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An approach of TRIZ methodology with inventive solutions for toys used by children with special needs based on the requirements of quality house (QFD)

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Abstract: - This paper will present a work based on the methodology of the Quality Function Deployment (QFD) with some solutions for the development of lego foam toy, so that it can attend the learning of children with special needs. In this sense, a research was done with professionals who work with children of this segment, and also companies that manufacture this type of educational toy. The relationships of the needs of these children have established new requirements for the lego foam toy designs. The quality house elaborated at the end of this study showed the distance between the market and the segment serviced, as well as new possibilities to manufacture more efficient and effective products.

Keywords: - *children, QFD, toys, TRIZ methodology*

I. INTRODUCTION

According to Santos [1], in Brazil, a large part of the companies, especially small and medium-sized companies, have difficulties in terms of decision-making in general. Decisions become even more difficult when they involve large investments of time and capital. Hence the importance of developing a toy that is appropriate to the needs of children and has a consistent economic viability. The toy market in Brazil has few companies with specific toy production for children with special needs. The reality is that there are some companies working in the educational toys segment, which makes the product more expensive and it reaches a small percentage of its audience.Santos [2] says that in order to position itself in the market it is necessary to be equipped with techniques for making decisions. So, to put yourself ahead of your competitors, a company needs technical support in their choices. For this, it is necessary to apply consistent methods that meet the expectations of its stakeholders.Every child likes to play, to discover new things and to find out herself. And It is during the first games and activities that begins the learning process of a children. In this sense, toys have an important role in this journey, because it is through them that children do the “act of playing", and it is from the playing that they begin to build and develop their personality.The toy choice should be well directed, as this product has a relevant role for the development of the child, especially when it envolves children with some type of need. It is fundamental for this segment that such toys should be selected appropriately, according to the points that should be stimulated in the child through the act of playing.When concerning to children with special needs, it is essential to recognize their characteristics exactly. According to Cunha [3] these children have a reduced attention span, and they have no sharp imagination or initiative. Therefore, it is essential that the toy besides offering stimulation, also have a follow-up to teach its use, and how to play.The present paper aims to propose improvements in the development of toys for children with special needs. In this sense, the process followed was the survey of these children’s needs, and consequently indication of the necessary requirements for these toys from the Quality Function Deployment (QFD) method. The research of children's needs was carried out with psychologists and pedagogues. Subsequently, the Inventive Problem Solving (TRIZ) methodology was applied so that the requirements were transformed into Engineering Parameters. And from the contradictions of these parameters were found the Inventive Solutions for this new product.

II. METHODS USED

To develop this paper we used the quality house that is present in the QFD Method and the Inventive Principles Method (MPI), contained in the TRIZ methodology.

2.1 The Quality Function Deployment (QFD) Method

The Quality Function Deployment method emerged in Japan in the late 1960s, Japanese companies were experiencing a rupture in their PDP (product development process), and until then the reverse engineering was used widely as a way to develop new products [4]. With the learning of the products disassembled, and assembled again in a smaller size; and the practice of listening more to the consumer, Japan's industry has begun to adopt the strategy of developing its own products. The QFD is a powerful decision support method. It has been developed with the economic environment in mind and it is based on a sequence of two-dimensional mathematical matrices that link some development process of new products areas, often different, and consists of calculating the classification of numerical indicators to be represented graphically as well as to create an easy-to-understand database, useful for decision making. Its main objective is to try to ensure that the final design of a product or service actually meets the needs of its customers [5].Back [6] talking about the method, claim that it is also known as the matrices method. Its complete form is the unfolding of four matrices, but the first matrix of this method, the house of quality, received a lot of attention by researchers and industry professionals, because it covers a good part of the process of project specifications elaboration.

2.2 The TRIZ methodology

The TRIZ methodology "aims to generate concepts for the solution of Inventive Problems, breaking the barriers of Psychological Inertia, against the Ideality" [7]. As Back [6] lectures on the subject, Altshuler was the founder of the methodology. He served in the navy in the 1940s as a consultant, supporting inventors in patenting inventions. Throughout his work he was faced with the need to find better alternatives to problem solving methods, as the existing ones were not enough.At the beginning of the research in 1946, in search of improvements, Altshuler concluded that the theory of invention should present the following premises:

- To be systematic, presenting step-by-step procedures;
- To be a guide, without it restricting the search space of the ideal solution;
- To present repetitiveness and not to rely on psychological tools;
- To allow access to the inventive knowledge body;
- To allow to add to the inventive knowledge body;
- To be familiar enough to inventors.

Throughout the study of a large number of patents, starting from these premises mentioned above, the researcher found common attributes in which they were actually identified as inventions. They all had an inventive problem, defined as a problem in which its solution causes a new problem. And they also presented an inventive solution, capable of eliminating the problems of conflicting parameters [6]. After identifying these points, common features in the patent definitions were related to patent analysis. From these relationships were found 39 engineering parameters. Another regularity found by Altshuler in his study was the means used to solve the problems that arose with the presence of conflicting parameters in the product/project. These solutions deduced to a generalized form gave origin to the 40 inventive principles (IPs). One way of disseminating this whole study for future research was through the creation of the Inventive Principles Method (IMP), by Altshuler. According to Back [6], "it seeks to maximize, minimize or maintain, within certain goals, the engineering parameters, using the solution matrix of contradictions and the inventive principles".According to de Carvalho and Back [8] there are two possible ways to use IPM. The simplest way is when it is used directly, in a simple search and attempt to apply an IP to find the improvement of the product/project. Another way is to identify the contradictions, to perform modeling over those conflicting engineering parameters, and to use the contradiction matrix (CM) to identify which IPs have the greatest potential to be applied.

III. THE METHODOLOGY APPLICATIONS IN THE PRODUCT

The applications of QFD and TRIZ were chosen by the good practices that have been achieved in the area of Product Engineering, mainly by large companies that apply these methodologies in the development of their prototypes.

3.1 Application of Quality Function Deployment QFD) Method

For the use of the QFD method, information was collected on the possible stimuli that this toy can work in a child, and which are appropriately relevant for children with intellectual disabilities. Based on research and reports from professionals in the area, the following needs were identified for children:

- To be able to stimulate creativity;
- To develop motor coordination;
- To stimulate sensory sense;
- To work with associative capacity;

- ➢ To stimulate reasoning;
- ➢ To practice work with the playful;
- ➢ To be a safe object;
- ➢ To have visual stimuli;
- ➢ And to have memorizing stimuli.

The relationship between the needs is shown in Fig. 1, which are punctuated as strong, medium or weak. These needs are put in a degree of importance according to the opinion of the experts. In addition, the KANO model was applied, which showed if each need was attractive, expected or mandatory.

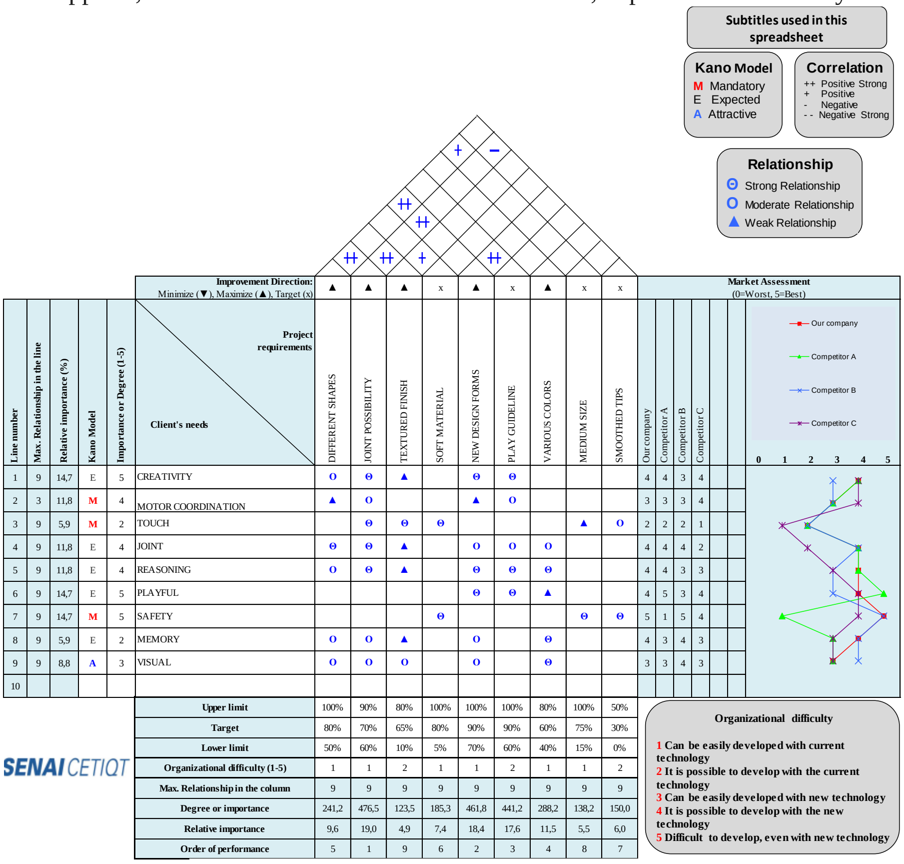

Figure 1: QFD of the new toy "foam stack block"

From the requirements listed, the new requirements for the new toy called "foam stack block" were raised. Such requirements have been formatted to be in accordance with Mercosul Standard 300 (Part I) on toy safety. The main requirements for the project development are:

- ➢ To possess varied geometric forms;
- ➢ One piece can be joined with another;
- ➢ To have finishes with textures;
- ➢ To be composed of a soft material;
- ➢ To be capable of forming drawings;
- ➢ To follow a guide to stimulate the play and the use of the toy;
- ➢ To display various colors;
- ➢ To have a medium size;
- ➢ To have softened tips.

The requirements traced were described in Fig. 1, as well as its correlations that make up the roof of quality house. At this point a negative correlation was found between the possibility of joining the toys and the softened tip (which is slightly rounded). Another important point of the requirements was the indication of their directions for improvement.The organizational difficulty encountered in developing the requirements took into account the raw material used to manufacture the parts of the product, as well as the ease of fit and adaptability to the child.Finally, the QFD showed the degree of importance of these requirements. This is a point of great importance because it shows which of the requirements has more importance in relation to the others. In this sense the possibility of joining and the possibility of new design forms had the highest degree of importance, which shows how these facilities are important in the development of children with special needs.It is worth mentioning that the benchmarking used in this QFD was performed with the professionals who answered the survey, and they knew other companies that manufactured products for these children.

3.2 The assembly of the product from QFD

With the elaboration of the product from the client's needs, the toy of Fig. 2 was created, containing the necessary requirements for the project.

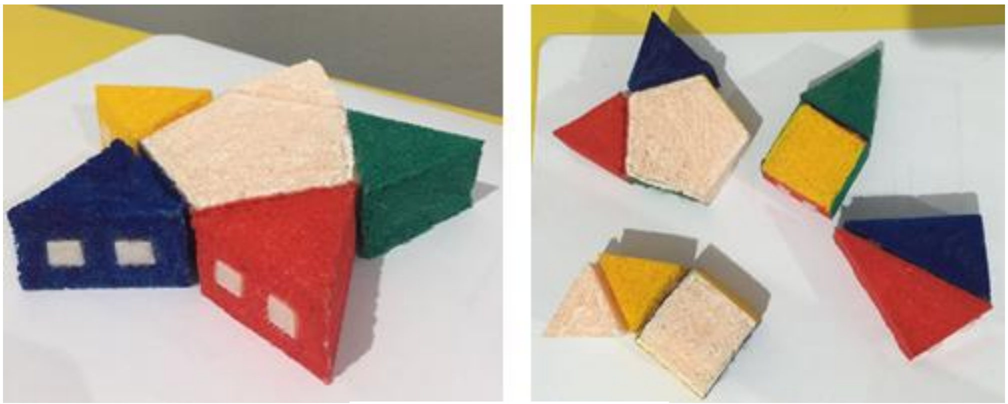

Figure 2: Assembly of the toy

The research continued with the transformation of the project requirements into engineering parameters according to the TRIZ methodology.

3.3 Determination of engineering parameters

According to the needs, the requirements of the product, previously shown, were related and the interaction of these characteristics is present in the representation of the quality house. From these existing requirements, when applying the IMP, the engineering parameters considered corresponding to them were selected.At this part of the development of the study it was important the informal research of products that use the TRIZ methodology, as well as the survey with product area professionals that elaborate products through this method.

Table 1 - Relationship between Product Requirements and Engineering Parameters

Product requirements	Engineering Parameters
Different shapes	12
Joint	13,35
Textured finish	24
Soft material	2, 16,14
New design forms	13,27
Play guideline	33, 36
Various colors	24
Size	2, 8
Smoothed tips	12

The engineering parameters listed in the table above are referenced by numbers. The following list shows the meaning of each of them present in the table.

- 2 - Weight of the static object;
- 8 - Volume of the static object;
- 12 - Form;
- 13 - Object stability;
- 14 - Resistance;
- 16 - Static object durability;
- 24 - Loss of information;
- 27 - Reliability;
- 33 - Convenience of use;

- 35 - Adaptability or versatility;
- 36 - Device complexity.

3.4 To seek an analogous solution to the problem in question

Engineering Parameters

Engineering Parameters	2	8	12	13	14	16	24	27	33	35	36
2	-	5, 35, 14, 2	13, 10, 29, 14	26,39, 1, 40	28, 2, 10, 27	2, 27, 19, 6	10, 15, 35	10, 28, 8, 3	6, 13, 1, 32	19, 15, 29	1, 10, 26, 39
8	35, 10, 19, 14	-	7, 2, 35	34, 28, 35, 40	9, 14, 17, 15	35, 34, 38	-	2, 35, 16	-	-	1, 31
12	15, 10, 26, 3	7, 2, 35	-	33, 1, 18, 4	30, 14, 10, 40	-	-	10, 40, 16	32, 15, 26	1, 15, 29	16, 29, 1, 28
13	26, 39, 1, 40	34, 28, 35, 40	22, 1, 18, 4	-	17, 9, 15	39, 3, 35, 23	-		32, 35, 30	35, 30, 34, 2	2, 35, 22, 26
14	40, 26, 27, 1	9, 14, 17, 15	10, 30, 35, 40	13, 17, 35	-	-	-	11, 3	32, 40, 25, 2	15, 3, 32	2, 13, 25, 28
16	6, 27, 19, 16	35, 34, 38	-	39, 3, 35, 23	-	-	10	34, 27, 6, 40	1	2	-
24	10, 35, 5	2, 22	-	-	-	10	-	10, 28, 23	27, 22	-	-
27	3, 10, 8, 28	2, 35, 24	35, 1, 16, 11	-	11, 28	34, 27, 6, 40	10, 28	-	27, 17, 40	13, 35, 8, 24	13, 35, 1
33	6, 13, 1, 25	4, 18, 39, 31	15, 34, 29, 28	32, 35, 30	32, 40, 3, 28	1, 16, 25	4, 10, 27, 22	17, 27, 8, 40	-	15, 34, 1, 16	32, 26, 12, 17
35	19, 15, 29, 16	-	15, 37, 1, 8	35, 30, 14	35, 3, 32, 6	2, 16	-	35, 13, 8, 24	15, 34, 1, 16	-	15, 29, 37, 28
36	2, 26, 35, 39	1, 16	29, 13, 28, 15	2, 22, 17, 19	2, 13, 28	-	-	13, 35, 1	27, 9, 26, 24	29, 15, 28, 37	-

Figure 3: Contradiction matrix of the new toy "foam stack block”

From the selection of the parameters an analysis was made in the contradiction matrix (CM) to find the analogous inventive solutions referring to the combination of the parameters used. Consequently, Fig. 3 represented the result of the comparison of each parameter, which shows a matrix with all possibilities of solutions.The CM highlighted all the IPs applicable to the parameters identified in the project. Among these IPs, those who have had the highest number of repetitions in the matrix were: 35, 1, 2, 10, 15, 28 and 40. Each of these IPs proposes solutions to the conflicts found in the interaction of the toy parameters.

3.5 The Inventive Solutions

From the prototype that was sketched based on the design requirements, as shown in Fig. 3, it can be identified that the inventive solutions found meet the initial proposal.IP 35 refers to the change of state, suggesting that it change the aggregation state, the concentration or consistency, the flexibility or the temperature of the object.

Segmentation refers to IP 1. Proposes dividing an object into independent parts or making a section on the object, increasing the object's degree of segmentation.Extraction, IP 2, recommends the extraction (removal or separation) of an undesirable part or property of the object and it uses only the necessary part or property.

Prior action, it refers to PI 10, proposes to be taken an action in advance, organizing the objects in order to perform such action in a timely manner.IP 15 refers to dynamicity, suggesting that an object or its environment automatically adjust to optimize its performance in each phase of the operation cycle.Replacement by mechanical means, referring to IP 28, recommends replacing the mechanical system by electronics, optics or software. Use electromagnetic fields to interact with the object. Change the field: mobile to static, or fixed to mobiles. Use particles in fields.Using composite materials, IP 40, indicates replacing homogeneous materials by composite materials.

IV. CONCLUSION

In this study, a product was elaborated from the joint use of the QFD methodology and the TRIZ method for the development of a toy for children with special needs. Through the research, it was possible to identify what the main characteristics the toy should present.The project is based on the idea of a toy with functional characteristics to give the opportunity to stimulate the association, the creativity, and the logical reasoning, during the kids games.The study has been premised on the elaboration of a safe toy, since its potential client is children with special needs. It was then decided to build the toy structure with foam and medium size (with dimensions sufficient to prevent a possible ingestion of any of the pieces), further increasing safety.About the level of toy maturity, it will depend on the level of each child because the degrees of these deficiencies are variants. For these cases it is spoken of mental age, which means, the actual age is not the same mentally. Compared to other toys, the "foam stack block” can be used by children from 9 months to 3 years.

During the application of the QFD tool, "playful" was highlighted as one of the most relevant necessities that the product needs to achieve. This item fits into the main characteristics that a toy, for mental development, needs to possess. Playful is performed as an exercise to develop creativity, which is absent or low, in children with autism or down syndrome, for example. This work should be done with the help of an educator, a psychologist or even the child's own parents.The application of the TRIZ methodology ratified what the QFD had already defined; especially with regard to the safety and applicability of the product.

As a proposal for future work, it is suggested that the toy produced be taken to the evaluation of the specialists who defined the requirements of the same, in order to validate the methodology proposed in this work. Santos [9] believes that the results of the project should reflect the collective and individual efforts made, considering its various aspects.

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