Workshop: Creativity promotion in systematic product development

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General Index

1. Creativity deconstruction: Motivating questions
2. Creativity promotion stages and techniques
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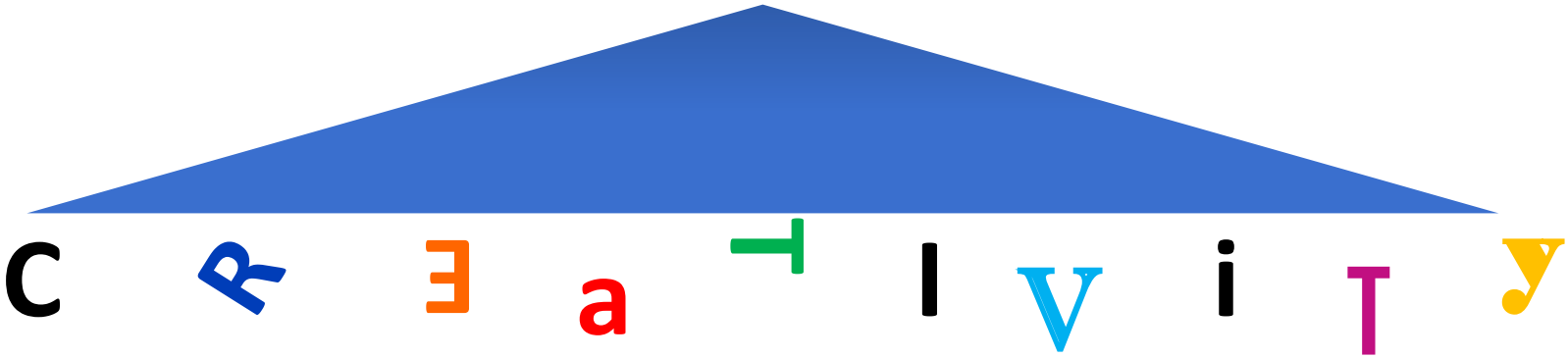
Case of study: Optimizing a hand prosthesis

1. Deconstructing creativity

1.1. Can we deconstruct creativity?

- **Are there some basic principles for creative design?**
- **Is creativity deeply rooted within the CDIO process?**
- **Deconstruction: Undersand how something was created by breaking down into subsystems or parts and studying them. Use the learning acquired for constructing related, alternative or improved systems.**

CREATIVITY

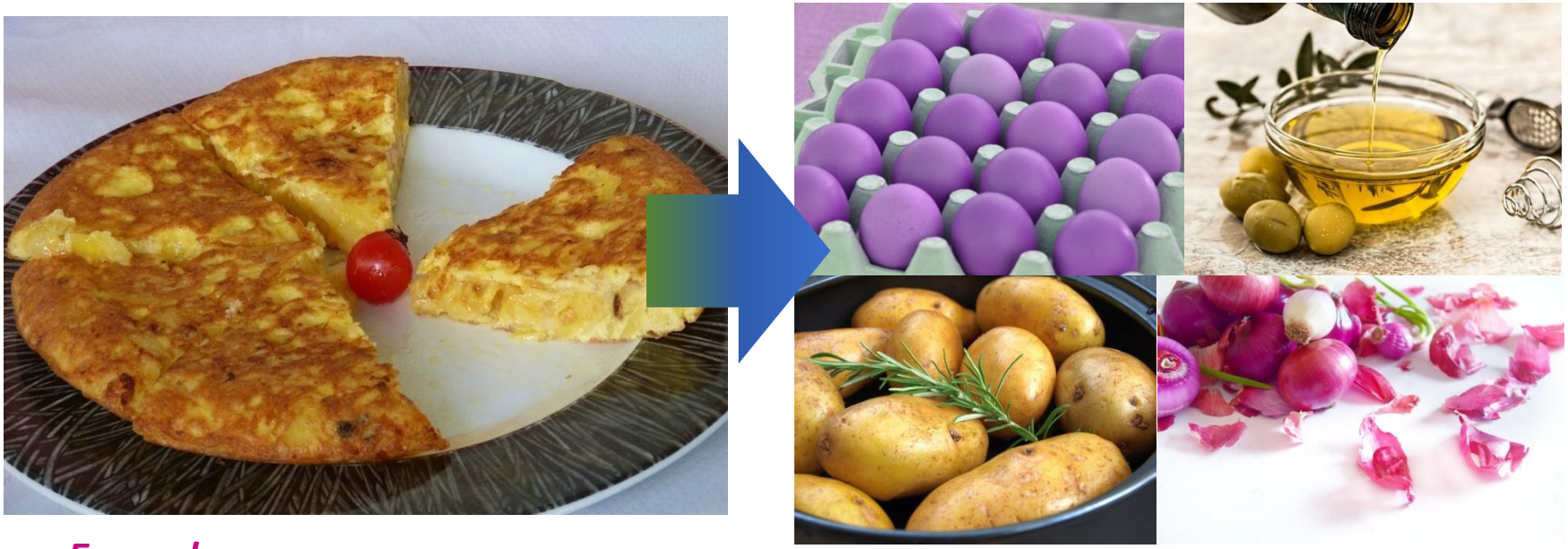


CREATE; VARIETY, ACTIVE, TRIVIA, CAVITY, TREATY, REACT, CARE, CITY, RACE, CAR, YEAR, AIRY, TRAY, CRY, CAR, EAR, ART…

1. Deconstructing creativity

1.1. Can we deconstruct creativity?

- Are there some basic principles for creative design?
- Is creativity deeply rooted within the CDIO process?



Example:
Deconstructing a Spanish omelette (and the segmentation principle)

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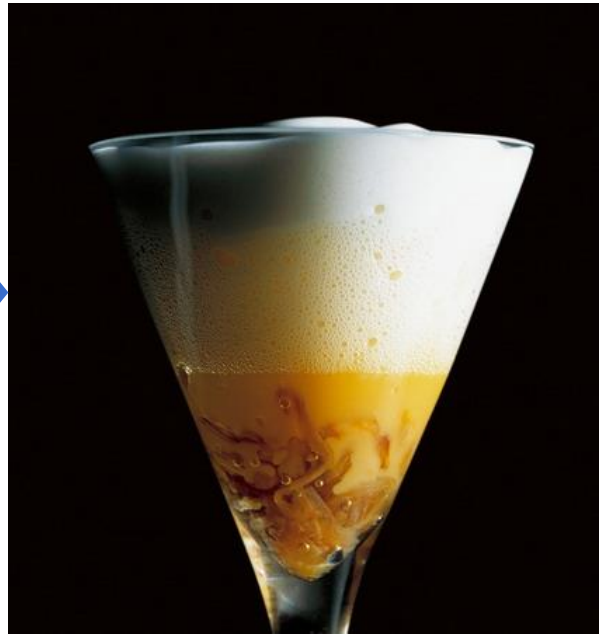


Deconstructed Spanish omelette by creativity master Chef Ferrán Adriá (former El Bulli restaurant) www.elbulli.com

See: El Bulli General Catalogue online

Example:

Deconstructing a Spanish omelette (and the segmentation principle)

1. Deconstructing creativity

Systematic variation

Inversion principle

Merging principle

Source: kitchenconfidante.com

Scalation principle

Source: passthepepper.org

Geometric evolution

Segmentation principle

1. Deconstructing creativity

1.2. Creativity: Art or Science?

- Is creativity an art or a science?
- Are artists more creative than scientists?
- Is creativity an innate ability?
- Are engineers creative people?
- What do you think?

?

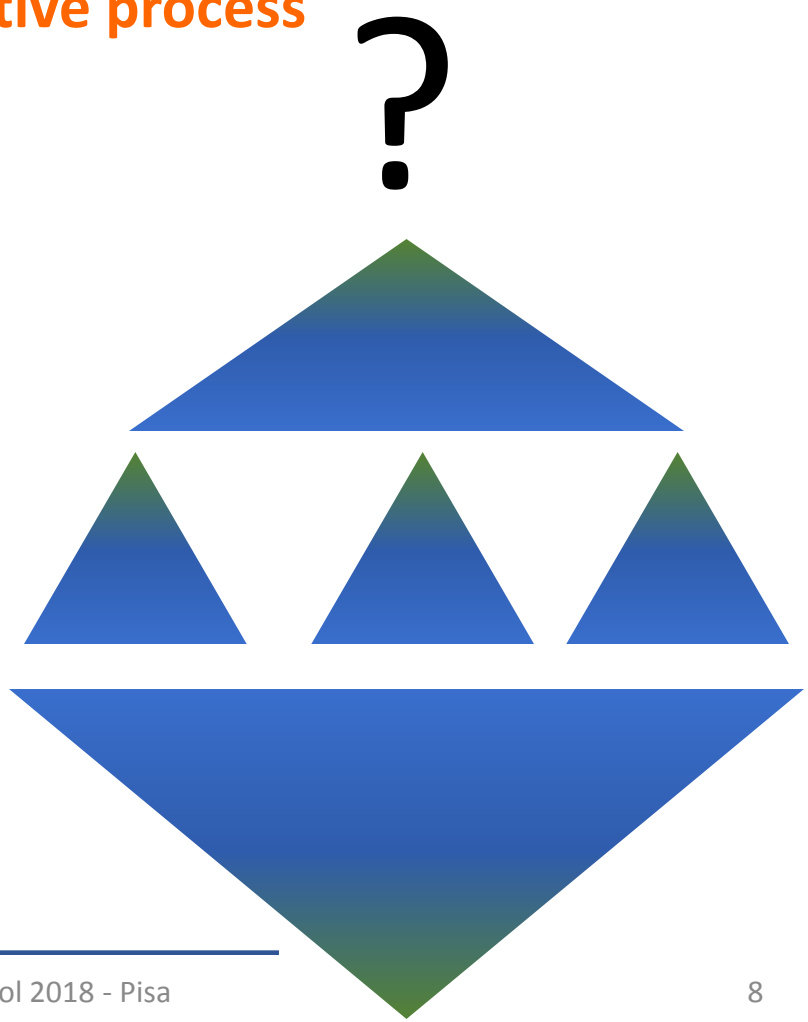
2. Creativity promotion: Stages and techniques

2.1. The main stages of the creative process

1. Generate ideas

2. Associate or combine ideas

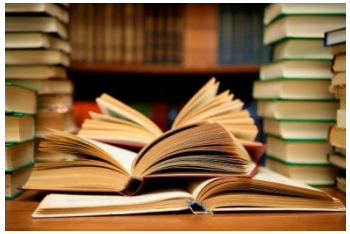
3. Evaluate and select ideas



2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

A) Generation of ideas:



- Traditional (and essential) methods:
  - Study and analyze the fundamentals
  - Study and analyze existing solutions
  - Check the references (books, webs, products, patents, publications…)
  - Meet with focus groups
- Out of the box generation / lateral thinking techniques:
  - Brainstorming / brainwriting
  - Lotus flower
  - Phillips 66
  - Random word
  - Bioinspired approaches

- Systematic problem solving methodologies:
  - CDIO approach to engineering systems (as main framework)
  - TRIZ methodology as support for some phases (explained further on)

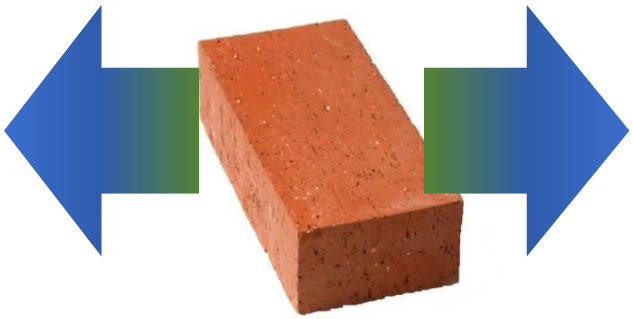
2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

A) Generation of ideas:

- **Let's generate, starting with a creativity test.**
- **The "brick test": "Take three minutes, and write down as many uses as you can think of for a brick".**
- **Sort of divergent thinking test (tests quantity, not quality)**

Conventional use



Creative use: Brick sculpture

2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

A) Generation of ideas:

- **Let's generate, starting with a creativity test:**

"Take three minutes and write as many uses as possible for a set of colour paperclips"

2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

A) Generation of ideas:

- **Let's start with our case of study (Brainwritting + Lotus):**

"Can we minimize the weight of a hand prosthesis without losing functionality?"

?

2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

B) Association or combination of ideas:

- Some useful techniques:
  - Morphological box (specially for generating and comparing product ideas)

	Solving principle 1	Solving principle 2	Solving principle 3	Solving principle 4
Subfunction 1 (i.e. structure)	A.1	A.2	A.3	A.4
Subfunction 2 (i.e. energy)	B.1 (i.e. battery)	B.2 (i.e. grid)	B.3 (i.e. solar)	X
Subfunction 3	C.1	C,2	C.3	C.4
SF4	D.1	D.2	X	X
SF5	E.1	X	X	X
SF6	F.1	F.2	F.3	X

Product Idea 1

Product Idea 2

2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

B) Association or combination of ideas:

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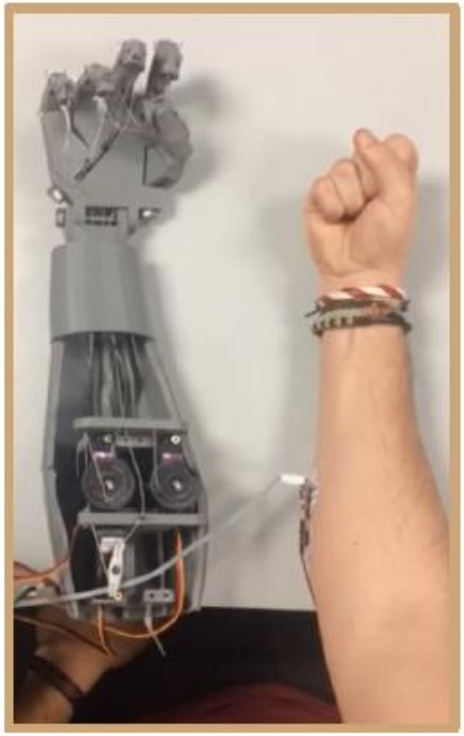
Subfunciones	Principios resolutivos		
Alimentación	Pilas	Baterías	Fuente de alimentación
Zona corporal	Mano	Parcial de mano	Externa de codo
Núcleo de sistema	Windows	iOS	Linux
Tipo de paciente	Adulto	Pediátrica	
Programación	Java	Arduino	Bash
Movilidad de la articulación	Multiarticulada	Pinza gancho	Giro
Tipo de fabricación	Titanio	Polímero	Impresión 3D
Customización	Sí	No	
Tipo de energía	Con control motor	Eléctrica	Mioeléctrica o activa eléctrica



Real example by UPM students: J. Chamorro, A. Del Valle, I. Pablos, P. Peñas & A. Sevilla

2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

B) Association or combination of ideas:

- Other common techniques:
  - Addition (incorporate a new functionality)
  - Extraction (purposely eliminate a part or component)
  - Merging (combine two ideas and their possibilities)
  - …Used since the Ancient Age in all sorts of mythologies
  - Can be also applied to product and process engineering

Bull + man = minotaur

Vespa with sidecar
Motorbike + car

But remember to <u>keep products as simple as possible</u>.

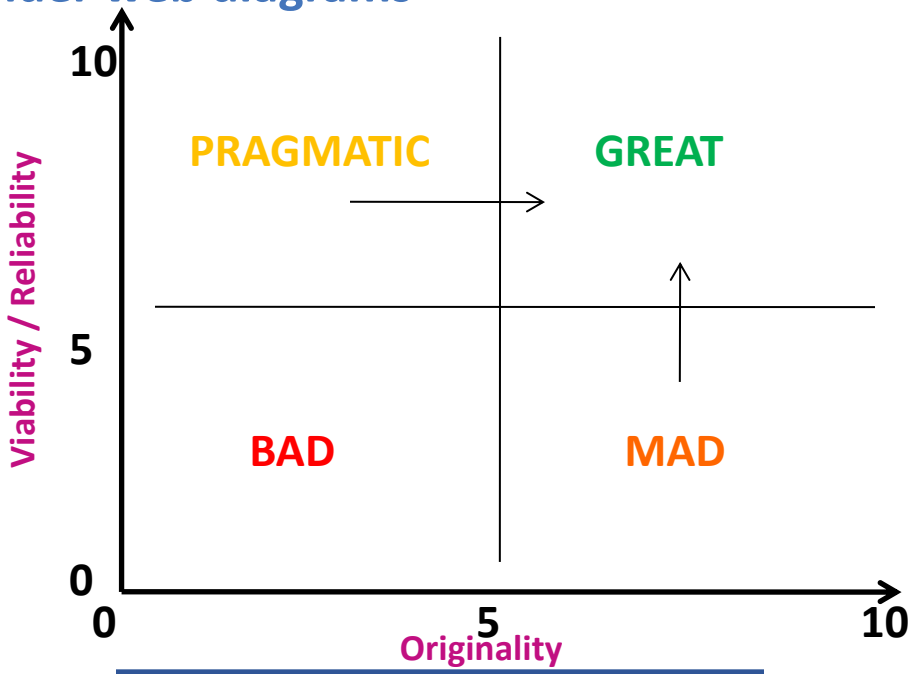
Over-engineered solutions tend to fail.

2. Creativity promotion: Stages and techniques

2.2. Techniques for driving the creative process

C) Evaluation of ideas:

- Viability vs. originality
- Diamond or spider web diagrams



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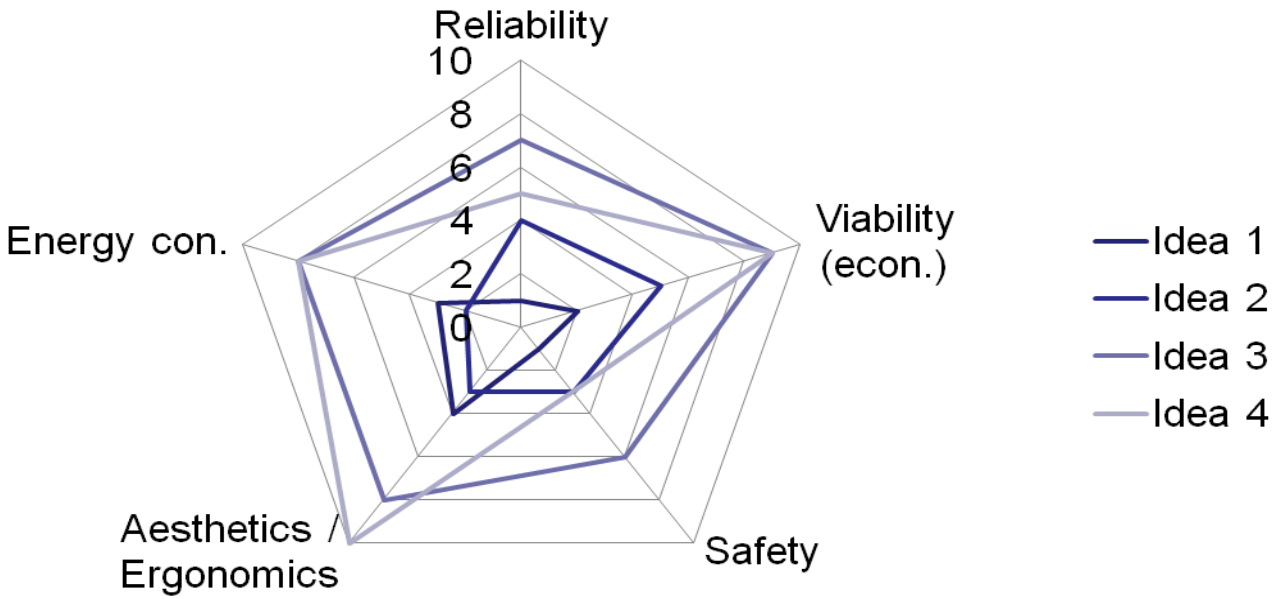
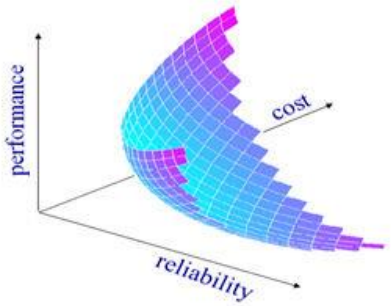


2. Creativity promotion: Stages and techniques

2.3. A brief introduction to TRIZ problem-solving methodology

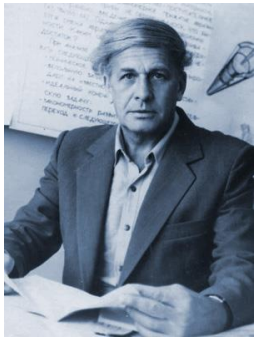
Key ideas:

- **Radical innovation rarely happens in Engineering.**
- **Engineering challenges share common inventive principles.**
- **Engineering challenges can be expressed as conflicts between "parameters to improve" and "parameters not to worsen".**
- **Challenges with similar relationships between parameters are usually solved using the same inventive / design principles.**



Example of trade-off surface

Source: www.sheffield.ac.uk/acse/staff/peter_fleming/intromo

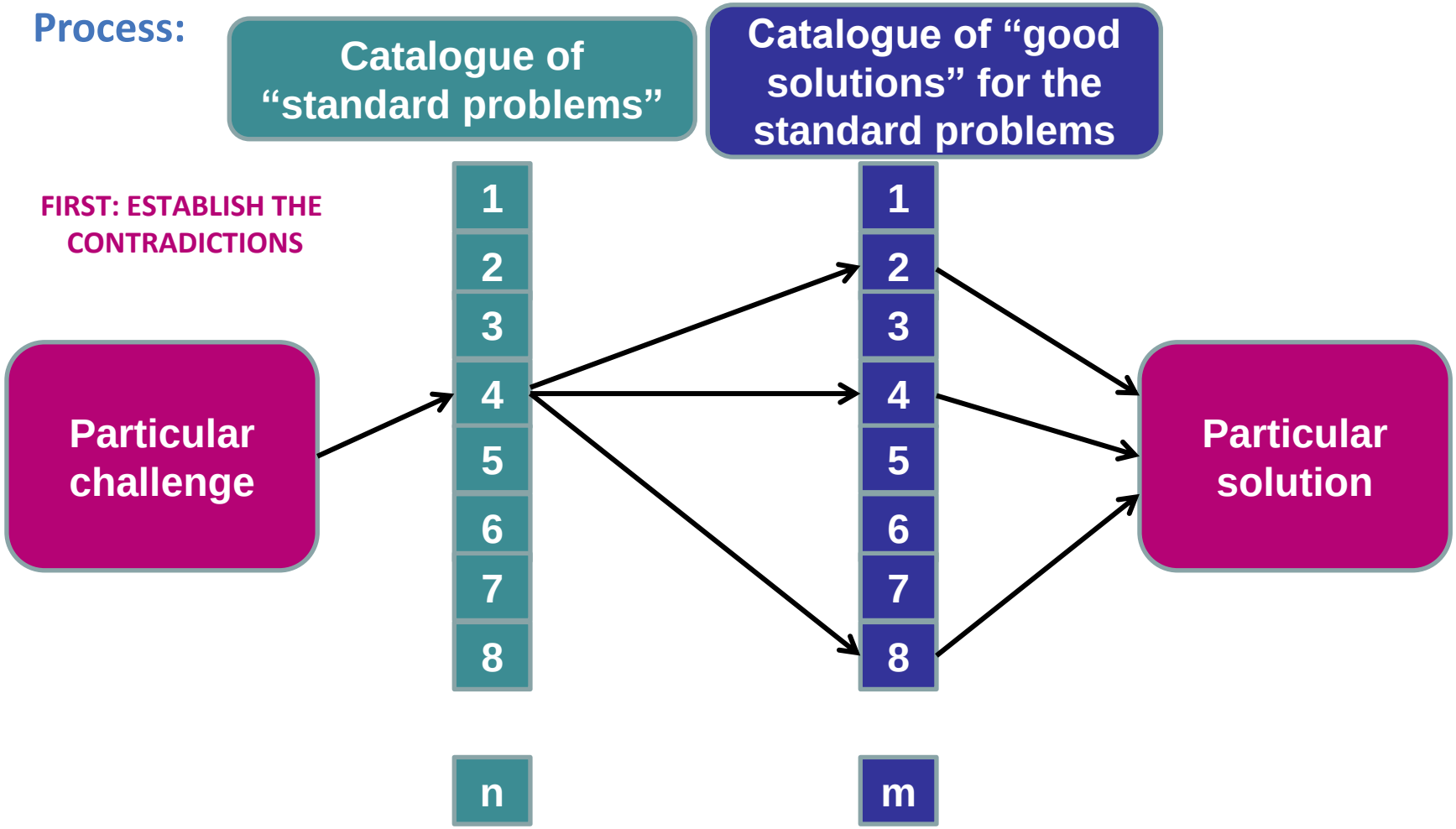


Methodology developed by Genrich Altshuller (1926-1998) and his team revising millions of patents
See: Altshuller foundation & TRIZ Research Journal

2. Creativity promotion: Stages and techniques

2.3. A brief introduction to TRIZ problem-solving methodology

Process:

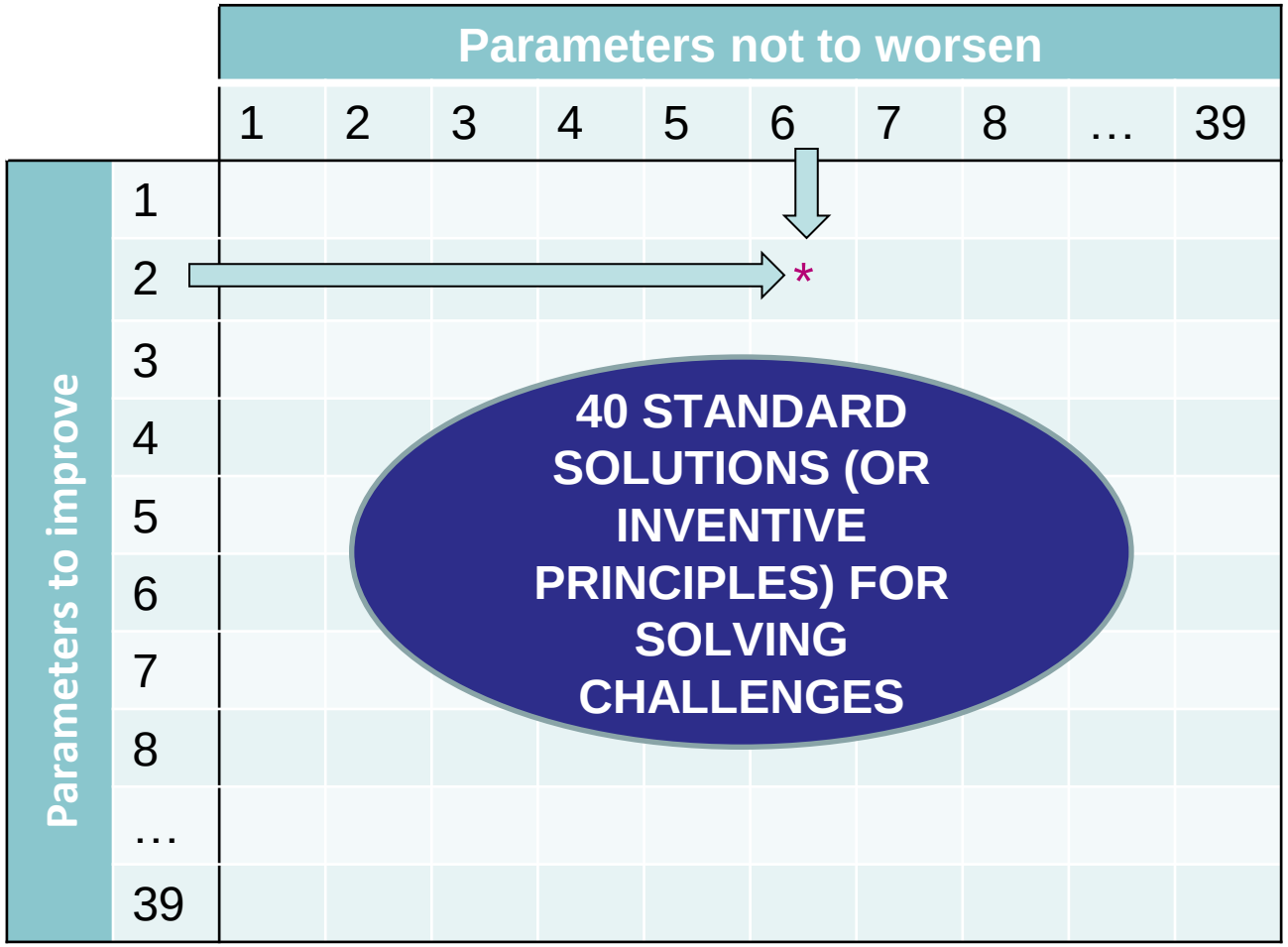


2. Creativity promotion: Stages and techniques

2.3. A brief introduction to TRIZ problem-solving methodology

Process:

TRIZ MATRIX FINDING THE INVENTIVE PRINCIPLES (*)



2. Creativity promotion: Stages and techniques

2.3. A brief introduction to TRIZ problem-solving methodology

Process:

Parameters taken into account: To optimize / Not to worsen

1.- Weight of moving object
2.- Weight of nonmoving object
3.- Length of moving object
4.- Length of nonmoving object
5.- Area of moving object
6.- Area of nonmoving object
7.- Volume of moving object
8.- Volume of nonmoving object
9.-Speed
10.- Force
11.- Tension, pressure
12.- Shape
13.- Stability of object
14.- Strength
15.- Durability of moving object
16.- Durability of nonmoving object
17.- Temperature
18.- Brightness
19.- Energy spent by moving object
20.- Energy spent by nonmoving object
21.- Power
22.- Waste of energy
23.- Waste of substance
24.- Loss of information
25.- Waste of time
26.- Amount of substance
27.- Reliability
28.- Accuracy of measurement
29.- Accuracy of manufacturing
30.- Harmful factors acting on object
31.- Harmful side effects
32.- Manufacturability
33.- Convenience of use
34.- Repairability
35.- Adaptability
36.- Complexity of device
37.- Complexity of control
38.- Level of automation
39.- Productivity

2. Creativity promotion: Stages and techniques

2.3. A brief introduction to TRIZ problem-solving methodology

Process:

List of TRIZ inventive principles

1. Segmentation
2. Extraction
3. Local Quality
4. Asymmetry
5. Combination
6. Universality
7. Nesting
8. Counterweight
9. Prior Counteraction
10. Prior Action
11. Cushion in Advance
12. Equipotentiality
13. Inversion
14. Spheroidality
15. Dynamicity
16. Partial, overdone or excessive action
17. Moving to a new dimension
18. Mechanical vibration
19. Periodic action
20. Continuity of useful action
21. Rushing through
22. Convert harm into benefit
23. Feedback
24. Mediator
25. Self-service
26. Copying
27. Inexpensive short life
28. Replacement of a mechanical system
29. Use pneumatic or hydraulic systems
30. Flexible film or thin membranes
31. Use of porous materials
32. Changing the colour
33. Homogeneity
34. Rejecting and regenerating parts
35. Transforming physical or chemical states
36. Phase transition
37. Thermal expansion
38. Use strong oxidisers
39. Inert environment
40. Composite materials

3. Creativity promotion and the CDIO cycle

3.1. Where to apply the techniques in the CDIO process?

Along the whole process, but mainly in the first conceptual stage

C.I.Product planning & specs.

- **Find a relevant need**
- **Study existing solutions**
- **Select an objective market**
- **Analyze economical viability**
- **Analyze related regulations**
- **Define objective price & cost**
- **Define technical specifications**

Brainwriting + lotus, Phillips 6-6, focus groups with experts…

Morphologial boxes or matrix-like representations for comparing among existing and potential solutions for new challenges

Always study the underlying principles and basic fundamentals, study within the field and related fields and searchf or existing alternatives, partial solutions and inspiration in books, patents, publications, colleagues and Nature.

3. Creativity promotion and the CDIO cycle

3.1. Where to apply the techniques in the CDIO process?

Along the whole process, but mainly in the first conceptual stage

C.II.Conceptual design

- Define main function
- Describe subfunctions
- Establish functional structure
- Analyze solving principles
- Generate product ideas
- Evaluate product ideas…
- … then, you have the concept

Brainwriting + lotus, Phillips 6-6, focus groups with experts…

Morphologial boxes or matrix-like representations for comparing among existing and potential solutions for new challenges

Spider web diagrams and other tables and evaluation sheets

4. Conclusions

Main conclusions

→ **Creativity can be trained and is a key ability of engineering professionals.**

→ **Understanding the stages of the creative process and applying some direct techniques helps to reach innovative solutions.**

→ **Systematic product / process development methodologies, including the CDIO process, help to promote innovation, while keeping reliable along the development process.**

→ **Incresing complexity may promote novelty, but creativity is more linked to innovative simple and confident solutions to challenges.**

5. References

Some references and websites

→ Altshuller, Genrich (1999). The Innovation Algorithm: TRIZ, systematic innovation, and technical creativity. Worcester, MA: Technical Innovation Center.

→ Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.H. (2007, 3rd ed.). Engineering Design: A systematic approach. Springer.

→ http://www.cdio.org (Worldwide CDIO Initiative)

→ https://www.mindtools.com (Creativity tools, tests and examples)

→ http://www.triz40.com (TRIZ with examples)

→ https://triz-journal.com

Thanks for your attention

UBORA: Euro-African Open Biomedical Engineering e-Platform for Innovation through Education

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