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Issue 13, February 2003

In this month's issue:

The Systematic Innovation e-zine is a monthly, subscription only, publication. Each month will feature articles and features aimed at advancing the state of the art in TRIZ and related problem solving methodologies.

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Convergence and Divergence in Language

Introduction

Any successful act of creation requires a combination of divergent and convergent thinking. By 'divergent', we mean opening up or increasing of creative possibilities. Convergent thinking occurs where we take an existing pool of information and seek to reduce it to – usually – some kind of 'best' option. Generally speaking, the creative process will involve a succession of pairs of divergent-followed-by-convergent activities. In the systematic creativity process described in Hands-On Systematic Innovation (HOSI), for example, we can observe two pairs of divergent-convergent activities – the first during the problem definition process, and the second during the generation and evaluation of possible solutions – Figure 1.

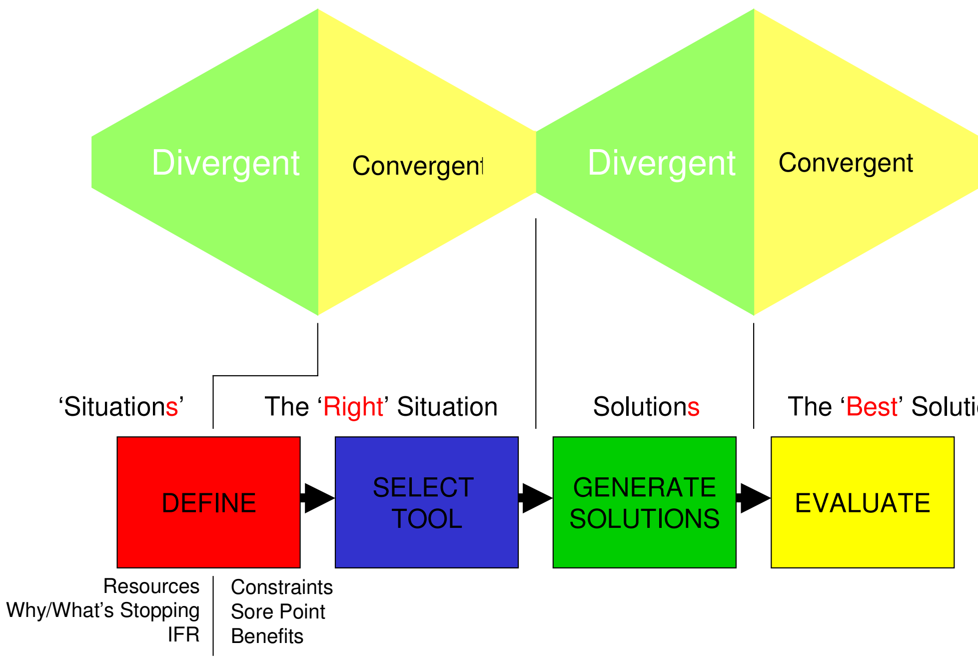


Figure 1: Divergence and Convergence in the Systematic Creativity Process
(Note that the process is illustrated for one complete cycle; it is common to repeat the cycle several times)

We aren't always explicitly aware of the divergent/convergent split. For the most part this lack of awareness is not a problem because the process we are using is 'managing' the flow between the two modes of thinking. In Edward de Bono's Six Thinking Hats™ concept (Reference 1) for example, it may be observed that the Green Hat is specifically associated with divergent thinking – generating new ideas – while the Black Hat is explicitly about convergent thinking, without us needing to be explicitly aware of either connection. There are, however, occasions when an awareness of the distinctions between divergent and convergent, and the different types of thinking each requires from us, can be very important indeed. Those occasions are the subject of this article.

A Short Diversion – 'Managed Diversion'

To many people, it is the idea generating, possibility-opening, divergent part of the creative process that is the only truly 'creative' part – it is the part where, after all, we are seeking to generate new ideas. Very often, this is the part of the process where most creativity tools and techniques have least to offer. Probably the one with most to offer outside of TRIZ comes from the work of Edward de Bono via the concepts described in his book 'Serious Creativity' (Reference 2). Perhaps the most well known of these is the simple 'random input' method. This is the 'method' whereby we select a random word from a dictionary and use the natural connecting capabilities of our brain to connect this word to the problem we are trying to tackle. As discussed in an earlier article (Reference 3), this random input is intended to take us 'out of the box'. As such we may see that it offers a highly divergent operation – in that it can take to literally any new place (for example using the random word 'cheese' to help us to think about better ways of designing wind-turbines). Some think that in this sense it is a technique that is too divergent. For those people, and again picking up a theme from Reference 3, we like to think of TRIZ solution triggers such as the Trends, Inventive Principles and Standard Solutions as representing *'managed divergence'* opportunities. That is they only take us to those new out-of-the-box places that other problem solvers have found to be useful directions.

Meanwhile, back to the main theme of this article, which is how our use of language affects our ability to think effectively in either the divergent or convergent thinking modes:

Convergence and Divergence in Language

The words we use when describing a situation are often critical in determining whether we are able to improve that situation. Psychological Inertia effects play an important role inside this phenomenon – so that, for example, as soon as we describe a need for a 'better anchor', we have immediately drawn a mental image of a large metal, spiked object and are trying to think of ways of designing better large metal, spiked objects, when in fact we might be much better off trying to think about 'ways to keep a ship in one place'. Psychological Inertia and ways to overcome psychological inertia effects are the subject of much discussion in HOSI.

Beyond psychological inertia (although definitely related), other great idea generation inhibitors are the 'killer' phrases we so often here in traditional problem solving sessions. These are expressions like 'we already tried that' or 'let's form a committee' or 'it would cost too much' or 'all right in theory', or the all time killer 'yes, but…'. They are the expressions we try and ban in brainstorming sessions because they are all about judgment and criticism and not about helping to generate new ideas. They are about convergence and not divergence. They have their place, in other words, but they should not be used during the divergent, expanding possibility part of the creative process. There are several references (Reference 4 is a particularly good one) containing check-lists of these types of idea-killer phrases. Many of us are aware, therefore, of the dangers they contain and are thus able to try and steer a course of avoiding or preventing them during idea generation sessions.

There is a third class of idea-killers, however, a class that is more subtle and difficult to manage than the previous two classes. This third class involves the words we use as part of every day life that although we might not be aware of it are actually very convergent in the way they are interpreted by our brains. Sometimes (most of the time, actually) these convergent words are essential to allow us to select from options and to decide what to do. Convergent thinking is the thing that allows us to get things done. Most of the times this is precisely what we need to do – we don't want to have to think about new ways of brushing our teeth every time we go to the bathroom, for example, we simply want to employ a standard 'teeth-cleaning' programme without the need to consciously think about what we're doing. As most of our lives are about 'getting things done' (outside the academic community of course!), most of the language we tend to use is convergent in its nature. During the 'divergent' parts of the creative process, however, this naturally 'convergent language' can be more effective idea killers than either psychological inertia or the things we know as 'killer phrases'. More effective because often we don't explicitly think of them as convergent.

Table 1 lists some of the main convergent words we use, and, where relevant, their divergent equivalents.

'Convergent' Words	'Divergent' Words
But (this would work, but…)	And (this would work, and…)
Either/Or (it's either A or B…)	And (A and B…)
The (the solution…)	A/An (a solution…)
Is (a bottle is…)	(Leads) To (but could lead to…)
Only (…is the only way)	A/An (…is a way)
True/False (it is true that…)	Often/Maybe (it is often true that…)
Always/Never (we always…)	Often/Maybe (maybe we…)
Must/Cannot (we must…)	Convention/Typically (conventionally…)
Maximum/Minimum (that is the maximum…)	Convention (conventionally…)
Law (the law says…)	Convention (conventionally…)

Table 1: Convergent and Divergent Words in Language

The table is intended to be used as a check-list of things to try and become conscious of when we are involved in the divergent parts of the creative process. Becoming aware of the convergent words being used can in fact open up many new creative opportunities. For example, the CREAX mindset is very much tuned to respond to statements like 'we always…' or 'the solution is' with questions like why? This type of question can be very annoying of course (especially when the person asking the question is thinking divergently and the listener is in (naturally) convergent mode), but it is absolutely fundamental we think to the generation of breakthrough definitions and solutions.

References

1) De Bono, E., '<u>Six Thinking Hats</u>', Key Porter Books, 1985.
2) De Bono, E., '<u>Serious Creativity</u>', Harper Collins, 1992.
3) Mann, D.L., 'Klondike versus Homing Solution Searches', TRIZ Journal, February 2002.
4) Basadur, M., '<u>The Power of Innovation</u>', Pitman Publishing, London, 1995.

Combining Inventive Principles

Introduction

Following on from the theme of convergent and divergent parts of the creative process discussed in the sister article to this one, is the knowledge that the 40 Inventive Principles uncovered during TRIZ research form one of the important elements enabling the managed-divergence, idea-generating part – Figure 1.

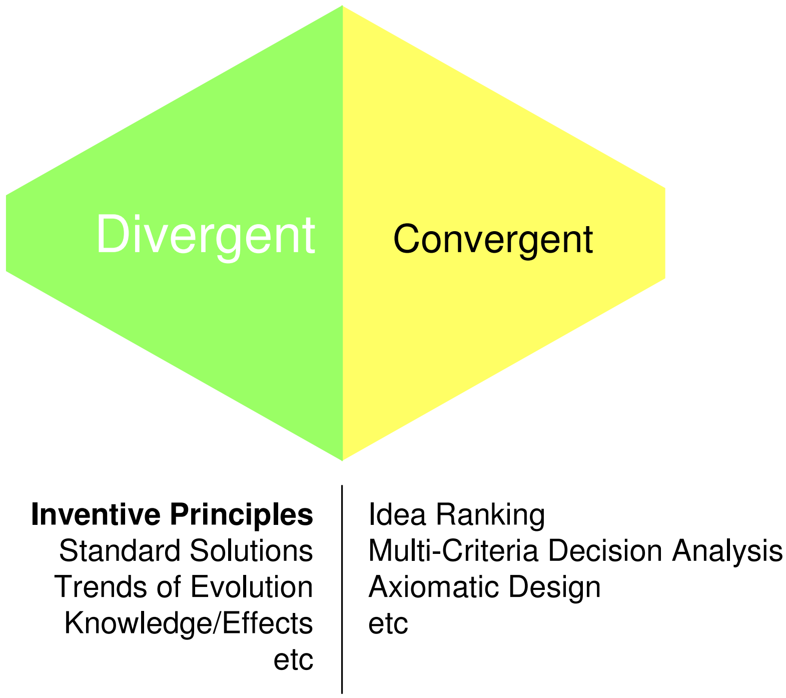
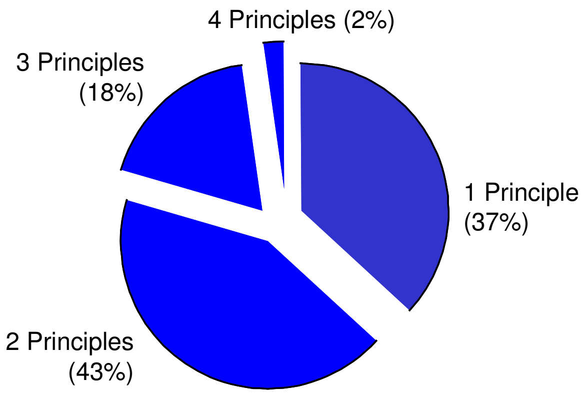


Figure 1: Relationship Between Inventive Principles and Divergence/Convergence

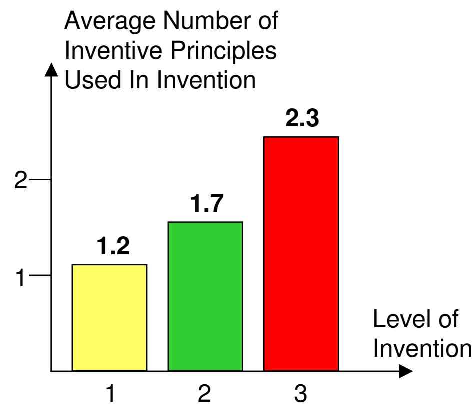
The Inventive Principles are thus most commonly used as means of focusing the generation of new ideas during structured brainstorming sessions; in effect they offer problem solvers ‘good’ solution directions.

A very common phenomenon when using the Principles in this structured brainstorming manner is that very often the ideas we are able to generate, while they will often be ‘good’, they are rarely ‘sufficiently’ so. Taking this a step further, if we examine the patent database and look there at the ‘best’ solutions, we see a very strong correlation between the quality of invention – as measured by Altshuller’s five levels – and the number of Inventive Principles that have been used – Figure 2. In the case of this figure, the data has been interpreted from Reference 1 – a collection of patents with a certain ‘wow’ element to them, plus the mass of patents being analysed by the CREAX analysis team.

Looking across the world of TRIZ providers it may be seen that many of the thought leaders have advocated moves away from using the Principles as they ‘do not give strong solutions’. This sort of statement is strictly speaking neither true nor helpful. To make the statement more accurate we need to modify it to include the words ‘singly’ or ‘individually’. Single application of a single Inventive Principle will tend to not give strong solutions. The response of those TRIZ providers who recognize this fact is often to try and expand the list of Principles to include supposedly ‘new’ Principles that in actual fact turn out to be combinations of other Principles – ‘divide into heavy and light parts’ is one suggestion for example. It is our view that this kind of combination is a very ineffective way of either generating the maximum number of ideas, or – more importantly – achieving the strongest possible solution. The theme of this article is to explore why this is so, and to define a strategy that enables us to generate ‘strong’ solutions in a way that fits best with the way the human brain operates.



(Data From Reference 1)



(Data From CREAX Patent Research)

Figure 2: Correlation Between Level Of Invention and Number of Inventive Principles Deployed in The Solution

Figure 2 clearly suggests that strong solutions combine ideas from several Principles. Demonstrating the best way to achieve this is probably best done through a case study example rather than a theoretical, abstract-level discussion. This, then, is how we will progress:

A Worked Example

The example started out as a real problem involving a desire to insert three CDs (as opposed to the normal one or two) into a conventionally sized jewel case – Figure 3.

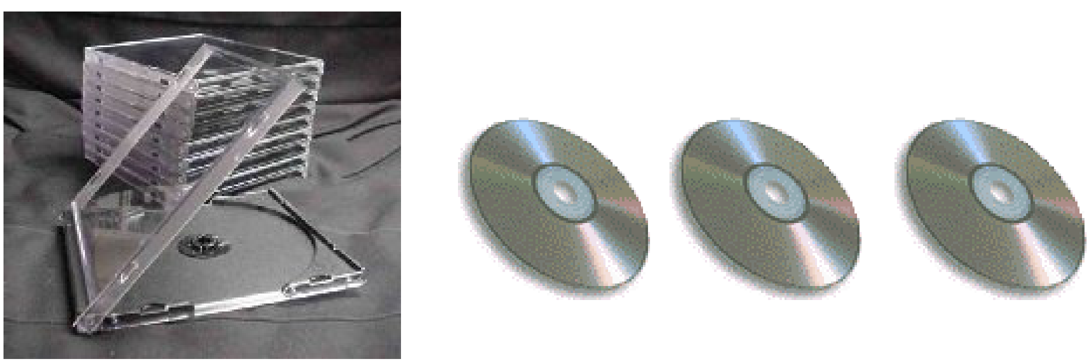


Figure 3: Typical CD Jewel Case

While this problem might sound like we won’t need too much rocket science to generate answers, it will hopefully serve to illustrate the principles involved in generating strong solutions, and more specifically, to demonstrate that combining individual ideas creates stronger solutions than we would otherwise. Our point is to demonstrate the process rather than focus on a specific solution (for reasons of IPR protection, we haven't included our actual final answer in any event); if you want to generate a stronger solution, the process we describe should help you to do just that.

Before we start, it is worth detailing some of the constraints imposed on the actual problem, as these are the things we will have to use when it comes to that (convergent) part of the process where we are looking to translate lots of possible solutions into one let's-go-do-it 'best' solution:-

1) External volume and shape of jewel case no different to current designs
2) Manufacture cost no greater than current design
3) No change in materials from those used in conventional designs
4) CDs must be adequately protected (including from each other) at all times
5) No learning curve for the user; the design must be 'instinctive'

In reality, we worked through this case study using the CreaTRIZ problem explorer structure (see the output of that exercise in the forthcoming book of Case Studies). When it came to the part of the systematic creativity process where we transition to the solution generation tools, while we could see the presence of several contradictions (volume versus protection and/or accessibility, design complexity, manufacturability for example), we decided that we would prefer to examine all 40 of the Inventive Principles. In large part this decision was prompted by the theme of this article, rather than for any problem-specific reason.

Figure 4 below illustrates the output obtained for two of the Principles. In simple terms, all we did for each Inventive Principle was to try and connect the Principle to something on or around the CD case. In that sense, we were simply using the 'natural' connecting skills of the brain.

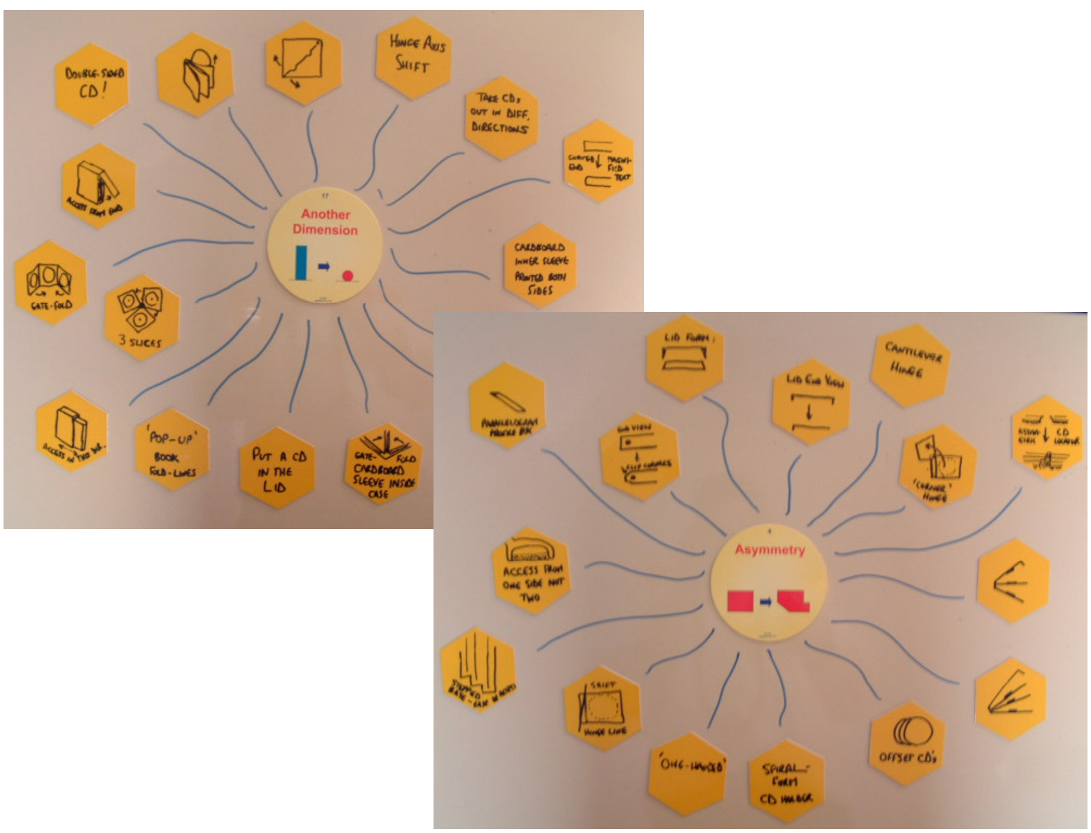


Figure 4: Use of MagNotes to Focus Brainstorming Around Two Inventive Principles

In simple terms, what the figure shows is the creation of a hexagonal MagNote (Reference 2) for each of the ideas we were able to generate through connecting Principle to the CD case problem. At this stage, we did no sorting of the ideas; the main purpose of the MagNotes in fact is to enable rapid (and importantly also physical) capture of ideas – so that as each idea was recorded, the written-on MagNote was placed on the display board and a new MagNote was picked up ready for the recording of the next idea.

One of the higher level beauties of the MagNotes is that after this first phase of divergent idea generation has been completed (in our case for all 40 Inventive Principles), we have generated a pile of ideas each recorded on a separate hexagon. In the words of Reference 2, each of these hexagons is thus seen to represent a coherent 'molecule of meaning'. Ideas generated during the session could have been recorded in a variety of ways of course, the great elegance of the MagNotes is that we are able to sort and re-sort the individual ideas/molecules-of-meaning as we wish afterwards.

It is then precisely this ability to re-sort and re-arrange ideas that is so important in the process of combining ideas. More particularly, when we are wishing to examine the benefits that might accrue through combination of individual ideas, we are able to cluster similar hexagons or co-locate hexagons that appear to have little connection and then try and repeat the process of using our brain to force connections. Figure 5 illustrates the results of some of this clustering and combination process for the ideas generated for the two Inventive Principles illustrated in Figure 4.

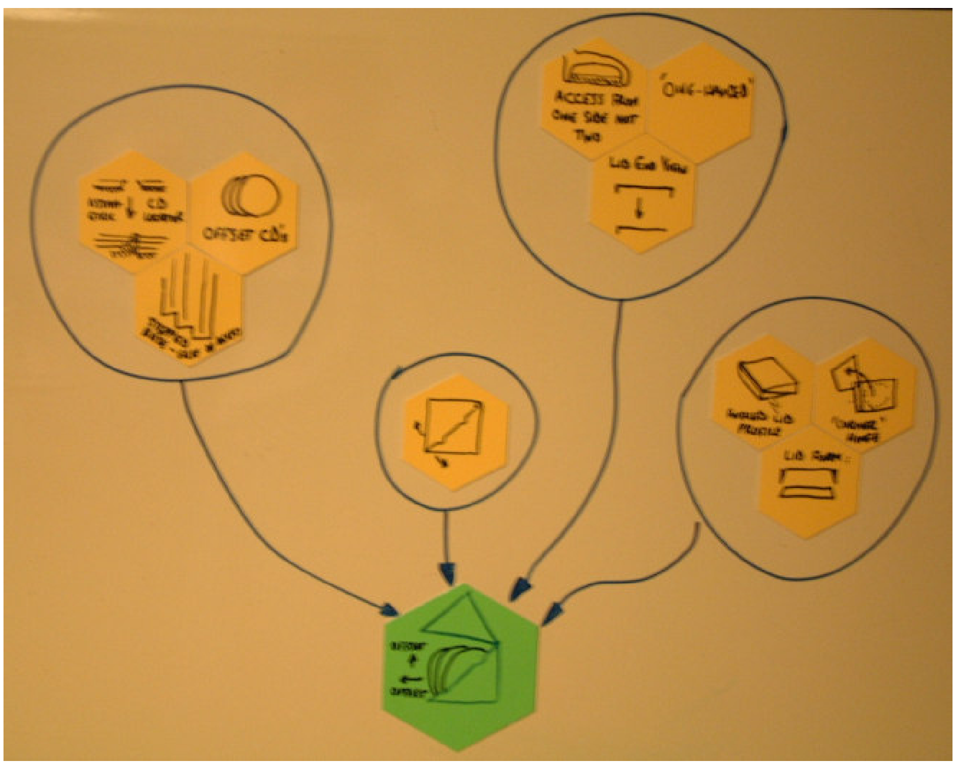


Figure 5: Using MagNotes To Assist In the Idea Combination Task

Although this process of re-placing MagNotes into different clusters and combinations might not initially appear to be achieving anything significant, what is happening when we perform these actions (and again the physicality of the process is important – as discussed in Reference 2) is that we are able to ensure that we distill ideas (rather than filter – an entirely different process; one involving loss of data), and that we are able to use each combination of ideas as the basis for further idea generation activities.

Points To Note/Conclusions

The overall idea generation/idea combination strategy using the MagNotes is illustrated in Figure 6. Essentially, by recording ideas on individual MagNote hexagons we are able to maximize the flow of new ideas by ensuring accurate capture. Downstream of this process, we can re-arrange and cluster the MagNotes to distill ideas and – more importantly in the context of this article – create a systematic means of combining ideas into what evidence from elsewhere tells us will be more powerful solutions than those obtained from single ideas generated from single Inventive Principles.

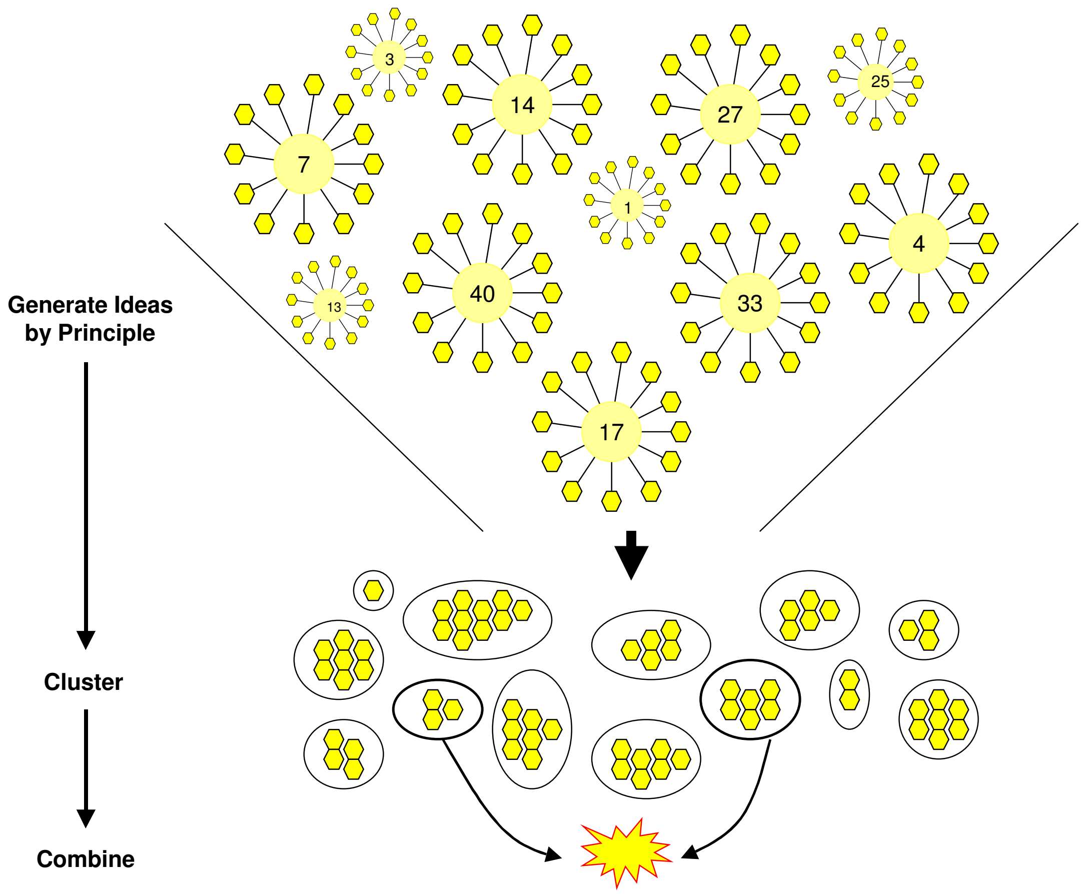


Figure 6: Several Inventive Principles Give Many Clusters Of Ideas

This process, like many others within TRIZ is about 'managing complexity'. The MagNotes force us to look at our ideas molecule-by-molecule in an ordered and recordable manner rather than everything at one time. This is important because our brains are not designed to be able to manipulate lots of ideas simultaneously (typically, we struggle above 7-9 simultaneous ideas; during the full CD case exercise, we generated nearly 200 MagNotes worth of ideas).

Other points of note:-

1) The example here has looked at the combination of individual ideas – 'molecules of meaning' – generated using the Inventive Principles. It is important to recognize that we can use exactly the same combination strategy by combining the individual ideas generated by using the other idea generation tools within the systematic

innovation armoury. As far as the MagNotes containing each generated idea is concerned it is completely irrelevant which tool was used to generate that idea.

2) Zooming In. One thing we haven't done here is gone around the loop again to try and improve the design we have derived by solving some of the other contradictions that still exist or might have emerged. Very often we will see further solution iterations zoom-in to look at the design from an increasingly detailed perspective – looking at the hinge or closure mechanisms, or (a problem that tends to affect the older members of the CREAX team) inability to read the information on the spine of the jewel case, for example – this zooming-in contradiction elimination design iteration process is something we will look at in more detail in a future article.

References

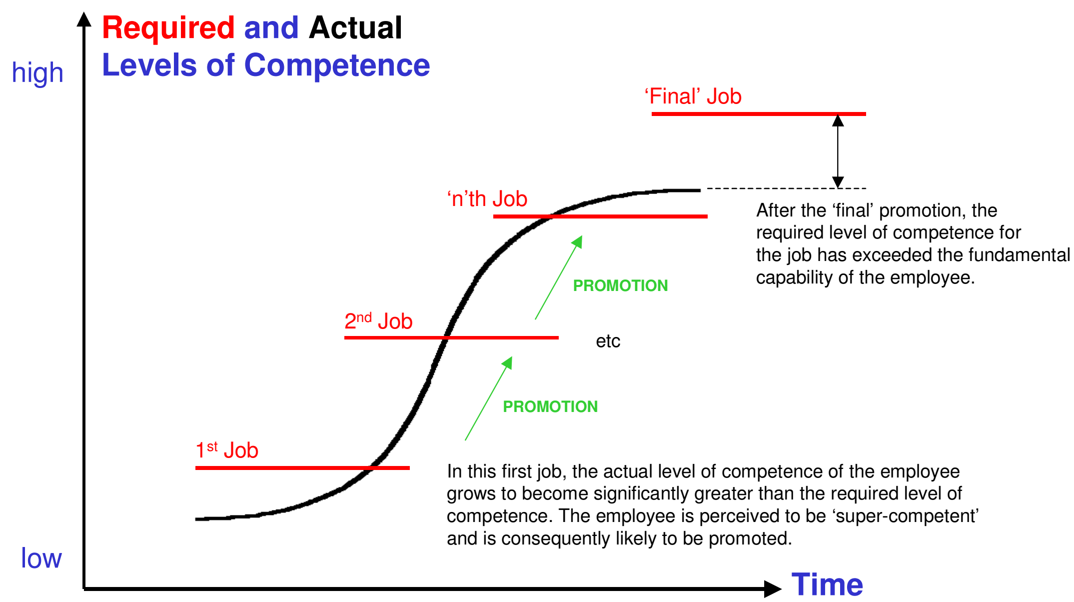
1) Mann, D.L., 'Assessing The Accuracy Of The Contradiction Matrix For Recent Mechanical Inventions', TRIZ Journal, February 2002.

Blake, A., Mann, D.L., 'Making Knowledge Tangible', TRIZ Jo

Humour – The Peter Principle

The Peter Principle was first introduced by Laurence Peter and Raymond Hull in a light-hearted but simultaneously deadly serious management book from 1969 ('The Peter Principle', Souvenir Press). The book described some of the pitfalls of bureaucratic organization, stating the original principle that *in a hierarchically structured administration, people tend to be promoted up to their "level of incompetence".* The principle is based on the observation that in such an organization new employees typically start in the lower ranks, but when they prove to be competent in the task to which they are assigned, they get promoted to a higher rank. This process of climbing up the hierarchical ladder can go on indefinitely, until the employee reaches a position where he or she is no longer competent. At that moment the process typically stops, since the established rules of bureaucracies make that it is very difficult to "demote" someone to a lower rank, even if that person would be much better fitted and more happy in that lower position. The net result is that most of the higher levels of a bureaucracy will be filled by incompetent people, who got there because they were quite good at doing a different (and usually, but not always, easier) task than the one they are expected to do.

Our interest exists because the Peter Principle not only describes a real phenomenon that can cause real problems in organizations (although not our own yet!), but also because it connects absolutely with the S-curve concept and the fact that all systems hit limits.



Of course, some people have a level of competence that exceeds the required level of competence even when they are right at the top of an organization (rather less if that organization is something a bit bigger – like a country). For the rest of us, what TRIZ tells us is that when the demands on a system are greater than its current FUNDAMENTAL limit, then that system can only bridge the gap by changing.

Anyway, we bring the Peter Principle subject up this month partly because its distant (for a management book at least) 1969 roots might mean that some of our readers may never have heard of it, but also because we recently came upon this rather elegant 'proof' of the Principle and why ignorance tends to rise up an organization:

1) Knowledge is Power.

2) Time is Money.

3) According to simple physics

$$\frac{\text{Work}}{\text{Time}} = \text{Power}$$

4) Hence, if Knowledge = Power, and Time = Money, then through simple substitutions,

$$\frac{\text{Work}}{\text{Money}} = \text{Knowledge}$$

5) Solving this equation for Money, we get:

$$\frac{\text{Work}}{\text{Knowledge}} = \text{Money}$$

6) Thus, if Work is held constant as a positive number (no matter how small!) Money approaches infinity as Knowledge approaches zero. In other words, the less you know, the more you make.

Patent of the Month

Patent of the month award this month goes to IBM for US6,506,660 awarded on January 14.

United States Patent	**6,506,660**
Holmes , et al.	**January 14, 2003**

Semiconductor with nanoscale features

Abstract

Described is a method of increasing the capacitance of semiconductor capacitors by providing a first solid-state electrode pattern on a semiconductor medium, etching topographic features on said first electrode pattern in a manner effective in increasing the surface area of said first electrode pattern, depositing a dielectric layer upon said electrode pattern that substantially conforms to said topographic features, and depositing a second solid-state electrode pattern upon said dielectric layer and sufficiently insulated from said first solid-state electrode pattern so as to create a capacitance with said first solid-state electrode pattern.

From the Background section-

This invention relates to improved semiconductor capacitors that are particularly useful for manufacturing improved dynamic random access memory (DRAM), among other semiconductor devices. Dynamic random access memory (DRAM) is well known in the art, the first commercially available DRAM having been the Intel 1103, introduced to the market in 1970. In a typical DRAM, information is stored in semiconductor capacitors on a metal oxide semiconductor (MOS) integrated circuit. Each semiconductor capacitor has a transistor associated with it, such that each transistor/capacitor combination forms a storage cell, or node, that can hold a single bit of information. Unfortunately, the capacitors leak so the storage nodes must be refreshed periodically. As these devices are scaled down to increasingly smaller sizes, the capacitance of the storage nodes is a limitation. There is a need for a method of increasing the capacitance of such storage nodes while also making them smaller.

The invention disclosure further goes on to describe the emergence of a contradiction that has previously inhibited the progress of the state of the art, and, in one simple paragraph describes the solution:-

"… a method of increasing the topography of a semiconductor capacitor such as to effectively increase the capacitance of the capacitor without increasing the size of the capacitor. This is achieved by superimposing a topography, such as an array of holes or islands, onto the electrodes of the capacitor, wherein the elements of the topography (i.e., the holes or islands) are generally about an order of magnitude smaller than the capacitor itself. By increasing the surface area of the electrodes, the capacitance of the capacitor is greatly increased without taking up valuable additional space on the semiconductor substrate."

Or, in TRIZ terminology:-

Thing we are trying to improve - capacitance (use of energy, loss of energy)
Thing that stops us - size (area)

Strategies used by the inventors to overcome the contradiction

- Principle 17, Another Dimension
- Principle 31, Porous Materials

Principle 17 is one of the strategies recommended by the classical matrix.

What qualifies the invention for the patent of the month award is the elegance of what the inventors have done (a powerful testament to the IBM manufacture skills), the incorporation of a self- feature -

What is claimed is:
1. A method for forming nanoscale features, comprising:

providing a substrate;

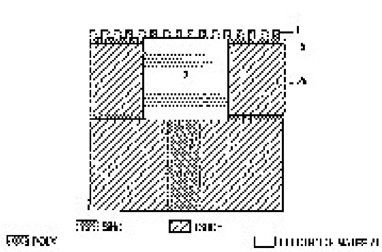
disposing a masking film over the substrate;

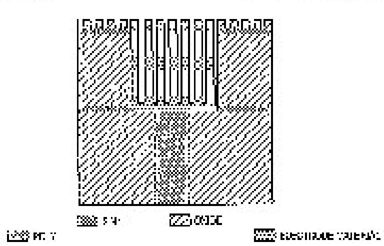
disposing a self-forming nanoscale mesh layer over the masking film;

patterning the masking film through the nanoscale mesh for forming a nanoscale mesh mask in a first portion of the masking film, re n portions of said masking film being only partially patterned; and etching the substrate through said first portion of the mask for forming nanoscale features.

…and the recognition that a simple evolutionary potential analysis of the prior art would have suggested the utilized solution directions immediately.

Worthy of note for our more general education, however, is the fact that an evolutionary potential analysis would have identified further opportunities to improve the capacitance versus area contradiction that the invention does not include.





Best of the Month

Our favourite Mono-Bi-Poly(Increasing Differences) author, Yevgeny Karasik picked out two papers for special attention in his latest issue of Anti-TRIZ-Journal; our own 'Complexity Increases And Then…' article, plus the paper by Nikolay Shpakovsky. We salute his witty comments and overall good taste on both counts, and hereby select Nikolay's paper as the best read of the month.

Beyond the boundaries of TRIZ we've also been ploughing our way through Edward O Wilson's book 'Consilience', in the vain hope that his ideas for a universal theory of everything might begin to encompass some TRIZ thinking. Alas they didn't, but the book nevertheless contains some nice launch-pads for potentially fruitful connections to TRIZ for those with the patience to read 330 pages of figure-less text. We will be sending our 'pictures-speak-a-thousand-words- please-remember-next-time' award to Professor Wilson in due course.

Investments – Environmentally Friendly Plastic Foams

Ohio State University engineers have found a way to make dense plastic foam that may replace solid plastic in the future. The engineers have also developed innovative manufacturing techniques to eliminate the use of chlorofluorocarbons (CFCs) in foam production. Professor James Lee at the University's Chemical Engineering Department recently unveiled a dense new foam material reinforced with tiny clay particles and early success in efforts to replace the CFCs in plastic foam with carbon dioxide.

The first part of this research concerns nanocomposites using additives like clay to make lighter plastic parts. Lee's nanocomposite plastic foam would be even lighter than the current generation nanocomposites, which are made from solid plastics. Lee's biggest contribution seems to be the combination of these nano-particulates with foam manufacture processes. The goal is to create plastic foam that is strong enough to replace solid plastic in structural applications, such as car or airplane panels. Nano-foam products would be lighter than solid plastics, but to the eye, they would appear the same.

The potential market for the technology is huge, because plastic foam touches nearly every aspect of modern life. Common products include seat cushions, carpet padding, home insulation, disposable diapers, fast food containers, coffee cups and packaging material. These diverse products are all created the same way. Manufacturers inject gases, specifically chlorofluorocarbons (CFCs), into hot liquid plastic. The gas forms bubbles to plump up mixture, which then solidifies inside a mould. When the gas bubbles are small and spread evenly within the material, the foam is stronger and denser. Lee and his colleagues found that if they added nanometer-sized clay particles to the liquid plastic, they could increase the foam's density. Small bubbles tend to form around the nanoparticles and cling to them. "The nanoparticles are like seeds. We plant the seeds, and bubbles grow around them. The clay also thickens the plastic, which keeps the bubbles distributed uniformly inside," Lee has been quoted as saying. While most structural-grade plastic foam contains bubbles close to several hundred micrometers across, the bubbles in Lee's nanocomposite foams were as small as 5 micrometers across. With a foam that contained 5 percent clay particles, the engineers were able to create boards that were just as strong, but only two-thirds as thick, as typical foam.

Professor Lee will be presenting more from the research – currently the subject of much industry interest – at the forthcoming NanoComposites 2003 conference to be held in Amsterdam in February.

TRIZ and Biology – 1) The Dung Beetle

The dung beetle has to solve a problem. It is trying to move large amounts of food in the most efficient manner possible – taking into consideration both the amount of food moved in one trip and the number of trips it has to make between the location of the food and home.

In simple terms, there is a contradiction between the desire to move lots of food (Amount of Substance) versus the amount of energy the beetle requires to do it.

The dung beetle solves the contradiction by forming the food into a ball (Principle 14B, Curvature, 'use balls, rollers spirals and domes'.)