# Generative Design Using the Design DNA

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## Abstract

Today, in our society where trends and fashions are rapidly replacing each other, companies become more competitive in the design sense, therefore a great demand for faster product development has surfaced. To satisfy the need for faster product development, the designers have to be more productive, more efficient, and this is only possible by using tools. The Designers' Avatar (DA) and Design Blender (DB) are generative design tools which uses many subtools and procedures aimed for increasing the efficiency of a designer. Design DNA (DDNA) is one of these tools, and in this paper I demonstrate how we use the DB and DDNA to come up with product families.

## 1. The Design DNA (DDNA)

As your DNA contains the genetic instructions used in the development and functioning of all known living organisms [1], the Design DNA contains generic information to be used in development and functioning of products (and perhaps experiences, service and even artificial life forms). DDNA is a multi-dimensional matrix of images, information and meta-data. The initial use for DDNA is perfect recreation of a design, however it can be used also for generative purposes.

### 1.1 Structure of the DDNA

Like the DNA composed of bits of information, DDNA is also composed of arranged information so that we can recreate a design from scratch. DDNA is a Multi Level Array. In detail, the DDNA is composed of one or many Spirits. The Spirits consist of one or many Nodes. Nodes consist of one or many Bits. Bits are single answers, nodes are set of answers, and spirits are group of set of answers.

### 1.1.1 Bits

The bit is very basic, indivisible information about the core properties of the object. The values contained in the bits are extremely simple and specific answers to specific questions. In most of the cases, the bits will contain either Boolean or Numeric values, but there are cases where they can be text or binary data as well. No matter what, the bit contains single information; a bit never contains a set of information. For example "the exact size of an object" is a bit. But "possible sizes of an object" is not; it is a node.

### 1.1.2. Nodes

Nodes are sets of bits, when several bits come together, they form a node. A node is an information matrix; a multi-dimensional array of images and information about a niche property of the object. For an example, the color range of an object could be a Node; it may contain many bits. Example: Color (White, Grey, Blue) etc. Sometimes, we can express Nodes with moodboards; which are visual mindmaps [2].

### 1.1.3 Spirits

Spirits are sets of nodes. Spirits describe an object in a limited manner. For example they could describe only the function, unique selling proposition, color, historical references or graphic features of an object. I categorize the Spirits into special categories such that as a rule of thumb, while designing if you keep the elements of one Spirit from each category and the Main Spirits constant, you arrive at a well built product family.

### 1.1.3.1 Prime-Spirits

Prime-Spirits define what the object is and what it serves for. There are two main spirits; they are: Functional Focus and Scale. Functional Focus determines what particular function the object satisfies [3]; it is a vehicle, it is a seating, it is a toy. The Scale defines scalar difference; such as a model chair, a children's chair, a real chair. Both the Scale and the Functional Focus must be kept constant for sure if you intend to come with a product family.

### 1.1.3.2 Proto-Spirits

They are the initial concepts and significant restrictions. The initial Inspirational Proto-Spirits are: Cultural Reference, Historical Reference and Conceptual Reference, they are spirits that inspire the creation of the object. The nodes in these spirits are usually reflected as moodboards. The Restricting Proto-Spirits are: Production Technology, Form, Intended Use, and Impact on Nature. We could add some other spirits into this group but I want to make clear separations.

### 1.1.3.3 Beta-Spirits

Properties of the object that appeals to our five senses, this is what adds the design taste to the objects, this is after the main inspirations and restrictions what we decide to come up with, a secondary set of aims and restrictions. The Spirits in this group are: Graphic Element, Unique Selling Proposition [4], Emotional Setting, Color, Texture, Material, Interface, Sound, Temperature, Softness, and Weight. There could be more spirits in this group. Character Spirits could also exist under the Beta-Spirits, we could count Reaction, Interaction and Character under this category.

### 1.1.3.4 Hyper-Spirits

It is true that with every detail we learn about an object, our valuation of the object is

altered; however there are certain properties that create a greater change. Hyper-Spirits are the properties of the object such that that after we know them, our understanding and evaluation of the object changes significantly [5]. Some examples would be: Price, Made-up History [6], Fabrication Quality, Producer, Designer, Place of Origin, Benefactor Group etc. These are usually featured on the packaging [7].

## 1.2. Coding the DDNA

DDNA can be written, formulated or coded in four ways; Pseudo DDNA (PDDNA), Sampled DDNA (SDDNA), Heuristic DDNA (HDDNA) and Generative DDNA (GDDNA).

### 1.2.1 Pseudo-DDNA (PDDNA)

Pseudo Design DNA (PDDNA) is a natural language expression of the DDNA. At PDDNA, the design is tediously explained with the uppermost details. This includes all the information to create or recreate the design. PDDNA aims for perfect recreation or creation of the design idea. Perfect recreation is the key here [8].

### 1.2.2 Generative Pseudo-DDNA (GPDDNA)

If we also include some "randomly picked or generated" values in our Pseudo Design DNA we can have the Generative Pseudo-Design DNA (GPDDNA). GPDDNA aims for generative and varied creation of the design ideas by repetitive processing.

### 1.2.3 Sampled-DDNA (SDDNA)

Sampled Design DNA (SDDNA) is composed of mixed media information that could be used to exactly create the design in mind. SDDNA is an expansion of PDDNA, it is further expressed by; Technical Drawings + Color Samples + Material Samples + plus any other necessary information that was not verbally described. A prototype joins this category. SDDNA aims for perfect recreation of the design idea.

### 1.2.4 Heuristic-DDNA (HDDNA)

This defines the archetype [9]. Heuristic DDNA expressions are written in one or many XML files (or any other format that could be understood by both humans and computers). This is a very detailed definition of the object to be designed, think it like a 3D data file that also includes physics data and even other programs inside. HDDNA aims for perfect recreation or creation of the design idea [10].

### 1.2.5 Generative-DDNA (GDDNA)

The GDDNA has specific values that have to be either generated or picked randomly from a set. GDDNA approach aims for generative recreation or creation of the design by repetitive processing of the GDDNA. When the GDDNA is processed repeatedly by the machines we have "generative design" and when the PGDDNA is processed repeatedly by non-machines we have "simulated generative design".

### 1.2.6 Design Blender (DB) and DDNA Extractor (DDNA-E)

The Design Blender is an idea-tool for mixing and blending different GDDNA together. DDNA extractor is an idea-tool to derive / extract nodes from existing cultural domains. DB & DDNA-E can be used together to increase form variety [11].

### 1.2.7 Designers' Avatar (DA)

The Designers avatar is a piece of software or a machine that both contains the GPDDNA and runs the GPDDNA. A human can also be a Designers' Avatar; he can learn and simulate the PGDDNA. The DA acts as a product platform itself, it can be used to increase the speed of design generation [12] however we still need designers to choose which designs to be confirmed at this stage..

### 1.2.8 Coding Order
The way to start is to have the PDDNA first; this is to create an object exactly from the code, if it works, you can now introduce randomness and generative tasks to it to come up with the PGDDNA, if it also works, you should now prepare the HDDNA, and if HDDNA is working you can proceed with the GDDNA. The DA is the last thing; the difference from DA from any others is that DA works by itself, other DDNA has to be run.

### 1.2.9 Simple Generative Pseudo Design DNA (GPDDNA) Example

Designers' Avatar "Dort"; creates A series of "generated" abstract expressionist drawings by Onur Mustak Cobanli, seeded by words.
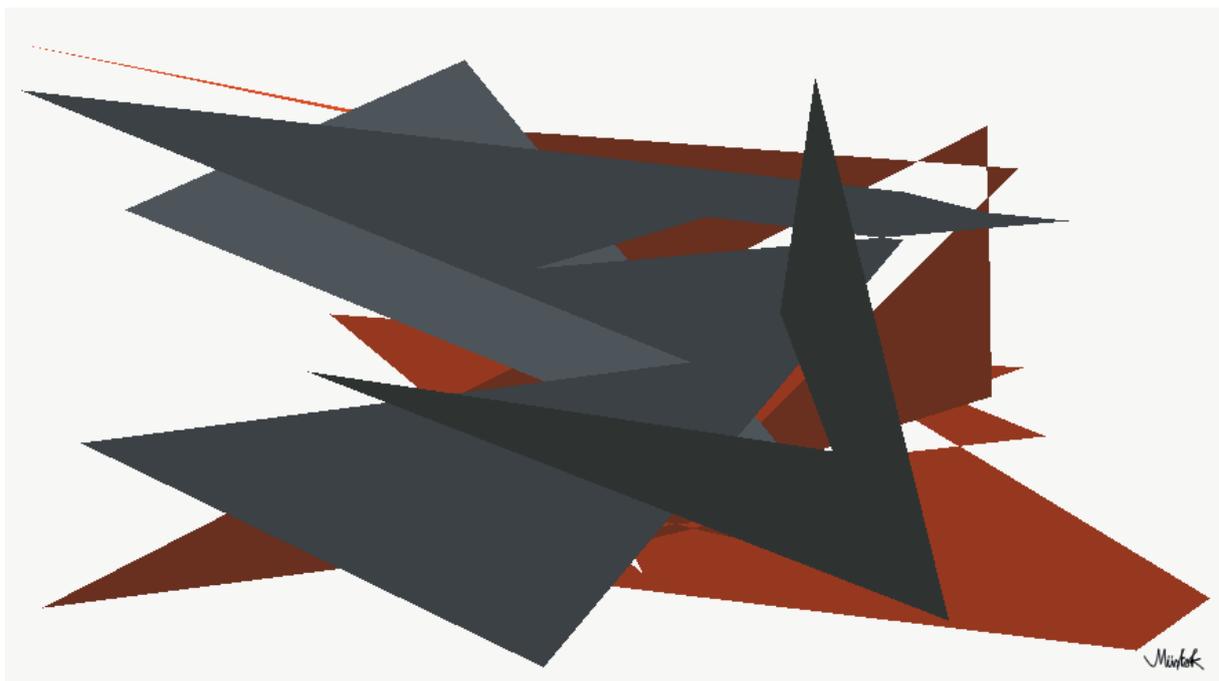


*Image 1. Abstract Expressionsit Drawing Generated by Avatar 4.*

The GPDDNA is as follows:

*Spirit Set consists of "Functional Focus", "Shape" and "Color". The "Functional Focus" is defined as a "Drawing" is "2D". "Shape" is defined as "Proportion" is "16:9", "Topology" is "Rectangle". "Graphics" is a "Set of 5 closed geometrical forms defined by five randomly generated (X,Y) point sets with words to seed the random generator". "Color" is defined as; "Background" is "White", "Foreground Color Range" is "Set of 33 different Set of 3 similar colors, one of them is picked randomly with words to seed the random generator".*

The drawings are seeded by the words "Painted" and "Dynamic" for the first example, and "Complexity" and "Design" the second drawing.

**1.2.10 Sampled Design DNA (GPDDNA) Example**
Of course we could write it in a different and clean way to understand easier; here is the Sampled DDNA (SDDNA). It is relatively easy to understand as it is aided by visual forms and prototype.
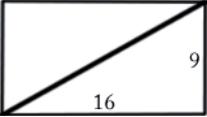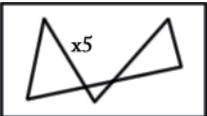
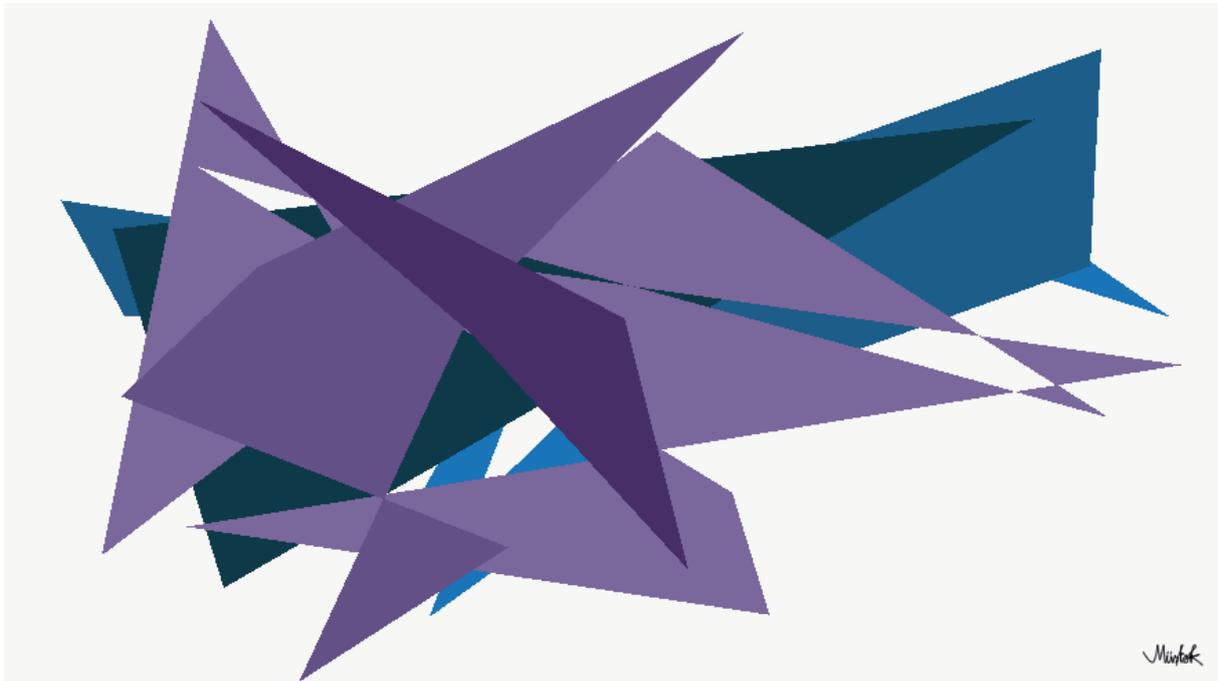| Functional Focus | Shape | Color |
|---|---|---|
| Drawing (2D) | Proportion (16:9) | Background (White) |
| |  |  |
| | Graphics ("Set of 5 closed geometrical forms defined by five randomly generated (X,Y) point sets with words to seed the random generator") | Foreground ("Set of 33 different Set of 3 similar colors, one of them is picked randomly with words to seed the random generator") |
| |  |  |

*Table 1. SDDNA Example*

*Image 2. Abstract Expressionsit Drawing Generated by Avatar 4.*

Let's proceed with some three dimensional products and start the real fun. However we need some more tools to do so, and we will introduce the Moodboard.

### 1.2.11 Moodboards

Moodboards are tools to express nodes in an intuitive and easy to understand way for humans to understand, developed artificial intelligence could also make use of the moodboards, the aim is to find a series of images or sounds that all share a common attribute or come up with many relevant series of images, sounds and data and find what is the "similar, shared attribute", such that from this sample series of images, we could derive others. When creating moodboards, we need to keep all other things constant [14]; for example, let's say that we are going to create a moodboard for forms, than the silhouettes are enough. In any kind of moodboard I suggest to find at least 40 different examples so that we could have a significant understanding, I usually go for 100.

### 1.2.12 Complex Design DNA Example

I have simulated the GPDDNA of Leaf Product Family, An Outdoors Furniture Family design by Onur Mustak Cobanli.

The GPDDNA is as follows:

*Spirit Set consists of "Form", "Material", "Production Technology", "Mood", "Functional Focus". The "Form" is defined as a "Similar to Leafs" is "expressed as a Moodboard". "Production Technology" is defined as "Rotomolding" is "expressed as a Moodboard", "Mood" is "Green, Natural and Soft" is "expressed as a Moodboard", "Functional Focus" is "Outdoor Furniture" is "expressed as a Moodboard".*

Let's create the SDDNA with the help of moodboards, first we start with the "Form", when we are creating the moodboard for the form, the silhouettes are enough; We search for leaf images, and then convert them into silhouettes. This is the research.



*Image 3. Moodboard composed of Silhouettes*

Here we can use this moodboard to identify some common elements, for instance for me is the rounded sized but somehow sharper edges, the fact that leafs become fatter in the middle and thinner at the edges, the symmetric tendencies of the leafs etc. We keep them as discoveries of the research.



*Image 4. Portion of Moodboard of Plastics*

For rotational molding, we learn that we need to use plastics, we make another moodboard, we search for plastic objects that are of our interest, we try to understand the best practices, we learn also the technical details, what is the wall thickness, how is mold parting, the answers are our discoveries.



*Image 5. Portion of Moodboard of Rotomolding Process and Relevant Products*

We continue creating an additional moodboard for rotomolding and how it is done. This is our research and we will use our discoveries as opportunities and restrictions while designing.

*Image 6. Portion of the Moodboard of Mood; Green and Soft*

The mood study is composed of many images that reflect what we want to achieve, what we want to reflect, so we are searching for common elements: color: green and green gradients, again very soft and organic shapes, we keep these discoveries in mind.



*Image 7. Portion of Moodboard of Outdoor Furniture*

Lastly, we make a moodboard for outdoor furniture, Here, at our research for outdoors, we find for example that they have "water holes", "inclined boddies" and easy to move features.

When we run our GPDDNA we come up with the following product family:
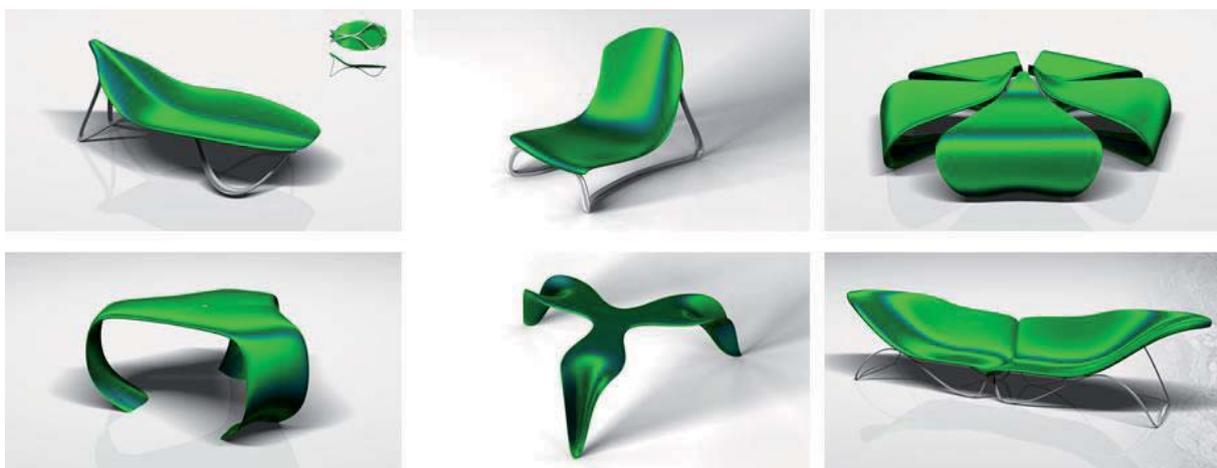


*Image 8. A product family simulated from the generative design dna*

## 1.3 Product Family Creation with DDNA

When we repeat running the GPDDNA, we are doing truly generative design, one key strength is that by this way, we can come up with product families and even product platforms. Here I have drawn the basic process flow diagram of how it works.

### 1.3.1 Creating Product Families from Scratch using Design DNA

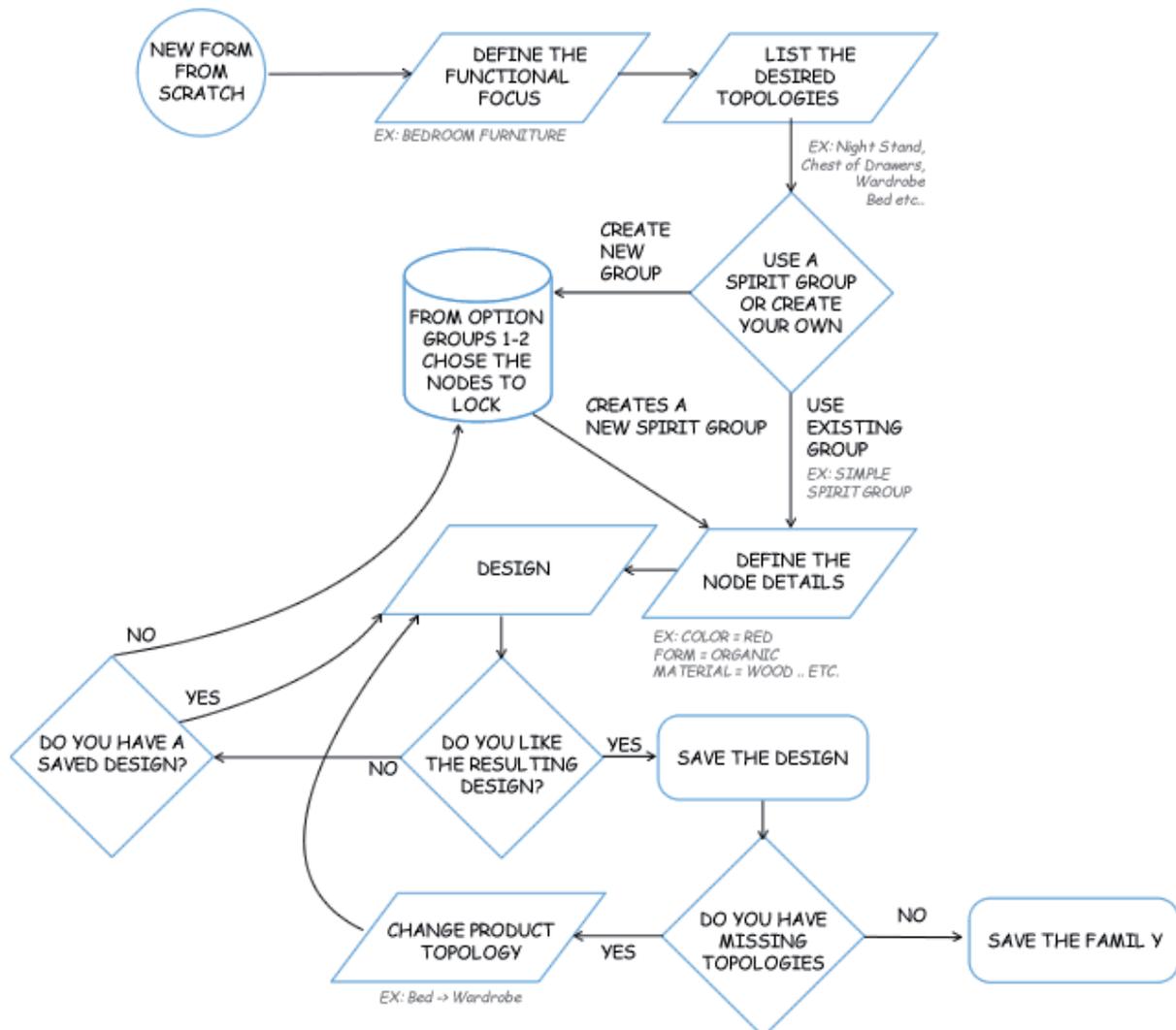The process flow diagram for creating a design from scratch:

*Chart 1. Process Flow for Creating Series of New Products from Scratch*

This process flow designs could be used as a basis for both writing the software and simulating the platform [15]. Here, in this process flow, we also see the locks; they are "things and concepts that you want to keep same in all the generated products", "topologies" are additional focus in the "functional focus" group; for example we said furniture, then our "topologies" will be chair, table, bench, sofa etc. "Spirit Group" refers to the DDNA.

This process flow is good if we do not have an initial idea. But what if we have an already existing design that we want to develop from? We need to derive the "Spirit

Group : DDNA" from this existing design; we underline the most important five-six key points that we want to see in all the other newly generated designs, we reconstruct the DDNA with this in mind.

## 1.3.2 Deriving product families from an existing product

The process flow diagram for deriving a product family from an already existing product is as follows.
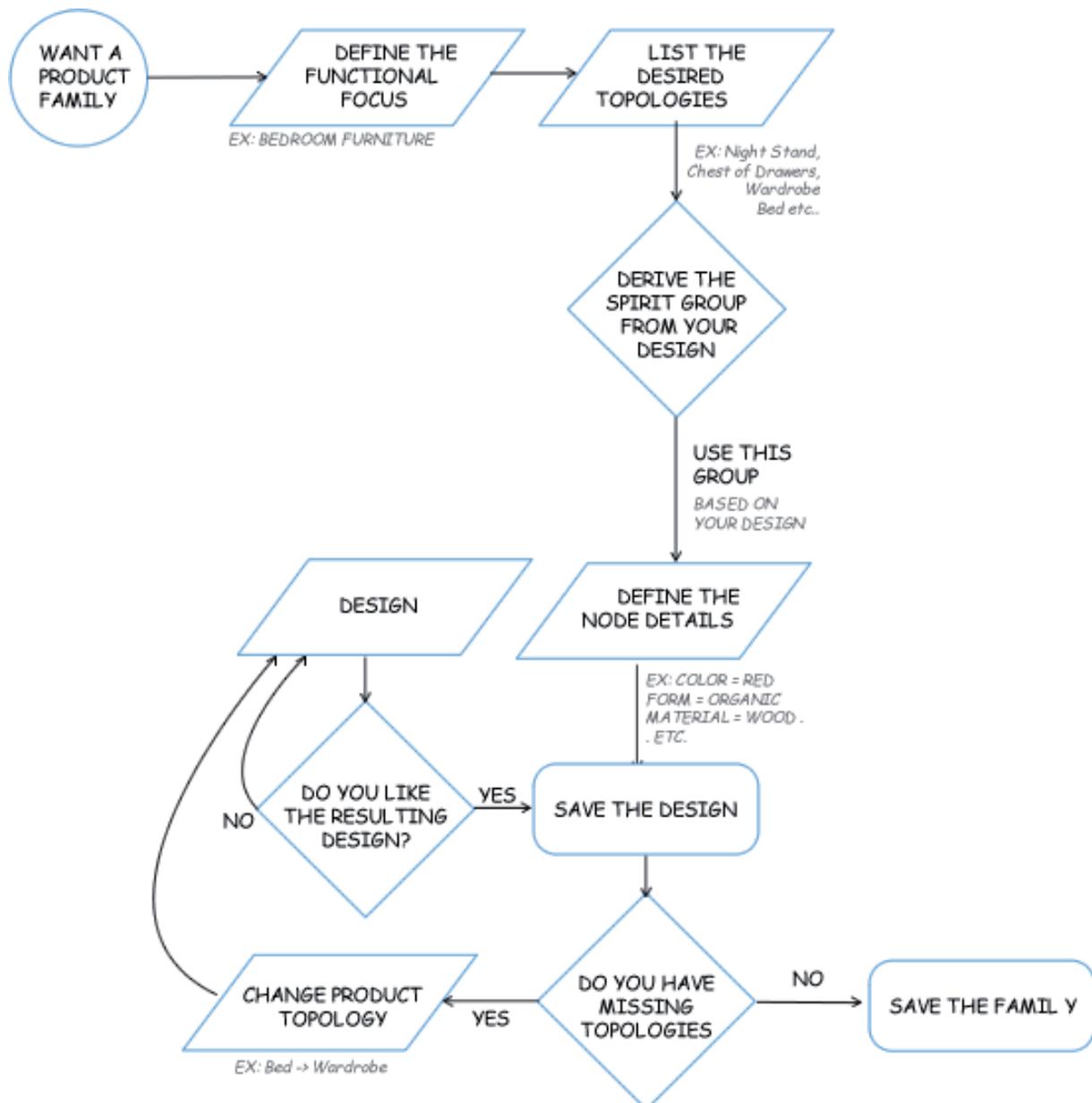


*Chart 2. Process Flow for Creating Series of New Products from Existing Products*

To repeat what's written; we start from an object, and derive the DDNA from it; then we identify the key components about the object; we try to answer several questions, we ask ourselves, what makes it special, what we like in it; what are the possible components that we can use again in other and new products etc so that we can use

these notes and information while fabricating the DDNA.

After the DDNA fabrication we repeat design processes several times, we sometimes modify the DDNA; increase or decrease the restrictions or change the type of restrictions so that we can arrive at a good product family or a platform [16]. I would like to make an example derivation from a product, we will underline key components and values that we would like to see in the newly generated product family.

### 1.3.4 Extracting DDNA from a Product

Similar to reserve engineering a product, we can extract the DDNA of a product. Let's start with the following product:



*Image 9. A Furniture Design, as the initial design*

Given our example, we extract the following spirits: **"**Form" is "Smooth and Round Edges" are derived in detail by the "radius of circle", "the legs". The "Production Technology" is derived as "woodworking", the "Historical Reference" is derived as "1960s Cars and furniture", "Color" is derived as "Body" is "Black", "Seating" is "Red", here we also choose the "Functional Focus" as "Indoor Furniture for Houses".
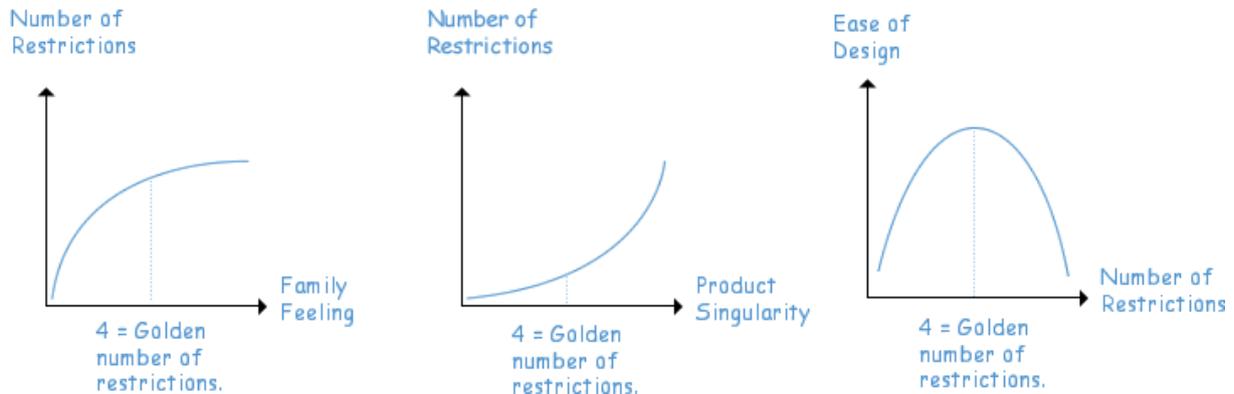
The product family we developped by deriving the DDNA from the initial design: Due to my lack of programming skills, I had to simulate the PGDDNA and repeat the task each time, following my process flow diagram while doing so. Of course, these are not all the results; I had eliminated many of the designs that were not good, and I believe this is the task of the designer to choose the best among generated ones.

*Image 10. Series of Products generated from the Initial Design*

### 1.3.5 Improving the Generated Product Families

What if we cannot come up with a good product family, than we need to play with the restrictions, by trial and error, I have found that the golden number of restrictions (number of spirit groups in the DDNA) is four (4) as at this point the design becomes easy to arrive at, we can change the type of restrictions, increase or decrease the number of restrictions.



*Graphs 1. 2. And 3. Relationship between number of restrictions, family feeling and product singularity.*

When we change the number of restrictions, the product singularity increases [17]; they become more similar, less varied, also at the same time, as we increase the restrictions (Number of Spirits we keep fixed in the DDNA), the family feeling increases.

### 1.3.5.1 Expaning Creation Possibilities with DNNA-E

Using the DDNA-E, we can extract DDNA from objects and we have seen that, however another great use is to use the DNNA-E to extract spirit groups from a culture; Here we make a very large moodboard and try to understand the common

elements; for example we focus on Chinese culture, and we can derive the color "Red", the object "Dragon", they can all be intercorporated into our designs to carry the "Chinese" feeling. As the number of relevant links between products and a culture increases, the value given by the society will also increase [18], this works up to a level.

### 1.3.6 Managing Existing Product Families with the DDNA

We can manage our existing product families with the DDNA approach; we can identify which products fit into our portfolio and which are standing out. At first it might seem difficult but actually, we apply a DDNA test; For each product in your line / product family, we extract the DDNA and then compare them with each other (we compare with the average or the median), if there exists a product that is significantly different from others, that that product does not belong to the family [19], we extend this to the design sense.

### 1.3.6.1 Advantages of Using the DDNA for Generating Product Families

Let's think about the existing approaches for controlling the product families; the Boston Consulting Group's Product Matrix measures the value based on financial performance [20] and choose the best performers within this products, but the financial data is not always easy to produce and design is totally undermined in this approach. In the R&D – Product Platform Approach, given the platform the engineers generate new products based on it, sharing components and production process across a platform of products the aim is to decrease production cost [21], it is quite efficient but you need an initial platform [22], it cannot be used to create a platform from the scratch. Marketing strategy and advertisement approach is also attractive, in this case you need to have designs that can fit into your brand, you can use white papers to define style but you need to have a brand first, the idea is to derive the DDNA from the brand! Another great option is to ask masters of design; however they will not tell you, those who would tell you are no longer with us and many designers do not write "how their creative processes work", many others like sharing however they can tell or reach only to their workers or students. Development and management of new products in a design way is not documented, however the DDNA approach can be used in this way. The DDNA approach can be used for developing and management of new product families and the system is fairly easy to understand and it can be thought to students, colleagues as well as computers for making the task generated.

## Conclusion

We have discussed what the Design DNA is and how we can use it to develop a single product or series of products / develop product families in a generative way, and even manage existing product families with the DDNA checks, the DDNA is a design philosophy that covers a wide range of tools and subtools that helps you design in an efficient way, the DDNA could also be conveyed to students and it could be used as an alternative approach to existing Product Platforms, Product Management Techniques, Branding-Product Methodologies and Matrices. DDNA is the design way of creating, recreating, generating, diversing and managing products.

# References

1. Saenger, Wolfram (1984). Principles of Nucleic Acid Structure. New York: Springer-Verlag. ISBN 0387907629.

2. Michael Erlhoff, Tim Marshall – "Design Dictionary: Perspectives on Design Terminology, Board of International Research in Design", Birkhouse, Berlin – Germany, 2008.
3. William Lidwell, Kritina Holden, Jill Butler – "Universal Principles of Design", Rockport,Massachusetts – United States of America, 2003.
4. Alina Wheeler – "Designing Brand Identity Second Edition: A Complete Guide to Creating,Building and Maintaining Strong Brands", John Wiley & Sons , New Jersey – Canada, 2006.
5. Max Weisbuch, Diane Mackie – "False fame, perceptual clarity, or persuasion? Flexible fluency attribution in spokesperson familiarity effects", Journal of Consumer Psychology - 19, 2009.
6. Max Werheimer, "Untersuchungen zür Lehre von der Gestalt, II", Psychologische Forschung, Berlin – Germany, 1923.
7. Robert G. Cooper, Scott J. Edgett, Elko J. Kleinschimdt - "Portfolio Management for New Products – Second Edition", Basic Books, New York – United States of America, 2001.
8. Marc H. Meyer, Alvin P. Lehnerd – "The Power of Product Platforms: Building Value and Cost Leadership", The Free Press, New York – United States of America, 1997.
9. Margaret Mark - "The Hero and the Outlaw: Building Extraordinary Brands through the Power of Archtypes", McGraw-Hill Trade, New Jersey – United States of America, 2001.
10. Daniel Kahneman, Paul Slovic – "Judgment under Uncertainty: Heuristics and Biases.", Cambridge University Press, Cambridge – United Kingdom, 1982.
11. Christopher Alexander – "Notes on the Synthesis of Form", Harvard University Press, Cambridge, Massachusetts – United States of America, 1967.
12. Steven C. Wheelwright – "Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality", Free Press, New York, United States of America, 1992.
13. Timothy W. Simpson, Zahed Siddique, Jianxin (Roger) Jiao. "Product Platform and Product Family Design: Methods and Applications", Springer, Lancester, 2007.
14. Steven Haines – "The Product Manager's Desk Reference", McGraw-Hill, New Jersey – United States of America, 2008.
15. Williams C.B. Allen J.K. Rosen D.W. – "Designing platforms for customizabile products in markets with non-uniform demand. Proceedings of ASME Design Methodology Conferance, Salt Lake City, Paper No: DETC2004/DTM-57469", Saltlake, United States of America, 2004.
16. Ulrich, K.T. Eppinger S.D. – "Product Design and Development", McGraw-Hill, New York, United States of America, 2005.
17. Thevanot H.J. And Simpson T.W. – "Commonality indices for product family design: A detailed comparison". Journal of Engineering Design 17. 2006.
18. M. Uzumeri, Sanderson S. – "A Framework for model and product family competition", Research Policy 24, 1995.

19. Vistaar Company White Paper rel. 2005– "Product Portfolio Planning" - Retrieved 1 May 2009, (Url: http://www.vistaar.com/portfolio_planning.php )

20. Michael S. Deimler, Carl W. Stern - "The Boston Consulting Group on Strategy: Classic Concepts and New Perspectives, Second Edition", Wiley, New Jersey – United States of America, 2006.

21. W.E. Souder, T. Mandakovic – "A system for Using R&D Project evaluation methods", Journal of Research Management, September 1978.

22. Gupta S. and Krishnan, "Appropriateness and impact of platform-based product development", Journal of Management Science 47, 2001.

23. Al Ries, Laura Ries – "The 22 Immutable Laws of Branding", Harper Collins Publishers, Newyork – United States of America, 1998.