# Assessing Degree of Novelty of Products to Ascertain Innovative Products

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**Abstract:** Substantial increase in competition compels design firms to develop new products at an increasingly rapid pace. This situation pressurizes engineering teams to develop better products and at the same time develop products faster [1]. Continuous innovation is a key factor to enable a company to generate profit on a continued basis, through the introduction of new products in the market – a prime intention for Product Lifecycle Management. Creativity, affecting a wide spectrum of business portfolios, is regarded as the crucial factor for designing products. A central goal of product development is to create products that are sufficiently novel and useful. This research focuses on the determination of novelty of engineering products. Determination of novelty is important for ascertaining the newness of a product, to decide on the patentability of the design, to compare designers' capability of solving problems and to ascertain the potential market of a product. Few attempts at measuring novelty is available in literature [2, 3, 4], but more in-depth research is required for assessing degree of novelty of products. This research aims to determine the novelty of a product by enabling a person to determine the degree of novelty in a product. A measure of novelty has been developed by which the degree of 'novelty' of products can be ascertained. An empirical study has been conducted to determine the validity of this method for determining the 'novelty' of the products.

**Keyword**: Novelty, Innovation

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## 1 Introduction

Continuous innovation is a key factor to enable a company to generate profit on a continued basis, through the introduction of new products in the market – a prime intention for Product Lifecycle Management. During product development, creative solutions can give a product advantage over other competing products. Creative products can therefore be used to increase the price of the products and to get a larger market share [5]. Without creative problem solving, products will be traditional, without a creative edge, which can cause loses on the market place [6]. A substantial part of the future income for a company will come from new products; thus, companies should introduce new products continuously in order to sustain in this competitive market and make profit. [7]. Thus, substantial increase in competition compels design firms to develop new products at an increasingly rapid pace. This situation pressurizes engineering teams to develop better products and at the same time develop products faster [1]. Creativity is the core ingredient of innovation and it enhances the possibility of generating superior products.

'Product design', in which the idea of a product is conceived and embodied, costs are committed and other qualities like manufacturability etc. determined, is the crucial stage for any product in its entire lifecycle. Generation of product concepts takes place in the initial phases of design where, innovation, the key for the generation of products thus satisfying the needs of the society, occurs. Miles & Moore [8] mentions that compared to the overall cost of a scheme, the design cost are a relatively small part; and yet they have a fundamental bearing on the overall costs, durability, serviceability and utility of the product. Good products are the result of good design. A central goal of product development is to create products that are sufficiently novel and useful. Thus, in the modern age we come across many so called 'new' products arising out of product development by various companies; this creates the requirement for identification of good products from the chafe, enabling us to recognize the good products and also identify better inventors/ designers.

The essential element that separates a product from any of its predecessors is its 'novelty'. Identification of novelty is important for the following reasons:

- It is the essential element that separates a product from any of its predecessors.
- Identify products that are more creative (new and useful)
- Determine the creativity of designers to recognize or recruit.
- Assess patentability

Again, in the day-to-day life we come across many products manufactured by several companies that are quite similar to each other (like pens, speakers etc.); and it might be difficult for us to identify which product is novel, since the difference among these products may be very small. Thus, apart from identifying novel products, this work also aims to ascertain the qualitative degree of novelty viz. very high, high, medium and low degree of novelty. Next section deals with the tem 'novelty' in greater detail.

## 2 Understanding Novelty

'New' is something that has been recently created. 'Novel' products are those that are new to the entire human race.

'Novelty' encompasses both new and original. Novelty is 'not resembling something formerly known' [9]. Novelty may also be defined with reference, either to the previous ideas of the individual concerned, or to the whole of human history. The former definition concerns P-creativity (P for Psychological), the latter H-creativity (H for Historical). H-creativity pre-supposes P-creativity, for if someone has a historically novel idea, then it must be new to the person as well as to others [10]. Thus a 'new' product can be termed as 'new' (this should not be confused with our general notion of 'new product' as something that is recently introduced or manufactured or used for the first time), when it comes through p-creativity. Later this product must be checked with all other available products in that category to assess its absolute novelty. Generation of novel products requires H-creativity.

For novelty detection the common characteristics of products could be compared and differences among these characteristics should indicate whether the new product is novel or not as compared to the old products that perform the same or similar task or function. On the other hand, if a new product fulfils a need for the first time in the history, the product must be taken as novel.

Identification of a 'novel' product is difficult since we are not aware of all the products available in all the countries. A database containing the names and characteristics of all the products in all domains from each country would be an ideal database that would have enabled one to assess with greater ease the novelty of a newly generated product. Absence of such a search system compels us to depend upon the knowledge base of the experts in that domain to which the newly generated product belongs. Amabile [11] suggests using a few experts to assess the novelty of a new product. If the product is completely new to them and also satisfies some form of need for the society, then the product can be taken as novel. It is imperative that to assess the novelty of a product, one should know both the time line of similar inventions (the sequence of invention of products belonging to the same category – in terms of the domain and functionality) and the characteristics of the previous similar products belonging to the same product line.

As incremental innovations take place more often than radical innovations, the number of products which are slight improvements over their predecessors are many in numbers, making assessment of novelty of these products hard. The methodology as discussed here deals with a process by which both an expert and a novice designer can assess the novelty with its degree, of a new product, by comparing the new product with the old ones.

The objectives of this paper are:

1. To develop a method to assess the novelty of a product.
2. To improve the same method to help assess the degree of novelty of a product.
3. To evaluate this methodology (initial evaluation).

## 3 Other Available Models For Assessing Product Novelty

Few attempts at measuring novelty are available in literature, [2, 4, 3] but more in-depth research is required in this area.

Saunders [2] work deals with finding the novelty of patterns restricting to mainly aesthetic novelty of patterns - 1) How often similar patterns have been experienced. 2) How similar these patterns have been and 3) How recently these patterns have been experienced. Computationally, novelty is detected using processes that estimate one or more of these properties for a given stimulus pattern and a representation of previous stimuli.

Hernandez and Shah [4] discussed about ideation effectiveness and proposed measures for novelty (i) using function of products (ii) using physical principles of products. Equations for assessing novelty has been proposed and explained. Two methods for novelty determination have been proposed. The first technique is based upon the grading of description of the functions that it satisfies. The second method is based upon posterior classification and counting of distinct solution ideas with respect to priori knowledge.

Chakrabarti and Khadilkar's [3] works deals with finding the novelty using the following criteria- Vertical Criteria Weightages: Need, Task, Sub-system structure (principle), Technology, Sub technology, Implementation and Horizontal Criteria: Main, supplementary, additional. The overall method for assessing product novelty is as follows: (i)• First compare, with the reference product, the product whose novelty has to assessed, and identify the differences,(i) Calculate the novelty value of each difference and add -for calculating novelty value for a difference, first multiply the weightage for novelty at the vertical level and horizontal level. Then multiply this value with the horizontal-level weightage at one level above in the vertical direction and then repeat this process to get an overall value.

Except this last work no other work above aims to assess the degree of novelty of a product. The proposed work is distinct from all available work since

1. It is based upon the well known product categorization systems (viz. the FBS and the SAPPhIRE model) giving a strong foundation for the development of this method and
2. With this method one will be able to identify novel products as well as their degree of novelty.

However, a detailed benchmarking of the proposed approach against the available approaches is underway.

## 4 Backgrond Of The Proposed Method

The inspiration of this work came from the following two observations:

1. While going through Altshuller's work, the inventor of TRIZ methodology [12], it is noticed that there are many levels of innovative products i.e. conventional inventions (32%), small invention (45 %), substantial invention inside technology (4%), Invention outside technology (4%) and discovery (1%) as found by Altshuller. Hence we feel that if products are different from each other

in terms of the level of innovation, and since it is known that innovation requires 'novelty', it follows that the products should also differ from each other in terms of the relative degree of novelty. Even though in all these above cases the patented idea is novel, the level of novelty must be different. The products or ideas that fall under 'invention outside the technology' should be more novel than that of those falling in the first category that is 'conventional invention'. The current approaches to assess novelty seem inadequate to honour this distinction.

2. Another observation is that, for similar products like pens, scientific calculators etc., any latest product might.3 come with only two or three more new functions and so this latest product should be taken as a novel product. In contrast, there are products like new medicines for curing life-threatening diseases such as cancer or AIDS for the first time in history – definitely a novel solution. In both the cases, the most recent products are novel, but the degree of novelty of the products mentioned in the second case is much higher than that in the first case. Novelty detection alone will not be able to differentiate between them - the degree of novelty should also be established.

## 5 Development Of A Methodology To Assess The Novelty Of A Newly Generated Product

To judge and compare various products it will be useful to compare the characteristics of the products. So, any methodology which breaks a product into its characteristic components should be suitable for comparing products. The widely used model in this regard is the Function, Behaviour and Structure (FBS) model. Many researchers [13, 14, 15, 16, 17, 18] have developed definitions and methodology for determining the FBS of products. Extensive work conducted on FBS models illustrates that FBS is a good way of classifying the characteristics of products. The definitions of function, behaviour and structure, derived from the above-mentioned references, as taken for this work are as follows:

- *Function:* Descriptions of what a system does – what is intentional and at a higher level of abstraction.
- *Behaviour:* Descriptions of what a system does, generally non intentional and at a lower level of abstraction. It can be taken as the way by which the function is achieved.
- *Structure:* Structure is described by the elements and interfaces of which the system and its immediate interacting environment are made.

Since novel products are those that are new (recently generated) and original (appearing for the first time in human history); it is implicit that if the function(s) of a new product are different from all other available products, then the new product should be very highly novel product – the need that it fulfils was not previously fulfilled by any other available products at that time, else the product may or may not have been novel. Some examples of highly novel products are (when introduced for the first time): television- to broadcast video and audio data over long distances without any physical connection between the sender and the receiver; camera (pin hole)- to capture image for

future use, similarly multi-utility systems such as X-ray machines or drugs such as penicillin are also highly novel products.

Next, if the new product structure matches with that of any other product then the new product cannot be novel, else it should be taken as novel (see the initial steps of the novelty detection method in Fig.2).

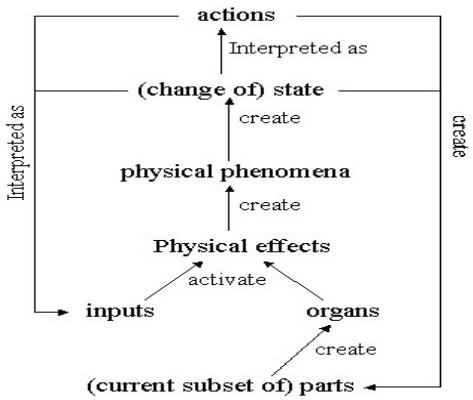
The above method should help us identify novel products, but it will not enable us to assess the degree novelty of products, which is required to distinguish among similar products as opposed to individual radical innovations. Thus, a more comprehensive FBS model should be used. In a comparatively recent study (Chakrabarti et al., 2005) the product characteristics (of an FBS model) have been subdivided into seven elementary constructs. We found that this model can be employed to assess relative degree of novelty of products. The seven elementary constructs are:

- *Action:* An abstract description or high level interpretation of a change of state, a changed state, or creation of an input.
- *State:* The attributes and values of attributes that define the properties of a given system at a given instant of time during its operation.
- *Physical phenomenon:* A set of potential changes associated with a given physical effect for a given organ and inputs.
- *Physical effect:* The laws of nature governing change.
- *Input:* The energy, information or material requirements for a physical effect to be activated; interpretation of energy/material parameters of a change of state in the context of an organ.
- *Organ:* The structural context necessary for a physical effect to be activated.
- *Parts:* A set of physical components and interfaces constituting the system and its environment of interaction.

The relationships between these constructs are as follows: *parts* are necessary for creating *organs*. Organs and *inputs* are necessary for activation of *physical effects*. Activation of physical effects is necessary for creating *physical phenomena* and changes of *state*, changes of state are interpreted as *actions* or inputs, and create or activate parts. Essentially, there are three relationships: *activation, creation and interpretation*.

Using the above constructs and links, a model of causality has been proposed and discussed [19]. The causal description language is acronymed as SAPPhIRE model, SAPPhIRE standing for **S**tate-**A**ction-**P**art-**Ph**enomenon-**I**nput-o**R**gan-**E**ffect, Figure 1.

**Figure 1** The SAPPhIRE model of causality




Now, coming back to the novelty detection issue, we see above that *physical effect* is the main construct that governs the output of a product to a large extent. So, products that are different in the physical effect level will be more novel than those that are different only at the *part* level. Hence, if two similar products works are based on the same physical effect and does the same action but one is only a structural improvement of a previous product, then the later product should be taken as a low novelty product.

Considering the above discussion a method for novelty detection has been developed as shown in Figure 2. In the initial part of the method, the FBS model has been used to identify novel products. Next the SAPPhIRE model has been employed to assess the relative degree of novelty among products.

If a product has many functions, then each of the functions should be compared with the existing products as many times as the number of functions. Apart from products, we believe that solutions and ideas could also be compared given that the ideas are matured enough for the FBS and SAPPhIRE models to be used.

### *5.1 Let us take a few examples to explain this model in greater details:*

**Very high novelty products:** The first safety lamp to be used in mines, sewing machines, staplers, dynamites etc. would fall into this category, when introduced for the first time. These products have very high novelty because no such products existed doing the same function at that time.

**High novelty products:** At the time when microwave cooker was invented there were electric cookers, gas cookers and kerosene fuel stoves. The electric cooker is more similar to the microwave since both runs on electricity, and yet it was found to have high novelty compared to the electric cookers. The FBS and the SAPPhIRE models of these cookers were found out and represented in brief.

**Figure 2** The proposed approach for Novelty Detection

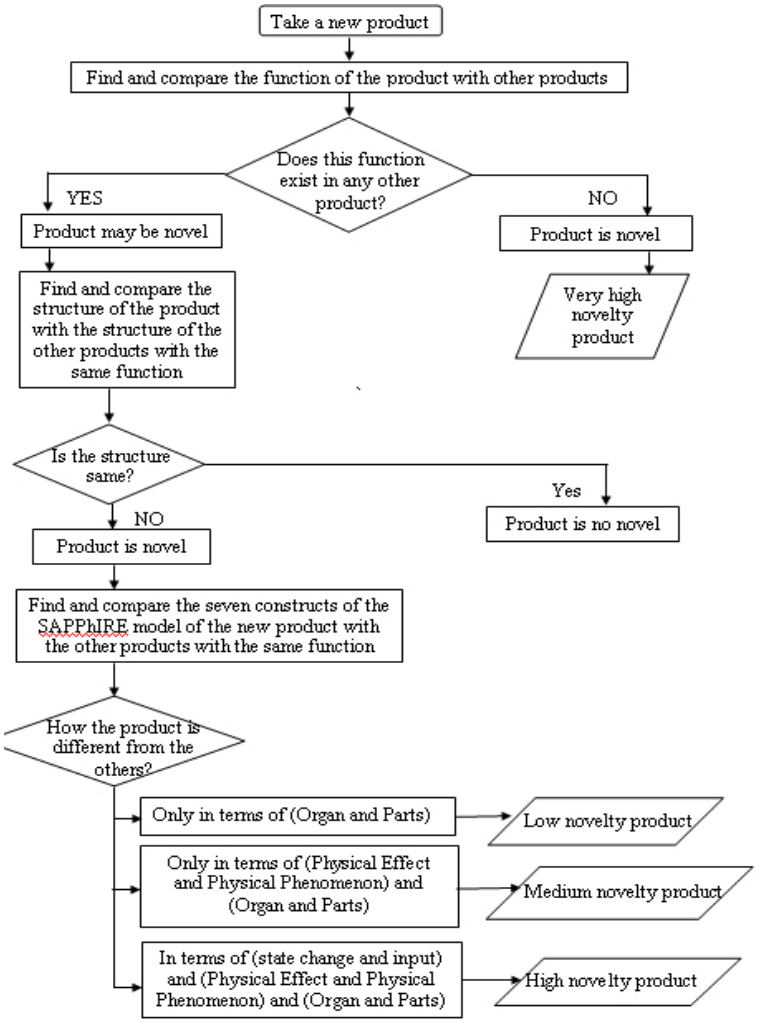


**Table 1.** Comparison of electric cooker and microwave oven

*For electric cooker:*

| FBS | SAPPhIRE |
|---|---|
| Function: To produce heat to cook food.<br>Behaviour: A coil heats up when electricity passes through it, thus producing heat to cook food in a container placed over it.<br>Structure: A container housing a coil placed inside a non conducting material. The two ends of the nichrome wire are connected to the electric plug. | Action: Generate heat<br>State change: The wire turns from cold to red hot<br>PP: Due to resistance in the wire the coil generates heat<br>PE: Ohms law, heat transfer laws<br>Organ: Ohmic resistance, specific heat capacity.<br>Parts: Coil, holder<br>Input: Electric power |

*For microwave oven:*

| FBS | SAPPhIRE |
|---|---|
| Function: To produce heat to cook food.<br>Behaviour: Microwave generated in one part of the oven goes inside the food particles and these particles vibrate internally producing heat.<br>Structure: Magnetron – the microwave generator, a closed container, controls and safety systems. | Action: Generates heat<br>State change: Rise in temperature<br>PP: vibration of the molecules of the molecules.<br>PE: Heat generation principles when micro wave is used<br>Organ: Oscillation of polarized food molecules, eddy current<br>Parts: Microwave generator, enclosure<br>Input: Electric power. |

Following the above method of novelty detection, from table 1, it can be concluded that compared to electric heater microwave oven is highly novel since it differs from its contemporary products both in terms of *organ*, *parts* or *input* and *PP*, *PE* or change of *state*. The other comparisons, of micro wave oven with gas cookers and kerosene fuel stoves have not been shown here, but since they are even more different from the micro wave oven than electric cookers, such comparison should have shown that micro wave oven is highly novel also compared to them.

## 6 Evaluation

To use this model one should be aware of the followings

1. The sequential innovation/invention of the products to be compared
2. The constructs of the FBS and SAPPhIRE models

One important requirement for the successful evaluation of this model is that the output of the model (that is the degree of novelty as determined), should match with the output of the experts (the degree of novelty as perceived/determined by the experts of the same field in which the product belong to.).

**Initial evaluation***:* Before evaluating the model with experts it is necessary to perform pilot and initial evaluation of this method. Initial evaluation has been done with

three in-house researchers. Each person is asked to select any two sets of products and note them in paper. Next, they are requested to analyse these products themselves and identify those products that they think is novel and by what degree. Later, they are required to assess the relative novelty of the same set of products using this method. In all the cases the novelty degree as determined by them without (using their own feeling and analysis) and with the software matched. This initially validates the model and calls for a comprehensive evaluations by experts especially from companies.

## 7 Limitations Of This Model

This model has certain limitations. Research is in progress to eliminate these limitations. The followings are the limitations:

1. Only two products can be compared at a time.
2. Improvement in material properties may not reflect in the outcome.
3. It requires clear understanding of FBS and SAPPhIRE models.
4. Complex products with many functions and sub-functions are tedious to compare.

## 8 Conclusion

A method for novelty detection of products and determining their degree of novelty has been developed. It is noted that product characteristics can be employed to ascertain the relative degree of novelty of products. FBS model has been used to determine the novelty of products and later SAPPhIRE model has been made use of to find out the relative degree of novelty of products. A single methodology that enables assessment of both the novelty of a product and the degree by which it is novel has been proposed. Initial evaluation supports effectiveness of this method. Further research is aimed to eliminate the limitations of this method to make it more general and fool proof, and benchmark it against other available approaches.

## 9 Further Research

Further research includes the following:

1. Comparing this model with other models to assess empirically the efficacy of this model over other models.
2. Eliminating the above mentioned limitations
3. Detailed evaluation with domain experts.

## Acknowledgement

We acknowledge the help of the evaluators for evaluating the model.

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