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Application of fuzzy- QFD for improving academic processes

Juan Carlos Osorio Gómez

Escuela de Ingeniería Industrial y Estadística

josorio@pino.univalle.edu.co

Ana Paola Giraldo Arias

apgiraldo@gmail.com

Escuela de Ingeniería Industrial y Estadística

Luisa Fernanda Martínez Bárcenas

lfmartinez@fanalca.com.co

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Abstract

This paper presents an improvement proposal for the Industrial Engineering program at the Universidad del Valle, which has been raised from the needs and requirements of stakeholders (students, graduates, teachers, managers and employers). These applications were treated with fuzzy-QFD approach, so that will translate into specific features of the program.

The information was lifted from surveys designed for each of those involved, and the handling of ambiguity in the information was processed from the elements of fuzzy logic, specifically the triangular numbers.

Finally, with the construction of the house of quality were defined strategic lines of action to direct improvement efforts and to define specific plans that will raise the performance of the program, geared towards the real needs of stakeholders.

Keywords: QDF, processes improvement, fuzzy logic, fuzzy QFD

1. Introduction

The improvement processes is one important subject into the industrial engineering, and the use of quality tools such as QFD for these is an important research field. This work presents an application of QFD with fuzzy logic in the improvement of the academic program of industrial engineering in the Universidad del Valle in Colombia.

This work consist in three sections: a literature review about QFD and fuzzy logic, the proposed model for the improvement of the program and finally some results derived application of model.

2. Literature Review.

2.1 Quality function deployment (QFD)

It was first introduced in Japan in 1966 and its first formal application was developed in 1972 (Sangüesa et al, 2006), (Chan and Wu, 2002). Although initially conceived as a tool for design and product development QFD has transcended these applications and today can be considered as an important tool in the field of multicriteria decision problems.

We can mention the following application fields of QFD (Chan and Wu, 2002): Product development, quality management, analysis of customer needs, product design, product planning and process, master planning, strategic planning, business process planning, quality of services, concurrent engineering, decision making, management, teamwork, scheduling, costing, and others.

Within the most important applications of QFD in educational systems we can mention Ermer (1991), Krishnan and Houshmand (1993), González et al (1994), Hillman and Plonka (1995), Mazur (1996), Per et al (1995), Seow and Moody (1996), Gustafsson et

al (1996) , Higgins et al (1994), Burgar (1994), Bier and Cornesky (2001), Hwang and Teo (2001); Lam and Zhao (1997) and Morelia and Michoacán (2002).

Two important jobs for more information on QFD are presented by Chan and Wu (2002), and Carnevalli and Cauchik (2008). Recent applications of fuzzy QFD can be reviewed in Bottani and Rizzi (2006), Bottani (2009), Celik et al (2009), Sohn and Choi (2001), Chen and Ko (2008), Liu (2009), Amin and Razmi (2009) and Bevilacqua (2006). While all are not focused on the educational subjects they are associated with business practice.

2.2 Fuzzy logic

In 1965, Zadeh published the article "Fuzzy Sets (Information and Control)" which marked historic milestone and provide the name of discipline. But not until the mid 70`s the fuzzy sets had a practical application in designing a fuzzy controller for a steam engine. Since then it has been associated with the term "Fuzzy Logic" any mathematical system that is based on fuzzy sets (Lazzary et al, 2000).

The fuzzy modeling allows the definition of metrics with which we can access the intangible factors and deal with heterogeneous measures. Also, what is sought through the fuzzy mathematics to describe and formalize the reality using flexible models to interpret the laws that govern human behavior and relationships between men (Tsai et al, 2008)

Fuzzy logic allows intermediate values expressed mathematically can go to an evaluator of a particular "situation" or "problem" qualitative, in which, not be satisfied to qualify with only two values, false (0) or true (1), knowing that in real life, is an event that cannot be defined as completely true or completely false, if not having a degree of truth or falsehood, which can vary from 0 to 1.

3. Fuzzy QFD model for processes improvement.

The following describes step by step methodology for the application of QFD in order to improve the quality of program depending on the requirements and desires of customers.

3.1 Identification of the customer's voice

Surveys were used as a tool for listening to the VOC. These were designed as flexible for customers to express all his opinions and desires. The surveys contain open-ended questions in which they express their opinion (which need and want, "what"), and in which each weigh what, according to their importance for improvement. The weighting of the "what" Fuzzy implies the scale used in this project and defined in the table 1.

After collecting the survey results, determine what the needs and requirements of customers "what" by Affinity Diagram of two levels, in which the second level is the grouping of the VOC and the first level is the grouping of requirements for second level.

Table 1. Weighting scale levels with triangular fuzzy numbers.

Weighting level	Triangular fuzzy number
VI(Very important)	(0.75, 1, 1)
I (Important)	(0.5, 0.75, 1)
MI (Medium Important)	(0.25, 0.5, 0.75)
UI (Unimportant)	(0, 0.25, 0.5)
VU (Very Unimportant)	(0, 0, 0.25)

3.2 Prioritization of customer requirements "WHAT"

The weight of the "what" was obtained through surveys. Customers prioritized their criteria in the scale defined in Table 1. Due to the quantity and variety of views expressed by customers, we had to build an Affinity Diagram to group these views. The prioritization of each category of second level was found through the unification of the weight of the "what" of the VOC is using operations including Fuzzy, by using the following formula:

$$W_i = \sum_{p=1}^5 K_p * \tilde{A}_p$$

Where

$$K_p = \frac{\text{Number of people who chose the level of weight } p \text{ in the second category levels}}{\text{Total persons who proposed improvements in the category of second level}}$$

\tilde{A}_p = Triangular fuzzy number corresponding to the level of weight p

In table 1 we show the correspondent p level. The weight of the "what" of each category of second level leads to the House of Quality and thus marks the step two of preparing it.

3.3 Identification of technical specifications

For the identification of technical characteristics, discusses each of the characteristics of academic and administrative processes to determine which could affect one or more "what" and thus include them in the House of Quality, in compliance with step number three.

3.4 Construction of the relational matrix

After identifying each of the engineering features "how" that affects one or more "why" defined the relationships between each "what" and every "how", taking into account what the relationship is improving every "what" if works in the "how" question. For this, use the scale defined in Table 2.

Table 2. Scale of degrees of relationship with triangular fuzzy numbers.

DEGREE OF RELATIONSHIP	GRAPHIC SYMBOL	NUMBER TRIANGULAR DIFFUSE
Strong	●	(0.7, 1, 1)
Medium	○	(0.3, 0.5, 0.7)
Weak	△	(0, 0, 0.3)

3.5 Construction of the correlation matrix

The correlations between each pair of engineering features "how to" represent the level of relationship between them, meaning that a positive relationship indicates that the two features complement or enhance each other and a negative relationship suggests otherwise. Therefore, the importance of this matrix is that if you ignore these relationships, looking for some improvement, this could lead to negatively affect some important engineering characteristics with the implementation of any that have been more, less or equally relevant to the meeting the needs and requirements of customers, which requires decisions to choose those features that complement and maximize customer satisfaction. These correlations are represented by symbols defined in Table 2.

3.6 Determination of the absolute importance of each feature engineering "HOW"

Fuzzy operation is performed corresponding to calculate the absolute importance in fuzzy numbers, taking into account the weight of each "what" and the relationships that each "how" each "what".

To obtain the absolute importance of each "how" is used in comparable terms the method of Yager (Yager, 1981), which holds that the entire value of a triangular number (a_1, a_2, a_3) is given by the following equation:

$$E = (a_1 + 2 a_2 + a_3) / 4$$

3.7 Determination of the relative importance of each feature engineering "HOW"

Taking the absolute importance as a real value, calculate the relative and it produces a ranking from highest to lowest weight, which determines the characteristics in which we must work to achieve the biggest improvements over what the client wants.

This step represents the main objective of the implementation of the QFD methodology, since this is where you define what actions or characteristics comprising the Improvement Plan for its degree of contribution to meeting the needs and requirements of customers, improving and the Quality Management Program. Also, appreciate the engineering features that will not be taken into account in the Improvement Plan as little impact on its customers' needs.

4. Results and conclusions

Finally, we obtained important ideas to realize activities than allowed the improvement in the academic program and we can concluded that QFD approach was successful for obtain the ideas and the priority of importance from the subjective judgments of the stakeholders

With The Fuzzy sets had been allowed involving into the analysis the subjectivity associate to the differences people involved into the program.

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