Separation Principles as an Early Exposure to TRIZ-Based Ideation in Engineering Design

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Introduction

Engineers in industry and entrepreneurship often seek training in ideation tools that facilitate brainstorming.

TRIZ – a Russian acronym translated "Theory of Inventive Problem Solving" – is a set of principles long employed to help foster innovative solutions to technical problems in many fields [1]. In various formulations, this has been part of engineers' training at GE, Intel, Samsung, Motorola, Boeing, Raytheon, IBM, HP, Xerox, P&G, and other companies.

About TRIZ

TRIZ has evolved as a broad system of approaches to help engineers conceive novel technical solutions when designing functional products. The approaches commonly include the following [2]:

- Identifying Recurring Patterns of Evolution
- Working Backward from an Ideal Final Result
- Exploiting Unutilized Resources
- *Resolving Conflicts Between Objectives*

These often involve abstracting a problem to find aspects in common with other/unrelated problems, and have been developed largely by analyzing millions of patents from many diverse disciplines.

The Separation Principles

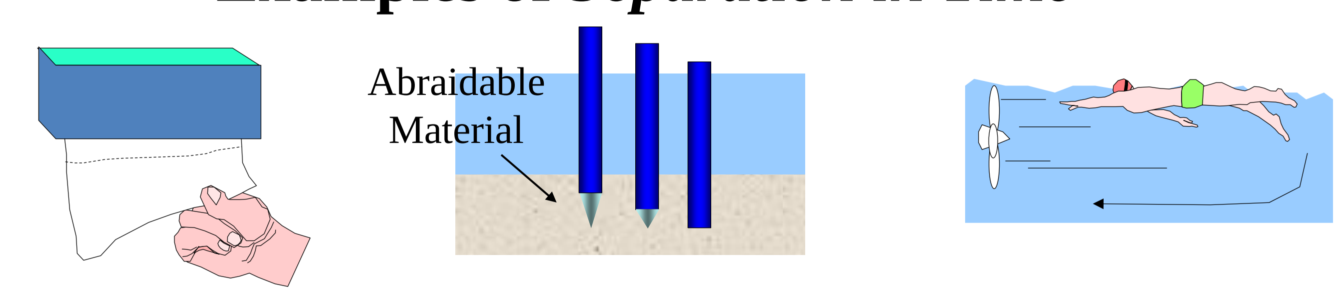
Resolving conflicts to avoid "trade-offs" is the most prominent aspect of TRIZ. The best-known tool for this is the "Contradiction Matrix," which is indeed valuable, but unfortunately requires some expertise.

An alternative formulation involving many similar concepts as the Matrix – the "Separation Principles" – is more generalized and deemed better for beginners. These Principles entail identifying where competing objectives or "design contradictions" may not be needed at the same *time*, in the same *space*, on the same *scale*, in the same *direction* or orientation, etc.

Pedagogical Implementation

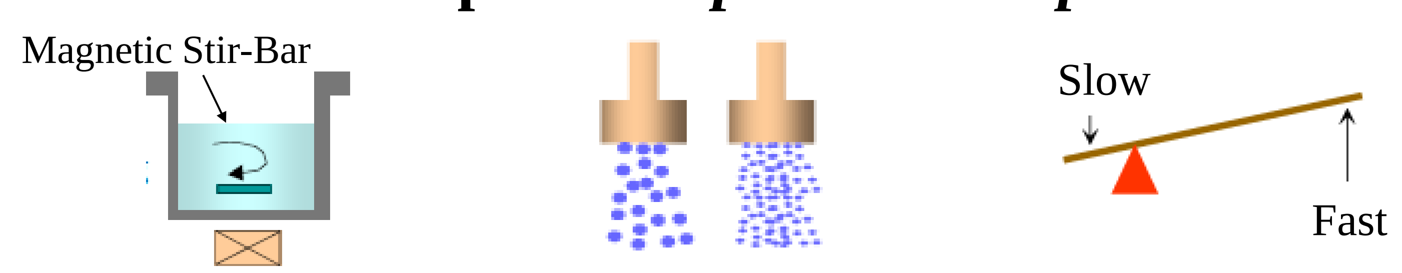
In the context of teaching Engineering Design in ENGR100 (Section 200) from a multidisciplinary and entrepreneurial perspective, the ideation phase was supplemented with open-source content on select TRIZ concepts [3] (portions were adapted for lecture, class activity, and student reference).

Examples of *Separation in Time*



"Partial Action" "Transforming State" "Cyclic Use"

Examples of *Separation in Space*

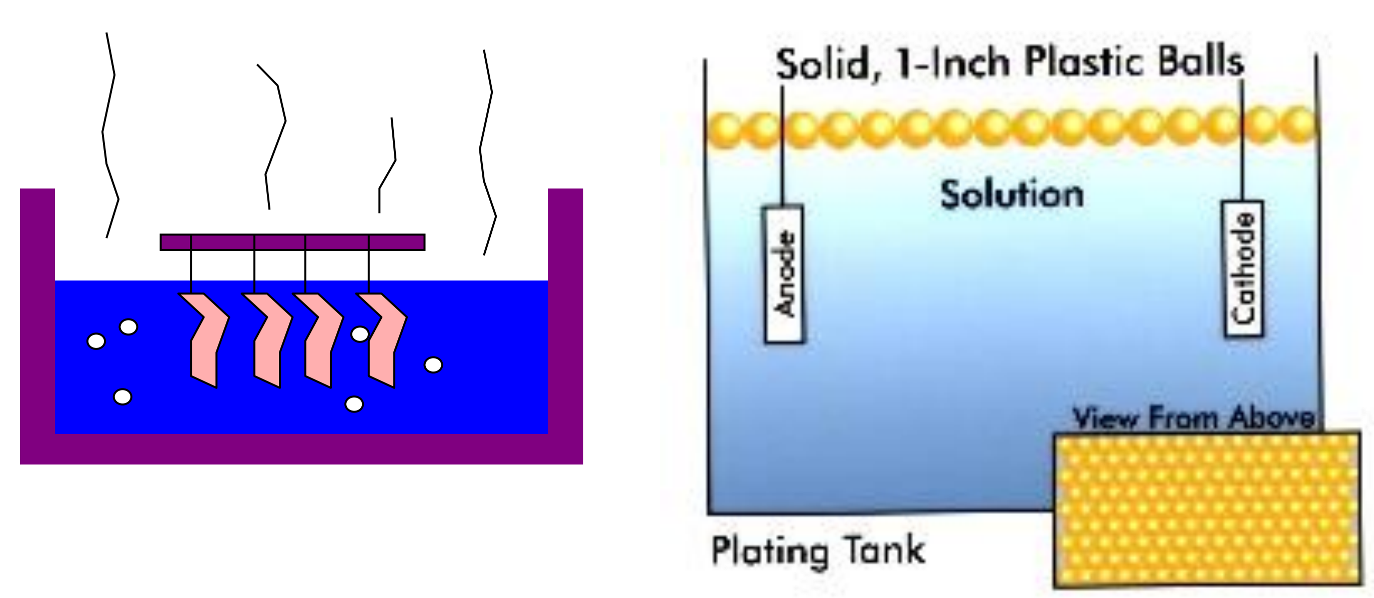


"Extraction" "Exchangeability" "Non-uniformity"

(Many such sub-principles and associated examples were covered for *Time, Space, Scale, and Direction*.)

Industrial Case Study on *Separation by Scale*

Problem: Plating tanks give off corrosive gases, but covering/uncovering the tanks slows production.



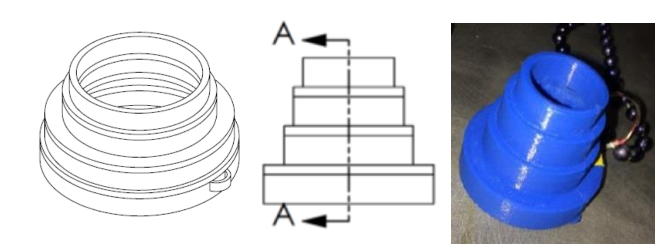
Solution: A "Cover" of Small Floating Objects [4].

Before exposure to the Separation Principles, the class was asked how this problem might be solved, and nobody suggested the above solution. After exposure to the Principles, several did so in a class exercise.

Example Student Projects/Prototypes

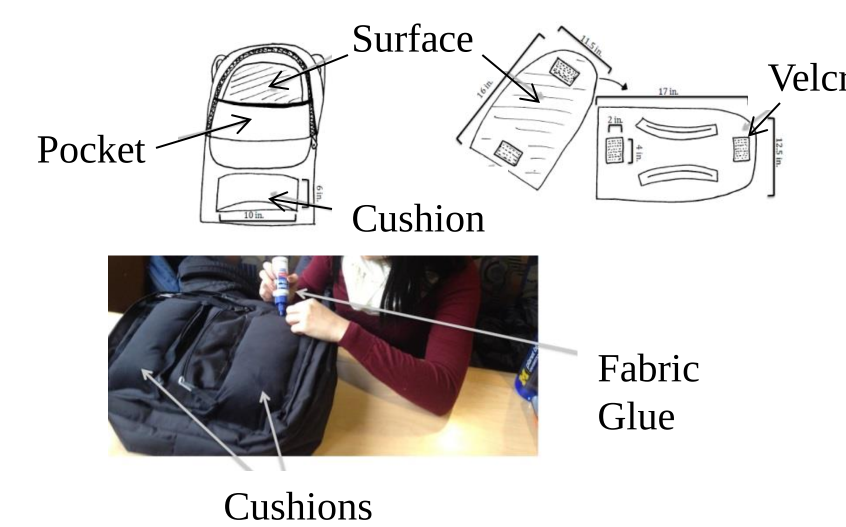
Ideation content taught included "traditional" [5] and TRIZ-based methods, with students free to use either. Each team first proposes a broadly-defined problem and then designs, builds, and tests a solution [6].

Personal Bottle-Top Sipper



Folding/Portable Tray

Desk-on-a-Backpack



Modular Utensils

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Many students commented positively on the perceived benefit of having some guidance in concept generation. Future study may involve quantitative assessment of impact of first-year exposure to Separation Principles.

References

[1] Jana, R., "The World According to TRIZ," Business Week (2006).

[2] Rantanen , K.,"Simplified TRIZ," Ch. 2 (2007).

[3] Opensourcetriz.com (Collaborative Authors).

[4] Engineering Laboratories, Inc., "Solid Plastic Balls replace plating tank covers," Thomasnet (2002).

[5] Dym, C., and and Little, P., "Engineering Design," 3rd Ed., Ch. 5 (2008).

[6] Relevant student-team course project deliverables from ENGR100 (Sec. 200), taught by Kenneth Alfano. The CAD was done in SolidWorks®, and 3D printing was done at the UM 3D Lab.