


Australian Government



RMIT
UNIVERSITY

Department of Education and Training

Educating the Edisons of the 21st Century:
Embedding tools of the Theory of Inventive
Problem Solving (TRIZ) into the engineering
curriculum

Edisons 21.com

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Supported by the Australian Government Department of Education and Training

Overview

- Short introduction to TRIZ
- Two stories
 - TRIZ in industry
 - TRIZ in education
- Short information on my fellowship plans
- Survey of engineering experts
- Discussion

Theory of Inventive Problem Solving (TRIZ):

- A generic name for a family of heuristics (tools) for problem analysis, problem reframing, failure analysis and creative problem solving that was conceived in Russia in the 1950s.
- Grounded on analysis of thousands of patents that revealed important trends of development of artefacts.
- The original six tools of 'classical TRIZ', were developed (by mid 1980s) specifically for the engineering design practice.
- Today TRIZ family contains over 20 tools (including software) that spread from weak to strong heuristics.
- TRIZ tools are widely used by engineers at multinational corporations like Intel, GE, Philips, Siemens, Bosch, Boeing, Samsung, LG, Cochlear...
- TRIZ tools have been taught at numerous universities worldwide.

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1940s: Altshuller and Shapiro Had a Dream...



... they wanted to
devise...
the ALGORITHM FOR
INVENTION

After 5 years of Gulag...

- 1956 first publication
- 1959 short algorithm (20 Principles)
- 1960 5 steps of the “Algorithm of Invention”
- 1964 ARIZ-64 (IUR)
- 1969 ARIZ-69 (with CT)
- 1971 ARIZ-71 (NC)
- 1985 ARIZ-85B (9 steps)
- 1991 ARIZ-91E (computer)
- ...2010 ARIZ-2010 (4 Parts)



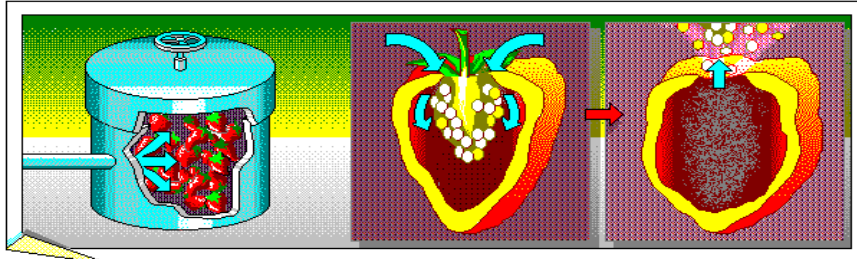
Analysis of Patents Revealed...

- that tasks from **different fields** are often solved by utilising **similar principles**

How to remove stems from capsicums?



Processing Capsicums (Patent 1945)



- Put capsicums inside enclosed chamber.
- Slowly increase air pressure in the chamber.
- Reduce pressure instantly.
- Seeds and stems separate from capsicum body **by itself.**

Over 200 ‘Capsicum’ Patents!

- Removing shells from sunflower seeds
- Cleaning filters
- Unpacking parts wrapped in protective paper
- Splitting diamonds along micro-cracks
- Producing sugar powder from sugar crystals
- And More!

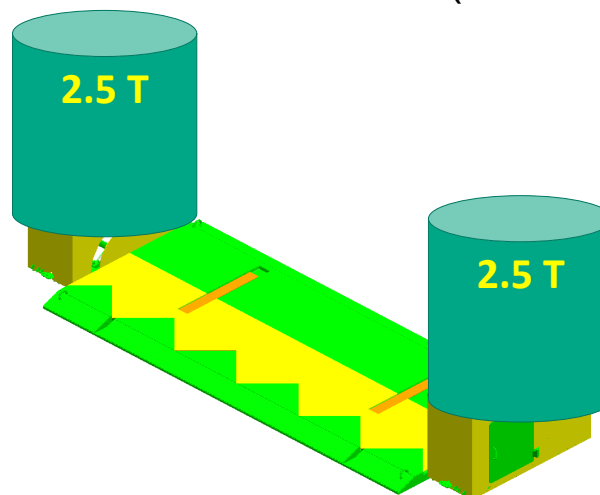
Story 1: TRIZ Can Help in Design



In early 2004 the government of the Republic of Singapore announced a tender on development of a mobile crash barrier...

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ST Kinetics: Crash Barrier (first version)



Additional 5 tonnes of ballast weight was needed

ST Kinetics: TRIZ Tools Used

- Two days of TRIZ application:
 - Situation Analysis (SA),
 - Method of the Ideal Result (MIR),
 - 40 Innovative Principles and
 - Principles of Separation.

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ST Kinetics: Mobile Crash Barrier

Method of the Ideal Result (MIR):

Step 1. Formulate the Ideal Ultimate Result (IUR): *I wish (main useful function) happens by itself.*

Step 2. Identify the natural reasons that prevent the IUR from occurring. Formulate a set of Target Tasks (TT).

Step 3. List all the available Resources.

Step 4. Consider every identified resource to deliver each TT: {*Can (the resource A) help in achieving the TT1?*}

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ST Kinetics: Mobile Crash Barrier

Method of the Ideal Result:

Ideal Ultimate Result (IUR): the ideal crash barrier is infinitely small and weightless, is able to stop an infinitely heavy vehicle, operates on its own internal energy alone and is always ready to stop an intruding vehicle.

- TT1: crash barrier needs to transform from light while transported to heavy when installed on the road;
- TT2: crash barrier needs to generate sufficient power to operate (raise and lower the blocking plate);
- TT3: crash barrier needs to be swift in activation in case of the emergency.

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ST Kinetics: Crash Barrier

Available Resources:

Substance resources: crash barrier, impacting vehicle, vehicles permitted to pass, road, operators, terrorist, other passengers.

Energy resources: electrical power from batteries or nearby building; kinetic energy from passing vehicles; kinetic energy from impacting vehicle; gravitation; hydraulic power; sun, wind, man power.

Field (Information) resources:

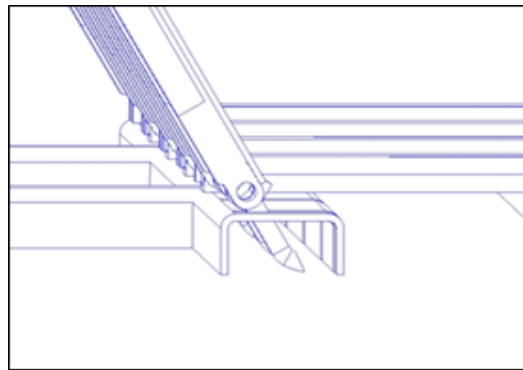
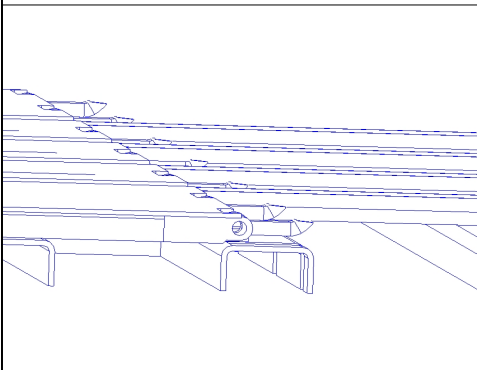
- Mechanical: collision, friction, direct contact, compression (oil), deformation, and others
- Acoustic: sound from vehicles and collision, and others
- Thermal: heat from engine and others
- Chemical: petrol
- Electric: 12V DC battery power **and more...**

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ST Kinetics: Mobile Crash Barrier

TT1: Can (*insert a resource*) help the crash barrier to transform from light while transported to heavy when installed on the road

Resource: **road**

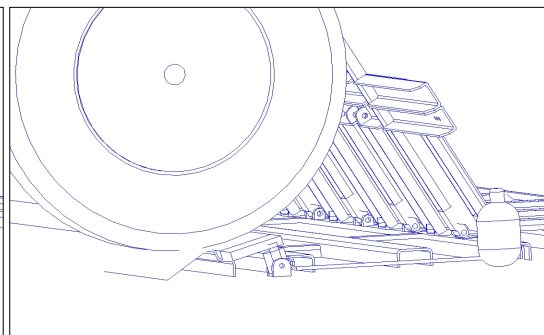
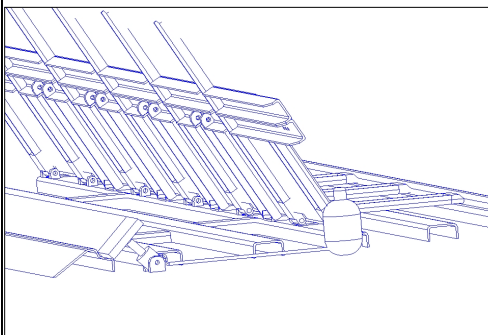


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ST Kinetics: Mobile Crash Barrier

TT1b: Can (*insert a resource*) insert the spears of the blocking plate into the road?

Resource: **impacting (intruding) vehicle**

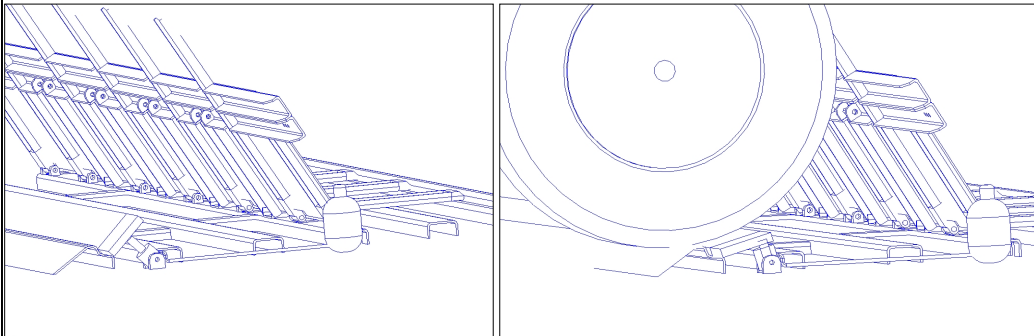


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ST Kinetics: Mobile Crash Barrier

TT2: Can (*insert a resource*) help the crash barrier to generate sufficient power to operate

Resource: **vehicles permitted to pass**



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ST Kinetics: Mobile Crash Barrier

New design: ST Kinetics won the tender and build the crash barrier for the Olympic committee meeting; patented the design; praised by Lee Kuan Yew...



Image: The Straits Times

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Story 2: TRIZ Can Help Students

Experiment:

- 4 groups of students enrolled in the Enterprise Engineering unit
- 17 to 21 students in a group
- randomly assigned to control (1 group) and experimental conditions (3 groups: Random Word, MATCEMIB and MATCEMIB+)
- the same problem (offered by the EWB Challenge) given for 16 minutes

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RMIT Experiment: Problem

Calcium carbonate, or lime, is a hard deposit found in kettles, the inner surface of pipes and other surfaces.

How to Remove the Lime Build Up in Pipes?

Write down as many ideas as you can



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Eight Random Words

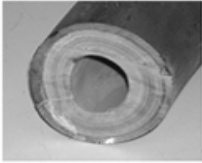
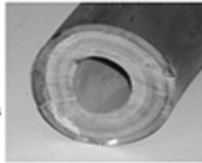
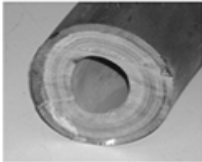
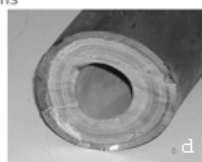
- Random words were generated by RMIT researchers (using a dictionary)
- The following are the eight random words that were used: **Archaism, Right angle, Lotus eater, Emitter, Ozone, Blowhole, Ball-and-socket-joint** and **Hanky-panky**

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Eight Fields of MATCEMIB

Fields	Interactions Including
Mechanical	Gravitation, collisions, friction, direct contact
	Vibration, resonance, shocks, waves
	Gas/Fluid dynamics, wind, compression, vacuum
	Mechanical treatment and processing
	Deformation, mixing, additives, explosion
Acoustic	Sound, ultrasound, infrasound, cavitation
Thermal	Heating, cooling, insulation, thermal expansion
	Phase/state change, endo- exo-thermic reactions
	Fire, burning, heat radiation, convection
Chemical	Reactions, reactants, elements, compounds
	Catalysts, inhibitors, indicators (pH)
	Dissolving, crystallisation, polymerisation
	Odour, taste, change in colour, pH, etc.
Electric	Electrostatic charges, conductors, insulators
	Electric field, electric current
	Superconductivity, electrolysis, piezo-electrics
	Ionisation, electrical discharge, sparks
Magnetic	Magnetic field, forces and particles, induction
	Electromagnetic waves (X-ray, Microwaves, etc.)
	Optics, vision, colour/translucence change, image
Intermolecular	Subatomic (nano) particles, capillary, pores
	Nuclear reactions, radiation, fusion, emission, laser
	Intermolecular interaction, surface effects, evaporation
Biological	Microbes, bacteria, living organisms
	Plants, fungi, cells, enzymes

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<p>Calcium carbonate, or lime, is a hard deposit found in kettles, the inner surface of pipes and other surfaces.</p> <p>How to Remove the Lime Build Up in Pipes?</p>  <p>Write down as many ideas as you can</p>	<p>Calcium carbonate, or lime, is a hard deposit found in kettles, the inner surface of pipes and other surfaces.</p> <p>How to Remove the Lime Build Up in Pipes?</p> <p>Lotus eater</p>  <p>Write down as many ideas as you can</p>
<p>Calcium carbonate, or lime, is a hard deposit found in kettles, the inner surface of pipes and other surfaces.</p> <p>How to Remove the Lime Build Up in Pipes?</p> <p>Biological</p>  <p>Write down as many ideas as you can</p>	<p>Calcium carbonate, or lime, is a hard deposit found in kettles, the inner surface of pipes and other surfaces.</p> <p>How to Remove the Lime Build Up in Pipes?</p> <p>Biological</p> <p>Microbes, bacteria, living organisms Plants, fungi, cells, enzymes</p>  <p>Write down as many ideas as you can</p>

Experimental Results

Group Information	RMIT		
	Stud.	Mean	Breadth
Control	21	2.02	2.05
Random Word	17	3.25	2.38
MATCEMIB	15	3.65	3.53
MATCEMIB+	18	5.13	4.44

Group Information	Czech Republic			Finland			Russia		
	Stud.	Mean	Breadth	Stud.	Mean	Breadth	Stud.	Mean	Breadth
Control	18	3.56	2.53	8	5.81	2.75	21	4.32	2.57
Random Word	16	3.78	2.47	8	5.69	3.38	24	3.29	2.38
MATCEMIB	17	6.50	5.53	5	9.30	5.60	20	5.65	4.30
MATCEMIB+	18	6.92	4.56	6	9.67	6.00	23	6.62	5.59

Group Information	Germany			Italy		
	Stud.	Mean	Breadth	Stud.	Mean	Breadth
Control	37 (s3)	3.9	2.3	16 (s7,8)	4.4	2.8
Random Word	27 (s8,9)	7.7	4.1	15 (s7,8)	6.5	3.0
MATCEMIB	47 (s2)	6.1	4.6	18 (s7,8)	6.4	4.7
MATCEMIB+	26 (s4)	9.5	6.0	15 (s7,8)	8.1	6.1

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Story 2: It Lasts!

- Three groups (Y3): paper-, web-based and control
- *Week 2*: 15 min video on Rule 1 of Su-Field Analysis followed by 16 min of idea generation (paper-based and web-based only with MATCEMIB templates)
- *Week 12*: students given 16 min to generate ideas (to clean barnacles from a ship hull)

Group	Week 2		Week 12	
	N	Mean (SD)	N	Mean (SD)
Paper+web	153	6.69 (3.83)	82	4.02 (1.80)
Control		N/A	8	2.58 (1.08)

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Fellowship Repository: www.edisons21.com

Educational materials, research papers as well as illustrations of TRIZ application (case studies) for academics and students

Suitability	TRIZ Tool	
Under-graduate students	<i>Situation Analysis</i>	2017
	<i>Method of Smart Little People</i>	
	<i>Operator Size-Time-Cost</i>	
	<i>Notion of the Ideal Ultimate Result</i>	
	<i>Fields of MATCEMIB</i>	
	<i>Substance-Field Analysis</i>	
	<i>Notion of Resources</i>	
Post-graduate students	<i>Separation Principles</i>	2019
	<i>Method of the Ideal Result</i>	
	<i>Contradiction Table</i>	
	<i>40 Innovative Principles</i>	
	<i>Nine Screens</i>	

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