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Morphologic matrix application as a tool to spring on creativity

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Abstract

Morphological analysis methodology has a broad spectrum of application: from technological management to the design of new products and services. Among the techniques applied for spurring creativity in "Managerial Skills to Engineers", Morphological Analysis has been that has had more success along the years. Traditionally has the feature of being a technique very structured that easily can be applied by the students for resolving different kind of problems, and actually the results confirm this asseveration.

Our group has applied this methodology since many years ago. First on doctorate courses of "Technology Management" and afterwards on training in different companies, degree and master subjects, and on Continuous Improvement actions (Kaizen blitz) in Almusaffes Ford Factory and first line suppliers. On this paper we discuss the experience applying it as a tool for developing new products combining with other techniques for spurring creativity as brain storming, lateral thinking, de Bono's hats, nominal group, etc.

In this communication are resumed some of the technique application results and the most interesting answers to the final questionnaire each year is passed for knowing directly student's real opinion.

Keywords: *Morphological marix, creativity, innovation, design, learning by doing.*

Introduction.

Morphological Analysis constitutes an interesting tool on technological forecasting looking for how the new technologies, in the different process' stages, could improve a process generating possible innovations (Gogu, 2005; Villegas-Medina, Pharm & Marquis-Faure, 2009; Weber&Condor, 1989; Kannengiesser, Williams & Gero, 2013). When a new technology appears, including when it is only an embryonic technology, it could be included making possible to surface new possibilities with different combinations with other stage's alternatives, what could be the germ of innovative ideas capable of generating important changes on the product, technology, service or process, and to become opportunities to the company.

In the subject of Management Skills for Engineers it is applied as a toll for training group members for developing capacities and abilities usually applied on improvement groups. These techniques look for building synergy for breakthrough creativity. Usually, we apply the forty tools proposed by Michalski (1998) in the same way that in Almusaffes Ford Factory Kaizen Blitz Actions.

On its basic feature consists essentially of two dimensions check list. First vertical ordinate of the matrix is a column of boxes lettered A, B, C, D, etc. These boxes record the essential stages or parameters of the technology, product, process or service analysed. By other hand each horizontal ordinate contains boxes that are numbered as 1, 2, 3, 4, etc recording different methods of developing essential stages. Once the matrix has been built the more important methodology step beguines: To link an alternative of each stage looking for new ways, although not necessarily all the steps must be utilized. First for depicting actual possibilities and later looking for new combinations that could drive to new feasible possibilities.

In other cases, when the main elements to consider are attributes that can be or not, namely a dichotomic variable, the way of building change slightly, but the basic concept is the same. Next point showed a classic example of each one of these two alternatives for building the matrix.

In other way, the constraint of two dimensions can be surpassed. Michalski, (1998) proposed the use of three or more dimensions in order to have a broader perspective and the possibility of discovering new possibilities. On fact the inclusion of a new dimension can be resolved by two dimensions matrices considering one by each one of the alternatives that have been proposed to the new dimension.

Table 1. Morphological matrix for textile wet processing systems. Source: Jones&Twiss, 1980

Alternates / Key parameters		1	2	3	4	Etc
Textile additive	A	DYESTUFF	Optical BLEACHING AGENT OBA	FINISH	ANTISTAT	
Fibre sustrate	B	PROTEIN	CELLULOSE	NYLON	POLYESTER	
Process medium	C	AQUEOUS	AQUEOUS SOLUTION	ORGANIC SOLVENT	AIR GAS VACUUM	
Additive fibre mechanism	D	SUBSTANTIVE	DIFFUSION	PRECIPITATION	REACTIVE	
Etc.						

Known	1	Reactive dyeing of wool in water
Known	2	Diffusion of OBA onto nylon in organic solvent medium
Suggested	3	Diffusion dyeing of polyster in vacuum

Clasical examples.

Going to the technique origins there are two examples (Jones&Twiss, 1980) that have been reflected profusely in the literature about technological forecasting. First of them reflects the process of textile wet processing. Depicting the 70's applied processes and suggesting new ones. And the second one is referred to laminated product processes and their development possibilities

As can be seen in tables 2 and 3, among the products that can easily be derived from the application of the morphological matrix are: sandpaper, water-resistant sandpaper for glass, magnetic tapes, cellophane, adhesive tapes of double layer, reflective fabrics, ...

Table 2. Laminate systems morphological matrix. Source: Jones&Twiss, 1980

PROPERTY ALTERNATIVES / KEY LAYERS		CLARITY		STIFFNESS		ADHESIVE		FILLER CONTENT	
		1. YES	2. NO	1. YES	2. NO	1. YES	2. NO	1. YES	2. NO
TOP	A								
MIDDLE	B								
BOTTON	C								

Table 3. Known laminate systems. Source: Jones&Twiss, 1980

1	B-1-3-6-8			Clear "cellophane"
2	B-1-3-6-8			Scotch tape
2	C-1-3-5-8			Scotch tape
3	B-1-3-6-7	B7	Glass beads	Reflector Scotch tape
3	C-1-3-5-8			Reflector Scotch tape
4	A-2-4-6-7	A7	Carborundum powder	Emery paper
4	B-2-4-6-8			Emery paper
5	B-2-4-6-7	A7	Magnetic iron oxide	Magnetic tape
6	A-2-3-6-7	A7	Pigment in paint	Non-skid stair tread
6	B-2-3-6-7	B7	Carborundum powder	Non-skid stair tread
6	C-2-3-5-7	C7	White pigment	Non-skid stair tread
7	A-1-4-6-8	A8	Layers are glass	Safety glass
7	B-1-3-5-8			Safety glass
7	C-1-4-6-8	C8	Layers are glass	Safety glass

Likewise, there is the opportunity to use this matrix as the basis of an extensive check list by inserting various ranges of alternatives, such as:

- Various metallic foils such as aluminium, coper, etc.
- Various plastic film materials.
- Use of textured films as perforates, dimple profiled, etc.
- Use of various fillers-powders, metals, air inclusions, etc.

Both in one and the other case the reality has converted some of these possibilities on real products, processes or technologies.

Results of the teaching application.

For proposing the problems to applying the methodology it is important that group members feel comfortable with the proposal. In practice usually is proposed a problem linked to members group knowledge and experience, for example one relating to their professional activity. In other cases, especially when the profiles of the group members are very different, a simple problem works better so everyone has the possibility to contribute with ideas and make them motivating.

One of those that we have used on a greater number of occasions has been the design of an innovative bicycle that could be distributed to NGOs for free and financed by a sponsor, so it should have a flat surface to place your logo. It should be suitable for use in wet areas and roads in poor condition, easy to maintain and low cost. On some occasions other features have been added, for example: the possibility of transporting more than one person or load, which was foldable, or protection from the sun and rain, ... Given that the exercise is sometimes repeated with groups from the same company or in the same subject, it is interesting to change the specifications. Other proposed problems have been:

- Aquatic tricycles for people with movement difficulties or elderly people that allow them to make exercise on the sea feeling the contact with the sea water.
- Sleep-boxes or cabins to rest in airports. These elements are rented by time and allow people to rest when they are linking flights.

Figures 2 and 3 have collected, only at the level of example, the matrices developed for the case of the innovative bicycle and in figures 1 some sketches or proposals of the final design.

Figure 1. Some final designs of innovative bicycle.

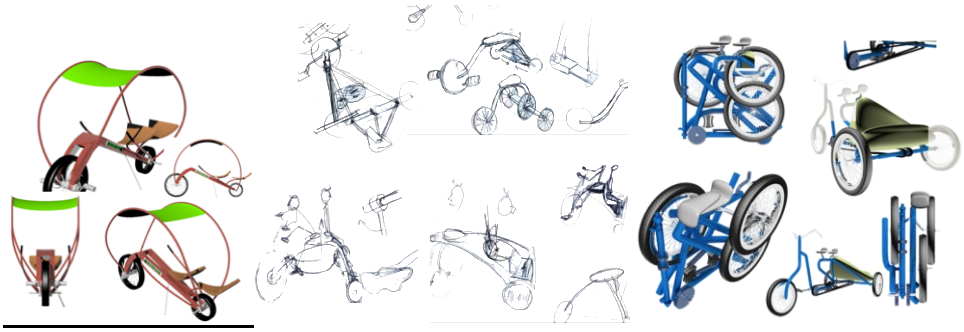
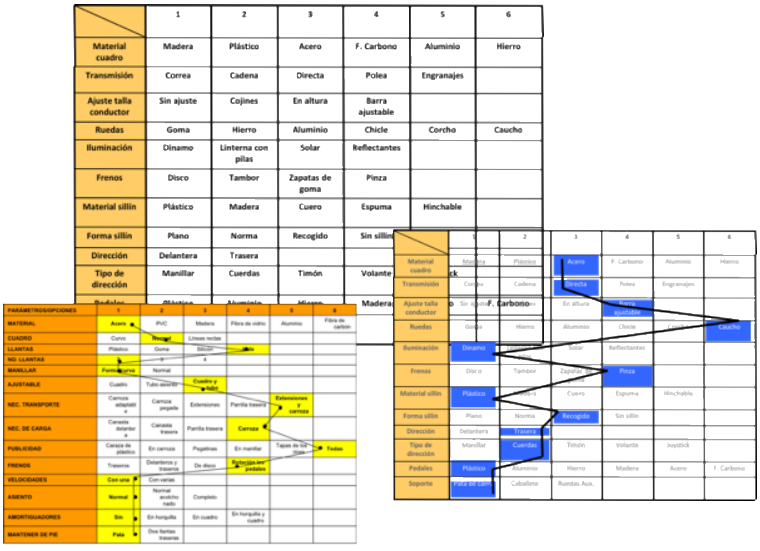


Figure 2. Examples of Morphological Matrix of a innovative bicycle.

	1	2	3	4	5	6
Materiales principales	Bambú	Acero inoxidable	Aluminio reciclado	Fibra natural	Madera	Plástico
Cuadro	Unión por ruedas	Extensible	Plegable	Telescópico	Rígido	
Ruedas	Goma	Caucho	Silicona			
Asiento	Cuero	Espuma	Silicona	Plástico		
Transmisión	Cadena	Correa	Polea	Engranaje	Pistón	Directa
Manillar	Doble altura	Lowrider	Sencillo	Plano		
Frenos	Zapatas	Pedal inverso	Manual	Rozamiento	Disco	Tambor
Pedales	Plástico	Hierro	Aluminio	Fibra Carbono		
Sistema bloqueo	Candado	Plegable				
Sistema almacenaje	Malla	Cesta	Caja	Bolsa		
Iluminación	Dinamo	Leds	Linternas	Reflectantes		

Figure 3. Examples of Morphological Matrix of a innovative bicycle.



Examples of class, often generated through final degree projects of the Master Industrial Engineer in companies, include the manufacture of blankets, carpets, tiles, stoneware floors, porcelain floors, inclusion of recycled materials in stages of a processes, plastic-based automation components, etc.

Results of questionnaire passed after the case presentation.

Throughout the course, students fill out a questionnaire on each of the cases and at the end a general one on the whole of the subject. Given that from one year to the next the profile of the students changes a lot, it is a way of being able to adapt content and methodology as the course develops and, on the other, it is a very interesting element when it comes to knowing the problems they are having and to and others are specific to each case or activity. provide them with effective feedback. Some questions are repeated in all of them

Table 4. Results of the questionnaire carried out after the presentation of the case and its co-evaluation.

	Rate. 0-10	Yes	Non
Do you feel that you have taken advantage of the time you have dedicated to the case in the sense of learning new concepts and how to apply them?	9,8		
Are you satisfied with your behavior as a member of the group during these two weeks?	7,6		
Are you satisfied with the solution that your group has developed for the case?	8,2		
Do you think that this methodology is really powerful when it comes to discovering new opportunities when it comes to improving products or processes?	9,9		
Did you find useful and simple to apply this methodology?	9.7		
Have you considered any application of Morphological Matrix to develop your final degree project?	7,1		
Do you think the group you has proposed a matrix enoug complete matrix?	7,5		
Would you have missed any more dimension? Are you satisfied with the sketch of the prototype that could be developed with the chosen combination?	6,3		
Do you think that the time you have dedicated to this activity has been useful to apply what you have studied to develop effective groups?	8,4		
Has the relationship between the group members improved since you created it on the first day of class?	6,8		
Do you think that the fact of knowing the roles of Belbin of all the members of the group has been interesting when distributing the tasks.	9,2		
Are you motivated to spend time studying this subject?		100%	
Are you satisfied with reverse teaching even if it involves extra personal work?		96,00%	
Has any conflict arisen within the group?		94,00%	

In the questions in which it is valued from 0 to 10 the mean is taken and, in the questions, yes/no the percentage.

Conclusions

Achieving personal involvement in improving their abilities and skills for group work is not usually easy with engineers, since they do not consider that these skills are going to be really important for the development of their professional future. Therefore, we try to apply catalysts that focus the student's attention with a technological base, a field in which they feel much more comfortable. As they have been reflected in the developed matrices and in the sketches into which they have been converted, the results are usually really interesting; but the main objective continues being to develop their capacities and abilities to teamwork, for which an anonymous questionnaire is passed at the end of each activity and another at the

end of the subject or training activity if it is in a company, which allow to know about results directly and enrich the continuous improvement process that our group tries to give to all activities.

In relation to the opinion of the students at the end of the presentation of the case, the following conclusions can be drawn in the last three years.

It is evident that the objective of motivating students to dedicate time to study and to carry out the work of the subject is, in principle, achieved with an assessment of these questions higher than 90%.

1. The fact of the existence of conflicts in the process is important since it is an indicator that dissenting opinions have been produced and that they have been defended, which implies the effective involvement of the group members. These conflicts will be exploited when the "Negotiation and Conflict Management" part is addressed since they will have close and personal references.
2. In the questions asked about the ability to apply the methodology, the score is very high, which, linking it with the fact that 63% consider that they could have incorporated a new dimension to broaden the range of opportunities, is once again an indicator of the involvement of the students.
3. The fact that in the fifth week of the course almost 70% of the participants consider that the relations between the group members have improved, which related to the assessment that they themselves make of their behaviour, is an indicator of the margin for improvement they consider to have. The statistical analysis of the data is pending, mainly through regressions.

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