# TEACHING TRIZ AS A SYSTEMATIC PROBLEM SOLVING METHOD: BREAKING MINDSETS

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**ABSTRACT**

Present education has often a dysfunctional approach in that it gives students knowledge and examples of how to solve problems using that knowledge, and then assumes that the student will somehow by a process similar to osmosis understand how to solve further problems in that domain. In reality there appears to be little focus on 'teaching' how to solve problems systematically, particularly real life problems that are 'messy' and extend into a number of domains. This paper shares experience and knowledge which is based on six years of teaching systematic problem solving in the UK and the special place that TRIZ has in this arena. Key areas covered are:-

- Creating a need in the student to learn more, i.e., discusses strategies that show that TRIZ has more potential than other present problem solving strategies
- An approach to teaching systematic problem solving with the emphasis on TRIZ
- Lessons to be learned and challenges for the future, including conjecture on why TRIZ has not been adopted more robustly.

**1. INTRODUCTION**

In a previous paper by the author (Filmore 2006), a detailed guide was given on how the author has been teaching TRIZ to undergraduates and postgraduates. In the light of further experience, the basic teaching philosophy approach has been little modified when running 'training' workshops for industry. This paper looks again at the approach but in particular focuses on the underlying philosophy rather than the mechanics and content of delivery. As an outcome, the paper speculates why it is that TRIZ has not been yet taken up with much greater interest.

As reported previously (Filmore 2006) the following the following are some of the key areas which were introduced when teaching TRIZ, to lay the foundations on which TRIZ tools could be established:

1. The background of patents being one of human kinds greatest sources of creativity and how these were analysed by Altshuller (TRIZ history)
2. Making students aware of what happens when they cannot solve a problem (by giving problems that require 'thinking outside the box') and so developing the awareness that a problem is often only a problem when one's own mind is limiting the 'solution space' etc.
3. Further reinforcing the awareness of how we naturally (as we are human) are affected by psychological issues and how TRIZ can help get around these mental barriers.
4. Developing an awareness of the difference between 'incremental' and 'breakthrough innovation' and so show how TRIZ can take students outside their own 'thinking space/ limitations' and thus develop solutions which they

would otherwise be unlikely to generate.

5. Show examples of good TRIZ results (cases and examples) with which students can identify and so become aware of the power of TRIZ (i.e., realise that they would not have thought of such solutions and that somehow the solutions are a 'leap forward'). Thus the student realises that TRIZ has more potential than their present problem solving strategies.
6. Introduce TRIZ theory in such a way that students can feel able to adopt it and that when they try using the tools, they work, i.e., approachable and non-threatening!

The previous paper looked in detail at points 1, 4, 5, and 6. This paper starts by looking at teaching systematic problem solving (which includes points 2 and 3 above), continues with considering the place of TRIZ in problem solving, and concludes by considering lessons to be learned and challenges for the future in getting TRIZ adopted widely.

## 2. SYSTEMATIC PROBLEM SOLVING

There are many books on problem solving e.g., Lumsdaine & Lumsdaine (1995). The starting place is often by introducing a process, for example see Figure 1.

1. Brain storming
2. Define the problem clearly
3. Analyse the problem
4. Collect data
5. Interpret the data
6. Generate possible solutions
7. Agree the best solutions
8. Cost benefit analysis
9. Present solutions
10. Implement solutions
11. Monitor and evaluate results

Figure 1: Showing a problem solving process. Adapted from Robinson (1993)

What is not made clear is that the first three stages can be very time consuming and can be a very significant part of the project work. Most students leap in at stage 4 by immediately trying to solve the problem in front of them. This is where the 'systematic' in systematic problem solving comes in, i.e., problem solving that at the outset defines the problem and secondly follows a process. The process should also include feedback loops, so that if at e.g., stage 6 above, the solutions appears too limited, then one needs to go back to stage 2 and redefine the problem etc. The area of problem solving skills is considered a high priority skill area in postgraduate (MSc) development. An analysis of responses from a course directors of 5 universities covering a number of MSc programmes, stated 'identification of problem essentials, initiative and originality were highly rated' (Mistry, White & Berardi, 2006). This was also reported as important from the employers' perspective when recruiting graduates. Interestingly under problem solving requirements for employers was the phrase 'developing strategies to change mindsets'. Opportunities that TRIZ presents to do this, is discussed in section 4.

**2.1 Developing an awareness of understanding the problem**

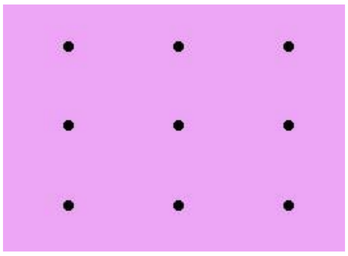
How is it possible to stop students starting to immediately solve a problem? My approach is to get the students to gain the awareness of this danger by attempting to solve some simple problems that they cannot solve. Key to this is that the examples must be simple, and the students have fun. A minimum of two different types of problems need to be used before the 'message' sinks in (i.e., take the students twice around the learning cycle). As an example, the first problem I give students is shown in Figure 2. The approach is to gradually illicit more and more ideas and for the ideas to get more and more 'creative'. Students then start to realise that they have been making assumptions which have been limiting their ability to solve the problem. Common assumptions: depth of moat (it may be 1cm), it is a moat rather than blue glass, the moat has sharks in it i.e., they must not get wet, the moat goes right around the back, they have to use both planks, they have to use one plank (NB common assumption is that if a 'resource' is available then it must be used), have to get into the

How do you get across the 3m moat, having only two, 2.7m planks?

Figure 2: The Castle Problem (acknowledgement Hannah Filmore)

castle (key mistake of not reading the question/ brief). When all the student assumptions have been listed, it is a good idea to introduce the (TRIZ) idea of resources available and list these. Examples are: planks, air, shouting to get someone in the castle to lower the drawbridge, the moat edging. At this point it is useful to point out that symmetry, dimensionality etc may be resources and even drop a loaded hint that the solution would not be possible with a perfectly circular moat. The solution of putting one plank across the right angle of the moat and then the other on top and to the far side is not really of importance. It is getting the students to see that it is there thinking that gets in the way of solving a problem, otherwise there would not be a problem!

A simple second problem is well known (see Figure 3). I suggest that students who know the solution do not tell others and if someone discovers the solution then they keep it hidden and only show the lecturer. When students have had 5 minutes and tried many solutions, I go back and suggest that again the reason that they cannot answer the problems is that they are making assumptions and thus limiting their thinking. After a pause I ask the students to list their assumptions. Usually when a student says that the lines have to terminate on a spot i.e., the lines cannot go beyond the outer series of spots, then a number see the solution. The final comment on this solution is that it is solved by 'thinking outside the box'; a phrase which many students have heard but not realised its implications! In summary at this point, it is useful to again point out that problem solving is all about really understanding the problem before even starting to solve it. A link here to TRIZ is useful, by saying that TRIZ has a number of tools to do this, including functional analysis and resource analysis. Other tools define the constraints and widen thinking with a time (past, present future) and size (sub system, system, super system) axes i.e., the 9 boxes tool etc (Mann 2002).



The aim is to draw the minimum number of straight lines which join all the dots, without lifting your pencil off the paper.
NB The answer has 4 lines

Figure 3: The box problem

**2.2 Defining the problem**

Before defining the problem, stage 1 of the problem solving process shown in figure 1 is brainstorming or mindstorming. It surprises me that many engineers and postgraduate students do not understand that brainstorming requires using the creative hemisphere of your brain and that the moment that any hint of analysis e.g., laughing at a suggestion, then the logical hemisphere takes over (as it has been trained to predominate for engineers and scientists) and stops the creative flow of ideas. I think it is useful to introduce the concepts of convergent (logical) and divergent (creative) thinking. The problem solving process is then to alternate using these (see Figure 4).

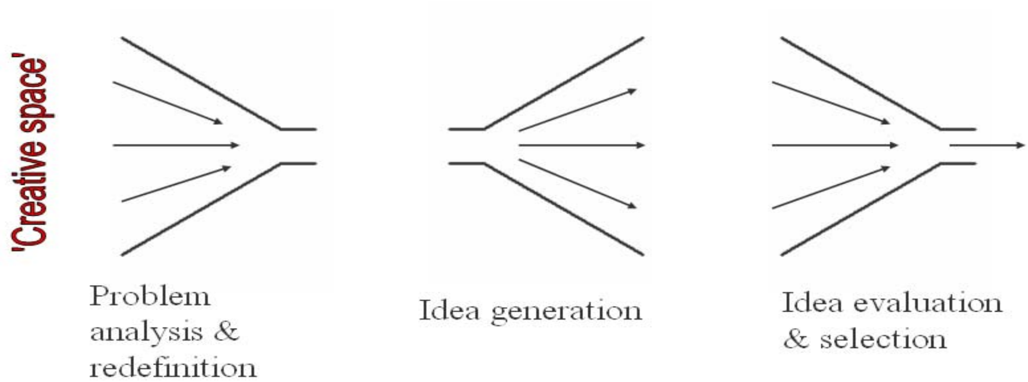



Figure 4: The Problem Solving Funnel

In the problem definition (stage 2) and analyse the problem (stage 3), I like to introduce 'The Six Word Diagram' from Rudyard Kipling's poem which starts:

> ***'I keep six honest serving-men***
> ***(They taught me all I knew);***
> ***Their names are What and Why and When***
> ***And How and Where and Who'***

This equates to the following question set:

**What** is the problem and what is not the problem?
**When** does it happen and when does it not happen?
**Why** does it happen and why does it not happen?
**Where** does it happen where does it not happen?
**Who** contributes to the problem and who does not contribute to the problem?
**How** do you recognise when the problem is present and how do you recognise when the problem is not present?

This has links with TRIZ the Problem Hierarchy Explorer tool and to Altshuller's simple Ideal Final Result Problem Definition Questionnaire (Mann 2002).

## 3. THE PSYCHOLOGICAL BARRIERS

Wishing to stimulate debate, I want to share some observations and will perhaps be controversial to this end. I still keep being surprised that students do not understand that they are all different! Is because engineers and scientists perhaps have less interest in themselves and others? I am always on the look out for effective ways to get my students to gain awareness here. I find a detailed look at how people learn i.e. the Learning Cycle (Kolb, 1984) and how this work has been taken on into how organisations learn (Kim, 1993) using the concepts of 'Mental Models' (Senge, 1990) of help. Two further areas that are approachable are mentioned here: that of 'Thinking Preferences' and an understanding of creativity.

### 3.1 Thinking Preferences

In their book on 'Creative Problem Solving' (1995), Lumsdaine & Lumsdaine report the work of Ned Herrmann on brain dominance (Herrmann, 2007). Dominance, or 'cognitive (thinking) processes', or 'preferred modes of knowing', have advantages in quick response time and higher skills level, which is why people default to a particular thinking process. Ned developed a questionnaire (the Herrmann Brain Dominance Instrument: HBDI) and from the results of now over a half million people, concludes that there are four identifiably separate dominances. Ned has found that 7% of the population have single dominance, 60% have double, 30% have triple and 3% have a quadruple dominance. The preferences (see Figure 5) 'A' and 'B' relate (metaphorically) to the left brain hemisphere (i.e., the logical, structured areas) and the 'C' and 'D' relate to the right hemisphere (i.e., the creative and holistic thinking areas). Herrmann relates these preference dominances to creative problem solving mindsets (see Figure 5: right) e.g., 'engineer' ('A' & 'D'), 'detective', 'explorer', 'artist' etc. A key point is that our preferences have been influenced by our (school and college) teaching and that individuals can strengthen non-dominate preferences by the careful choice and practice of specific activities (e.g., daydreaming and sketching etc. for developing quadrant 4).

### 3.2 Creativity

I find that initially considering the barriers to creativity is a practical approach that students can relate to easily. Some barriers (source unknown) are:-

- 'Tramline Thinking: i.e., the problem of precedence (the way things have always been done is the only way).
- Fear of Looking Foolish: limits our contributions to those safe and conventional (from

experience at school).

- Evaluating Instantaneously: not giving ideas a chance (because at first they appear impractical, impossible or simply crazy.
- One Right Answer (a commonly held view which tends to drive people into an analytical thinking mode and to look for the single obvious answer).'

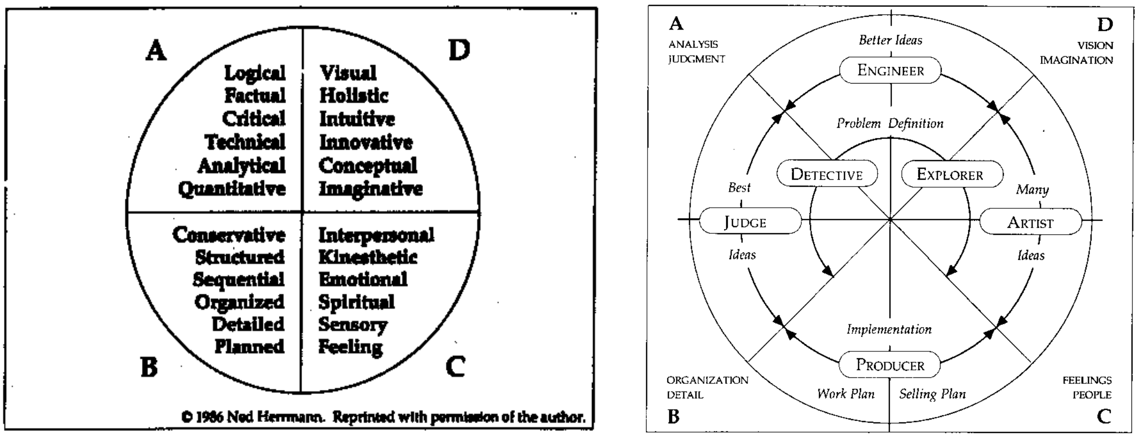



Figure 5: The Four Quadrant Herrmann model of Thinking Preferences.
Source: Lumsdaine & Lumsdaine (1995)

This leads to the awareness that there are different barriers within one self and within a company/ organisation (see Figure 6). The creativity model shown in this figure helps a realisation of the holistic nature of being an effective problem solver.

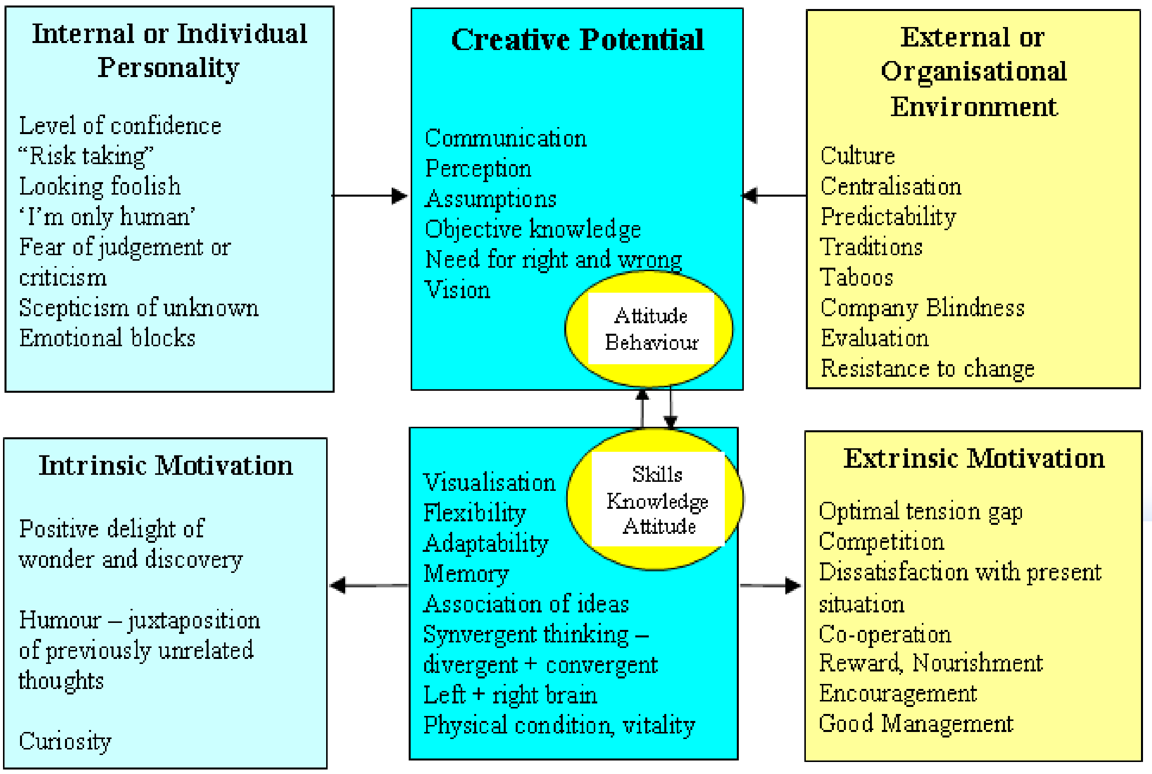



**Figure 6: The Creativity Model (Baille, 2002)**

## 4. LESSONS TO BE LEARNT

So how does utilising the above techniques in learning facilitation (teaching) help develop systematic problem solving and what are the implications for TRIZ adoption? An early paper by Mann (2001) points out the problem of teaching problem solving. If the 'teacher' moves from a problem towards the solution then all the time the student is in the dark until the last moment. If on the other hand, the teacher starts with the solution, 'the solution is viewed as 'obvious', often to the point of being almost facile'. As Mann (2001) says 'In fact the very 'obviousness' of a solution is very often used as a test of how 'right' the solution is. The more 'obvious' the answer, the better the solution.' This is why I think that the teacher has to first to develop an awareness in the student that they themselves are the reason why a solution is not being found! This awareness has to encapsulate the habits of: not understanding the problem, not fully defining the problem, overlaying assumptions, not being aware of resources available, using only specific thinking preferences (which includes not being able to brainstorm effectively), not being aware of psychological barriers etc. In my experience it is only after developing an awareness of these 'barriers' that students can appreciate the need for tools that help with this breakthrough process. It is now that the basic TRIZ tools can be introduced and here I agree with Marco Aurelio de Carvalho (Campbell 2002) when he says 'concentrate on TRIZ basic concepts of contradiction, ideality, resources and system approach and try to use them for problem solving'. I would add that then looking at a good case study (e.g., Filmore 2006), is essential and then finally looking at results that show whether TRIZ is effective (e.g., Filmore & Thomond 2005).

## 5. CHALLENGES FOR THE FUTURE

So why has TRIZ not yet taken off fully? Campbell (2002) has asked this question and has had a number of comments on his thoughts. I do appreciate that TRIZ appears to the overworked engineer as just another one of many new tools/processes (6Sigma, QFD, Functional Analysis, FTA, FMEA, Taguchi, VA/VE, TQM, Lean etc.). What has though not been made clear is its ability to challenge mindsets (that are open to being challenged) and thus deliver breakthrough change. Table 1 attempts to rectify this. It should though be emphasised that TRIZ can often compliment other techniques e.g., TRIZ and Taguchi (Wu, Tzann-Dwo, 2004).

To be provocative I would say that engineering education has failed by emphasising compromise/ balancing of trade-offs, and school science/ technology education has failed by emphasising logical thinking. I think we should start teaching children in primary school's to analyse a problem in terms of what sort of problem it is, change it into a contradiction, look for the ideal etc.

| TRIZ tool/ approach | Points helping in breaking mindsets |
|---|---|
| Resources and Constraints | * Helps understand and define the problem, and that everything available may be a resource |
| Functional analysis | * See the problem visually/ holistically/ overview as a system of interactions.<br>* Understand relationships and the different types of interactions e.g., excessive, harmful, insufficient etc.<br>* Identifies intangibles. |

| | |
|---|---|
| Ideal Final Result | * Balancing trade-offs is a limited way of thinking. Start with the ideal and work backwards to a practical position.<br>* It helps identify the benefits.<br>* Some things are free! Believe it! |
| Contradictions | * Do not use the word 'problem'. Defining a contradiction in terms of an improving and worsening pair(s) makes the issue seem more manageable. Also being able to formulate the contradiction in terms of space or time etc. further helps to open possibilities of understanding. |
| The Matrix | * A great resource of solution triggers<br>* Brainstorm or use other creative approaches e.g., using Synetics starting with these given triggers |
| Trends | * There is a (physical) limit where putting in large effort will get very little reward i.e., little increase in efficiency/ ideality etc.<br>* Other industries have jumped s-curves already, so why reinvent the wheel?<br>* The difference between incremental thinking and breakthrough thinking (i.e., jumping s-curves).<br>* Which trends have you not considered as being relevant? |
| 9-Windows | * Gets one away from the 'present' and 'systems' level thinking, by forcing one to consider the past and future and sub and super system level. |
| Problem Hierarchy tool | * Elucidates why you want to solve the problem and what is stopping you etc.<br>* Helps define broader and narrower problem levels |

Table 1: Initial ideas as to how TRIZ helps to break mindsets so that problem solving becomes easy.

## 6. CONCLUSION

This paper shares experiences from many years of teaching problem solving and TRIZ. It shows that making people aware of their limiting thinking preferences, their assumptions, their initial limiting problem understanding and definition, greatly enhances their problem solving abilities. The paper then continues to show how the TRIZ tools can be appreciated more widely by recognising their mindset breaking potential.

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