# THE HIERARCHY OF NEED, FEV MATRIX IN THE CONCEPT GENERATION TOWARDS THE EXISTING PRODUCT DESIGN IN PRODUCT DEVELOPMENT: A WATCH PRODUCT

**Fevi Syaifoelida[1], A.M Megat Hamdan[2], Murrad. M[2]**
[1]*Mechanical Engineering Department, Universiti Tenaga Nasional(UNITEN)*
[2]*Mechanical Engineering Department, Universiti Pertahanan Nasional Malaysia (UPNM)*
For correspondence; E-mail: Fevilia@uniten.edu.my
For correspondence; E-mail: megat@upnm.edu.my
For correspondence; E-mail: muhamad@upnm.edu.m

***ABSTRACT:*** *Customer satisfaction is a measure of how products and services supplied by a company meet or surpass customer expectation. How to translate it is important because it provides business owners, including industry with a metric that they can be used to manage and improve their businesses. In a competitive marketplace where businesses compete for customers, customer satisfaction is seen as a key differentiator. Good quality measures need to have higher satisfaction loadings, good reliability, and low error variances. Nowadays, the lack of understanding towards the customer requirement is one of the issues that need to be considered in designing process. How to achieve this target? Most of the tools in design such as Pugh Matrix, is one that considered the highest weighted to become the best or selected one in concept selection, but how about the existing product in the market? How to make it more valuable in the market? The solution is by knowing which element in a product is important or require by consumer and neglect the unimportant by going through the redesign process. In order to achieve this idea, design selection tool has been used in this study as a concept selection, Pugh Matrix. While in concept generation process, it required the critical thinking about the design process, Fev Matrix is introduced. It will help to create or generate the important element in an existing product towards redesign, improvement and manufacture the product demand in future.*

**Keywords:** Concept generation, Concept selection, Fev Matrix, Existing design evaluation

## 1. INTRODUCTION

An effective product is a product that is capable to meet customers' satisfaction. In order to have a delightful and a satisfied customer, you should understand who are your customers, which includes their lifestyle, background and interest and what your customers want. The vital problem is each customer have different opinions and perception on what they need. Failing to understand the customers need may contribute to company's loss. Therefore, companies should explore the common issues facing new product development, to gain a better understanding of how the voice of the customer can fit into the improvement procedure to address these issues.

In developing and designing a new product, we need to focus on the end user of the product, the person who lastly buys and uses the product, which is the customer. We need to know what the customer needs, wants, and requires the product. In this perspective, because of the level of production value itself that plays an important thing to be explored according to the requirement and satisfaction of the customer, the existing design of product must be looked back. Product development can be described either can be fully genuine idea to develop (innovation) or idea improvement (upgraded) from the existing design. Jordan [1] supported that the functional and emotional considerations should collaborate to ensure the excellent product design happens to the optimal success in product development.

Based on this reason, what actually the initial “spark” for the demand in product design is a customer’s own the process decision. Here, due to the emotions can change a person's behavior which is a response to environmental conditions [2], but how to unlock those customer decisions to be something that could be in the right interpretation?

Second, by predicting those interpretations is by knowing the priority demand towards the product existing design. It requires one tool as a concept generation process in order to brainstorm and generate idea as the critical thinking design phase and will be the new spark in the next concept selection. How to interpret this concept idea as a creative method, to find the new idea to solve problems and to generate the new product innovation?

Third, this idea is a good technique to collaborate with some other techniques, especially before going through the concept selection, such as Pugh Matrix. It is very useful for quality improvement of complicated product features or procedure. The other existing idea generation techniques, one as the pioneer method, Attribute List [3] focused on identifying attributes of a process or product and ways to improve all attributes on existing products or services without considering how to translate those elements in existing product to become the new one or plus with the new features (improvement/upgraded).

There is various type of idea generation techniques is condensed in order to facilitate ease of comprehension and application among creative idea [4-6; Beyer & Kholtzblatt, 1999 [7] and [8] as claimed by Herring, Jones and Brian [9] in their paper.

Based on the reason above, this study, therefore proposed the Hierarchy of need, Fev Matrix in product development as the integration of the quality element attributes in product development (idea generation technique) that also act as one of the "initial spark" or "missing link" before proceeding in concept selection technique.

## 2. THEORETICAL APPROACH

### 2.1 Pugh Matrix

There are numerous tools available in the stage of design process such as weighted decision matrix, concept generation, concept selection which has a branched out of Pugh Matrix. Concept generation uses qualitative criteria or consider the interrelationships among decision elements in order to meet the customers' requirements [10]. Concept selection is a process where decision makers perform design evaluation, by which we mean the determination of the quality (value or worth) of a design concept against established objectives as a function of one or more its attributes [11]. As written by Dr Stuart Burge [12] "The Pugh Matrix (PM) is a type of Matrix Diagram that allows for the comparison of a number of design candidates leading ultimately meets which best a set of criteria. It also permits a degree of qualitative optimization of the alternative concepts through the generation of hybrid candidates." Pugh Matrix will be in conjunction towards the matrix proposed in this case study, the tools that will be used are concept generation followed by concept selection.

### 2.2 Product

User experience gives satisfaction to the customer when they used the product. In the end, it all comes to the end user of the product. How does one define and describes user experience? It could be from the little things, but it gives a big impact to the users. It might be the button positions, the usability of the keyboards, the easiest to hold the phone, and even how to answer calls. All these things affect customer's satisfaction while using the product. These days, new products come out almost every day. Companies need to think ways to make their product stand out from the other products. One of the key factors is the product design. That is what will give the first impressions to the customers. Each day the industries face increasingly higher competition in their business related to the customers' demands and product design requirement. But what makes a design different from the others? One thing that is lacking in design community today is the needs to please clients first. One of the keys is study back from the existing design launched, interpret and can be seen which element give more impact and satisfaction towards users' experience. A watch product is taken as the case study.

## 3. METHODOLOGY

An early stage process is a Fev matrix, the hierarchy of need that is used as a conveyor tool to translate the demand of the customer to the final specification needed in a design. An early stage process is constructed. All are constructed into a Fev Matrix, table desired of existing design sorting (Table 1).

**Table 1: Fev Matrix, Hierarchy of needs, a table desired**

H1

| Design Concept | Customer Score | Element 1 | | Element 2 | | Element 3 | | Element 4 | | New idea/Add-on element | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Sub-element | | | | Sub-element | |
| | | a | *Technical Draw* | a | b | a | *Technical Draw* | a | b | a | a |
| Design 1 | | | | | | | | | | | |
| Design 2 | | | | | | | | | | | |
| Design 3 | | | | | | | | | | | |
| Design 4 | | | | | | | | | | | |
| Design 5 | | | | | | | | | | | |
| Design 6 | | | | | | | | | | | |
| Design 7 | | | | | | | | | | | |
| Design 8 | | | | | | | | | | | |

H4 — H3 — H2

All those requirements in the table are based on or are suited towards the Hierarchy of need, Fev Matrix as depicted in Figure 1. It acted as translating from the existing product into the four hierarchies of needs or four steps in a builds up matrix called Fev Matrix of design development First, existing design sorting elements (Hierarchy 1:H1), in this phase all the details on product will be sorted into a breaking elements from the main elements into the sub-sub-elements. In this step, the technical draw may be used instead of word for better understanding among customer (Hierarchy 3: H3). Step 2, Fev Matrix desire of input and output (H2) is a possibility of design required is built up (combination formula-permutation theory is used for combination design validity checking) and be rated in one of matrix table. Customer desire sorting (H3) is run among the chosen population (customer). The final design concept is considered as a H4, last hierarchy concept generation and final design selected among the possibility design built.

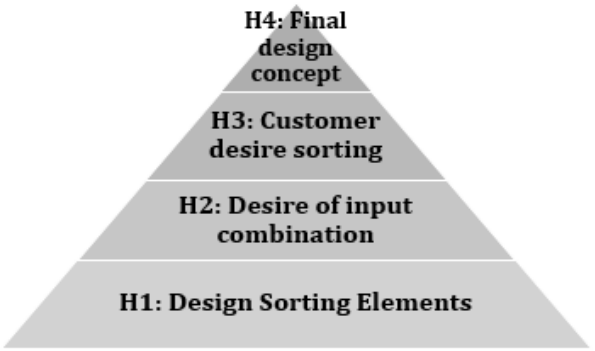


**Figure 1: Hierarchy of need in product development (product desire)**

A watch product is used as a case study. It consists of overall elements of watch parts consisting of size, body and mechanism. Each part is then further into their sub-parts. Size is further classified into small, medium and big. Whereas the body is divided into straps, casing and buckle. Type of straps is the leather, plastic and stretchable. The casing consists of round and square. Mechanism taken into account is analogue and digital. All these details are constructed in a table design considering the Hierarchy 1 (H1): Existing design Sorting Elements (Table 2). Phase 2 is H2 (Fev Matrix desire of input and output), that calls as half of Fev Matrix, which is all the possibility of design required is built and be rated in one matrix as depicted below (Table 3). As from the phase 2, the main elements in watch product colored by grey and it will depend on a product how we guide the elements into it, either using the word or by helping from the technical draw.

**Table 2: Hierarchy 1 (H1): A watch existing design Sorting Elements**

| Design Concept | Customer Score | Size | | | Body | | | | | | | Mechanism | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Strap | | | Case | | Buckle | | | |
| | | small (18mm) | medium(22mm) | big(24mm) | Leather | Plastic | Stretchable | Round | Square | Yes | No | Analog | Digital |

| Design Concept | Customer Score | Size | | | Body | | | | | | | Mechanism | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Strap | | | Case | | Buckle | | | |
| | | Small (18mm) | Medium (22mm) | Big (24mm) | Leather | Plastic | Stretchable | Round | Square | Yes | No | Analog | Digital |
| Design 1 | | x | | | x | | | x | | x | | x | |
| Design 2 | | x | | | | x | | x | | x | | x | |
| Design 3 | | x | | | | | x | x | | x | | x | |
| Design 4 | | | x | | x | | | x | | x | | x | |
| Design 5 | | | x | | | x | | x | | x | | x | |
| Design 6 | | | x | | | | x | x | | x | | x | |
| Design 7 | | | | x | x | | | x | | x | | x | |
| Design 8 | | | | x | | x | | x | | x | | x | |
| Design 9 | | | | x | | | x | x | | x | | x | |
| Design 10 | | x | | | x | | | | x | x | | x | |
| Design 11 | | x | | | | x | | | x | x | | x | |
| Design 12 | | x | | | | | x | | x | x | | x | |
| Design 13 | | | x | | x | | | | x | x | | x | |
| Design 14 | | | x | | | x | | | x | x | | x | |
| Design 15 | | | x | | | | x | | x | x | | x | |

Each box (Table 3) is then filled up accordingly to ensure that each design has been filled that serve a wide range of design characteristics. All the possibility design required is built. So the formula of combination- permutation theory [13] is used as a checker either the number of possibility design concept are built correctly. The completed of a Fev Matrix, desired table of Hierarchy of need (Table 3).

$nCr = n! / r! (n-r)$ ……(1)

A total of 72 design options is available in matrix table that considered all elements in a watch product. Then the idea of Hierarchy 3, H3 is used which is the priority of concept design is continued towards the 90 customers were then being interviewed to choose their most preferable design (Table 4). Based on the 72 options, the best 5 (Design 4,6, 11, 45 and Design 51) (Table 4) were chosen based on the highest rank chosen by the customers. According to Fev Matrix, the top 5 designs are selected as the final design, proceed to design process and illustrated in Figure 2. The new combination elements of the watch are sketched by CATIA in order to see the consistency of design (Figure 3). This shows the smooth flow concept generation before inserting or proceeding towards the concept selection (Pugh Matrix), it is adopted as a case study or continuity from the Fev Matix. The juxtaposition concept between generation and selection show the linking bridge between them. In order to create the specification to reflect on

the best characteristic watch, the main parts of wrist watch are than analyses. It is analyses based on the matrix above

(Table 3&4). From the matrix, the varying size, straps, casing, buckle and mechanism has been adopted as the main factors related to the elements in the wrist watch. This is then further classified into the concept generation.

**Table 4: Hierarchy 3 (H3): Most preferable design by the customer (Customer Score) and Hierarchy 4 (H4): final design concept by red colored**

| Design concept | Customer Score | Size | | | Body | | | | | | | Mechanism | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Strap | | | Case | | Buckle | | | |
| | | small (18mm) | Medium (22mm) | Big (24mm) | Leather | Plastic | Stretchable | Round | Square | Yes | No | Analog | Digital |
| Design 1 | | x | | | x | | | x | | x | | x | |
| Design 2 | H3 | x | | | | x | | x | | x | | x | |
| Design 3 | | x | | | | | x | x | | x | | x | |
| **Design 4** | **11** | | x | | x | | | x | | x | | x | |
| Design 5 | | | x | | | x | | x | | x | | x | |
| **Design 6** | **20** | | x | | | | x | x | | x | | x | |
| Design 7 | | | | x | x | | | x | | x | | x | |
| Design 8 | | | | x | | x | | x | | x | | x | |
| Design 9 | | | | x | | | x | x | | x | | x | |
| Design 10 | | x | | | x | | | | x | x | | x | |
| **Design 11** | **8** | x | | | | x | | | x | x | | x | |
| Design 12 | | x | | | | | x | | x | x | | x | |
| Design 13 | | | x | | x | | | | x | x | | x | |
| Design 14 | | | x | | | x | | | x | x | | x | |
| Design 15 | | | x | | | | x | | x | x | | x | |

| Elements | Design 4 | Design 6 | Design 11 | Design 45 | Design 51 |
|---|---|---|---|---|---|
| **Specification** | **Option 2** | **OPTION 1** | **Option 5** | **Option 4** | **Option 3** |
| **Type of straps** | leather | stretchable | stretchable | plastic | stretchable |
| **Type of casing** | round | round | square | square | round |
| **Buckle** | yes | yes | no | yes | no |
| **Mechanism** | digital | analog | digital | analog | analog |
| **Size** | medium | medium | big | small | medium |

**Figure 2: Concept generation of a watch (from Hierarchy of need, Fev Matrix)**

| Function | Sub-function | Design 4 | Design 6 | Design 11 | Design 45 | Design 51 |
|---|---|---|---|---|---|---|
| **Durability** | Material Quality | -1 | 1 | 0 | -1 | 0 |
| **Maintenance** | Parts Availability | 0 | 1 | -1 | 1 | 1 |
| | Installation | 0 | 1 | 0 | 1 | 1 |
| | Maintenance Cost | 1 | 1 | 0 | 1 | 0 |
| **Marketing** | Design | -1 | 1 | 1 | -1 | 1 |
| | Affordable | 0 | 1 | 1 | 0 | 0 |
| **IMPORTANCE** | | -1 | | 1 | 1 | 3 |

**Figure 3: Final Design selected**

**Figure 4: Final design (Design Concept 51)**

## 4 ANALYSIS AND DISCUSSION

### 4.1 Concept Generation

Concept generation is the direct way where individual customer's experience is the factor which generates his or her satisfaction. The top 5 watches obtained from the Fev matrix are then further classified into the concept generation. Concept generation means by starting with a set of customer needs and target specifications, then the process concludes with an array of product alternatives from which a final datum is selected. Concept generation is done in order to pick the best option with the best characteristic which correlates into both customers' expectation and engineering requirement [14]. The specification in the table below is based on the matrix that consists elements of a wristwatch.

The option 1 which is the concept 6 is being chosen out of 5 option listed. Option 1 which is the stretchable watch is being chosen after a thorough screening of all the specifications to obtain the best design in every aspect possible with most demand characteristic. Option 1 is to use as a reference datum for the final design selection in concept generation.

.**Table 5: How the concept is translated from Fev Matrix into Pugh Matrix**

| Design concept | Customer Score | Size | | | Body | | | | | | | Mechanism | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Strap | | | Case | | Buckle | | | |
| | | small (18mm) | Medium (22mm) | Big (24mm) | Leather | Plastic | Stretchable | Round | Square | Yes | No | Analog | Digital |
| Design 1 | | x | | | x | | | x | | x | | x | |
| Design 2 | | x | | | | x | | x | | x | | x | |
| Design 3 | | x | | | | | x | x | | x | | x | |
| **Design 4** | **11** | | x | | x | | | x | | x | | x | |
| Design 5 | | | x | | | x | | x | | x | | x | |
| **Design 6** | **20** | | x | | | | x | x | | x | | x | |
| Design 7 | | | | x | x | | | x | | x | | x | |
| Design 8 | | | | x | | x | | x | | x | | x | |
| Design 9 | | | | x | | | x | x | | x | | x | |
| Design 10 | | x | | | x | | | | x | x | | x | |
| **Design 11** | **8** | x | | | | x | | | x | x | | x | |
| Design 12 | | x | | | | | x | | x | x | | x | |
| Design 13 | | | x | | x | | | | x | x | | x | |
| Design 14 | | | x | | | x | | | x | x | | x | |
| Design 15 | | | x | | | | x | | x | x | | x | |

| Elements | Design 4 | Design 6 | Design 11 | Design 45 | Design 51 |
|---|---|---|---|---|---|
| Specification | Option 2 | OPTION 1 | Option 5 | Option 4 | Option 3 |
| Type of straps | leather | stretchable | stretchable | plastic | stretchable |
| Type of casing | round | round | square | square | round |
| Buckle | yes | yes | no | yes | no |
| Mechanism | digital | analog | digital | analog | analog |
| Size | medium | medium | big | small | medium |

| Function | Sub-function | Design 4 | Design 6 | Design 11 | Design 45 | Design 51 |
|---|---|---|---|---|---|---|
| Durability | Material Quality | -1 | 1 | 0 | -1 | 0 |
| Maintenance | Parts Availability | 0 | 1 | -1 | 1 | 1 |
| | Installation | 0 | 1 | 0 | 1 | 1 |
| | Maintenance Cost | 1 | 1 | 0 | 1 | 0 |
| Marketing | Design | -1 | 1 | 1 | -1 | 1 |
| | Affordable | 0 | 1 | 1 | 0 | 0 |
| IMPORTANCE | | -1 | | 1 | 1 | 3 |

### 4.2 Concept Selection

The Pugh Matrix is a sort of Matrix Diagram that takes into consideration of comparison of a number of design candidates leading ultimately meets which best a set of criteria [12]. Within the Pugh Matrix, four concepts were chosen (as indicated in the top 5 designs) in regards to obtaining the best overall concept for the design. Design (Concept) 6 is chosen as a datum to be compared with the other four designs. The sub-function was obtained from the empirical analyzation of the specification obtained in concept generation. A range of -1,0 and 1 is given as to show the rate of importance. -1 denotes that the function doesn't bring any benefit as compared to the datum, 0 to show no changes and 1 denotes the benefit greater than datum. From the formulation, Concept 51 was chosen as the best concept for the design. The design characteristic is referred back to concept generation.

According to Griffin [10], methods of the concept generation using qualitative criteria or consider the interrelationships among decision elements in order to meet the customers' requirements. Considering the market of the wristwatch in the current situation, the design criteria to meet customers' satisfaction are the type of straps, type of casing, buckle, mechanism and size which is then to be compared with the few wrist watch design concepts. From the interrelationship, a concept is set as a datum based on the most preferable characteristic. The next step is to proceed with the Pugh Matrix where the final wrist watch design could be obtained.

A Pugh Matrix can be utilized at when there is the need to choose among various options. The Pugh Matrix is easy to use and relies upon a series of pairwise comparisons between design concept against a number of criteria or requirements. The Pugh concept selection matrix is used to find the best technology alternative. Each candidate design concept is compared against the datum design, the criteria by criteria and a weighted score are decided by 0= same, 1 = better and -1= worse. Hence, it can be concluded that concept 18 has the best design characteristic which is most preferable to the customers'.

However, how does the design concept obtained? This design concept is obtained based on the questionnaire and the element of a wrist watch which from the Fev Matrix. From above concept selection table, it can be concluded that concept 51 (Figure 4) has the best design characteristic which is most preferable by the customers'; where the design characteristic of concept 51 can be obtained from concept generation. Ultimately concept 51; stretchable straps, with no buckle, round casing, analogue mechanism and medium in size is chosen. The objective of this case study has been achieved which is identifying the final best design.

## 4. CONCLUSION

Based on the above method, the concept is chosen based on a flow (4 hierarchies of need in Fev Matrix). The final selection was obtained from the Pugh Matrix by helping from Fev Matrix in concept generation. Fev matrix is a new tool/ technique which acted to connect the 'missing link' to the concept design (Table 5). As illustrated by the Pugh matrix, the 'final concept' from the Pugh matrix is obtained from the concept generation. But how does the concept generation obtain the "concept" design from? The key point here is, the "concept" design was obtained from the Fev Matrix, also known as the early thinking process of design. A series of concept will be illustrated to the customer which will be

evaluated than on. Conclusion, the final design concept of the Fev Matrix is being able to connect to the flow of design from concept generation to Pugh Matrix in concept selection or as a decision maker because the direct customer evaluation is in the hierarchy. Besides, it can be one tool/technique in the product innovation/improvement from the existing product design.

## 5. REFERENCE

[1] P. Jordan. (2000). Designing Pleasureable Product. New York, Taylor & Francais.

[2] M. Hartono. and T.K. Chuan. (2011). A Proposed Integrative Framework of Kansei Engineering and Kano Model Applied to Services. The 2nd International Research Symposium in Service Management, Yogyakarta, pp.484-492.

[3] Crawford, R. P. (1954). The techniques of creative thinking. New York: Hawthorn.

[4] H. Aldsersey-Williams, J. Bound, and R. Coleman (1999). Methods Lab: User Research for Design. Helen Hamlyn Research Centre, Royal College of Art, London.

[5] B. Lee, S.R. Klemmer, S. Srivastava, and R. Brafman. (2007). Adaptive Interfaces for Supporting Design by Example, Stanford University, Stanford.

[6] A.F. Osborn, G. Rona, P. Dupont, and L. Armand (1971). The constructive imagination: How to take advantage of its ideas, principles and process of the creative thought and brainstorming, Dunod, Paris.

[7] Beyer and Kholtzblatt (1999) missing

[8] M.W. Newman, and J.A. Landay. (2000). Sitemaps, Storyboards, and Specifications: A Sketch of Web Site Design Practice, Designing interactive systems: processes, practices, methods, and techniques. New York, pp. 263-274.

[9] Herring, S, C., Jones, B, R., Bailey B, P. (2009). Idea Generation Techniques among Creative Professionals. Proceedings of the 42nd Hawaii International Conference on System Sciences, pp. 1-10.

[10] Griffin, A. (1997). Drivers of NPD success. Product Development Management and Association. Chicago: The 1997 PDMA Report.

[11] Thurston, D. L. (1991). A formal method for subjective design evaluation with multiple attributes. Research in Engineering Design, Vol. 3, pp.105-122.

[12] Berge, S. (2009). The System Engineering Tool Box. Pp. 1-25.

[13] Fahidy, T.Z. Journal Application Electrochem (2007). Vol.37, pp. 1271-1278.

[14] Chen, L-S and Ming-Chu Weng (2003). A Fuzzy Modal for Exploiting Quality Function Deployment. Mathematical and Computer Modelling, Vol.38, pp.559-570.