

# Utilizing Quality Function Deployment (Qfd) for Service Quality Improvement of a Metrology Laboratory in Northern Mindanao, Philippines

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## Abstract

**Introduction:** Quality Function Deployment (QFD) was applied in this study to improve customer satisfaction at the Regional Metrology Laboratory (RML), the primary calibration laboratory in Northern Mindanao. While technical proficiency was maintained at the RML, a better understanding and addressing of the evolving needs of its customers beyond just technical requirements was sought.

**Objectives:** This study aims to investigate strategies that the metrology laboratory can undertake in order to improve its calibration services. These strategies are identified by aligning through quality function deployment (QFD) the technical considerations of the laboratory towards the customer requirements identified from ServQual dimensions.

**Methods:** Data collection was conducted through focus group discussions and interviews with laboratory personnel, and online surveys with customers. Customer requirements were evaluated using ServQual, while technical requirements were drawn from the lab's QMS. Statistical analysis was used to rank customer requirements, which fed into a QFD process using the House of Quality. This process helped prioritize technical requirements based on their potential impact on customer satisfaction, providing the laboratory with actionable strategies for quality improvement.

**Results:** The survey responses revealed that the Assurance dimension, related to employees instilling confidence and providing courteous service, was of highest priority to customers. Conversely, the Responsiveness dimension, regarding promptness and helpfulness, was ranked lowest. Through the QFD process, 'high customer satisfaction,' 'accreditation of laboratory,' and 'training of personnel' were identified as technical requirements that should be maximized, while efforts for 'maintaining environmental conditions' could be minimized.

**Conclusions:** The study provides actionable insights for the metrology laboratory to enhance customer satisfaction. By focusing on improving communication, safety, and overall assurance to customers, while maintaining efforts in other ServQual areas, the lab can meet key customer expectations. Additionally, maximizing efforts in areas identified by QFD and optimizing resource allocation by minimizing efforts in maintaining environmental conditions can lead to more efficient and effective service delivery.

**Keywords:** quality function deployment (QFD); service quality improvement (SERVQUAL); metrology laboratory; calibration services; Philippines.

## 1. Introduction

Quality Function Deployment (QFD) is a systematic approach to design quality to satisfy customers [1]. It was developed in the early 1990s with the goal of enhanced customer satisfaction, organizational integration of expressed customer wants and needs and improved profitability [2]. It is a service

planning and development model that provides an algorithm for service providers to assure quality and customer satisfaction at the same time maintaining a sustainable competitive advantage. Its goal is to enhance customer satisfaction, boost profitability and integrate customer wants and needs in the organizational plans [2]. It seeks to

deliver value by identifying both spoken and unspoken customer requirements, translating them into actionable service features and communicating them to the organization. It prioritizes the “voice of the customer” and so, it helps service providers to address gaps between customer expectations and actual service experience. Also, it is used by managers to adopt a more customer-driven perspective, that shows the differences between what they visualize as customer expectations and the actual expectations of the customers [2].

The QFD process must be able to consolidate customer requirements, service specifications, target values and competitive performance within a visual planning matrix. QFD requires the construction of “quality tables”, which guide the detailed decisions for the service development process. The House of Quality (HOQ) is the first and most commonly used matrix in the QFD methodology[2].

QFD has found many applications in design processes for both products and services. It is often employed in ergonomics such as in the design of daycare centers in the Philippines where it was used to define customer requirements of height compatibility of chairs and tables, adjustable tables, adjustable chair, chalkboard height and backrest inclination [3]. QFD was also utilized in developing job design concepts for the planning of industrial instrument calibration works in a pineapple manufacturing plant also in the Philippines [4]. ServQual is often employed with QFD for designing services. This approach was used in a study to overcome challenges in the banking sector in Greece [2]. This was also used with the Kano Model for the quality improvement of fast food restaurants in Taiwan [5].

The Regional Metrology Laboratory (RML) is the primary metrology laboratory in Northern Mindanao, Philippines. It is the only laboratory that is duly certified to perform the calibration service since the 1990s For almost 30 years, it has provided the widest variety of calibration services to different customers in industries, academe and government, ranging from calibration of road tankers, calibration of bucket and small volume apparatus to calibration of measuring instruments for weight, temperature, electrical, length and pressure. These services allow its customers to

keep their measuring instruments in accurate measuring condition and enable the customers to make proper measurements for purposes of production, quality control and assurance, environmental monitoring and regulatory compliance. The Metrology laboratory currently operates with a Quality Management System (QMS) according to ISO/IEC 17025:2017 Standard for Testing and Calibration Laboratories. The system defines general technical requirements and quality objectives that must be maintained by the laboratory [6] such as, (a) Short Lead Time, (b) High Customer Satisfaction, (c) Accuracy of Result, (d) Confidentiality of Result, (e) Impartiality of Officers, (f) Preventive Maintenance of Equipment, (g) Accreditation of Laboratory, (h) Training of Personnel, & (i) Maintaining Environmental Conditions. With a very dynamic economic landscape in Northern Mindanao, the laboratory faces new challenges from the ever-increasing demands of its customers. Thus, it is necessary for the laboratory to develop improvement strategies that will satisfy the quality objectives but more importantly, the requirements of its customers.

Understanding customer service is crucial for improving the quality of services that the RML provides, and the Service Quality (ServQual) model stands out as a widely adopted and influential service quality measurement tool across various sectors. Its applications span diverse fields such as fast food, education, banking, and arts and culture, where it has successfully identified key service elements that drive customer satisfaction and illuminated the relationship between service quality and customer satisfaction. Furthermore, the effectiveness of the SERVQUAL methodology has been demonstrated in identifying gaps between customer expectations and perceptions in cafeteria services, facilitating service quality monitoring and enhancement [7]. This study underscores the broader applicability of SERVQUAL for assessing customer expectations and perceptions across various service settings, including those relevant to the RML, solidifying its position as a versatile tool for service quality management. The vital role of continuous improvement in service quality within higher education, where stakeholder expectations are ever-evolving, has been emphasized [8]. This highlights the importance of adapting to these

changes to enhance operational efficiency and service delivery, further underscoring the need for ongoing assessment and improvement strategies like those facilitated by SERVQUAL. A study by Maghsoodi et al. [1] explored the aspects of the five-dimensional ServQual model and its automation to solve complex selection problems. The study mentions five dimensions of ServQual model which are described as follows:

- (1) Tangible: The appearance of facilities, equipment and personnel of the service provider
- (2) Reliability: The ability to provide assured service as guaranteed correctly and reliably
- (3) Responsiveness: The willingness to provide guidance to customers along with delivering prompt service
- (4) Assurance: The acquaintance and courtesy of employees and their ability to motivate trust and confidence
- (5) Empathy: The delivery of individualized and adjusted care and attention to customers.

While the Metrology laboratory is able to identify the technical requirements of its services as these are clearly stated in their QMS and technical documents, the laboratory needs to have a better understanding of the needs of its customers. Customer requirements of calibration services can be very dynamic and are not limited to the technical requirements being considered by the laboratory. This is why this study utilized the ServQual dimensions to better identify non-technical needs of the customers. With such understanding of customer needs, the laboratory then needs to adopt its strategies, to identify which technical requirements are better suited to meet the identified customer requirements.

## 2. Objectives

This study aims to investigate strategies that the metrology laboratory can undertake in order to improve its calibration services. These strategies are identified by aligning through quality function deployment (QFD) the technical considerations of the laboratory towards the customer requirements identified from ServQual dimensions. By delving into the nuanced realm of customer expectations, this study not only equips the RML's management and calibration officers with invaluable insights but

also fosters a customer-centric culture that ensures sustained relevance and market competitiveness. Ultimately, the beneficiaries extend beyond the confines of the laboratory, as enhanced calibration services resonate positively with the broader clientele, enriching their experiences and bolstering operational excellence.

## 3. Methods

### *Site and Participants of the Study*

The study was conducted among the quality manager, calibration officers and customers of a calibration laboratory in the City of Cagayan de Oro, Northern Mindanao, Philippines. Focus group discussion (FGD) and interviews were conducted among the five (5) calibration officers and one (1) quality manager of the laboratory. The customers were located in different areas in Northern Mindanao and were reached virtually online.

### *Data Gathering Instrument*

Customer requirements were identified based on generalized ServQual dimensions and incorporated in an online survey tool. This survey was floated to customers through email. Technical requirements were identified from QMS, and other technical documents of the metrology laboratory as gathered in the FGD and interviews. QFD and elements of the House of Quality (HOQ) were identified through FGD and interviews.

### *Statistical Treatment of Data*

For ServQual, the 5-point Likert scale responses from the survey were summed up according to five (5) ServQual dimensions. The likert scale totals were multiplied with assigned weights (5-strongly agree down to 1-strongly disagree) to obtain the score of each ServQual dimension. The final score of each ServQual dimension was used to rank the ServQual dimensions as an input to the customer requirements portion of the HOQ, thus starting the QFD process.

### *Procedures for QFD*

Customer and technical requirements were analyzed in the HOQ to determine implementation priorities. The HOQ was constructed according to the steps described below:

- (1) Identify customer requirements (WHATs): This was according to ServQual dimensions as described above.
- (2) Evaluate the importance of customer requirements (WHATs): The weighted survey score

of ServQual dimensions served as the basis for ranking and weighting the customer requirements as described above.

(3) Proposed technical requirements (HOWs): The requirements were obtained from the FGD, and interviews of calibration officers and their quality manager based on the metrology laboratory's QMS and technical documents.

(4) Conduct technical requirements (HOWs) correlation analysis: In the FGD, calibration officers and their quality manager discussed and determined the correlations among the technical requirements.

(5) Construct customer requirements to technical requirements correlation matrix (WHATs and HOWs): In the FGD, calibration officers and their quality manager discussed and came up with a correlation matrix between customer requirements to technical requirements.

(6) Prioritize technical requirements (HOWs): The sum of the products of the importance of each WHAT is correlated to a HOW, and the corresponding Technical Importance Rating (TIR) for each HOW was calculated. A TIR indicates that the technical requirements (HOWs) can strongly influence customer satisfaction, and therefore is a higher priority to implement.

(7) Decide on direction of improvement: Based on their TIR, the authors recommend a direction of improvement (maximize, stay on target, or minimize) for every technical requirement (HOW). This is the basis for the strategies that the metrology laboratory shall undertake to improve the quality of its calibration services.

#### 4. Results and Discussion

This study started with a survey of Service Quality (ServQual) among the customers of the Metrology Laboratory and then proceeded with the Quality Function Deployment (QFD) to build the House of Quality (HOQ) for their calibration services.

##### *Demographics of Respondents*

The study consisted of responses from 42 participants, all customers of the Metrology Laboratory. The demographics are summarized in Table 1. Majority of the respondents are in the categories of male (64%), 25 to 35 years in age (38%), 5 to 10 years in work tenure, or assigned in marketing and sales (24%).

##### *ServQual Survey Results: Customer Requirements*

This study utilized a survey tool consisting of twenty (20) questions describing five (5) ServQual dimensions with 5-point Likert scale responses. The responses for four (4) questions under each dimension were summarized as shown in Table 2. In total, 168 responses are expected from the 42 participants answering the four (4) questions in each ServQual dimension. Around 82% to 85% of the responses are in the 'strongly agree' scale for each dimension. This means that all dimensions are relatively necessary to the customers.

The Likert scale responses are then weighted and added to determine the score of each dimension. This is shown in Table 3. When weighted, the responses show a clearer disparity between the five dimensions. With this, the ServQual dimensions are ranked from least (1) to greatest priority (5) in terms of their total score.

##### *QFD Process: Customer Requirements*

With the ServQual dimensions ranked accordingly, relative weights are assigned according to the QFD process. This is also shown in Table 3. The analysis shows that the Assurance dimension has the highest weight among the customer requirements. This dimension consists of employees instilling confidence in customers, making customers feel safe, consistently showing courteous behavior, and answering customers' questions. The Responsiveness dimension has the lowest weight. This dimension consists of employees showing prompt service, willingness to help customers, being readily available to respond, and keeping customers informed.

##### *QFD Process: Correlation of Technical Requirements*

The next QFD process is identifying correlations among technical requirements of the calibration services. This is shown in Figure 1. Among them, the 'impartiality of officers' has the lowest correlation. This means that it is not directly affecting the attainment of other requirements. 'Short lead time' has the highest negative correlations. This means that it is negatively affected when other technical requirements are not met. 'High customer satisfaction' and 'accreditation of laboratory' had the highest positive correlations meaning that these are better attained when the other requirements are met.

*QFD Process: Relationships of Customer and Technical Requirements*

The next QFD process is identifying relationships between the Customer and Technical Requirements. This is shown in Figure 2. The strongest relationships are shown by the following technical requirements: 'high customer satisfaction', 'accreditation of laboratory' and 'training of personnel'. All had four (4) strong relationships and one (1) moderate relationship. 'Maintaining environmental conditions' had the weakest relationships with three (3) weak relationships and two (2) strong relationships.

*QFD Process: Rating Technical Requirements and Identifying Directions of Improvement*

The next QFD process is rating the technical requirements. The relationships (strong, moderate,

weak) are weighted accordingly and multiplied to the relative weight of the customer requirements in order to obtain their Technical Importance Rating (TIR).

This is summarized in Table 4. 'high customer satisfaction' and 'training of personnel' had the highest TIR at 820 while 'Maintaining environmental conditions' had the lowest TIR at 367. The relative weight of their TIR is used to identify the directions of improvement, shown also in Table 4. 'Maximize' is recommended for 'high customer satisfaction', 'accreditation of laboratory' and 'training of personnel' while 'Minimize' is recommended for 'maintaining environmental conditions'. The full house of quality (HOQ) is presented in Figure 3.

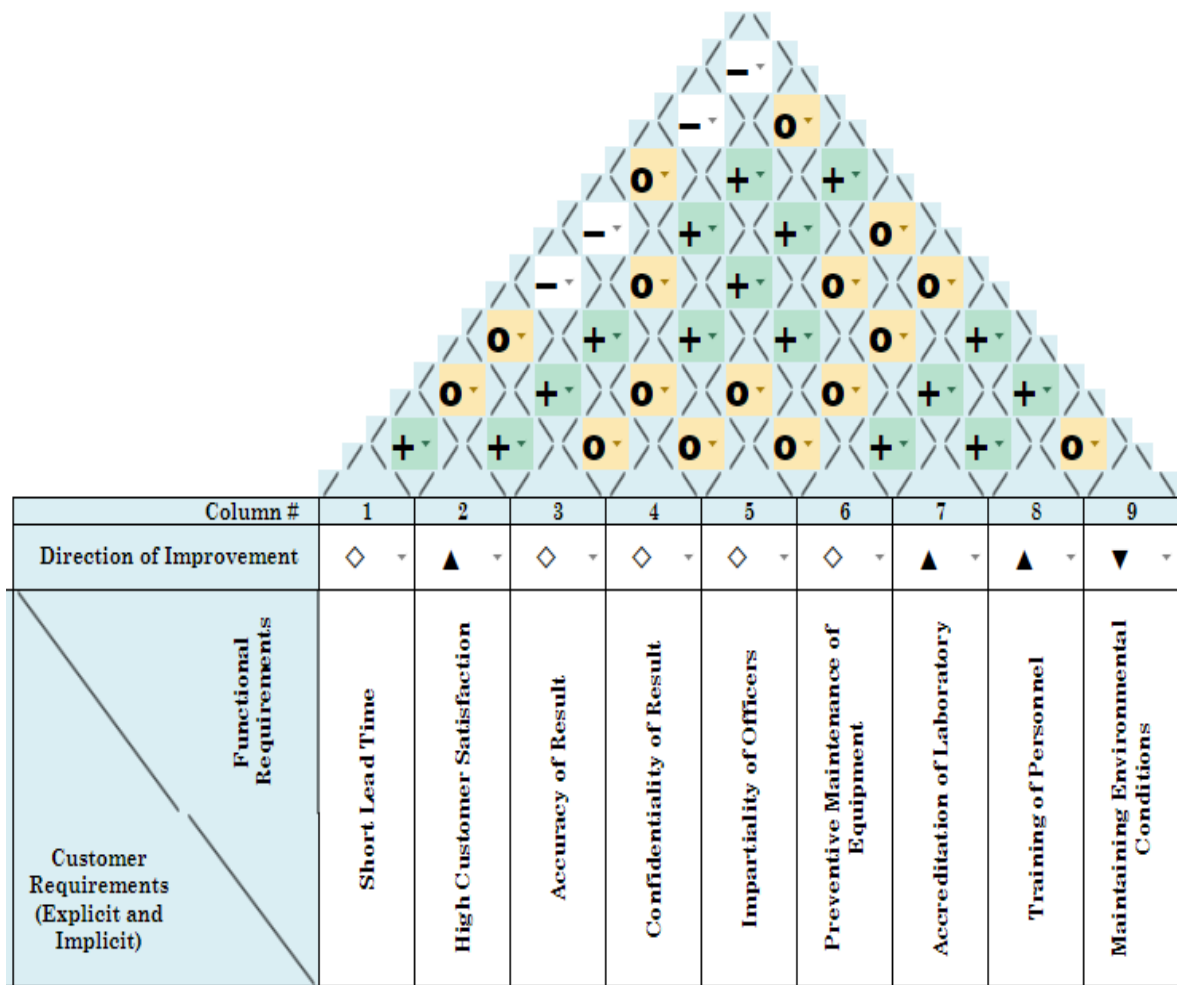


Figure 1. Correlation among technical requirements

Customer Requirements (Explicit and Implicit) \ Functional Requirements	Short Lead Time	High Customer Satisfaction	Accuracy of Result	Confidentiality of Result	Impartiality of Officers	Preventive Maintenance of Equipment	Accreditation of Laboratory	Training of Personnel	Maintaining Environmental Conditions
<b>Tangible</b> (Visually appealing facilities, professional appearance, well maintained equipment, modern technology)	○ ▾	○ ▾	● ▾	▽ ▾	▽ ▾	● ▾	● ▾	○ ▾	● ▾
<b>Reliability</b> (Performing services correctly, correctness and accuracy of results, services delivered as expected, handling customers' service problems)	● ▾	● ▾	● ▾	○ ▾	○ ▾	● ▾	● ▾	● ▾	● ▾
<b>Responsiveness</b> (prompt service, willingness to help customers, readily available to respond, keeping customers informed)	● ▾	● ▾	▽ ▾	○ ▾	● ▾	○ ▾	● ▾	● ▾	▽ ▾
<b>Assurance</b> (employees instill confidence in customers, making customers feel safe, consistently courteous behavior, employees answer customers' questions)	○ ▾	● ▾	● ▾	● ▾	● ▾	○ ▾	● ▾	● ▾	▽ ▾
<b>Empathy</b> (giving customers individual attention, convenient operating hours, prioritizing customer's best interest, understanding customers' specific needs)	● ▾	● ▾	▽ ▾	○ ▾	○ ▾	○ ▾	○ ▾	● ▾	▽ ▾

Figure 2. Relationships of Customer and Technical Requirements

Table 1. Summary of Demographics of Respondents

Demographic	Type	Frequency	Percentage, %
Gender	Male	27	64%
	Female	15	36%
	<b>Total</b>	<b>42</b>	<b>100%</b>
Age	18-24 years old	5	12%
	25-34 years old	16	38%
	35-44 years old	13	31%
	45-54 years old	5	12%
	55-64 years old	3	7%
	<b>Total</b>	<b>42</b>	<b>100%</b>
Tenure	0-2 years	12	29%
	2-5 years	10	24%
	5-10 years	14	33%
	10-15 years	3	7%
	15-20 years	2	5%
	20+ years	1	2%
<b>Total</b>	<b>42</b>	<b>100%</b>	
Work Assignment	Accounting and Finance	2	5%
	Government Laboratory	7	17%
	Government Office (Non-Laboratory)	3	7%
	Human Resources	6	14%
	Marketing and Sales	10	24%

Demographic	Type	Frequency	Percentage, %
	Production, Repair and Maintenance	8	19%
	Quality Control and Assurance	4	10%
	Research and Development (R&D)	2	5%
	<b>Total</b>	<b>42</b>	<b>100%</b>

**Table 2. Frequency of Responses for ServQual Dimensions**

Service Quality Dimension	Strongly Agree (SA)	Agree (A)	Don't Know (DK)	Disagree (D)	Strongly Disagree (SD)	Total
Tangible	138	16	6	4	4	168
Reliability	138	17	5	4	4	168
Responsiveness	137	14	9	5	3	168
Assurance	142	13	5	4	4	168
Empathy	140	15	5	5	3	168

**Table 3. Weights of Responses and ranking of ServQual Dimensions**

Service Quality Dimension	(SA)	(A)	(DK)	(D)	(SD)	Weighted Total	Rank
Tangible	690	64	18	8	4	784	2
Reliability	690	68	15	8	4	785	3
Responsiveness	685	56	27	10	3	781	1
Assurance	710	52	15	8	4	789	5
Empathy	700	60	15	10	3	788	4

**Table 4. Summary of Technical Importance Rating and Directions of Improvement**

Functional Requirements	Product Targets	Technical Importance Rating (TIR)	Relative Weight	Direction of Improvement
Short Lead Time	Calibration results available after 5 working days	620.00	11%	Target
High Customer Satisfaction	above 95% Overall Customer Satisfaction	820.00	15%	Maximize
Accuracy of Result	Proficiency testing for calibration method passed	633.33	12%	Target
Confidentiality of Result	Results received by customer or authorized representative only	473.33	9%	Target
Impartiality of Officers	Coding system of samples maintained	513.33	9%	Target
Preventive Maintenance of Equipment	PM of each equipment conducted annually	500.00	9%	Target
Accreditation of Laboratory	ISO 17025:2015 accreditation maintained	740.00	13%	Maximize
Training of Personnel	All officers trained annually	820.00	15%	Maximize
Maintaining Environmental Conditions	Ambient Temperature and Relative Humidity maintained	366.67	7%	Minimize

### Conclusions and Recommendations

In terms of customer requirements, the Assurance dimension has the highest weight. This dimension consists of employees instilling confidence in customers, making customers feel safe, consistently showing courteous behavior, and answering customers' questions. The author recommends the calibration officers of the Metrology Laboratory to consider keeping the customers assured not just in terms of procedure, methodology and results but also in communicating and keeping them safe and assured of the quality and results of the calibration services.

The Responsiveness dimension has the lowest weight. This dimension consists of employees showing prompt service, willingness to help customers, being readily available to respond, and keeping customers informed. While on the lowest priority of the customers, the author recommends the calibration officers to continue the delivery of this and other aspects, as the ServQual dimensions complement one another.

From the QFD, 'Maximize' is the direction of improvement recommended for 'high customer satisfaction', 'accreditation of laboratory', and 'training of personnel'. This means that more effort and attention should be directed toward attaining and maintaining these requirements. This is consistent with the QMS of the laboratory.

'Minimize' is the direction of improvement recommended for 'maintaining environmental conditions'. This means that less effort and attention may be directed by calibration officers toward this requirement. This can be achieved by automating the monitoring and control of environmental conditions.

By following the said directions for improvement, the metrology laboratory will be able to satisfy the assurance dimension as well as other quality dimensions of the calibration services it provides to its customers.

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QFD: House of Quality

Project:	Metrology Laboratory
Revision:	1
Date:	11 June 2015

Correlations	
Positive	+
Negative	-
No Correlation	o

Relationships	
Strong	•
Moderate	o
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

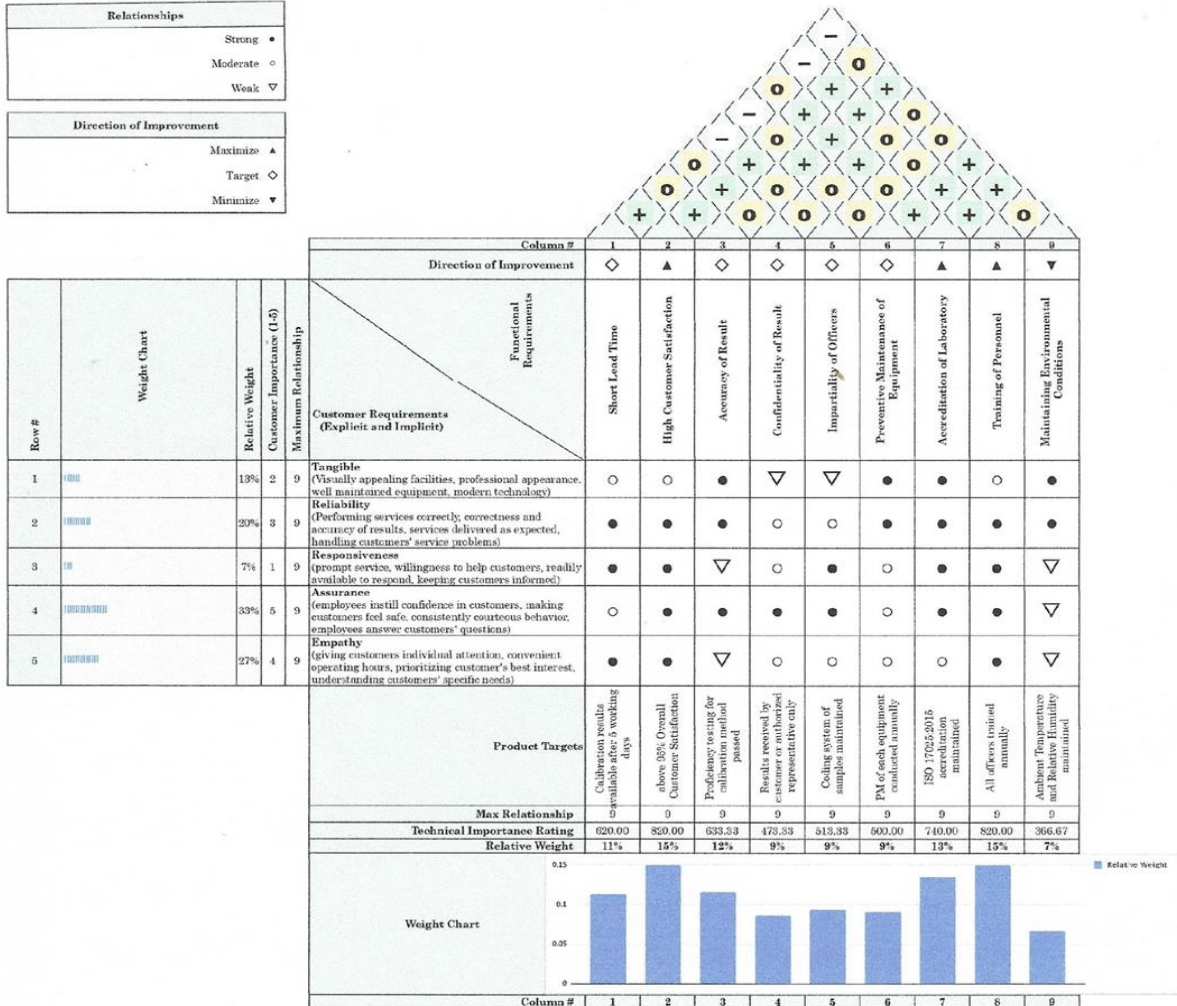


Figure 3. Full House of Quality (HOQ)