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A MEASURE FOR ASSESSING PRODUCT NOVELTY

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Abstract

New products have to be introduced in to the market at regular intervals of time, in order to maintain regularity in sales and profits. In this paper, we propose a measure for assessing novelty of new products. The basic ideas on which the measure is based are 1) novelty of a product could not be assessed without assessing its similarity or difference with existing products as reference. 2) There are several levels of novelty, based on how different a product is in its principle, technology and implementation from the existing products. Validity of the measure has been tested using an in-house experiment in which designers were asked to evaluate novelty of a set of products with respect to a given, existing product as reference.

Keywords: creative design, innovative products, drivers of innovation, creativity measure

1. Introduction to problem

Introduction of new products into the market at regular intervals is essential for companies to keep their competitive edge over their competitors. In order to introduce products of high quality within a short time, companies need to recruit creative, competent designers. Selection of creative designers is hard, as valid, elaborate creativity assessment techniques as applicable to product development are not available. Also, although an aim of design schools is to train their students to be creative, judging the outcome of the training is not easy.

Creativity is generally regarded as the ability to develop novel and useful ideas. Assessment of novelty of products or a product idea, developed by a designer, will help assess her creativity. If we know as to what characteristics make a product or a product idea novel, then guidelines based on these characteristics could also be used for training designers. Assessing product novelty therefore is the focus of our research. The primary objective of this paper is to develop rigorous criteria for assessing novelty of products and product ideas.

2. Research approach

The research approach is based on the design research methodology of Blessing, Chakrabarti and Wallace [1], and has the following steps-

1. Identify and collect available data on definitions and measures of creativity, innovation and novelty / newness: analyze these definitions and cluster them into broad categories.
2. Analyse the differences and similarities among these definitions in greater detail to arrive at common fundamental definitions for assessing product novelty.
3. Formulate measures of product novelty based on these definitions.

4. Formulate a method for assessing novelty based on these measures so as to rate a product for its novelty.
5. Test and verify the measure and the method developed by comparing estimations of novelty, of a set of test products, using the method with the opinion, of a group of designers, about the novelty of these test products.

2.1 Literature survey

2.1.1 Definitions of innovation:

There are more than 20 overlapping definitions of innovation; few significant ones are stated here. Langrish [2] summarized that: “Innovation is used by different writers in three different senses:

- A new 'thing' which has been used.
- A process separate from the process of invention (innovation in this sense is the next step after invention).
- A process involving research aimed at a discovery. The making of a discovery or invention and the use of the discovery or invention. In this sense innovation includes invention and is not separate from it.'”

In all the definitions identified, the words commercial and “new product and/or process” are included, which suggests that innovation includes the development of commercially interesting, new products. However, not all new products are equally new. For instance, Langrish et al. [3] classify innovation into four levels:

- Radical breakthrough innovation: innovation leads to a new technology,
- Major innovation: the innovation makes several chapters of the standard book out of date or requires the addition of a new chapter or chapters.
- Incremental innovation: the innovation requires alteration to a chapter or additions of a few paragraphs to the book.
- Improvements: the innovation makes zero or very slight difference to the standard book.

In this classification, novelty appears to be based on at what level the new product (i.e. the metaphorical new book, book chapters or paragraphs) is different as compared to the existing product (i.e., the metaphorical standard book).

2.1.2 Definitions of creativity and novelty

There are several available definitions of creativity in product development. For instance Dasgupta [4] defines creativity in product development (taking microprogramming as an example) as the following:

(1) The attribute "creativity" is a property of some cognitive act or process - in this case, this being the process that produced the idea or the invention or the design concept called microprogramming.

(2) However, the process is deemed to be "creative" only because of, or only as the consequence of, a set of independent attributes or properties attached to the product of that process -in this particular instance, the product being the concept of microprogramming.

Ramirez [5] maintains that "Creative artifacts arise when the resulting meaning is composed of novel components or in a novel combination or even a novel meaning. An example of the latter is referred to as visionary design…"

Guilford [6, 7] assessed creativity based on some characteristics of the solutions generated by the subjects. The characteristics are as follows:

- Fluency- it largely relates to the number of concepts generated in given time.
- Flexibility: - the extent to which people desert their old ways of thinking and strike out in new directions (variety).

There are few definitions of product novelty [4] where it is defined with respect to existing knowledge. "Psychologically novel" products are novel relative to the knowledge body of the people related to it, while "historically novel" products are always novel, even when compared with all existing knowledge available about those products. Similar categorisations are given in TRIZ methodology [8]: "…level(s) of inventiveness within a field can be categorised as having a range from level 1 (personal knowledge) to level 5 (universal knowledge)." These suggest that for assessing novelty of a product, (knowledge of) a reference product is required with respect to which this can be measured. In our case this has to be historically novel. Thus novelty must be always be assessed relative to some reference.

2.2 Overall conclusions from the literature survey

Based on existing literature, we identify two broad views of product novelty:

1) Product oriented view: if some aspects of a new product are sufficiently different from that of an existing one, the new product is considered novel. This has two sub-views: a) external feature based, when product differentiation is based on external features such as aesthetics, and b) technology based, where aspects like working principle, material, manufacturing process, components, layout etc are considered [9].

2) Influence oriented view: depending on the degree of creative influence of the external factors such as people (designers), process (design methods) or environment (company) involved, the likely degree of novelty of a product could be assessed [10]. However, this influence-oriented view provides only a secondary measure of product novelty, since in order to adjudge the degree of creative effects of an influence, one would have to first assess this in terms of the degree of novelty of the products created as a result. This argument is supported in various findings including [3], in which creativity is defined as the process of creating new products. In all our discussions of product novelty, we take the view that any product, to be acceptable as novel, must satisfy the need for the product while being new.

In order to decide as to whether a product is different in some respect from another, the "another" must be taken as reference, and the aspects (e.g. working principle, components etc.) used as criteria, for comparison.

It can therefore be said that novelty is defined only in relation to the knowledge base available in a given domain, i.e., we define the novelty of a new product relative to the existing products available as reference.

2.3 A Measure for assessing product novelty

The criteria, based on which novelty can be assessed, are divided into two levels: a vertical level of criteria based on a set of fundamental characteristics of a product, and a horizontal level of criteria based on their relative importance in the overall functioning at that level.

2.3.1 Vertical level of criteria

These criteria provide the difference between two products in terms of various technological characteristics. The characteristics of a ball pen (figure 1), is taken to explain these terms.

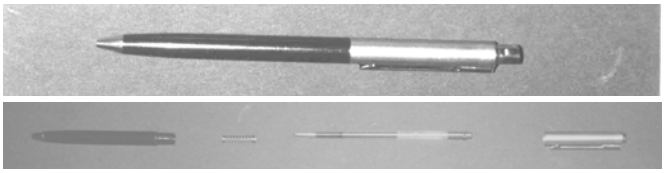


Figure 1. Ball point pen

- Need: it is defined as the basic reason for designing a product. In the case of a ballpoint pen, its need could be taken as that of producing a recognizable pattern on a given background. This criterion is used to judge as to whether two products could be compared for novelty at all: the question of novelty is relevant only when products considered satisfy the same need. It is, however, not included in the measure for assessing novelty, since all products will have satisfied the need for them to be compared for novelty.
- Task: it is defined as the function(s) to be performed; in order to satisfy a given need as defined by the designer. In the case of the pen, the task could be taken as that of dispensing a coloured medium to produce a pattern on another medium.
- Sub system structure based on function: it is defined as the division of a product based on its functions only. For the pen, the subsystem structure consists of 1) an enclosing and support system having a function of enclosing all the sub systems present as well as providing a means of holding the pen, 2) an ink dispensing system having the function of dispensing a coloured medium (ink) at a controlled rate adequate for continuous writing, and 3) a dispensing tip-protecting system that protects the tip of the ink dispenser.
- Working principle: this is defined as the working principle of the sub systems of a product. In the pen example, the working principle of the ink dispensing system is to use a coloured medium using cohesion and viscosity to store it and to dispense using adhesion between the medium and the surface. The working principle defines the domain in which a given product lies. A screw jack belongs to the mechanical domain, while an AC induction motor to the electrical domain, since they respectively are based on principles from these domains.
- Technology: Hubka and Eder [11] defined 'technology' as the specific way of delivering an effect to an operand. In the example, technology of the ink dispensing system is based on the use of a closed geometry, i.e., a tube as the technology for the reservoir, and a closed geometry, which is tapered at one end making a socket, and a spherical geometry (a ball) that can roll within the socket freely, together to form the technology for the refill.
- Implementation: it is defined as the specific use of a given technology for a given task or a given product. This has three main parts: material, process and layout (i.e., the way the systems are placed relative to each other and also how are they physically connected.)

2.3.2. Horizontal level of criteria

These criteria differentiate between the importance of the aspects at a vertical level. There are three important characteristics at each vertical level:

- Main function: this is the primary function of the product. The refill in the ballpoint pen can be taken as the main functional part and its function taken as the main function.

- Supplementary functions: these are the functions that help the main functional part to work at its minimum performance level. For example, in the case of the pen, the enclosing and support system, although not essential for writing, can still be very important for providing the minimum acceptable quality of writing of a pen.
- Additional functions: these are functions that do not affect the primary functioning of the product. In the example, a rubber gripper has this additional function, since a supporting system without a gripper would still allow the pen to work at its minimum expected level.

2.4. Rating novelty using relative weightages for the criteria

The weightages for the various criteria, and the method developed for novelty assessment are detailed in the following sections.

2.4.1 Vertical and horizontal level of the product aspects

The following are the weightages used in the novelty assessment method (see Section 2.4.2):

Vertical Criteria	**Weightages**
Need	
Task	*Wta*
Sub-system structure (principle)	*Wp*
Technology	*Wte*
Sub technology	*Wste*
Implementation	*Wi*

Horizontal Criteria	Main	supplementary	additional
Weightages	*Wm*	*Ws*	*Wa*

2.4.2 Method for assessing novelty

The overall method for assessing product novelty is as follows:

- First compare, with the reference product, the product whose novelty has to assessed, and identify the differences
- 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. Repeat this multiplication until the highest level in vertical direction is reached. Once, this is done for each difference, add them to obtain the overall value. This procedure is explained in detail in two examples given in section 2.4.3.

2.4.3 Examples

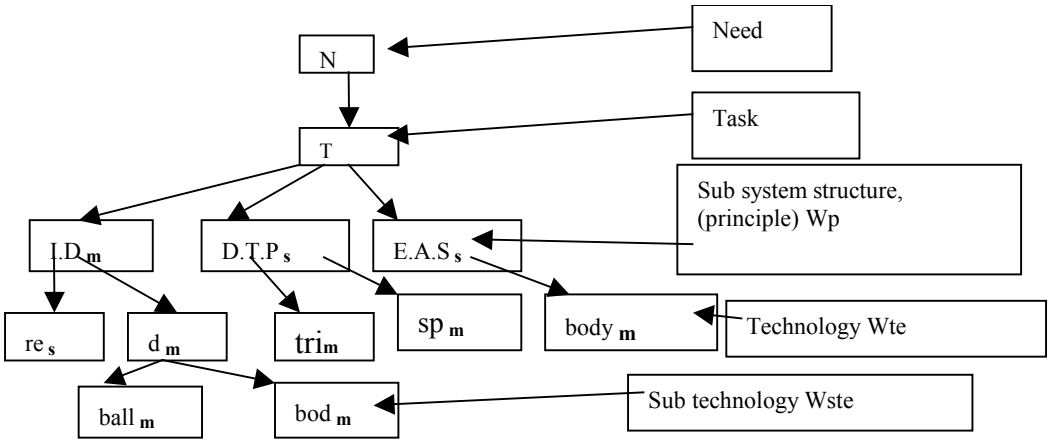
In the first example, we take a ballpoint pen as the new product whose novelty is to be assessed, and an unspecified pen as reference. The horizontal level scores will be decided by identifying the functional importance of the criteria at each vertical level. The ink dispensing system performs a main function at the sub-system structure level. It uses two technologies: the reservoir and the dispensing tip (figure 1). In ink dispensing, the dispensing tip performs the main function, while the reservoir provides a supplementary function. The dispensing tip can also be divided into sub-technologies such as ball and tip body. Both of these are important for the basic functioning of the dispensing tip, so both of them are main functions

at this level. Now, if one sub-technology (say, ball) and one technology (say, reservoir) is new, compared to the reference pen, we can rate the product's novelty as follows.

As ball is a sub-technology, its weightage at the vertical level is *Wste*, and we need to multiply this by the weightage at the horizontal level, which is for a main function, *Wm*. Therefore, the score at this level is *(Wste*Wm)*. We should come down to this sub-technology level only after having inspected all the vertical levels above, so that we are already sure that the higher-level criteria do not already make it novel. However, since the overall functional importance of a difference is based on how important its contribution is at all vertical levels, we need to multiply its vertical level weightage with horizontal level weightages at all vertical levels from the current ones above. In this example, at the technology level the ball belongs to the dispensing tip at the level above, which is a main function (figure 2). So we have to multiply the novelty value *(Wste*Wm)* at the sub-technology level, by the weightage for main *(Wm)* at the technology level. Therefore, the value of the ball at the technology level is *((Wste*Wm)*Wm)*. Now, at the sub-system structure level, this technology (dispensing tip) belongs to the ink dispensing system, which is again a main function at that level. Thus, we need to multiply the value at the technology level by *(Wm)* again in order to obtain the overall value for novelty of the ball at the sub-system level as *(((Wste*Wm)*Wm)*Wm)*.

In a similar way, the reservoir is new at the technology level and it is a supplementary function at that horizontal level. Therefore, the novelty score for the reservoir at this level is *(Wte*Ws)*. Now, this technology belongs to the ink dispensing system, which is a main function at the sub-system level. Therefore, the novelty score for reservoir at the sub-system level is *((Wte*Ws)*Wm)*. This is the overall novelty score for this technology.

If a product has two or more things new, then we have to find the novelty value for each and add them up. In the example case, both the ball and the reservoir are novel, so we add them in to an overall novelty value for the pen as *[(((Wste*Wm)*Wm)*Wm) + ((Wte*Ws)*Wm)]*.



N: - need; T: - task; I.D.: - Ink dispensing; T.P.: -Dispenser tip protection; E.A.S.: -Encasing and supporting system; re: - refill; D:- dispensing tip; tri: -trigger; sp: - spring; body: - main body; ball: - dispensing tip ball; bod: - dispensing tip body. m: - main function; s : - supplementary function; a: -additional function.

Figure 2. Ball point Pen (reference product)

Since additional functions and implementation should not make a considerable difference in the novelty rating, we accounted for them by assigning a constant value to be added to the novelty value obtained otherwise. This rating system is explained in the second example.

In the second example, we take the ballpoint pen (figure 1) as the reference product, and assess two new pens – an ink pen and a fibre tip pen - for their relative novelty. All three pens have three sub-systems: 1) an ink dispensing system 2) a dispensing tip protection system, and 3) an enclosing and supporting system. The pen in figure 2 is a description of the reference product. Its ink dispensing system is the same as that explained in the first example. The enclosing and supporting system has a plastic body divided into two parts for opening and inserting the refill. The dispenser tip protection system has a trigger at the top end for taking the writing tip in and out. The first new product - product 1 - is an ink pen in which the ink dispensing system comprises of a nib and a plastic core covered by the nib. The enclosing and supporting system comprises of a body that is divided into two parts and can be opened to re-fill the reservoir with ink. The upper part of body itself act as the reservoir. The dispenser tip protection system comprises of a cap which can be placed over the body and which covers the dispenser tip. The other new product – product 2 - is a pen in which the ink dispensing system consists of a fibre tip. Its reservoir is also made up of fibre material, which holds the ink by capillarity. The body of this pen is divided into two parts.

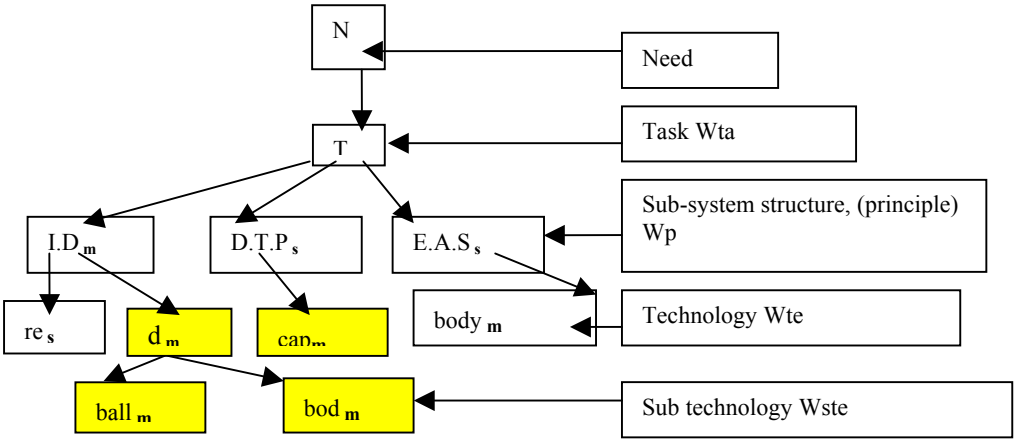


Figure 3. Ink pen (product 1)

The ink dispensing system of each pen is distinct from that of the other, in terms of the dispensing tip. The reservoir of the product 2 is new compared to the reference product. Also, both products 1 and 2 are different from the reference in terms of their dispenser tip protection system as they have caps as opposed to a trigger as in the reference. A diagram explaining all the systems in terms of their levels and their novelty at these levels is given below, see figures 2, 3 and 4 (blocks shown in yellow are the novel parts of the products).

In the case of product 1, both sub-technologies of the tip dispensing technology (ball and tip) are new, making this technology new. Therefore, we can directly consider its novelty at the technology level. The novelty value for the dispensing tip is thus given by *((Wte*Wm)*Wm)*, and that for the dispensing tip protection system is *((Wte*Wm)*Ws)*, making the overall novelty value for the ink pen as *[((Wte*Wm)*Wm) + ((Wte*Wm)*Ws)]*.

New product 2 (fibre tip pen) is different from the reference in three technologies: the reservoir, the dispensing tip and the dispenser tip protection system. The novelty value for the reservoir is *((Wte*Ws)*Wm)*, for the dispensing tip is *((Wte*Wm)*Wm),* and for the dispensing tip protection system is *((Wte*Wm)*Ws)*. The overall novelty value for the fibre tip pen is therefore *[((Wte*Ws)*Wm) + ((Wte*Wm)*Wm) + ((Wte*Wm)*Ws)]*. Consequently, using the proposed method, the fibre tip pen would be considered more novel compared to the ink pen, when a ballpoint pen is taken as the reference.

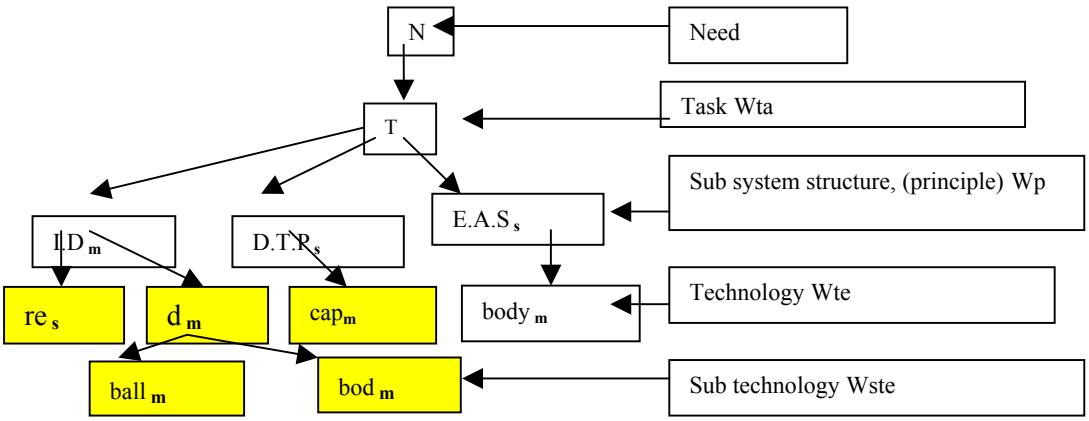


Figure 4. Fibre tip pen (product 2)

2.5 Verification of the results

For verification of the results (the validity of the measure and method), we conducted an experiment on a subject group of 13 designers. They are engineers and architects either pursuing or with M.E.; about half of them have industrial experience. The experiment was conducted using four computer mice as test products - termed A, B, C and D - of which product A was taken as the reference. First, the subjects were explained how each mouse worked. The subjects were then asked to rate novelty of each individual product (B, C, D) with reference to product A (part 1). After this, all the terms that were used by the researchers for assessing novelty were explained to the subjects, who were asked to assess, using the explained terms, as to how products B, C and D differed from A (part II). Their opinions were then compared with the estimations given by the proposed method.

The products used for the experiment were as follows

- Product A: a normal mouse with cord, having three buttons as signal sources and having a roller ball inside to trace movement of the mouse on the notepad; data connection to the CPU is through a PS\2 port.
- Product B: a three-click button mouse with cord where the central button is of disc roller scroll type. Position tracking is done using a ball inside, which operates the photo device to trace the movement of the mouse on the pad. Data transfer is through a PS\2 port.
- Product C: this mouse looks similar to mouse A, but contains different technology for tracing the mouse movement. It uses the images of the surface below to trace the position and is an optical mouse. It has a photo diode that blinks continuously; and the reflected light is traced by a camera, which gives the image of the texture of the surface, based on which position of the mouse is inferred. It uses an USB port for signal input.
- Product D: This is also an optical mouse with scroll disc at the centre instead of a button as in mouse B. This mouse can be used from a distance. It has the same technology as mouse C for tracing position and motion. A receiver connected to the computer traces signal transmitted from the mouse. An USB port transfers signal to the CPU.

Product B has the following differences: only the technology for its scroll button is different from the reference. Its purpose is position tracking, which is a supplementary function. So the novelty score for this product is *((Wte*Ws)*Wm)*. Product C has the following differences: its principle, technology and implementation for position tracking is different. As all parts of the position tracking system are new, we consider its principle itself as new. The novelty value

therefore is *(Wp*Wm)*. Product D has its Principle, technology and implementation for position tracking as new; also, one additional sub system for cordless signal transmission is new. So its novelty value is *((Wp*Wm) + (Wa))*.

The proposed method, therefore, estimates that product D is the most novel; product C has less novelty than product D, and product B is the least novel.

Table 1 shows how, in part I, the 13 subjects rated the four products shown to them in the test for their relative degree of novelty. The number shown in each cell of the table shows how many subjects rated the product with that degree of novelty.

Table 1. Novelty rating in part I

Product name	Low novelty	Moderate novelty	High novelty	Very high novelty
A	11	2		
B	1	11	1	
C	1	4	7	1
D			8	5

Table 2 shows the novelty ratings given by the subjects to the same products after they were explained the criteria used by the method for rating novelty of these products. Results in both the tables show that designers' opinions about the relative novelty of these products were the same as that predicted by the method, which provides some initial validation for the measure.

Table 2. Novelty rating in part II

Product name	Low novelty	Moderate novelty	High novelty	Very high novelty
A	9	4		
B	0	11	2	
C	0	4	7	2
D			7	6

Specific findings from the experiment are as follows:

All the subjects who gave a moderate novelty rating to mouse B said that this was because the only difference it had was the way the cursor can be controlled. This generally supports our rating structure in the vertical direction. For rating, many subjects used the differences in external features of the mouse. To take this into account, we need to extend our overall novelty assessment measure by including task and implementation into it. However, for a product developer these are vital differences, and must be taken into account for measuring product novelty.

3. Conclusions

The goal was to develop a measure for assessing product novelty and test its validity. We have developed a set of basic criteria with which novelty of a product against an existing, reference product could be assessed. We use weightages of these criteria and integrate them

to form an overall qualitative assessment of novelty for the product. We have done a preliminary evaluation of the validity of the measure and the method by doing an experiment based on opinions of designers. However, in order to develop these measures into quantitative metrics, we need to quantify the weightages by collecting statistical data about their relative values, possibly by conducting further experiments similar to the ones done here for verification of the research output. Further work includes the following

- Consolidate the measure with further experiments and developing quantitative measures.
- Use this for developing measures for comparing novelty of two product ideas.
- Comparing two sets of products with a reference set.
- Use these for developing measures of creativity in product development.

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