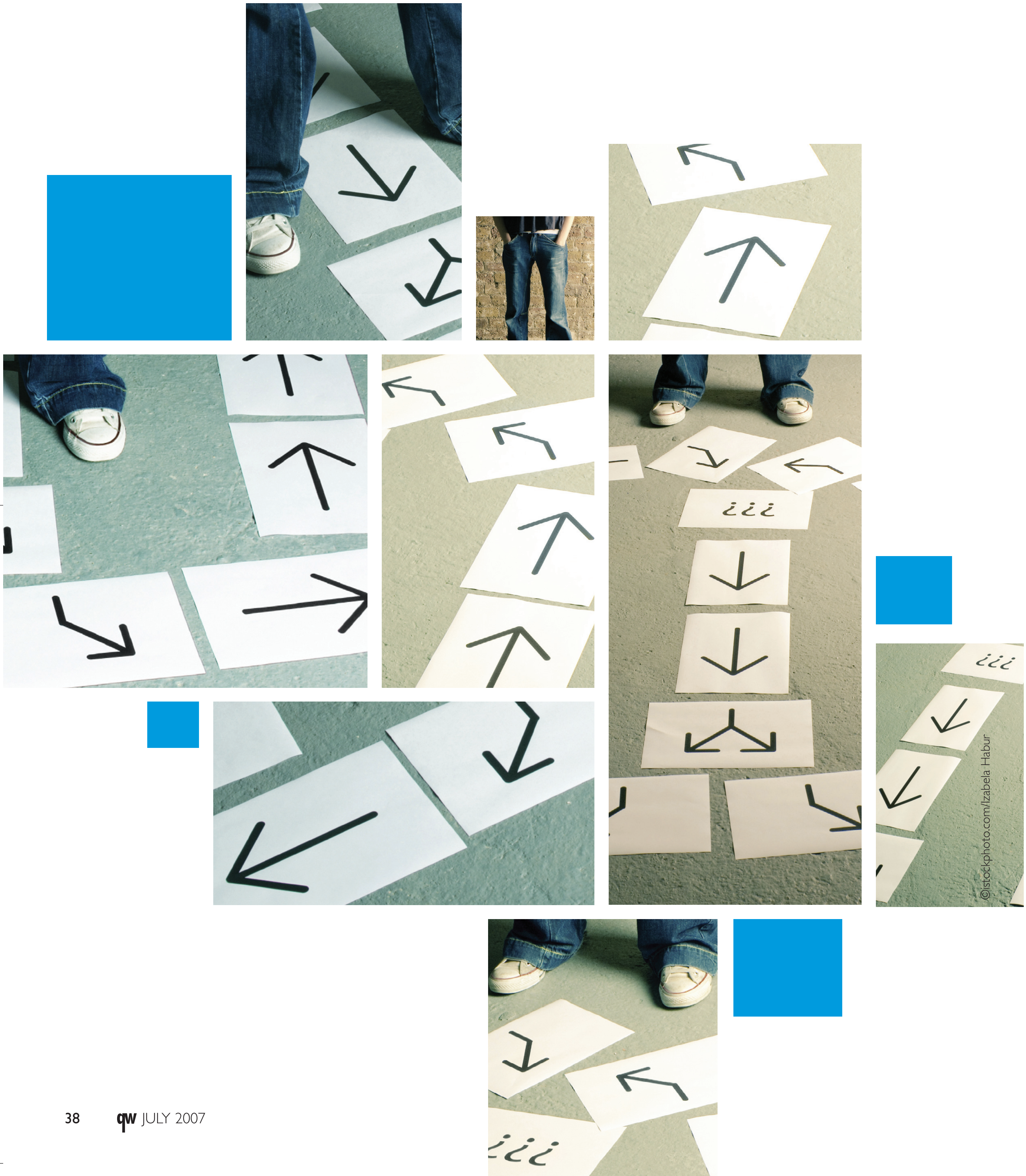

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practical magic

Efforts in the quality profession have resulted in significant improvements in products and services over the past 20 years. There have been some impressive innovations too. But do you ever ask the question: 'Why did it take so long?' **Jack Hipple** thinks the Soviet-invented TRIZ approach might just provide the answer

TRIZ, a Russian acronym for 'theory of solving inventive problems', is a unique problem-solving, design and forecasting tool kit and algorithm developed in the former Soviet Union. The reason it's causing a stir is because of its rejection of traditional approaches to innovation. Forget brainstorming, with TRIZ it's about the application of typical 'left-brain' properties: logic, sequential thinking and rationality. TRIZ's originator, Genrikh Altshuller, was a patent examiner for the Soviet naval patent office in the 1950s. Without computers or Excel spreadsheets, Altshuller, himself an inventor, studied thousands of patents across different areas of science and technology and recognised four key characteristics:

- true breakthrough patents were very rare, accounting for less than five per cent of the hundreds of thousands of patents he reviewed
- breakthrough inventions had a key common trait: they resolved a very difficult, long standing contradiction in product design or process performance. An example of this would be the resolution of weight and volume design contradictions through the improvement of time and productivity by preliminary action, ie doing something in advance
- the number of inventive principles used in these breakthrough inventions, regardless of the technical or business area, was limited and this limited number of principles could be used across multiple areas. For example, the principle of preliminary action can be used to increase production line effectiveness, (pre-placement of materials where they are needed) as well as to prepare an organisation for potential major changes through proper communication
- inventive problem-solving and product improvement was a science and could be taught and learned. These repeatable patterns of invention could be collated in a learnable, retrievable way, eliminating the need to brainstorm and guess at solutions to problems. This meant that science could replace psychology as a primary approach to both problem-solving and product design. This flies in the face of the long-held belief that invention and innovation are some kind of unknown, 'right-brain' process that rely on random intuition and subjective psychology

What is TRIZ?

The TRIZ algorithm and tool kit became known to the west around 1990, following 30 years of development in the former Soviet Union. TRIZ is now used by major corporations such as SC Johnson, Proctor and Gamble, Motorola, Hewlett Packard, GE, Unilever, and Dow Chemical.

The first element of TRIZ is the recognition that a breakthrough new product or invention comes as the result of the resolution of a contradiction. For example, the design of the asymmetrical engine cowling for the stretched Boeing 737 was the resolution of the contradiction between area and length, allowing the engine to meet Federal Aviation Administration (FAA) ground clearance standards. In quality, we sometimes use tools such as the 'house of quality' where customer requirements are compared with the capabilities to supply. This frequently identifies contradictions in product performance versus what is desired by the customer. A customer may want a system that cleans and smoothes a metal part, such as sandblasting, but does not want the sand particles embedded in the part surface afterwards. This provides the focus but does not tell us how to resolve the unmet need or contradiction.

With TRIZ tools we can say that we want a system that is initially present and abrasive, then disappears after it performs its functions. Blasting with dry ice accomplishes this. Consider also the contradiction of razor blade design. We want a close shave but not one so close it tears the skin. The separation of blades accomplishes this and is an example of TRIZ separation principles.

A significant limitation of brainstorming, or other psychologically based tools, is that they only use the brainpower and knowledge of the participants in the exercise, stimulated by any number of techniques. TRIZ provides a powerful mechanism for bringing the knowledge of all the world's breakthrough inventive concepts into the problem-solving arena. If we assemble a group of automobile engineers and ask them to try to solve the problems of the current automobile seat headrest, they will rely on their knowledge of dummy testing. It is unlikely that they will consider that a baseball catcher's glove has been doing this same thing for over a 100 years and that possibly a catcher's glove designer should be brought into the room. TRIZ captures all of the world's inventive principles in retrievable ways.

The original use of TRIZ was in the engineering and technical areas but as its general utility and robustness has been shown as it is now used in software programming and organisational design and communication contradiction resolutions, as well as specialist areas such as human factors and ergonomics. However, TRIZ does not normally provide a specific detailed answer to a challenge, only the general concept of solution. This must be coupled with the subject matter expertise around the product or service.

Define the ideal final result

The TRIZ approach starts by defining the ideal final result. This can be approached by resolving a contradiction that will make a product or service more 'ideal', or simply by looking at a current product or service with no particular issue of concern and asking how it could be made more ideal.

Alternatively, it can be visualised as an equation which has as its numerator the useful functions of a product or service and as its denominator the negative aspects or side effect of its use and manufacture. The ideal final result is this ratio going to infinity. For example, we would like to have all the features of a product or service with none of its costs. It is critical in this step of the process that we defer judgment about the practicality of this idea. This is extremely difficult for experienced industry people to do. Consider the design of a system to identify occasional empty soap boxes in an assembly line.

The typical non-TRIZ brute force approach to this is to design an x-ray system that can see

40 principles of TRIZ

These principles are listed in the order that they are most frequently used.

35 Transformation of physical/chemical states
10 Prior action
1 Segmentation
28 Replacement of mechanical system
2 Extraction
15 Dynamicity
19 Periodic action
18 Mechanical vibration
32 Colour change
13 Inversion
26 Copying
3 Local quality
27 Inexpensive short lived objects versus expensive/durable object
29 Pneumatic/hydraulic constructions
34 Rejecting and regenerating parts
16 Partial or overdone action
40 Composite materials
24 Mediators
17 Moving to a new dimension
6 Universality
14 Spheroidality
22 Convert harm into benefit
39 Inert environment
4 Asymmetry
30 Flexible thin films/membranes
37 Thermal expansion
36 Phase transition
25 Self service
11 Cushion in advance
31 Use of porous materials
38 Use of strong oxidizers
8 Counterweight
5 Combining
7 Nesting
21 Rushing through
23 Feedback
12 Equipotentiality
33 Homogeneity
39 Prior action
20 Continuity of useful action

through the boxes and some kind of a robotic arm to remove non-filled boxes. The TRIZ approach would be to ask how an unfilled box can identify itself with little or no expenditure of money. In fact the preference would be to use the information we already have. In a real case, a simple floor fan was moved close to the assembly line and the empty boxes 'removed themselves' using not just the resources at hand, but the actual negative aspect of the problem – the emptiness of the box. This kind of TRIZ solution can be commonly seen in practice.

What is seen as a negative aspect of a product or system turns out to be a key resource in solving the problem and this resource is typically 'free'.

Even if we cannot get to the ideal ratio of infinity in this type of equation, the thought process always produces breakthrough ideas.

This first step of defining the ideal final result presents two major challenges. If TRIZ is used in a consumer products framework as opposed to a process or engineering sense, users in a market research or new product survey may not be able to envision an ideal product. The second barrier is on the other side of the fence as the manufacturer or service provider cannot envisage how to achieve such a result.

As a result, the provider may propose concepts for evaluation that fall far short of the ideal state. The definition of an ideal product or service ('something that performs its function and doesn't exist') can also provide a basic challenge to an organisation's product or service strategy. In spite of the psychological challenges, this step is the most important part of the process.

TRIZ provides several approaches to getting the ideal result. The first is the recognition and use of resources within the product or service system at hand. In other words, how can we creatively use the elements of the system to achieve a more ideal function without adding things, or adding useful functionality without overly complicating a product or service? The evolution of the multifunctional copier, fax machine, and phone system is an example. This is increasing useful complexity while the example of the soap box quality problem discussed previously is at the other extreme – we want a result without any system.

Another example is the use of the force of gravity (free and available at any time to any of us) in the redesign of ketchup and shampoo bottles, or a new computer keyboard that uses the mechanical energy of typing to recharge its battery. When we look at this challenge without TRIZ, we do not recognise all the resources available in the system, including all space, time and field inputs. We frequently do not recognise that all inputs to a system, like typing, generate byproduct resources and fields. Many fields are automatically generated by other fields and these byproduct forces are always available. Frequently, we are unaware of these because of our limited personal knowledge. TRIZ provides an extensive list of resource conversions.

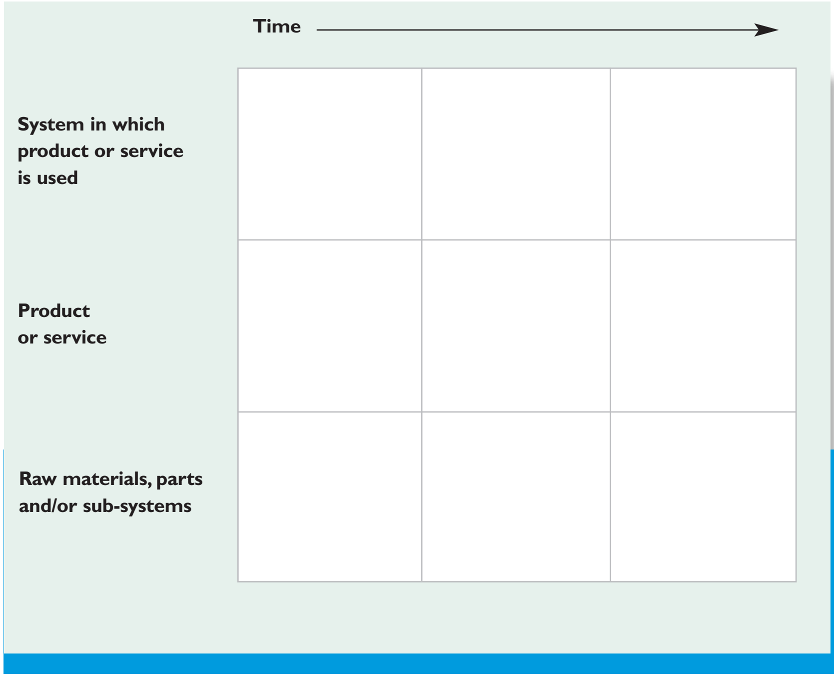

Figure 1. A tool to establish the integration of a product or service into its super-system

System integration

The second step is the integration of a product or service into its 'super-system'. Any product or service can be represented on what looks like a 'noughts and crosses' box, as seen in figure 1.

It is key to consider whether the function of your product or service can be integrated into or performed by the super-system in which it is used. Consider how sunglasses, formerly two separate systems, are now one super-system – glasses that change darkness as a function of light intensity. Think also about office machine integration. We no longer have separate copier, fax and printer. They

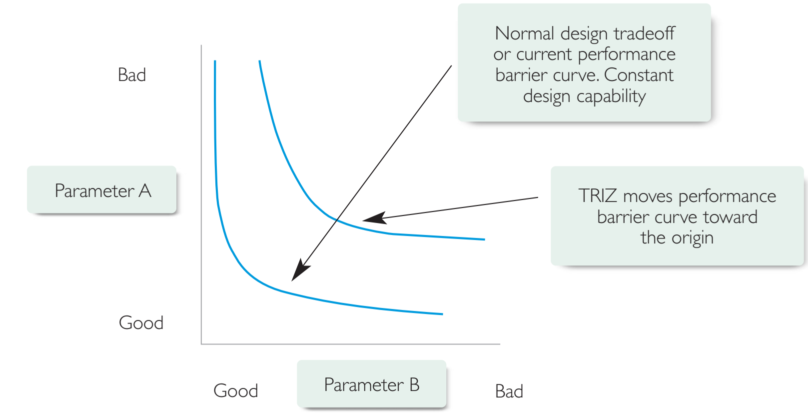

Figure 2. Overcoming contradictions: with TRIZ thinking, the curve is moved towards the origin

are now being integrated into one machine. The integration of products or services into their super-systems is one of the key TRIZ forecasting and planning principles.

This principle is critical in new product and business development planning. If a copier business is optimising the details of its copying machine and is not aware of this principle, it will soon be out of business. A supplier of inks to both copier, fax and printer will also be at a major competitive disadvantage unless it understands the system integration that is occurring.

From a quality standpoint, a user will often prefer to use one device or service rather than multiple products or services.

Trimming

Trimming is the third mental approach used to attain an ideal result. This is a way of asking how a function of a product or service can be performed without one of its primary components, thus eliminating complexity, cost and maintenance.

Consider the new mobile phone that is only able to receive incoming calls. This greatly reduces the cost for consumers and targets a niche market of child and elderly care.

A simple way to start this thinking is to list all the parts of a system or organisational process and arbitrarily eliminate it. Then ask yourself the question: 'how can its function be achieved with the elements that are left?' You will probably be surprised at the ideas you come up with.

Overcoming contradictions

Overcoming contradictions is another approach to achieving an ideal product or system. We mentally set up a product design conflict as a 'no win' situation. We may want a heavier but more efficient car. We may want a copier that is easy for the manager to use, but also contain the complexity required for an office assistant. In other words, we mentally move along a tradeoff curve – weight versus efficiency, usefulness versus complexity. With TRIZ thinking, we move the curve toward the origin, as shown in figure 2.

The first form of TRIZ was a 39 x 39 contradiction table with parameters of systems (length, strength, pressure etc), a means of identifying contradictions between these parameters, and then linking these contradictions to the TRIZ 40 inventive principles (see box on page 40). If we take the example of the new engine design for the Boeing 737 as it advanced from its 737-300 to its 737-400 stage, the contradiction of engine area versus its length became a design contradiction in that a large circular engine cowling resulted in too small a ground clearance to meet US FAA requirements. Using the contradiction table, we want to increase the area of a moving object (the engine), but its length (diameter) gets 'worse' (too large). One of the inventive principles suggested is asymmetry and, as a result, if you look at a current B-737 jet, you will see that the shape of the engine cowling is no longer round, but asymmetric.

The original 40 inventive principles have been summarised, with examples, for many different fields including engineering, business and software. Thereafter, a set of solutions for contradictions within a parameter ('I want something to be short and tall, thick and thin') were discovered. The list, known as the TRIZ separation principles, can be subdivided in several ways, but here is one approach:

- separation in time – does the parameter need to be the same all the time? Think about registration fees for a conference as a function of when you register
- separation in space – how can we modify the property or performance at different places? Consider the extra revenue produced by subdividing seating in an aeroplane or stadium
- separation between the parts and the whole – can we design the system to have different

properties at the micro level versus the macro level? Consider a bicycle chain – it is very rigid at the micro level, but very flexible in a macro sense

- separation upon condition – can we change product performance or response based on the condition it faces? Take the over-the-counter drug pseudoephedrine. As a sleeping aid, it sells for one price, but as a decongestant, it is packaged differently and sold at a higher price

All of these illustrate the use of TRIZ separation principles to make a product more effective. To use these principles to improve product quality, look at the contradictions faced in improving product quality or its usefulness in the hands of a customer. Instead of compromising around these contradictions, the TRIZ separation principles can be used to resolve the contradiction and make a major breakthrough in product service design.

Lines of evolution

The last part of the evolution of the TRIZ tool kit and algorithm was the discovery that products, systems and organisations evolve in predictable patterns, frequently involving major predictable discontinuities. Examples would be the replacement of manual typewriters with electronic typewriters and the displacement of landline phones by mobile phones. Using these tools we can improve customer studies as well as new product and business planning. Depending on how these TRIZ lines of evolution are analysed and subdivided, there can be several hundred lines of evolution that are derived from eight original ones. A few of these relate to issues already discussed (ideal products, use of resources, resolution of contradictions). Let's look at some of these additional ones to clarify their use in improving product quality.

One of these lines is the trend in products and systems to become more dynamic. When we view the development of breakthrough and improved products, this frequently involves making a product more responsive to particular conditions. New windscreen wipers and car radios whose speed and volume, respectively, increase with car (engine) speed (noise) are examples. So are grocery coupons issued on the back of till receipts based on what a customer has bought. TRIZ and this line of evolution tell us that a system will always progress to a more dynamic state, so anything in a system or product that can be made more dynamic, especially if it improves quality on demand, is an area for focus and attention.

Another of these lines is one that says systems and products evolve toward integration into their super-system. Any product we make is used within a system and this system, in turn, is used and integrated into a higher level system. Consider the checkout process in your local supermarket. The pricing information that used to be stamped on a product is now a barcode that is scanned (increasingly by the consumers themselves – trimming in action) into a computer system which also tracks inventory, automatically reorders, and prints out an appropriate coupon on the back of the sales receipt.

When we think about this line in the context of quality, it is best to remember that our products are used in someone else's system and anything we can add to our product to improve the quality of the super-system we are supplying to is a good thing on which to focus.

The other learning point here is that our product could become obsolete when it is trimmed and its functionality replaced by another part of this super-system. When was the last time you saw a paper airline ticket? Or a CD for an installed piece of software on your computer? In both of these cases, the function of the CD and the paper ticket are now included in the computer and reservation system respectively and the original items no longer exist, unless the consumer is willing to pay an extra fee.

Finally, there is field evolution. This is more technical, though equally important. TRIZ teaches us that systems evolve along the following path: mechanical, thermal, chemical, magnetic and electromagnetic. Think about the evolution of communication. We first had writing on cave walls and banging on drums, then smoke signals, then inks, then electronic typewriters, and finally email and portable phones.

Each of these moves improved quality from the customer's viewpoint. Consumer interviews won't necessarily elicit these ideas as the consumer may not even be aware of the next field, let alone how to use it in making or delivering a new product or service.

Not all of us have the inventive genius of Da Vinci, but with TRIZ that's unimportant. Real, practical innovation is possible with a little left brain logic qw

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