The Theory of Inventive Problem Solving (TRIZ) and Systematic Innovation-a Missing Link in Engineering Education?

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Abstract

This paper aims to outline the Theory of Inventive Problem Solving (TRIZ) and the broader concept of 'systematic innovation' in an attempt to fuel discussion over the need and form that the teaching of creative problem solving should take in engineering curricula. The recent emergence of the approach in the West has created much interest with industry and a growing awareness in academia. All three UK universities represented in this paper have introduced TRIZ to their engineering curricula to some extent and give an account of their experiences. Although TRIZ originated in mechanical engineering the paper demonstrates the underlying principles are more broadly applicable and are closely related to another approach, namely, the Theory of Constraints. The positioning of the approach relative to other design tools is an active research area and the opportunity to integrate the approach is discussed.

1 Introduction

Although the importance of innovation in design is increasingly acknowledged the tools available to help generate new ideas are general purpose, far from systematic and poorly suited to the specific needs of engineering design. Consequently most engineering curricula leave innovation largely to the students creative talents.

The TRIZ methodology claims that, 'Inventive problems can be codified, classified and solved methodically, just like other engineering problems'.

There are three premises on which the theory is based:

1 The ideal design with no harmful functions is a goal.
2 An inventive solution involves wholly or partially eliminating a contradiction.
3 The inventive process can be structured.

Although the paper focuses on TRIZ and the application of systematic innovation in engineering it concludes with the underlying principles common to another systematic innovation process, namely the Theory of Constraints (TOC) which is closely associated with organisational design.

The Taguchi approach to robust design and Quality Function Deployment emerged in the West in the early 1980s and some are claiming[1] that TRIZ completes the trio. Whether this is the case time alone will tell, but industrial interest is clearly growing with many large companies sponsoring or participating in the International TRIZ conferences, namely, Ford, Boeing, Kodak and Xerox[2] (Domb, 1998). An Internet search on TRIZ will demonstrate the high level of commercial and academic interest in the subject.

2 Creative Design

Traditionally engineering design has been taught from a specialist functional perspective where tools and techniques are associated with the sub-functions such as electronics, mechanics, graphics etc. More recently the need for a holistic view of the product design has been supported by integrated publications such as Total Design[3] (Pugh, 1991) and Engineering Design[4] (Cross,1994). Here the broader view of the design process considered the 'design core' to include the market (user need), product design specification, conceptual design, manufacture and sales. In this way the sub-optimisation bias has been addressed and industry led methods, such as Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA), Taguchi and more general functional analysis tools are practically supporting the integrated design process. The lack of tools to support the creative activity in design and problem solving has, as a consequence, become more acute. Value Engineering encourages a creative view of the design process, but only includes generalised tools, such as brainstorming, synectics and various lateral-thinking techniques, such as analogy and inversion. These are very general techniques that help to generate ideas, but are not geared in any way to meeting engineering design needs. More engineering related tools include Morphological Analysis [4](Cross, 1994) and Pugh's Concept Evaluation/Generation method. [3](Pugh,1991,pp74-86). These tools have until recently been the latest practical developments to be widely adopted in engineering design texts, however the opportunity and pressure for creative design is growing and there is clear commercial need to better educate engineers in creative problem solving. The authors consider that the theory and practical tools behind TRIZ satisfies this need.

3 TRIZ: Brief history

TRIZ is a Russian acronym for 'The Theory of Inventive Problem Solving', which was originally developed by Genrich Altshuller, [5](Altshuller, 1988) 1926 to 1998. In 1946 he was a young mechanical engineer working in the patent office of the Soviet navy, where he was intrigued by how inventions were made and wondered whether there were any systematic patterns to inventive thinking. He started his work by studying thousands of patents, looking for commonalties, repetitive patterns and principles of inventive thought. As he found them he codified and documented them eventually publishing, and acquiring a following of scientists, engineers, and inventors, but for many years his work was stifled due to political pressure. Together the research continued, eventually resulting in the screening of more than 2 million patents (Ideation, 1999) and from which numerous analytical and knowledge based tools for solving inventive problems were developed.

It was not until '*perestroyka'*, that TRIZ was able to flourish in Russia, but it is estimated that TRIZ has been taught to about 50,000 Russian engineers. In 1989 the Russian TRIZ Association was established with Altshuller as President and in the early 1990s the work started to be acknowledged in the West.

4 TRIZ: Tools and approaches

As you can see, like Taguchi and TQM, TRIZ has a long pedigree but has only recently emerged in the West and the merits of the approach and its relationship with others is still being assimilated. TRIZ is associated with developing creative thinking processes but also exploiting a knowledge base. The use of computers to support this knowledge management is also closely associated with TRIZ, but this paper is primarily concerned with the educational thinking processes. These thinking process tools and approaches are addressed under the three premises of TRIZ introduced earlier.

4.1 The ideal design with no harmful functions is a goal.

Finding the ideal solution to a needed effect or function with no additional resources or negative secondary effects is referred to in TRIZ circles as Ideality.

$$\text{Ideality} = \frac{\text{All useful effects or functions}}{\text{All harmful effects or functions}}$$

Ideality is a cornerstone of TRIZ and the above definition is more than just a formula**.** The ideal being that 'the function is performed without the existence of a system'. This statement is extreme, and pushes us beyond the notion of incremental improvements to the other end of the scale – highly innovative solutions. In actuality, this "ideal" state is Utopia, but it still remains the prime objective. Ideality is one of the basic premises of the TRIZ methodology, and is the driving force behind everything it tries to achieve.

It is common in the evolution of designs, briefly covered later, for additional functions to result in additional complexity. However, the need to direct thoughts as to how the existing resources can fulfill the new functional need is a conceptual focus.

The process of finding the ideal solution is closely associated in TRIZ with taking advantage of the resources already available in the system. Because they are often overlooked it is necessary to develop an ability to identify them as part of the process and the teaching of TRIZ includes exercises in explicitly identifying the resources available in a situation.

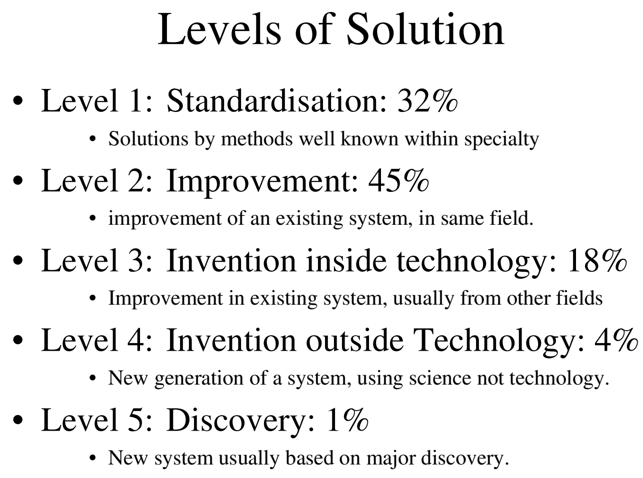
A resource:

-Is any substance (including waste) available in the system or its environment
-Has the functional and technological ability to jointly perform additional functions
-Is an energy reserve, free time, unoccupied space, information, etc.?

Some of the same thinking is clearly evident in Value Engineering where the goal is to enhance the functional value of a product while at the same time minimising the harmful functions, such as cost. Having said that, the practical use of Value Engineering often defaults to Value Analysis and cost reduction alone and is not supported by solutions systems, as is the case with TRIZ.

4.2 An inventive solution involves wholly or partially eliminating a contradiction.

Altshuller's (Altshuller, 1988) early work on patents resulted in him classifying inventive solutions into five levels as displayed in figure 1. Through this work he discovered that inventive solutions centred on eliminating contradictions. Where contradictions are performance trade-offs. Examples of which could be strength vs. weight, speed vs. efficiency, etc. and Altshuller called these technical contradictions.



Levels of Solution

- Level 1: Standardisation: 32%
  - Solutions by methods well known within specialty
- Level 2: Improvement: 45%
  - improvement of an existing system, in same field.
- Level 3: Invention inside technology: 18%
  - Improvement in existing system, usually from other fields
- Level 4: Invention outside Technology: 4%
  - New generation of a system, using science not technology.
- Level 5: Discovery: 1%
  - New system usually based on major discovery.

• Figure 1 Altshuller's solution levels

His work identified that level 2 solutions partially eliminated the contradiction and levels 3 and 4 would completely eliminate the contradiction using existing technology.
Altshuller believed that he could help anyone develop their capability to innovate at levels 2,3 & 4.

Having identified the significance of contradictions he went on to classify them into 39 parameters and then identified common principles that were repeatedly used to resolve them. This was his first attempt at structuring the inventive process and the principles that commonly correlated with certain contradictions were tabulated in what is now called the contradiction matrix.

4.3 The inventive process can be structured.

This early work convinced Altshuller that there was potential to structure the inventive process and it led to several further developments which are briefly covered below. In each case empirical data has been used to correlate using the principle of abstraction.
The principle of abstraction is widely applied in mathematics, engineering and medicine. Kaplan[6] (Kaplan,1996) very effectively used the principle to provide a framework for the TRIZ tools, which has been developed here. As knowledge grows in any particular field the development of the knowledge base can be viewed as going through three stages. The first is classification where data is stratified in various ways and grouped together; in a similar way problem and solution types may be classified in different ways. The second stage is correlation, where the relationship between the different classifications and other factors are identified. At this stage although relationships are identified the causal factors are not fully understood, if at all.
The third stage is cause and effect, where the rough relationship has been isolated into a more rigorous understanding of cause and effect. For example research in medical science has demonstrated many correlations between certain classes of food and contracting certain classes of cancer, but the complex cause effect relationships are still

not fully understood. In some situations our understanding of a field of science is such that we can predict cause and effect relationships accurately but in many we can't.

Figure 2 below, illustrates this process where the problems and solutions are classified to seek out a relationship or correlation that might be used in the future to predict generic solution areas that could be used as a lead to solving a specific problem.

In abstracting the general case it is necessary to classify the generic problem and solution types before being able to correlate the two and establish a generic solution. Having established the link it can then be used to derive specific solutions.

As you will see the solution systems derived within TRIZ use this principle of abstraction, that involves classifying problems and solutions to establish common correlation links. There is however always a need for some original thinking when it comes to the specialisation. This basic model will be referred to as we look at the different solution systems of classical TRIZ. Figure 3 shows how this applies to Altshuller's first solution system based on the technical contradictions and the 40 principles.

Figure 2:The general case for inventive problems

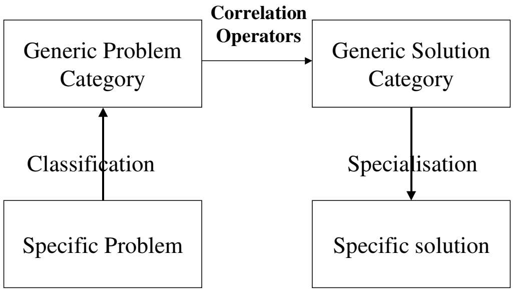
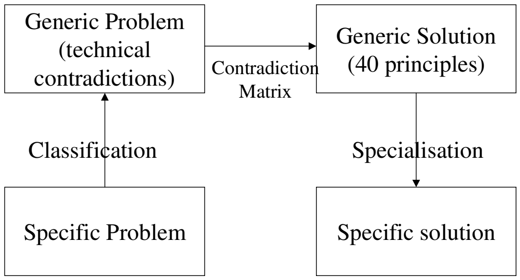


Figure 3: Use of the general case

Applied to technical contradictions



4.4 Physical Contradiction Solution System

Over a period of time Altshuller identified a further level of abstraction from the technical contradictions. He found that in many cases the technical contradiction or trade-off could be presented as two extremes of one feature, which he called a physical contradiction.

Put more formally: A physical contradiction requires mutually exclusive states as they relate to a function, performance or a component.

Fig 4 :The second level of abstraction

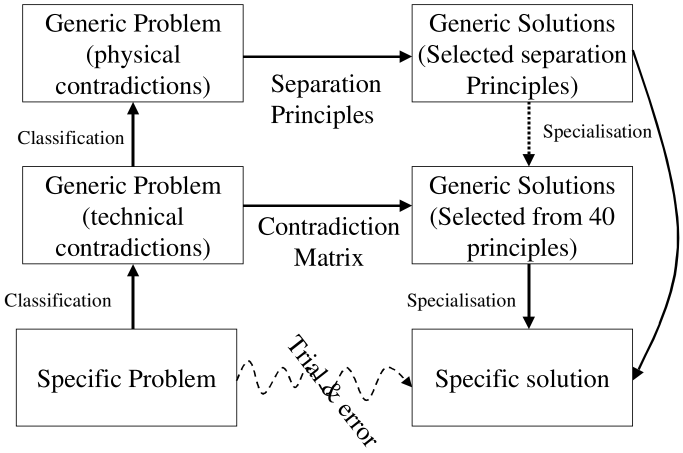


Figure 4 shows the relationship between Technical & Physical Contradiction solution systems

Typical physical contradictions include: Fast vs. slow; hard vs. soft; solid vs. porous; rough vs. smooth; moveable vs. stationary; dark vs. light; hot vs. cold; big vs. small; sharp vs. dull; free vs. busy; etc.

Altshuller identified a special set of principles, or operators, to go with the physical contradiction classification and these are called the separation principles.

Having formed physical contradictions from the technical, four separate principles are used to help break the contradiction.

Separation of opposite requirements in space:
  A characteristic is made larger in one place and smaller in another.
  A characteristic is present in one place and absent in another.
Separation of opposite requirements in time:
  A characteristic is made larger at one time and smaller at another.
  A characteristic is present in one time and absent in another.
Separation within a whole and its parts:
  One value at the system level and another at the component level.
  A characteristic exists at the system level but not at the component level.
Separation upon conditions:
  A characteristic is higher under one condition and lower under another.
  A characteristic is present under one condition and lower under another.
  E.g. phase transition: solid-liquid-gas-plasma.

High performance aircraft example:

The ideal shape and area of an aircraft wing is different for take-off, manoeuvrability and speed. Rather than compromise, separate by time, and adjust the wing shape and area as required.

The separation principles do not replace the earlier 40 principles, but they tend to be associated with certain separation principles. (?) separation = 40 ?

4.5 Substance Field Modelling

Altshuller's third and final system for classifying inventive problems and correlating with inventive solutions is sometimes called Substance Field Analysis, S-field, or Su-field analysis for short. This method, developed between 1974 and 1977, sits along side Contradiction Analysis and has wide potential application, but particularly where a contradiction does not emerge.

Further detail on this may be obtained through several text sources[7] (Salamatov) but the abstraction model applies again in this case with 76 standard solutions.

4.6 Evolutionary Patterns in technology development

Understanding evolutionary patterns can help to develop a step improvement in a design, so gaining technological competitive advantage. This approach therefore differs in that it is not reacting to a problem situation, but looking to the future in a proactive manner.
It obviously has potential relevance in deciding on R & D investments.
Knowledge about patterns of evolution provides the opportunity to anticipate and predict the need and emergence of novel developments rather than just developing the current paradigm. There are eight evolutionary patterns developed by Altshuller and to illustrate the first is illustrated below.

4.6.1 Evolution in Stages

The most obvious pattern of evolution is often referred to as an S curve, or Sigmoid Curve. The innovation satisfies an initial need and is subsequently rapidly improved before the improvements begin to stagnate. At this stage further conflicts emerge and new S curves need to be developed if stagnation is to be avoided.
Analysis of case studies has established the following steps[7]. (Salamatov, 1999)

1 Demand formation.
2 Formation of main useful function.
3 Synthesis of new technical system.
4 Growth of main useful function. (towards this end it is often taken to an extreme)
5 With the increase in the main useful function a certain part of the system deteriorates, bringing a technical contradiction and the opportunity to formulate a further inventive problem.
6 The inventive problem is solved.
7 Change of the technical system in accordance with the invention.
8 Increase of main useful function (see step 4).

An example of stage 4 in warship design, was the development of armoured plating. In 1860, 100-125mm armoured plate was common. By 1881 it had risen to 600mm in the warship aptly named ‘Inflexible’. Step five had certainly been reached, with speed and manoeuvrability seriously impaired. Material developments in steel and the use of bulkheads were two responses to this need.
A more recent example would be the development of the vacuum cleaner and the shift from filter bags to the dual cyclone designed, originated by Dyson. In this case the part of the system to deteriorate was the filter bag system that clogs with use. More and more powerful motors had a limited impact on this technical contradiction.

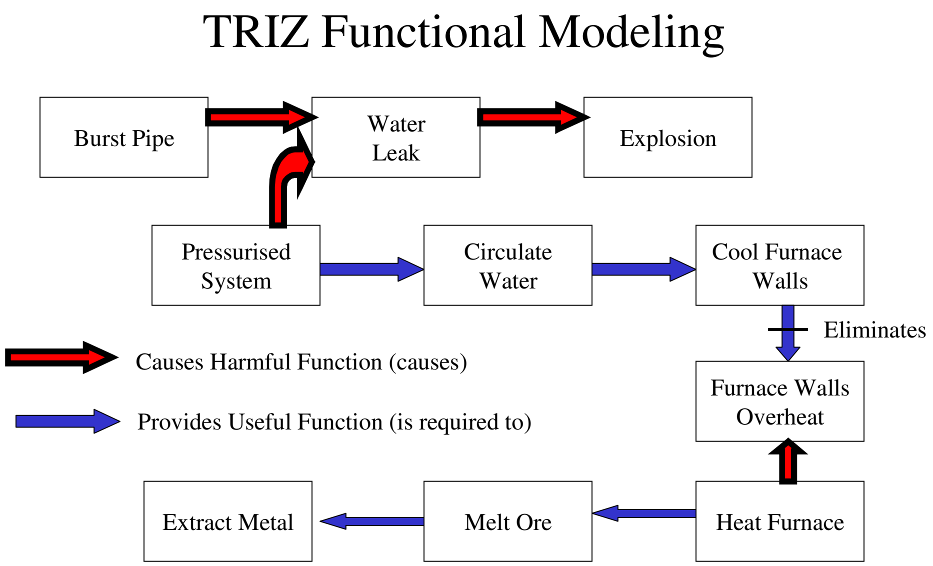
4.7 TRIZ Functional Modelling

The work we have covered to this point is now called classical TRIZ, but post 1985 some of Altshuller’s colleagues continued the work independently. One aspect of this work was developed via two close associates of Altshuller, namely Alla Zusman and Boris Zlotin and their team originally at the Kishnez TRIZ School in Moldova and now at Ideation, Int., Inc., USA.
This solution system is developed from the concept of Ideality covered earlier and the desire to maximise the useful functions and minimise the harmful functions.

$$\text{Ideality} = \frac{\text{All useful effects}\ \uparrow}{\text{All harmful effects}\ \downarrow}$$

This approach has similarities to standard functional analysis used in systems analysis, but with negative as well as positive affects being mapped.

The first step is to define the system, regarding the useful functions and the harmful effects, together with the useful sub-functions often designed to counter these harmful effects.



The problem in the above system is the leaking of water from the cooling system that causes an explosion due to rapid vaporisation.

The model above shows it is a subsystem to the primary system of extracting metal from ore. In both these systems there is a physical contradiction with useful and harmful effects.

In the primary system heat vs. don't heat

In the subsystem pressurise vs. don't pressurise

Therefore the separation principles could be used here.

However, this functional analysis attempts to view the system functions holistically as there is more than one place to deal with the problem. For example, if it were possible to resolve the primary function physical contradiction there would be no need for the cooling system at all.

Zusman & Zlotin developed a range of verbal statements to challenge the thinking behind each arrow to help break the psychological inertia. These take two forms: the preventive statement for harmful functions and the alternative statements for useful functions.

Some examples are given below.

Problem statement developments from the Furnace Functional Model

1. Find a way to eliminate, reduce or prevent [the] (Water Leak), under the condition of [the] (Burst pipe) and (Pressurised system).
2. Find an alternative way to obtain [the] (Pressurised system), that provides or enhances [the] (Circulate water), and does not cause [the] (Water Leak).
3. Find a way to enhance [the] (Pressurised system).
4. Find a way to resolve the contradiction: [the] (Pressurised system) should exist to obtain [the] (Circulate water), and should not exist in order to avoid [the] (Water Leak).
5. **Find a way to do without [the] (Pressurised system) for obtaining [the] (Circulate water).**
6. Find a way to eliminate, reduce or prevent [the] (Burst pipe).
7. Find an alternative way to obtain [the] (Circulate water), that provides or enhances [the] (Cools furnace walls), and does not require [the] (Pressurised system).

(Extract from Ideation IWB Software)

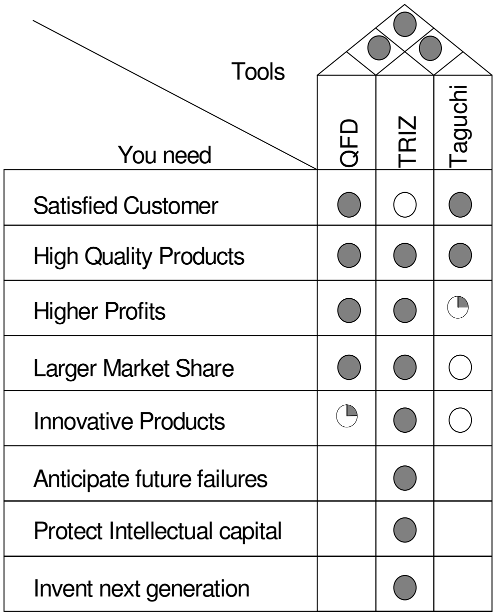
74

From statement 5 there could be a development to explore the requirement to pump water, but not at high pressure, if this is possible? What is the alternative way to pump water that will not leak when a crack appears? If the pressure inside the pipe were less than outside there would be no leak.
Use of a vacuum pump (i.e. atmospheric pressure is used to circulate the water) is a possible solution to the problem.

5 Positioning and further development

As mentioned in the introduction many authors are now positioning TRIZ with QFD & Taguchi, as displayed in figure 6. QFD providing the integrated link with the customer needs and wants and Taguchi providing the rigor of engineering analysis to develop a robust design. TRIZ is helping to fill the void between the two in structuring the innovation process. The contradiction matrix in the roof of the QFD House of Quality provides a natural target zone for

The relationship of QFD, TRIZ and Taguchi [1](Terninko, 1998)



You need \ Tools	QFD	TRIZ	Taguchi
Satisfied Customer	●	○	●
High Quality Products	●	●	●
Higher Profits	●	●	◔
Larger Market Share	●	●	○
Innovative Products	◔	●	○
Anticipate future failures		●	
Protect Intellectual capital		●	
Invent next generation		●	

Figure 6

TRIZ. However that assumes the customers wants can reflect the innovation yet to be offered to the market.

A separate but parallel industrial development to TRIZ over the past 20 years is the Theory of Constraints (TOC), which is also an innovative problem solving tool, but in manufacturing/ business management. It is interesting to note the common interest in contradictions. In TOC the major tool for innovation is referred to as the Conflict Resolution Diagram and the effect-cause-effect cognitive mapping tools has similarities to TRIZ functional modelling. Work on integrating the underlying principles behind these two approaches is a developing research topic for the authors[8] (Mann & Stratton, 2000).

6 Teaching in practice

Many engineering and product design curricula are acknowledging the need for innovation and trying to encourage creativity. TRIZ clearly complements the existing tools and techniques and has been developed to meet the specific needs of the engineering environment. It has been introduced to BEng university courses this year at Bath, Liverpool John Moores and to a lesser extent at Nottingham Trent. Early indications are very positive with some very good practical applications. The best response has been where time permitted project based applications of the thinking skills and the results are potentially of commercial interest.

6.1 Teaching TRIZ at the University of Bath

The University of Bath commenced teaching of an optional innovation studies course to final year engineering undergraduates in September 1999. Although covering other topics – QFD, Design for Manufacture, Robust Design, etc, a large proportion of the 100 hour course was devoted to teaching the Russian Theory of Inventive Problem Solving, TRIZ. This is the first time such a course has been offered in the UK. The course format has previously been described[9]. (Busov et al., 1999)

Based on the University's experience in offering short courses for industry on TRIZ, it was felt that a crucial factor in ensuring the success of the course was that it included large quantities of time in which they students were exercising the TRIZ methodology, rather than just listening to the theory.

A second factor involved a decision to exclude all forms of TRIZ-based software from the course, this despite the fact that the Department has a licence for the Invention Machine TechOptimizer software. The decision was made on the grounds that none of the TRIZ-based software is currently capable of capturing the manual thought processes necessary to make TRIZ work.

Initial assessed exercises focused on use of different parts of the TRIZ toolbox. The largest exercise – comprising 25% of the overall course mark – consisted of a simulation of a real engineering business scenario. In the scenario, each student was given a simple product – for example pepper-mill, stapler, shower-head, propelling pencil, tripod, camping seat, etc – and placed in a position in which a new competitor had emerged and was offering a product with the same functionality but at a 30% lower price. Hence a new solution – either offering increased functionality or significantly reduced cost – was required in a very short space of time. Students were free to decide in which direction they were going to solve the problem, and also which of the TRIZ tools they were going to use to help solve the problem.

The exercise worked so well that a sizeable proportion of the students derived solutions which appear to be not only practically viable, but are also patentable. Even more encouraging was the fact that a wide variety of the different TRIZ tools were used – some students used all of them – and all were seen to offer demonstrable benefit over traditional creativity methods.

In terms of the overall course, the feedback given by the students was consistently positive, with several going on to use TRIZ in their final year projects, and one or two potentially looking to conduct post-graduate research into TRIZ and its application. The course will be offered again in the next academic year.

One or two interesting points to be fed into next year's course were raised during the teaching of the course:-

6.1.1 TRIZ demands a number of shifts in thinking relative to traditional design and creativity approaches. The idea of contradictions and 'contradiction elimination' (as opposed to the conventional 'design is a trade-off' approach) was seen as the most significant of these paradigm shifts. Such shifts need to be approached with care as the effect of seeing the TRIZ method for the first time can come as something of a shock.

6.1.2 TRIZ offers what is progressively looking like a universal problem definition and problem-solving framework, into which other methodologies have a place. The course concentrated primarily on the link between TRIZ and QFD, but as research progresses, the course needs to increasingly expose students to the way TRIZ works synergistically with other methods which students may already be more familiar with – such as Design for Manufacture and Assembly, and some of the Pahl & Beitz material which forms a staple in many engineering design curricula.

6.1.3 Stretching the course out over a longer period may also be beneficial. There was a marked contrast between the capabilities of students after the undergraduate course relative to those finishing an intensive two or three day short course. TRIZ definitely needs time to soak into the consciousness. Plus there is considerable scope for further reading offered by online journals like TRIZ Journal. TRIZ Journal (www.triz-journal.com) was in fact used extensively throughout the course as a source for additional reading. Some care is required in plotting a coherent route through the journal - due to some inconsistency in the message and quality of the Journal articles - but it is already approaching a level of maturity whereby a whole text-book worth of education material is available quickly and at no cost.

6.1.4 The value of getting students to exercise the TRIZ methods cannot be over-emphasised. Next time around, the level of interaction will be further increased with a) more short in-lecture exercises, and, b) more exercises set in ‘real world’ scenario conditions.

6.2 Teaching TRIZ at LJM University

The development of our dedicated problem solving course is relatively new and only been incorporated into our full-time undergraduate degrees this academic year. However, we had already introduced aspects of TRIZ to some existing modules to gauge reaction. This gradual introduction has been very useful as these modules were for the more mature part-time and masters students, so their feedback more critical and insightful. We generally found the majority of students who favour the TRIZ approach tend to be those of a technical disposition, and what was particularly favoured were the simpler techniques that stay in the mind. I’ll simply refer to as the 'mental' tools and include:
Physical Contradictions and Separation Principles.
The generic problems and solutions of Su-Field and use of METHCHEMEM mnemonic.
Problem localisation and Resources.

Strangely, students see the point of the Technical Contradiction Matrix as a reference tool, but become disenchanted in using/studying it quite quickly. Perhaps the 40 Inventive Principles are too many to hold readily in memory, and I personally attempt to overcome this by relating them to Osborn's SCAMPER mnemonic (basically they are verbs that 'trigger' thoughts on transformations and actions), and include them in this form in the mental tools. If student wish to delve deeper into the method or have detailed lists of Inventive Principles, 76 standard solutions etc. then assistance is provided. To force students into too much detail leaves them bewildered, we have found that those who take to the 'mental' tools are those who will enthusiastically seek to go into greater depth.

Of greatest difficulty was the introduction of several laws and patterns within Directed Evolution / Trends. I attempted this with a full-time second year undergraduate module in Technology Futures for non-engineers. Its dangerous to make claims on one module, but the general standard of understanding technology definitely rose. However, many of the concepts were very difficult for the students to understand on anything more than a superficial level. They require a lot of contact time and patient explanation with very many diverse examples. I would be inclined to include far more understanding of 'systems' concepts before repeating this.

Overall, many of my students have taken to TRIZ and enjoyed the classes. There are a few who have taken it further as part of their final projects and many more who wished to but could not be accommodated. Its too early to say if the introduction of TRIZ has a marked effect on the quality of student ability in general, but where it has been introduced the reaction has been definitely positive.

6.3 The teaching TRIZ at NTU and on the EPS

The Theory of Constraints has been taught as part of undergraduate modules for many years in the Mechanical & Manufacturing Engineering Dept and the Business School. The underlying similarity with TOC drew attention to TRIZ, which has already been included in an existing module on systems analysis and design and a MSc module on design in tandem with Taguchi and Quality Function Deployment. These additions were exploratory, but in the light of this experience the teaching of TRIZ to undergraduate courses in Mechanical Engineering is to be developed for 2000/2001 and as recommended by the Bath experience this will be more project based.

The EPS programme this February included a two-day module on systematic innovation for the first time. This module incorporated a range of creative thinking approaches majoring on the Theory of Constraints and the Theory of Inventive Problem Solving. It is proposed in the light of experience to concentrate on TRIZ and its relationship to the broader range of design tools for EPS September 2000 with far more emphasis on exercises and mini projects.

7 Conclusions

TRIZ has stood the test of time in Russia and is rapidly being acknowledged as a major contributor to the development of innovation skills within industry and academia. Fully understanding synergistic potential of this approach is in its early stages, but is showing significant potential. The need to develop innovative thinking skills in both business and engineering is a stimulus to exploring TRIZ and other approaches such as TOC, but also investigating the underlying principles. The teaching of TRIZ on engineering curricula in the UK is expanding rapidly, and the educational results of its introduction on undergraduate programmes appear very promising.

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Graduated from the University of Nottingham with a degre in Mechanical Engineering and the n spent 15 years working at Rolls-Royce. During his time at the company he worked in a variety of posts, culminating in a role as strategy manager in charge of the company's small engine R&D. He left the company in 1995 to undertake full-time research into systematic innovation and creativity methods at the University of Bath. He first started using TRIZ in 1992, and he has been teaching, developing products and solving problems using TRIZ and related methods for a range of blue-chip companies since 1995. He is the author of over 50 patents, patent applications, and conference papers, and is a regular contributor to the on-line TRIZ Journal.

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