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APPLICATION OF QFD AS A QUALITY TOOL: STUDY CASE IN THE SERVICES SECTOR

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Paulo Vinicius Meireles[1]
Ms Elizabeth Zanetti[two]

Summary

This article presents the application of QFD as a quality tool in the services provided in a Driving School, aiming to meet the needs of its customers. The QFD (Quality Function Deployment) method proved to be effective in quality planning in identifying possible non-conformities in your business processes and solving them using quality tools such as: Pareto Diagram, Checklists, among others. To this end, simplifications were made to the original QFD methodology based on the literature researched and the practical knowledge of the authors. The methodology used for this case study was: qualitative research (interviews with the company administrator) and quantitative research (application of customer satisfaction survey questionnaires) in a total sample of 90 students, distributed in: (30) for company researched and (60) in companies meet customers' wishes. The company, therefore, is interested in providing constant improvement in its service levels in order to have a competitive advantage. **Key words:**QFD. Quality. Services. Quality tools.

Abstract

This article presents the application of QFD as a quality tool in the services provided in an Auto school, aiming to meet the needs of its customers. The QFD (Quality Function Unfolding) method proved effective in quality planning in identifying possible non-conformities in your business processes and solving them using quality tools such as: Pareto Diagram, Checklists, among others. To this end, simplifications were made in the original methodology of the QFD based on the literature researched and on the practical knowledge of the authors. The methodology used for this case study were qualitative research (interviews with the company administrator) and quantitative research (application of customer satisfaction survey questionnaires) in a total sample of 90 students, distributed in: (30) for the researched company

[1]Postgraduate (Specialization in Production Engineering) – UNINTER – International University Center, Bachelor in Information Systems – FADILESTE.
[two]Master in Production Engineering UFSC, Specialist in HR Psychology-UNICAMP, Bachelor in Business Administration-FESP. Specialist/EAD. Adjunct Professor at UTP. TCC advisor FAEL, UNINTER and UFTPR.

and (60) in companies X and Y. After the application of the QFD, it was possible to verify what qualities were demanded, the company's quality characteristics, procedures, and priority resources, as well as proposed quality improvement actions to meet customers' needs . The company, therefore, is interested in providing constant improvement of its service levels to have a competitive differential.
Keywords:QFD. Quality. Services. Quality Tools.

1. Introduction

The competitiveness that exists in the market today forces companies to improve their products and services, seeking their quality and implementing techniques and methods that can achieve the organization's strategic objectives. This article will demonstrate Quality Management techniques specifically the method, concepts, origin, benefits and results of using QFD[3].This methodology aims to unfold the**Required Quality**of customers (Listen to the voice of the customer) and translate into**Quality Characteristics** by**Quality Matrix**, where the criteria of customer needs are related to the specific attributes of the company's product/service through the**Relationship Matrix.**The entire method will be seen in the next sections of this article.

The research problem is summarized in the following question: How to improve the customer satisfaction index in the services provided by the company under study? Then a Case Study was carried out at the company CFC[4]GOOL using Product Engineering: QFD, seeking to listen to the customer's voice and convert this voice into planned quality in order to achieve a level of quality in the services provided. The objective of this article is to evaluate and improve the level of customer satisfaction in relation to the services provided by the company compared to direct competitors, where the level of competitiveness is high, so that the company that best meets their needs wins customer preference. This study helped the company to implement a quality policy in its business processes. The methodology used in this article was exploratory field research in which the data collection instruments used were: Survey questionnaires student satisfaction, using the Likert scale (scale from 1 to 5) in the company under study and in Companies X and Y in a total sample of 90 students. Another form of data collection was an interview with the company administrator. Quantitative (statistical) analysis was used to list the non-

[3]QFD - from English*Quality Function Deployment*
[4]CFC – Driver Training Center – “Autoescola”.

compliance in the selected criteria. By applying the QFD method, the company will be able to improve its level of quality of services provided to its customers.

2 Quality function deployment (QFD)

In a globalized, accelerated and competitive scenario, with rapid technological changes, a marked reduction in the life cycle of products and growing consumer demands, companies began to develop methods and techniques that allowed them more agility in response time and increased productivity. , development of products with high quality, total customer satisfaction and lower cost, in this context the QFD method emerged as a tool capable of promoting efficiency[5] and effectiveness[6] in the development of products and services. This article will describe a case study in a service company with the applicability of QFD for continuous improvement of its business processes.

2.1 Origin of QFD

The origin of QFD began in Japan in the late 1960s, by professors Akao and Mizuno. Dr. Yoji Akao and other quality experts in Japan developed the QFD technical tools and organized them into an easy-to-understand structure, i.e. in the form of diagrams and matrices, applied in the product/service development process to ensure the quality and that satisfies the end consumer.

In Brazil, "QFD was introduced through an article by Akao and Ohfuji (1989) presented at *International Conference of Quality Control*, held in Rio de Janeiro" (MIGUEL, 2008). With the dissemination of this new methodology, Brazilian companies began to implement it in their quality systems, with the aim of developing new products and services and incorporating it into their organizational strategy. QFD has proven to be very effective and efficient and brings immense benefits in product development planning: with the lowest cost, less development time and reducing the risks of rework with project modifications, reduces warranty costs, reduces initial production costs

[5] Efficiency: is a measure of the use of resources in this process
[6] Efficiency: is a measure of the achievement of results

and incorporates a project knowledge base by introducing the voice of the customer into the development process. See table 1 for some companies that use QFD.

TABLE 1 -*Some Companies that use QFD*

Brazil	USA	Japan
Alvin Meritor	3M	Mitsubishi
BrasilPrev	Apple	Hitachi
Fiat	Ford Motor Company	Nissan
Sadia	General Motors	Pioneer
Springer Carrier	IBM	Ricoh
Votocel	Intel	Shimizu Construction
Weg	Xerox	Tokyo Electric Power

Source: (MIGUEL, 2008, p.63).

2.2 Definitions

The QFD methodology (*Deployment of the Quality Function*) according to Akao (1990) apud Carpinetti (2012, p.106) consists of the

> Conversion of consumer requirements into product quality characteristics and the development of design quality for the finished product through systematic breakdowns of the relationships between consumer requirements and product characteristics. These developments begin with each component or process. The overall quality of the product will be formed through this network of relationships.

The concept of QFD for other authors such as Rodrigues (2014, p.41) "is a technique that seeks to identify, define and ensure the quality of the product/service according to the consumer's desire".

For Cheng, Melo Filho (2010, p.44) QFD is conceptualized as

> A way of systematically communicating information related to quality and of orderly explaining work related to obtaining quality, aims to achieve the focus of quality assurance during product development and is subdivided into Quality Deployment (QD) and Quality Deployment. Quality function in the strict sense (QFDr).

The deployment of quality seeks to translate and transmit the information necessary for the development or improvement of products (goods and services) that meet consumer needs and requirements, through systematic deployments, starting with determining customer requirements and ending in designed quality. In summary, QFD is based on matrices, the process begins with the identification of*requirements*

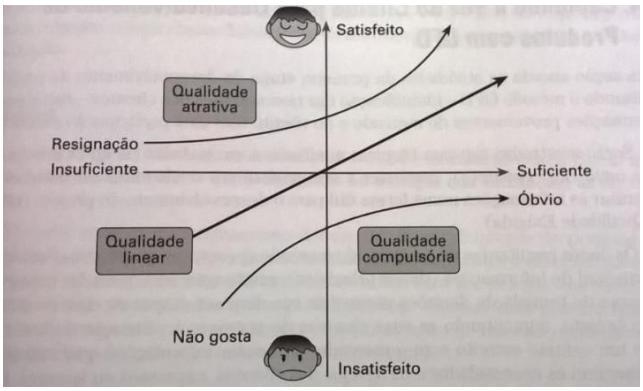
of customers("what the customer wants and the order of importance of the requirements) and translate it into *quality characteristic*("as" product specifications) and perform the interrelationship between the tables, thus forming the*Relationship Matrix*. And the next step is to analyze the competition (*Planned Quality*) and finally arrive at the result of *Engineered Quality*. This technique will be detailed more clearly in section 2.3.1.

And to conclude, two other important concepts are: what is a**Product or Service.** "A product is something that can be offered to a market to satisfy a need or want. Products include physical goods, services, people, organizations, information and ideas" (SELEME, PAULA, 2012, p.26). While "The service comprises any act or performance, essentially intangible, that one party can offer to another and that does not result in the ownership of anything" (SELEME, PAULA, 2012, p.28).

2.3 The QFD method

In this section, the construction and elaboration of the QFD method will be addressed, through the Quality Matrix, which is the basic tool for determining the quality of the product/ service project in which it will be developed by the multidisciplinary project team. Before starting with the 1st stage of building the Quality Matrix, we will describe a model developed by**Kano** where there is a relationship between customer satisfaction and the level of performance of the product or service.

Figure 1 –**Kano Model:**Relationship between customer satisfaction and product performance level.



Source: Cheng, Melo Filho (2010, p.101).

In this Model, Prof. Noriaki Kano and his collaborators identified a relationship between customer satisfaction and the level of product performance, as perceived by customers, let's see the classification according to Cheng and Melo Filho (2010, p.100):

> Linear quality items: these are the quality items that bring greater satisfaction to customers, as the level of product performance increases, that is, they are the items that bring satisfaction to customers when they achieve sufficiency in performance, while their absence or insufficiency brings dissatisfaction. Items of obvious, compulsory or mandatory quality: These are quality items considered obvious, when performance is sufficient, but their absence or insufficiency causes dissatisfaction. They are related to the basic needs of customers who assume that the product satisfies them. Attractive quality items: these are quality items that, even with insufficient performance, are accepted with resignation by customers, in a "no way" way. However, sufficiency or presence brings great satisfaction. They are related to needs that, if satisfied by the product, would surprise and delight customers.

With this analysis we will be able to evaluate the real needs and desires of customers in relation to the perception of quality in the product/service. For example, in the recent past a cell phone was considered an item of attractive quality, because due to its cost, few had them. Over the years, with the growth of technology, cell phones have evolved into digital models with Internet access (some had it and some didn't), making it a linear quality. Today, practically all models have Internet access and social networks, making it an obvious quality for the consumer. Figure 2: Evolution of the quality required by customers in products.

Source: Author (2015).

2.3.1 The Quality Matrix

The Quality Matrix is a type of visual diagram that serves as a tool for the successive breakdown of quality requirements in the product/service development project, in other literature (it is also called the*House of Quality*). According to Carpinetti (2012, p.107)

> The quality matrix can be defined as the matrix that has the purpose of executing the quality project, systematizing the true qualities required by customers through linguistic expressions, converting them into substitute characteristics and showing the correlation between these substitute characteristics (characteristics of quality) and those true qualities.

The quality matrix works as a complete system, where the input is to listen to the voice of the customer through interviews and questionnaires, that is, the conversion of requirements demanded by customers (considering the degree of importance) transforming them into quality characteristics (extraction characteristics into requirements); identifying relationships between customer requirements and quality characteristics; and the conversion of relative weights of requirements into relative weights of characteristics. The output of the system is the projected quality, with the technical characteristics of the product.

Figure 3: Quality Matrix - view of the elements that constitute it. Source: Author (2015).

Next, 7 steps will be demonstrated for building the QFD quality matrix and its respective elements.

1: Customers' requirements-These are customers' linguistic expressions converted (qualitatively) into real needs. They must be obtained from market research and technical publications (interviews, questionnaires). However, requirements are not always obtained directly from customers and can be generated within the company itself.

2: Define the degree of importanceof each requirement for the customer, based on a pre-determined numerical scale (1 to 5), which can be relative or absolute through customer surveys.

3: Quality characteristics–Define the project requirements (product/service) through the company's internal technical details, that is, "How" product specifications.

4: Correlation matrix-It is the ceiling of the quality matrix. This matrix crosses the quality characteristics with each other, always two by two, allowing us to identify how they relate to each other. These relationships can be mutually supportive when the favorable performance of one characteristic helps the favorable performance of the other characteristic, or favorable conflict of one characteristic undermines the favorable performance of the other characteristic. Consider 4 levels of relationship: strong positive, positive, strong negative and negative.

5: Relationship matrix–Identify the relationship between customer requirements and project requirements through correlation of variables that must be carried out by internal technicians responsible for the project. Consider 3 levels of the relationship: strong, medium and weak. (Between "How?" and "What?").

6: Planned Quality–It is divided according to table 1:

Table 1 - Planned Quality

evaluation of performance	***Our company/ Company X/ Company Y.***	It is quantitative market research that seeks to identify how customers perceive the performance of the company's current product, compared to its main competitors. This will serve as a basis for analyzing the "scores" of competing products and for projecting the quality of the product under development. Use the same rating scale (1 to 5).
Planning **improvement**	***Plan quality***	It is planning the performance of the product under development, for each customer requirement. According to Cheng, Melo Filho (2010) "it is to establish the required quality plan. It is a numerical value that must have the same scale that was used to evaluate the degree of importance of each customer requirement" expressed by a note on the scale (1 to 5).
	Index of Improvement	"Based on the definition of the quality plan, the improvement index is the way to insert the company's intention into the final importance of the requirements (absolute and relative weight), that is, the company's strategic plan" (CARPINETTI, 2012). To calculate this index, it is the division between the value (score) of the Quality Plan (desired performance for the product) by the value of Our Company (Effective performance of the current product), that is, it reflects how many times the product needs to improve its performance, in relation to the current product, to achieve the planned situation.
	Argument from Sale	"It is a consideration made by the company, especially by the commercial area, on the appeal that a certain requirement presents to enhance the acceptance and sales of the product" (CARPINETTI, 2012). The weights are assigned: strong sales argument (1.5), average sales argument (1.2) and no argument (1).
	Absolute Weight	This weight is determined by multiplying: Degree of Importance X Improvement Index X Sales Argument. It represents the priority of meeting each requirement under the logic that improvement efforts must be concentrated on three points: the most important requirements, the requirements that are in line with the company's strategy and the requirements that the company needs to improve significantly.

Weight	***Relative Weight***	This weight is determined by converting the absolute weight into a percentage (%), by dividing the absolute weight of each requirement by the result of the sum of all absolute weights. Relative weights are intended to facilitate quick perception of the relative importance of requirements.

Source: Author (2015).

7: Designed Quality:

2.3.1.1*Absolute Weight:*The calculation is used to convert the relative weights of qualities required for the absolute weights of each item of quality characteristics is as follows:

Add in column the product between the relative weights of the required qualities and the respective online values of the correlations identified for the quality characteristic items. In other words, multiply the correlations by the relative weights of the qualities required per row of the matrix, and add this product per column.

2.3.1.2*Relative Weight:*The following formula is used to calculate the relative weights of quality characteristics:

Relative weight= Absolute weight

(Sum of all absolute weights)

2.3.1.3 Competitive technical assessment:

The process of measuring and comparing the values of the quality characteristics of the company's current product compared to competing products allows an analysis of the technical performance of current products on the market to be carried out. The values obtained are organized and arranged in the Projected Quality of the Quality Matrix (CHENG, MELO FILHO, 2010).

The value of the quality characteristic of the company's current product must then be measured (define the current position). When the company develops a new product, this field in the matrix may be left blank, and must be filled in during the prototyping process.

Next, the value of the quality characteristics of competitor products must be measured and a comparative analysis carried out with our product.

2.3.1.4 Performance Target

To define these target values, the following must be analyzed: the correlations of quality characteristics with the required quality items; the weights assigned

to quality characteristics items; comparisons made between current values and those of the competition; the company's technological capacity; the necessary costs and project objectives (CHENG, MELO FILHO, 2010).

2.4 Benefits and Results of QFD

The QFD methodology provides many benefits and positive results in the development of products/services for the organization, among the benefits we can mention, according to Miguel (2008, p.64):

- Reduction in the number of design changes;
- Reduction of customer complaints;
- Greater market share;
- Reduction in development time by an average of 30%;
- 20% reduction in initial production costs for new products;
- Increased communication between departments and functional areas of the organization;
- Construction of knowledge base due to the registration process and documentation;
- Greater customer satisfaction.

3 Case study

3.1 Preliminary analysis

The case study presented in this article was carried out at the company ***CFC Gool*** (Driving School) located in the city of Ibatiba/ES, operating in the market for 10 years, has a current staff of 10 employees and a fleet of 08 vehicles see (**Appendix F**). The company provides services in the region with a difference recognized by its customers (students), in vehicle driving training, refresher courses, 1st license, category change, among others. Seeking to improve the quality level of its services, the company, through its owner Mr. Silas Gonçalves Amorim (Administrator), kindly contributes with this article, to identify the real needs of its students.

The methodology used to collect data was questionnaires applied to a sample of 90 students, carried out between the months of April/May 2015:

3.1.1 Questionnaires to assess the degree of satisfaction with the services provided to their customers students, see the model in**Appendix A;**

3.1.2 Direct interviews with the company administrator to list the criteria (primary requirements) of services.

The results of this research carried out with students can be seen in the **Appendix B,**in which a data spreadsheet was built in MS Excel to collect data with statistical analysis. The quality tool used in question was the**Verification list,** which according to Rodrigues (2014, p.32) "Aims to serve as support for the definition and tabulation of data from a sample observation, identifying the frequency of previously selected events".

Table 2 shows the results of the analysis carried out in the data sheet of the**Appendix C,**in which the first 3 criteria are the most critical: Content of the booklet, Promptness when clarifying doubts and Teaching Instructor in practical classes, are those that presented the greatest number of non-conformities in relation to the goal desired by the company. An analysis, for example, the criterion*Instructor teaching in practical classes*needs to improve in relation to the company's target by 21% (Improvement index). With these results, the organization will need to plan, control and act to improve the processes analyzed in question. Table 2 shows the results of the analysis carried out in the data sheet of the**Appendix C**. In which the accumulated frequency (Fr) and the accumulated frequency in % were calculated.

Table 2 - Non-compliance rate

	Criteria	Qty. no conformity	Frequency Accumulated (Fr)	Frequency Accumulated (%)
A	Booklet content	23	23	14.02%
B	Promptness when clarifying doubts	23	46	28.05%
W	Instructor teaching in practical classes	20	66	40.24%
D	Assessment System / Simulations	16	82	50.00%
AND	Comfort and Suitability of Facilities	15	97	59.15%
F	Material used in the Classroom	14	111	67.68%
G	Course Price	10	121	73.78%
H	Instructor/Student Interaction	8	129	78.66%
I	Instructor Teaching in the Classroom	6	135	82.32%
J	Other reasons	29	164	100.00%
	Total (n):	**164**		

Source: Author (2015).

The result in table 2 is shown in**Pareto Diagram**[7]"Its main objective is to explain the priority problems of a process through the 20/80 relationship (20% of

[7]"The Pareto Principle is demonstrated through a vertical bar graph (Pareto Chart) that arranges information in a way that makes the order of importance of problems, causes and themes in general clear and visual" (CARPINETTI, 2011, p.80).

causes explain 80% of problems" (RODRIGUES, 2014). We concluded that 82.32% of non-conformities originate from 9 causes (A to I).

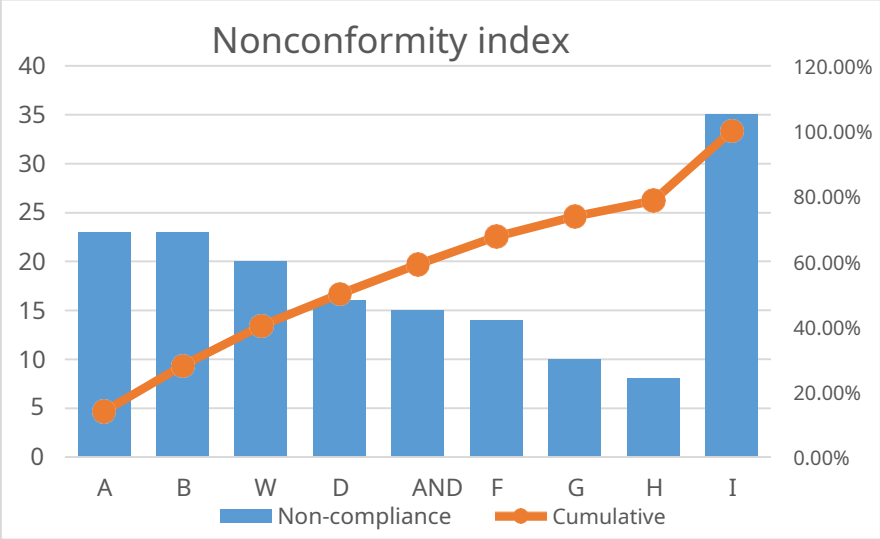


Figure 5: Pareto Chart: Non-conformity rate.
Source: Author (2015).

3.2 Customer satisfaction index

In this section we will analyze the student satisfaction index in the company**CFC Gool** compared to its competitors**Companies X and Y**. According to the results obtained, see**(Appendix D)**By applying questionnaires to companies, we can identify which company best satisfies its customers in relation to the primary requirements. According to Rodrigues (2014, p.103)**Client**"is a person or organization that is the beneficiary or user of a product (good or service, for financial or other return, produced by a supplier". And the concept of **Customer Satisfaction**"is the feeling of pleasure, comfort or disappointment resulting from the perception of the benefits of the product, good or service compared to what was expected" (RODRIGUES, 2014, p.103). The scale used in the research is known as**Likert Scale** where the degree varies between 1 (very dissatisfied) to 5 (very satisfied). Figure 6 shows the result of the satisfaction index with 90 students with a total of 1710 questions answered between the companies.

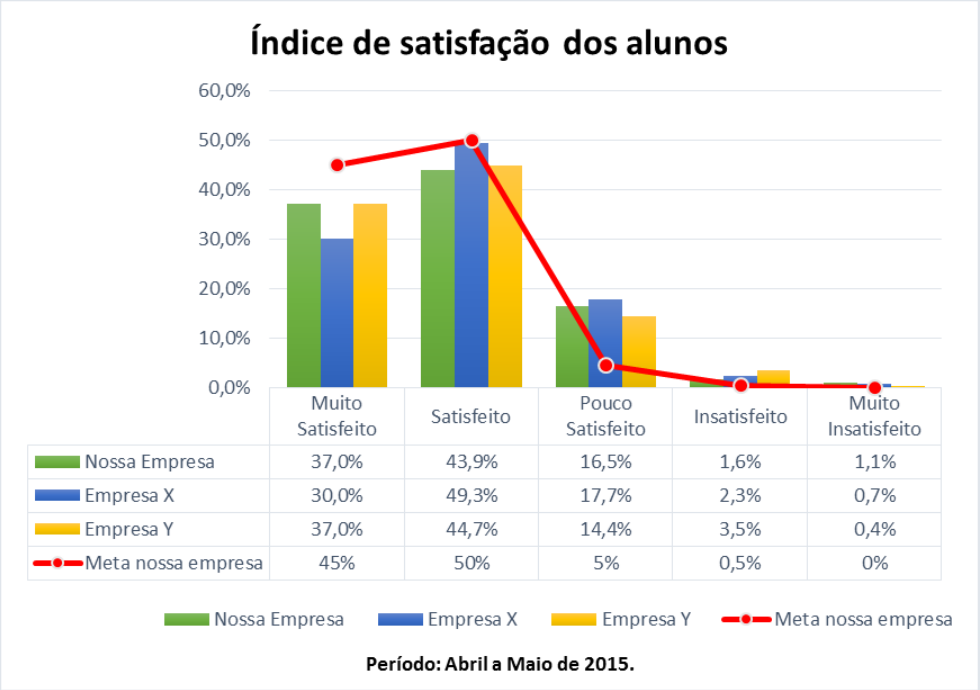


Figure 6: Graph: Student satisfaction index. Source: Author (2015).

3.3 Application of the QFD Method

The QFD quality tool used in the case study company proved to be efficient in analyzing the students' original requirements and converting them into required quality with the degree of importance of each requirement attributed by the students in the research, that is, through developments of the original data in the required quality (Scene). Table 3 shows the result of the analysis of the translation of the customer's voice into required quality.

Table 3 – Customer Requirements

Original data			Required quality	Degree of Importance
Level 1	Level 2	Level 3	Scene Level 4	
1. Administrative	1.1 Reception		1.1.1 Promptness in student service	**4**
			1.1.2 Clarity in the information provided	**4**
	1.2 Financial		1.2.1 Course fee	**4**
			1.2.2 Payment methods	**3**
2. Facilities Physics	2.1 Company		2.1.1 Location and access	**3**
			2.1.2 Comfort and suitability	**4**
	2.2 Classroom		2.2.1 Environment with a pleasant temperature	**3**
			2.2.2 Environment with good lighting	**4**
			2.2.3 Quiet environment	**4**
			2.2.4 Good sound environment	**3**
3. Effective teaching			3.1.1.1 Instructor conveys the subject well	**5**

	3.1 Class theoretical	3.1.1 Good instructor	3.1.1.2 Instructor clarifies doubts well	**5**
			3.1.1.3 Instructor interacts well with students	**4**
		3.1.2 Material didactic	3.1.2.1 Easy-to-use and understandable material	**4**
			3.1.2.2 Material used in classroom presentations	**4**
			3.1.2.3 Easy-to-use and understandable assessment and simulation system	**3**
	3.2 Practical class		3.2.1 Instructor teaches efficiently	**5**
			3.2.2 Instructor clarifies doubts during traffic	**5**
			3.2.3 Flexibility in class schedules	**3**
			3.2.4 Good quality vehicles (Cleaning, safety and maintenance)	**4**
			3.2.5 Instructor with good professional qualifications	**4**
			3.2.6 Teaching methodology	**5**

Source: Author (2015).

For Cheng,Melo Filho (2010, p.110) The translation of the customer's voice into the required quality is “obtained from customers through market research, or by other means, producing a large amount of information that is called original data or primitive information ”. With this preliminary analysis we can build the quality matrix, which will have all the information necessary for the process of improving the quality of services provided by the company. See on**Appendix E**The***Quality Matrix***complete version of the company CFC Gool.

The result of the quality matrix provides us with more details in the**(APPENDIX E)**, which quality items required by customers are priorities for the quality expected by the company's services. And through these requirements, the items of service quality characteristics were obtained for quantification and the correlation between the two tables and the following conclusion was reached:

1.*Ranking Quality required by priority customers (“What”):*1st position (Material is easy to use and understand – relative weight 9.2%), 2nd (Course value – 7.3%) and 3rd (Instructor teaches efficiently – 6.9%). These items are the priorities that students require from the services provided by CFC Gool with the expected quality.

two.*Ranking Priority Quality Characteristics (“How” – Company):*1st (Index of student approval – Relative weight 9.9%), 2nd (No. of enrollments/month – 8.6%) and 3rd (No. of students enrolled in the period – 8.4%). These items of quality characteristics that need to be prioritized to better meet the quality requirements demanded by students, comparing the existing correlations between “What?” It is like?".

3. *Technical Benchmarking Analysis (Competitive Assessment):*These indices were measured in the 3 companies based on interviews and historical data, and through the Improvement Plan (Goal), a comparison was made between their values, and it was concluded that how much Our company needs to improve to achieve the company's goal quality of services, and be more competitive, have credibility and profitability. Figure 7 shows the result of this analysis.

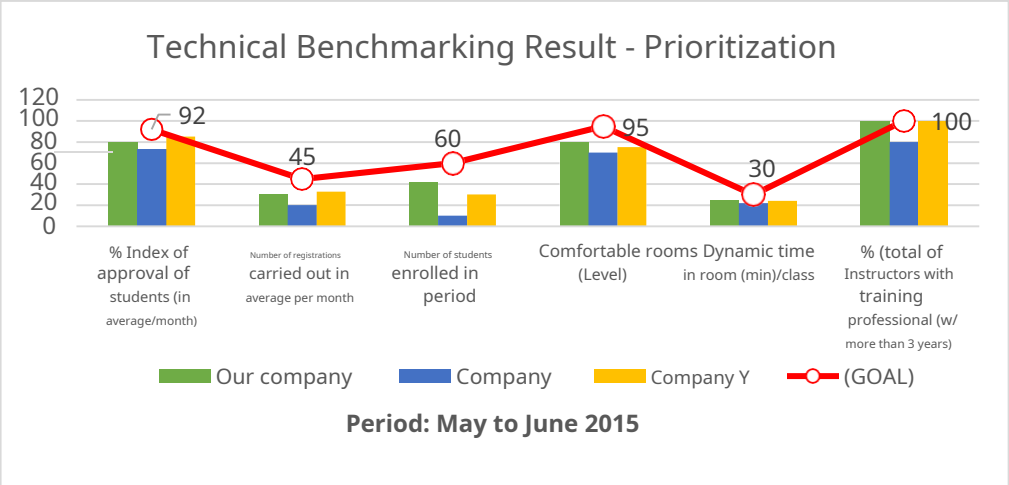


Figure 7: Graph: Competitive Benchmarking Result. Source: Author (2015).

3.4 Strategic action plan

The Action Plan is a planning of all the actions necessary to achieve a desired result, that is, a goal. The objective of the plan is to identify and relate existing activities, so that strategic decision-making is quick and effective in solving problems. The 5Ws tool[8]and 2Hs[9]what

> It involves the use of questions (prepared in English) that begin with the letters W and H. The questions aim to generate answers that clarify the problem to be solved or that organize ideas in problem solving (SELEME, STADLER, 2012 , p.42).

At the**Appendix F**The 5W2H Action Plan of the company CFC Gool is demonstrated in detail, which after the results of the analysis of the application of the QFD method, it is concluded that it is necessary to implement quality control and prioritize the most important requirements (with greater relative weight) to satisfy the real needs of customers.

[8]**5Ws: W**hat (What?),**W**ho (who?),**W**hen (when?),**W**here (where?),**W**hy (why?).
[9]**2Ws: H**ow (how?),**H**ow Much (how much?).

Final considerations

The purpose of this article was to provide the implementation of the QFD methodology in a company in the service sector, which, after studying and applying the method, managed to achieve the company's strategic objectives, with improvements in quality and customer satisfaction. Achieving greater competitiveness, credibility, market recognition in the segment, reduced costs and increased profitability. The results of improving service quality can be seen in the**(APPENDIX E - F)**with greater detail and clarity.

For future work, complementary to the application of QFD in CFC Gool services, The following is recommended: Carrying out a feasibility study of the suggested improvement plans, in order to effectively execute the plan; Monitoring carried out by all employees, in relation to the suggested quality characteristics; Update the company's QFD Matrix in order to compare performances; Application of QFD focused on just a group of customers considered priority (focus) by CFC Gool.

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