# EVALUATION AND CONTINOUS IMPROVEMENT OF MECHANICAL ENGINEERING PROGRAM USING THE QUALITY FUNCTION DEPLOYMENT TOOL

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***Abstract.*** *This work intends to show the possibility and the efficience in the evaluation quality of the teaching processes using an engineering tool, in this case the Quality Function Deployment "QFD" aiming to provide resources to design of improvement on the institution. The case study of the adaptation will be basic on an mechanical engineering discipline in the desingn area of the Polytechnical School at the São Paulo University, PME-2421 Machine Elements, in which we will see the potenciality of the tool application to the teaching process as a service activity. These results led us to know better where we should invest in order to improve the general quality of the studied subject, avoiding unnecessary investment or expenses.*

***Keywords****: Quality Function Deployment, QFD, Teaching Quality, Total Quality*

## 1. Introduction

The Quality Function Deployment was developed in Japan in the late sixties when Japanese industry, just after the second world war, started to grow stronger. The QFD started then in this environment with the concept or method to the development of new products with Total Quality (TQM). At introduction of QFD in USA and Europe during the eighties, it was taken from the Japanese industry and soon improved and applied to the services and industries under intense competition.

In the early nineties H. Brian Hwarng and Cynthia Teo started to propose QFD in educational processes. Three categories of applications were proposed. At first to improve the administration efficiency and customer satisfaction (Clayton, 1993; Jaraiedi and Ritz, 1994; Lam e Zhao, 1998; Montwani 1996; Pitman, 1995). The second was dedicated to educational and engineering design of curricular plans using ideas of Total Quality Management (TQM) and QFD (Benjamin e Pattanapanchai, 1993; Chang e Ku, 1995; Koksal e Egitman, 1998; Krishnan e Houshmand, 1993; Owlia e Aspinwall, 1998; Rosenkrantz, 1996; Seow e Moody, 1996). The third application of the QFD was in the strategies in the research. In this step three items are evaluated, the student, the university and the industry.

## 2. Objective

The main objective of this work is to develop a methodology for the evaluation and the continuous improvement of the quality in a program of mechanical engineering. As a test for the methodology a discipline was chosen, in this case a course of machine elements.

## 3. Definitions

Evaluation of quality in universities, aiming to improve the educational process as a whole, creates some challenges. This occurs because of various reasons such as the "product" (education) will be use by the students for a very long time (mostly for the duration of their professional life); the "objectives" of both students and teaching institutions are not always clear; the parameters of measurements many times are subjective and difficult to quantify; the results might not be immediate and the students have different profiles and also it is not very common to have institutions that certify the quality in education.

Thus the problem is what to do and with which tools can be used to help the higher education to improve quality and make plans and how the implementation process will be done.

This work provides an answer; it is the utilization of an engineering tool successful in manufacturing processes and services areas called Quality Function Deployment (QFD). In this work education will be considerer as a service activity only for research purposes.

## 4. QFD Matrix

The Quality Matrix will be needed in order to work with QFD methodology. In order to obtain the matrix it is mandatory to establish the quality dimensions. According to Hayes (1995), there two was to proceed. First there is a systematic that requires the provider to establish the quality dimensions of its product or service. The other way is to involve the clients on the determination of the quality dimensions.

In this work, the first approach was used because there were no inputs from the customers since it is a new discipline with just one year of implementation. However, if possible the second way is preferable since it will take into account the opinion of the customer.

The QFD Matrix is shown on the attached figure. The main topics addressed on the matrix are: Support structure (conditions of the classrooms); course structure (number of weekly classes, degrees of detail on the subjects, integration with other disciplines); teachers (professional profile, knowledge of the subject, relationship with the students), general resources (libraries, administration), evaluation (used criteria, compatibility with taught material). The matrix will be presented in more the detail on following items.

## 5. Customer in the Educational Process.

Considering the treatment of education as a service activity the first step is to identify and determinate who is the customer in order to identify its necessities. This step is very important to begin the process of quality improvement. However, this identification is not as simple as it seems to be at a first glance. The educational process has many agents and depending on the perspective some of them can be seen as a customer.

Identify students as primary customer and to identify their genuine necessities is very important for the development of programs of quality of education. However, some authors (Hwarng & Teo, 2000) believe that, generally in education (public or private), employers such industries, services and other businesses are the real customers and students are the result of educational system. Other authors (Hwarng & Teo, 2000) affirm that the government also makes part of the customers group, since it provides funds for education or for the parents to finance their children.

A convenient and complete way of knowing customers of education is to use the Juran´s triple role concept also known as the TRIPOL diagram (Hwarng & Teo, 2000; Juran, 1982). In this case the roles of customer, processor and supplier are defined according different viewpoints. A service provider can be seen as a customer of other agents that provide inputs for the service. It can also be seen as a processor for turning the inputs into products and as a supplier for providing the product to another group of clients.

Figure 1. illustrated the Juran's TRIPOL concept

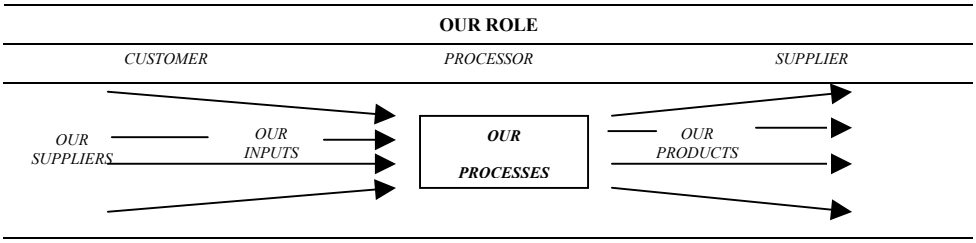


Figure 1 Illustration of the Juran's TRIPOL concept

Table 1 shows the TRIPOL concept applied to the identification of several customers in the educational environment, the teacher, the student, the parents, the industry and the society. It can be seen that some customers also play different roles as processors and suppliers.

Table 1 Triple roles of customer, processor and supplier (Hwarng & Teo, 2000)

| *Triple role of:* | *Customer* | *Processor* | *Supplier* |
|---|---|---|---|
| Professor | Receives students from previous courses | Teaches courses; Does research work | Supplies students to following courses |
| Student | Receives education | Learns from courses | Supplies workforce for the industry |
| Parent | Educated children | Moral upbringing; Correct learning attitude | Supplies university with students; provides financial support |
| Industry/Society | Receives educated workforce; receives research output | Hires graduates; Provides industry training | Supplies society with goods and services |

## 6. Methodology

The Matrix of Quality can be built according to two ways. The first one base on customers voice (market demands obtained with surveys converted into quality requirement and then it is obtained the elements of Quality), or by the method of extraction through reasoning that questions what would be the elements important to quality. For this work the second way was chosen because it was not possible to have a survey of customers since the discipline was new.

The following items describe the steps of building the quality matrix.

### 6.1. The necessities of students with its Importance Index

The necessities of students with its Importance Index have been determined with the group of professor of the area. Students were not involved on because the discipline was new and a new curriculum was introduced. Similar to the procedure described by Kaminski et al. (2004) the grades used to evaluate the importance each item range from one to six, in which the highest grade represents greatest importance or total satisfaction. The results presented on the matrix have been obtained by using a simply arithmetic average from the answerers from the survey.

### 6.2. Determination of levels of Satisfaction

Levels of satisfaction measure how the customer is satisfied in each of the categories presented on the matrix. The range, like the importance index, goes from one to six, with six representing the total satisfaction. It would be desirable to have this measurement with students that finished the discipline, since during the course student perception and evaluation may change. However, sometimes it is difficult to obtain the opinions of former students, specially after graduation, because the teacher will loose contact with students.

### 6.3. Determination of Involved Processes

The processes involved in the subject have been obtained by analysis with the current professor. Sometimes it can be useful to have the customers which processes they see as important. However, at the beginning of the implementation of the methodology it is easier for the provider to establish the processes that are important. The processes are listed below:

- Allocation of the day of the week of courses
- Allocation of the teacher (if exist more of one)
- Organization of calendar
- Dissemination of information to students
- School registration
- Preparation of the discipline by the teacher
- Administration of the discipline by the teacher
- Students evaluation process
- Equipment and premises maintenance

### 6.4. Determination of correlation between Customers necessities and the Processes of the discipline.

The matrix has a section that presents the relation between Quality Requirements and Elements of Quality. Three levels of co-relation have been determined. To a strong correlation the value is five, for simple correlation the value is three. For a weak correlation the value is one. In cases were there is no correlation no value were attributed. This is similar to the methodology proposed by Ohfuji, Ono & Akao (1997).

### 6.5. Assembly of Matrix Quality

In the Quality Matrix, the lines represent the necessities of customer. The first column presents the importance index, the second the satisfaction index. The next nine columns present the processes of the discipline for each process there is a correlation value with one of the customer necessity. The last column presents the improvement rate.

### 6.6. Calculation of Improvement Rate

The difference between the importance and satisfaction index divided by satisfaction index of a certain necessity represents its own improvement rate. In other words means how much does the satisfaction index has to be changed to reach an ideal condition so that the importance and satisfaction index are the same.

Negative rates mean that necessities are well fulfilled, but with little importance for the students. So, they may indicate that much effort is being done in areas that are not much relevant while others remain without proper attention. This is a important information to teachers and curricular developers.

### 6.7. Calculation of Expected and Current Performance Rates

To evaluate the Current Performance and Relative Performance it is necessary to multiply the Importance and Satisfaction indexes by the relationship index and afterwards add the results of each column. The Expected Performance will be obtained from the Importance index. Meanwhile the actual performance will be obtained from the Satisfaction index.

The Relative Performance is the result of the division between the two items mentioned above. That means what the students would like to obtain from the discipline, what they really have obtained and what would be a better relation between these two variables.

### 6.8. Calculation of the Impact Rate in the discipline

The Impact Rate is subtracted from the expected Performance Rate. The methodology in use considerers that the higher the expected performance the higher will be impact in the subject process. Through that the expected performance of each process is classified in descending order, when one is the process with higher expected performance.

## 7. The Process Analysis

Once the matrix is built (figure 2) and its results are obtained, the process impact analysis, related to customers satisfaction, will be the next step. By considering the results presented on the matrix it is possible to determine which are the highest or lowest impact processes as far as the satisfaction is concerned, which means those with better or worse actual performance and those with better or worse relative performance.

Analyzing the results for the importance and the satisfaction it is possible to determine which areas require improvements and how much each an aspect needs to be improved. It also show areas in which some improvement will be seen as a major development and others in which any change will not be considered relevant by the customers.

| | Importance | Satisfaction | Allocation of the day of the week of the discipline | Allocation of the teacher (if exist more of one) | Organization of the calendar | Dissemination of information to students | School registration | Preparation of the discipline by the teacher | Administration of the discipline by the teacher | Process of student evaluation | Equipment and premises maintenance | Improvement Rate (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Support structure** | | | | | | | | | | | | |
| Location and Access | 3,3 | 5,3 | 1 | | | | | | | | | -37,7 |
| The thermal comfort of the classrooms | 4,5 | 2,6 | | | | | | | | | 3 | 73,1 |
| The acoustic of the classrooms | 4,1 | 3,8 | | | | | | | | | 3 | 7,9 |
| The comfort in relation to exist insects | 4,5 | 3,5 | | | | | | | | | 3 | 28,6 |
| The visual comfort (illumination, wall colors) of classrooms | 4,9 | 3,3 | | | | | | | | | 3 | 48,5 |
| The comfort of the desks | 5,6 | 2,2 | 1 | | | | | | | | 3 | 154,5 |
| **Course Structure (Mechanical Eng.)** | | | | | | | | | | | | |
| Supply of information regarding the program aims | 5,9 | 4,1 | | | 3 | 5 | | 3 | 1 | | | 43,9 |
| Degree of previous knowledge that the students must be have to follow the discipline | 4,6 | 4,1 | | | | | | 5 | 3 | 3 | | 12,2 |
| Prerequisite supply of information to follow the program | 4,6 | 4,3 | | | 3 | 3 | 1 | 1 | 1 | | | 7,0 |
| The extension (num.topics) of the discipline | 4,4 | 4,1 | | 5 | 5 | | | 3 | 3 | | | 7,3 |
| Number of class hours for discipline | 3,8 | 4,5 | 1 | 5 | 5 | | | | | | | -15,6 |
| Frequency classroom in the week | 4 | 5,1 | 3 | 5 | 5 | | | | | | | -21,6 |
| Convenience of the beginning and ending schedules of the lessons | 4,8 | 4,7 | | 3 | 3 | | | | | | | 2,1 |
| Degree if depth of the topics approached in the discipline | 5,1 | 3,9 | | | 1 | | | 5 | 5 | 5 | | 30,8 |
| Integration between courses of the program | 5,7 | 4,3 | | 1 | 1 | | | 5 | 3 | | | 32,6 |
| Size of the groups (amount of students per room per courses) | 5 | 3,2 | 3 | 3 | | | 5 | 3 | 1 | 1 | 1 | 56,3 |
| **Teacher** | | | | | | | | | | | | |
| Mutual respect between teacher and students | 5,5 | 4,5 | | | | | | 1 | 5 | | | 22,2 |
| Punctuality and assiduity of the teacher | 5,6 | 5,4 | 3 | 3 | | | | 1 | 3 | | | 3,7 |
| Exploitation on the part of the teacher of the lesson time | 5,3 | 4,6 | | | | | | 5 | 5 | | | 15,2 |
| Preparation of the lessons by the teacher | 5,8 | 4,6 | | | | 5 | | 5 | 5 | | | 26,1 |
| Technological resources used by the teacher | 5,1 | 4,2 | | | | | | 3 | 3 | | 3 | 21,4 |
| Easiness of communication, on the part of the teacher | 5,6 | 5,2 | | | | | | 5 | 5 | | | 7,7 |
| Accessibility to the teacher out of the classroom | 5,1 | 5,1 | 5 | 3 | | | | 1 | 3 | | | 0,0 |
| Bibliographical material made available | 4,8 | 4,5 | | 1 | | 5 | 1 | 5 | 1 | 1 | | 6,7 |
| **General resources** | | | | | | | | | | | | |
| Access to discipline information (schedule, period) | 4,3 | 5,5 | | | | 5 | 1 | | | | | -21,8 |
| Access to the library | 5,3 | 4,3 | 5 | | | | | | | | 3 | 23,3 |
| Efficiency of administrative staff | 4,9 | 4,9 | | | 5 | | 3 | | | | 3 | 0,0 |
| **Evaluation** | | | | | | | | | | | | |
| Adequacy of evaluation method in general | 5,4 | 4,2 | | 1 | | | | | 3 | 5 | | 28,6 |
| Evaluation criterion demands on what the students needs to know | 5,1 | 5,1 | | | | | | | | 5 | | 0,0 |
| Level of evaluations compatible with level of given content | 5,5 | 4,7 | | | | | | 1 | 3 | 5 | | 17,0 |
| Strictness of criterion for evaluations | 4 | 5,3 | | | | | | 1 | 3 | 5 | | -24,5 |
| Stated period for evaluation result delivery is met | 4,1 | 5,2 | | | | 3 | | | | 5 | | -21,2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Expected Performance (absolute)** | 108,5 | 138,4 | 142,2 | 113,6 | 53,4 | 276,0 | 293,0 | 169,6 | 121,7 | 1416,4 |
| **Expected Performance Rates (relative) %** | 7,7 | 9,8 | 10,0 | 8,0 | 3,8 | 19,5 | 20,7 | 12,0 | 8,6 | 100,0 |
| **Current Performance (absolute)** | 100,1 | 136,7 | 140,5 | 122 | 45 | 232,1 | 254,3 | 162 | 89,6 | 1282,3 |
| **Current Performance (relative) %** | 7,8 | 10,7 | 11,0 | 9,5 | 3,5 | 18,1 | 19,8 | 12,6 | 7,0 | 100,0 |
| **Current/Expected (relative %)** | 92,258 | 98,772 | 98,805 | 107,39 | 84,27 | 84,094 | 86,792 | 95,519 | 73,624 | |
| **Impact on the discipline** | **8** | **5** | **4** | **7** | **9** | **2** | **1** | **3** | **6** | |

Figure 2 – QFD Matrix

## 8. Conclusion

This work intends to develop a methodology to evaluate and to improve quality in an engineering course. As a sample a discipline was evaluated, but the objective is to test this further in the same area (Mechanical Design), through the adaptation of the QFD applied to teaching.

Our main conclusion is that QFD application is possible. It shows many information and it allows an observation in which areas is possible to improve.

For instance an item of the customer needs, “Location and Access” that belongs to support structure, has its Improvement Rate as an negative value, in another words it means that the customers are very satisfied, however this item are not considered to be that much important. On the other hand, the item “Comfort of the desk” belongs to support structure too, the Improvement Rate has a high positive value, so there is room to improvement and this item is seen as a very important to the costumers.

So, in order to have more customers satisfied without increase on budget, efforts from one item that is not much important and is already optimized can be transferred to other aspect regarded as important to costumers and that need improvement.

On the other hand, observing the columns of the quality matrix that represent the processes, it is possible to recognize that the high values in the “Expected Performance” will have major influence in costumer satisfaction. In the studied case, the process “Administration of the discipline by the teacher” is the one with major impact for the customer therefore this process will be the one in which the teacher has to pay attention most.

Analysis of the different processes and costumer demands is made easier with the quality matrix. Quantities such as performance indexes can direct the teacher or the institution on which measures will have to be taken in order to improve a discipline or program.

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## 5. Responsibility notice