units	Values
Tangibles	1	I have a professional appearance for an interview	No. of workshops conducted on Professionalism	Number	Integer Value
			No. of formal outfits that could be rented	Number	Integer Value
	2	I have a professional resume	No. of workshops conducted on resume & cover letter writing	Number	Integer Value
Reliability	3	I get opportunities with potential employers	No. of career fairs held	Number	Integer Value
			No. of companies participating in the career fairs	Number	Integer Value
			Number of companies invited to hold seminars	Number	Integer Value
			Number of alumni invited to be connected to university	Percentage	Percentage
	4	I have my resume easily accessible to companies	Provide companies with online access to resumes of all students	Boolean Value	Yes/No
	5	I get a job that pays well	Expected Salary Amount	Money	Dollars
	6	I get job offers	No. of interview calls received	Number	Integer Value
Responsiveness	7	I get a resume evaluation	No. of staff members appointed for resume evaluation	Number	Integer Value
			Waiting time to get an appointment for resume evaluation	Time	Days
	8	I have interviewing experience	No. of mock interviews conducted	Number	Integer Value
			No. of staff appointed for conducting mock interviews	Number	Integer Value
Assurance	9	I am comfortable during an interview	No. of workshops conducted on Interviewing and Business Ethics	Number	Integer Value
	10	I stand out to a potential employer	Number of etiquette dinners offered	Number	Integer Value
	11	I am prepared for an interview			
Empathy	12	I can work overseas	No. of International companies participating in the career fairs	Number	Integer Value
	13	I know what different jobs are available	No. of workshops conducted on setting up and accessing online job accounts for students	Number	Integer Value
			Number of job e-mail alerts sent	Number	Integer Value
	14	I get a job that fits me	No. of staff members in career guidance and counseling team	Number	Integer Value
	15	I have a job that I enjoy			

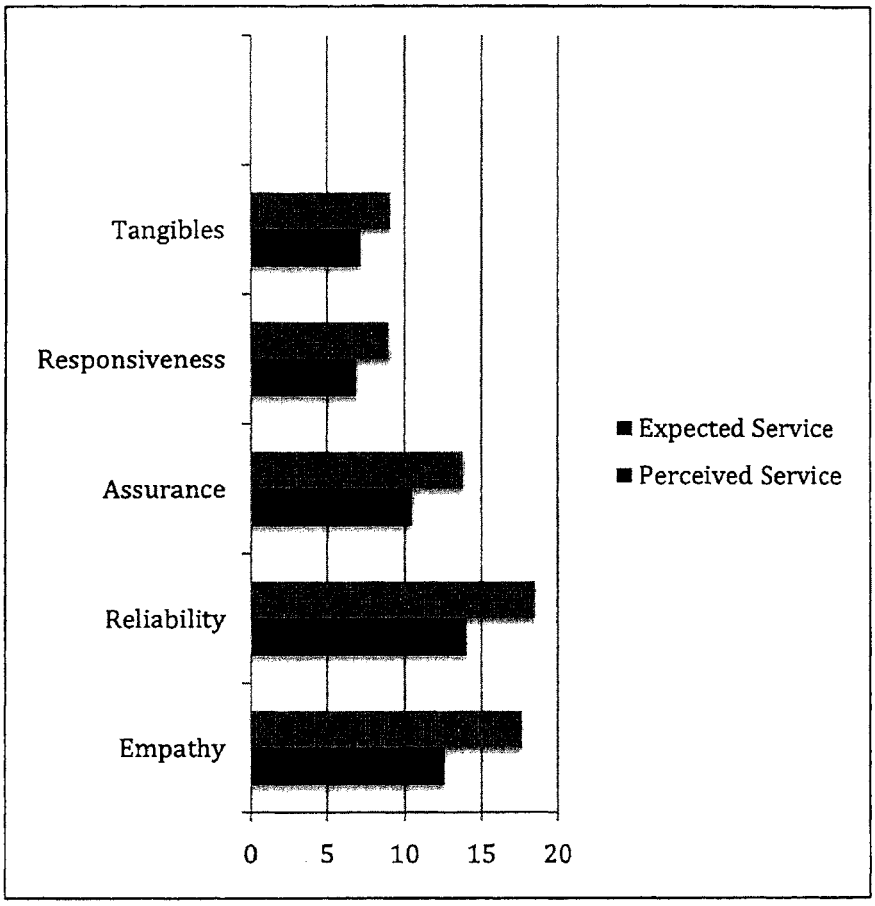
Exhibit 8. Symbols Used to Represent Technical Correlations

++	Strong Positive Correlation
+	Positive Correlation
-	Negative Correlation
▼	Negative Low

Exhibit 9. Prioritizing Service Characteristics

Priority Level	Service Characteristics	Weight /Importance
1,2	Number of mock interviews conducted	179.8
1,2	Number of staff appointed for conducting mock interviews	179.8
3	Number of staff members in career guidance and counseling team	171.1
4	Number of interview calls received	157.4
5	Number of staff members appointed for resume evaluation	138.5
6,7	Number of companies participating in the career fairs	133
6,7	Number of career fairs held	133
8	Number of workshops conducted on resume & cover letter writing	85.4
9	Number of workshops conducted on professionalism	83.9
10	Number of companies invited to hold seminars	87.0
11	Waiting time to get an appointment for resume evaluation	75.3
12	Number of workshops conducted on setting up and accessing online job accounts for students	66
13	Expected salary amount	64.1
14	Provide companies with online access to resumes of all students	61.6
15	Number of job e-mail alerts sent	59.1
16	Number of workshops conducted on Interviewing and Business Ethics	47.3
17	Number of alumni invited to be connected to university	35.8
18	Number of International companies participating in the career fairs	24.6
19	Number of etiquette dinners offered	22.2
20	Number of formal outfits that could be rented	18.6

Exhibit 10. Graph showing the gaps between expected & perceived service for the 5 SERVQUAL Dimensions



SECTION

2. CONCLUSION

Quality function deployment, house of quality and SERVQUAL are the various tools that have been used in this research. It has been illustrated how these methodologies could be applied in the service as well as product sector to increase the customer satisfaction level, profit levels of the organization and quality of the products/services being produced. These methodologies could be applied to improve existing products and services as well as in the development of new products and services. The authors hope that this study could attract more product/service process development teams and organizations to adopt QFD in their development process to develop successful products/services and achieve high customer satisfaction with increased profit levels. This research intends to contribute to the literature on the application of QFD methodology in the product and service sector.

3. FUTURE WORK

The future work involves integration of Quality Function Deployment with various other quality assurance tools to develop effective methodologies that could be applied in product as well as service industries to improve customer satisfaction and profit levels of an organization. The various integrated methodologies developed could be applied for improving a product or service process and the variation in the results could be compared to draw certain observations. The survey respondents' domain can be expanded for each of the case studies presented in this research and the results can be evaluated and compared.

VITA

Anusha Uppalanchi was born on 18th January 1988 in Hyderabad, a city in Andhra Pradesh state, South India. She received her Bachelor of Technology degree in Information Technology from Sreenidhi Institute of Science and Technology in 2009. She graduated with Master of Science degree in Engineering Management in December 2010. Her areas of interest are quality assurance, six sigma and project management.