

# THE PRACTICAL USAGE OF THE INVENTIVE PRINCIPLES – SFRE GROUPING

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# Introduction

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- POSRI & POSCO TRIZ College?
  - POSRI(POSCO Research Institute), the main agent of POSCO TRIZ College, has provided a variety of TRIZ programs.
  - POSCO TRIZ College is not a typical academic institution, but POSCO's training center specialized in TRIZ.
  
- The Activities of POSRI (i.e. POSCO TRIZ College)
  - POSRI has pursued TRIZ-driven innovation of POSCO & POSCO Family.
  - POSRI focuses on facilitating POSCO's practical & result-oriented TRIZ activities. → [Education & Consulting](#)
  
- Therefore,
  - This research proposes a practical usage of the inventive principles.
  - This research is based on training materials for TRIZ beginners.

# Issue-1

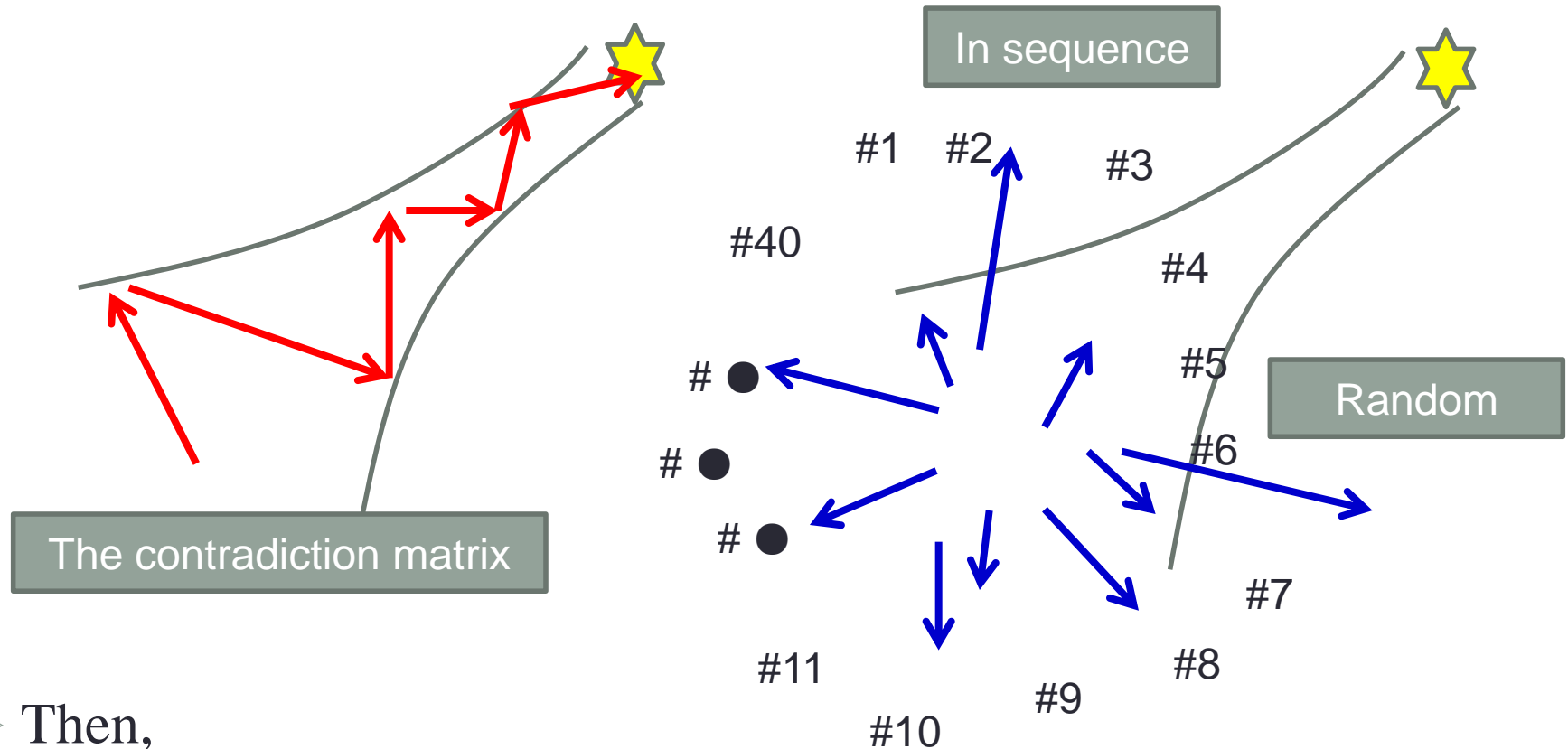
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- Now,
  - The inventive principles are one of the most popular TRIZ tools.
  - However, the tool has limits in its application to resolve actual problem.
  
- The shortcomings on application of the inventive principles
  - The inventive principles itself
    - Too various concepts
    - Not MECE(Mutually Exclusive & Collectively Exhaustive).
  - Selection of a specific inventive principle
    - Wrong choosing through the contradiction matrix
    - Increasing trials-and-errors

## Issue-2(Comments)

- The shortcomings on application of the inventive principles
  - The inventive principles itself
    - There are too various concepts without indication of semantic relationship.
    - It is difficult to memorize and use them.
    - Each principle is not MECE(Mutually Exclusive & Collectively Exhaustive).
  - Selection of a specific inventive principle
    - Generally, there are several kinds of methods to select and utilize a specific inventive principle – using the contradiction matrix or selecting one in sequential or random order. However, each of these methods has critical drawbacks.
    - First, choosing key principles through the contradiction matrix is the most classic and basic method. However, it is difficult to draw a specific contradiction and a specific parameter from a problem situation. Therefore, the contradiction matrix might lead to using a wrong principle when a solver chooses a wrong contradiction and parameter.
    - The second and third methods are using the principles sequentially or randomly without a situational analysis of a given problem. These methods are subject to trials-and-errors. They also bring about dispersion of thinking, and decrease the efficiency of problem solving.

# Issue -3



➤ Then,

- How can we memorize the inventive principles easily and use them practically? → The grouping of the inventive principles

# Theoretical issue -1

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## ➤ General process of problem solving

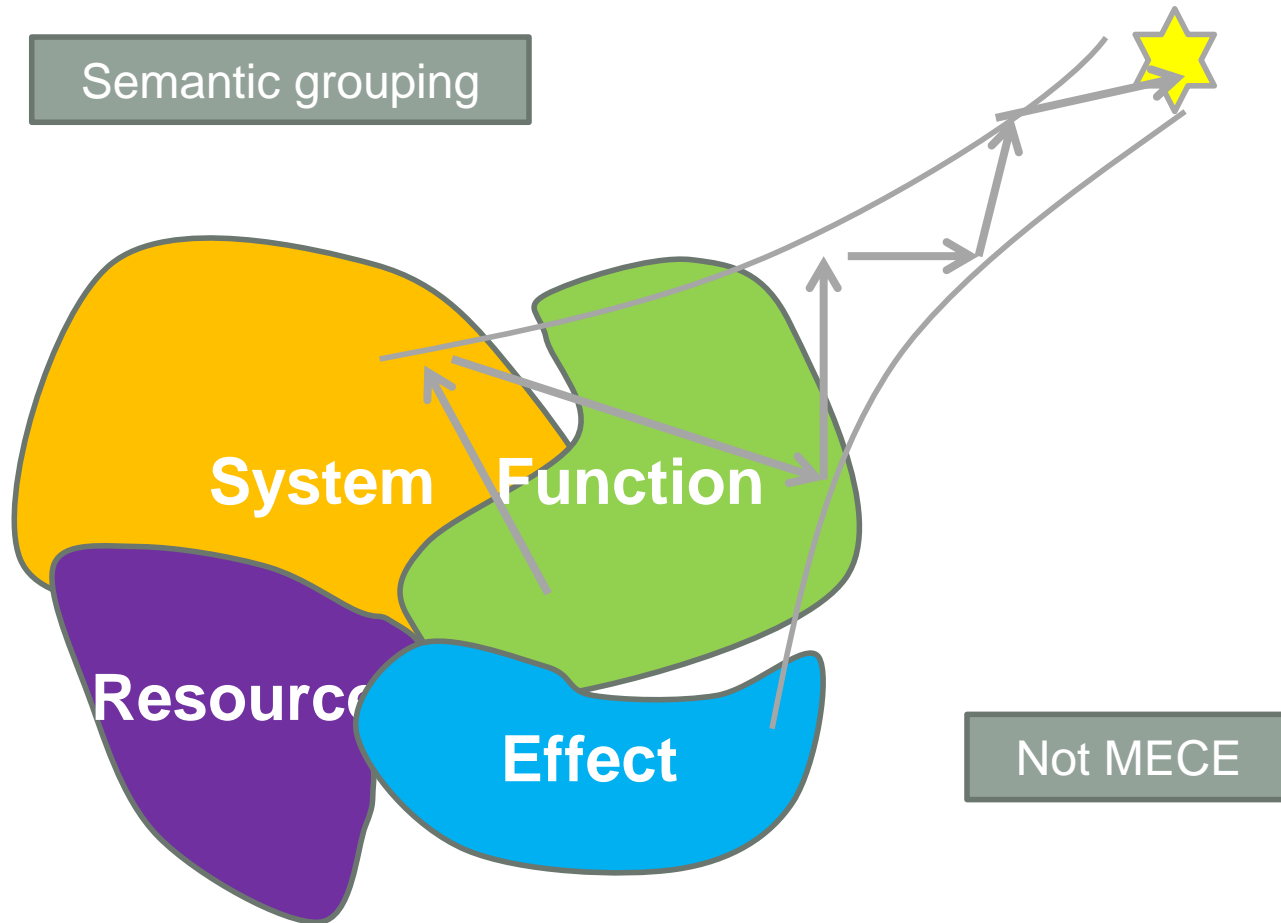
- Problem
  - It means a perceived gap between the existing state and a desired state.
- Generally,
  - Problem solving starts with setting a goal. After that, it is followed by examining the current state and defining obstacles or contradictions of the given problem.
- Also,
  - The contradiction never comes alone.
  - System changes entail contradictions.
- Therefore,
  - Setting objectives takes priority over identifying contradictions, and it is relatively easy to do.

## Theoretical issue -2

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- The meaning of the inventive principles
  - They represent common and repetitive patterns of changing artificial systems.
  
- Patterns of changing systems : Main agents & Aids
  - They are categorized as two kinds of phenomenon from system theory perspective : System itself, and its function. (Of course, two phenomenon are not mutually independent.)
  - Additionally, two kinds of aids cause system changes : Utilizing resource and Knowledge(i.e. scientific effects in TRIZ).
  
- That is,
  - The inventive principles are classified as 4 groups - System, Function, Resource, and Effect.
  - This research called this as SFRE grouping.

# SFRE groupings -1





# SFRE grouping -2

Grouping	Details
System	<ul style="list-style-type: none"> <li>● Merging : Overall change of shape</li> <li>● Trimming : Modification of components</li> <li>● Adjustment : Detailed change of shape</li> </ul>
Function	<ul style="list-style-type: none"> <li>● Treatment : Functional treatment on time scale</li> <li>● Alternation or Introduction : Change of function</li> <li>● Change : Change of mechanism</li> </ul>
Resource	<ul style="list-style-type: none"> <li>● 1<sup>st</sup> Resource : Ready resource, Neighboring resource, Void,</li> <li>● 2<sup>nd</sup> Resource : Resource analysis, Derivative Resource(ARIZ4.5)</li> <li>● 3<sup>rd</sup> Resource : Reception of particles by Experimental Standard(SS5.5)</li> </ul>
Effect	<ul style="list-style-type: none"> <li>● Scientific Effects : Physics, Chemistry, etc.</li> <li>● Domain Knowledge : Know-how or knowledge of relevant field</li> </ul>

# SFRE grouping -3

System	Function	Resource	Effect
<ul style="list-style-type: none"> <li>● <b>Merging</b> <ul style="list-style-type: none"> <li>5. Combining</li> <li>6. Universality</li> <li>3. Local quality</li> </ul> </li> <li>● <b>Trimming</b> <ul style="list-style-type: none"> <li>1. Segmentation</li> <li>2. Taking away</li> </ul> </li> <li>● <b>Adjustment</b> <ul style="list-style-type: none"> <li>4. Asymmetry</li> <li>7. Nesting</li> <li>8. Counterweight</li> <li>12. Equipotentiality</li> <li>14. Spheroidality</li> <li>15. Dynamicity</li> <li>17. Another dimensions</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● <b>Treatment</b> <ul style="list-style-type: none"> <li>9. Prior counteraction</li> <li>10. Prior action</li> <li>11. Cushion in advance</li> <li>16. Partial or Excessive action</li> </ul> </li> <li>● <b>Alternation or Introduction</b> <ul style="list-style-type: none"> <li>13. Inversion</li> <li>20. Continuity of useful action</li> <li>21. Rushing through</li> <li>22. Convert harm into benefit</li> <li>23. Feedback</li> <li>25. Self-service</li> </ul> </li> <li>● <b>Change</b> <ul style="list-style-type: none"> <li>18. Mechanical vibration</li> <li>19. Periodic action</li> <li>28. Replacement of a mechanical system</li> <li>29. Pneumatic or hydraulic construction</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● <b>1<sup>st</sup> Resources</b> <ul style="list-style-type: none"> <li>24. Mediator</li> <li>26. Copying</li> <li>27. Disposable object</li> <li>30. Flexible ‘shells’ or thin films</li> <li>31. Porous material</li> <li>32 Change the color</li> <li>33. Homogeneity</li> <li>34. Rejecting or regenerating parts</li> <li>40. Composite materials</li> </ul> <p style="margin-left: 20px;">ARIZ 4.3 Modified S</p> <p style="margin-left: 20px;">ARIZ 4.4 Void</p> </li> <li>● <b>2<sup>nd</sup> Resource</b> <ul style="list-style-type: none"> <li>Resource analysis</li> <li>ARIZ 4.5 Derivative Resource</li> </ul> </li> <li>● <b>3<sup>rd</sup> Resource</b> <ul style="list-style-type: none"> <li>SS5.5 Reception of particles</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● <b>Scientific Effects</b> <ul style="list-style-type: none"> <li>35. Transforming the physical/chemical state</li> <li>36. Phase transition</li> <li>37. Thermal expansion</li> <li>38. Strengthen oxidation</li> <li>39. Inert environment</li> </ul> </li> <li>● <b>Domain Knowledge</b> <ul style="list-style-type: none"> <li>Know-how,</li> <li>Engineering,</li> <li>Programming,</li> <li>Business, etc.</li> </ul> </li> </ul>

# Practical usage of SFRE grouping

- How can we use SFRE grouping practically?
  - The kernel of this usage is to use a specific group corresponding to the system change without defining contradictions of the problem situation.
  
- Specifically,
  - First, a solver makes a decision whether to change SYSEM or FUNCTION, and uses one(i.e. analogical reasoning). After that, use another.
  - Next, the solver needs to consider about the other groups – RESOURCE and EFFECT. (In practice, RESOURCE and EFFECT groups are less frequently used.)
  
- Consequentially,
  - This method does not require strict definition of contradiction, and prevents dispersion of thinking. Further, it improves the effect of analogical reasoning through semantic grouping.

# Framework for Ideation

➤ Framework of SFRE grouping

- POSRI provides this framework for TRIZ beginner.

	No.	Idea
<b>S</b>	Example) #1	Example) separated saddle.
<b>F</b>		
<b>R</b>		
<b>E</b>		

# Example for SFRE grouping

## ➤ Task

- Design a new saddle of a bicycle.



	No.	Idea
<b>S</b>	#1 Segmentation #17 Another dimensions #2 Taking away # 15. Dynamicity	#1 separated saddle. #17 change of saddle's angle #2 removing a saddle / #15 transformable saddle
<b>F</b>	#28 Replacement of a mechanical system #23 Feedback / #13. Inversion	#28 Using motor #23 change of saddle's shape (on speeding) #13 handling pedal
<b>R</b>	#31. Porous material #24 Mediator #30 Flexible 'shells' or thin films	#31 porous saddle #24, #30 thin guider / safer
<b>E</b>	#37 Thermal expansion	#37 change of saddle's shape by heat

# Application & Activity

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## ➤ Now,

- POSRI (i.e. POSCO TRIZ College) has provided these methods for TRIZ beginners and practitioners, which turned out to be effective.

## ➤ Training Assignments

- Training assignments include conceptualizing product design(e.g. a chair, a bicycle, and so on).
- Process of a task : Problem analysis → **Ideation** → Elaboration

# Products of the trainees -1

## ➤ Task #1

1. 목표성적 / IFR  
=> 침대와 같은 의자

2. 자원  
• 물질: 발바닥, 목받침대(고정식) 의자 스트 요거.  
• 공간: 사람이 누워서 있는 공간(1.8m), 시간: 유행시간(4hr)  
• 압력 간격(1m)

3. 기능

각도에 따라 조정

슬라이딩 레일 → 고정형 목받침 → 침대와 같은 "의자"  
∵ 어느 각도에서도 목이 편안한 의자

4. 모순 T.C

슬라이딩 레일 O → 목받침대가 가벼워야 함 / 목받침대가 무거워야 함

슬라이딩 레일 X → 누움경우 목이 불편

반려원리	개인 Idea	Idea			
		IFR	자원	기능	원인
System		17. 발바닥 받침대 이용	18. 목받침대 2중	19. 자석을 이용한 자석 링	
Function		18. 목받침대 2중	23. 목받침대 목 받침대	19. 발바닥 받침대	
Resource			23. 목받침대 목 받침대	24. 목받침대 받침대	
Effect			24. 목받침대 받침대	25. 목받침대 받침대	

발명원리	Idea
S	①: 종이를 받쳐주는 기능 + 낮은 압력 0.01원 받치 ②: 다기능 ③: 귀찮음 ④: 슬라이딩 레일은 신발 밑창에 작용
F	⑩: 가격요구 → 피복의 요구로 교체(마찰 증가) ⑪: 예비장치 ⑫: 추가적 작용 ⑬: 유용성 기록
R	⑭: 스트 내 다른 요거를 함께 활용 ⑮: 목받침대 ⑯: 목받침대
E	⑳: 목받침대 받침대 ㉑: 목받침대 받침대

# Products of the trainees -2

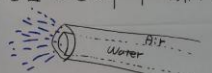

## ➤ Task #2

항 목	내 용
조 No / 구성원	1조 김광욱(조장) 김선민, 차문환, 김동관, 이효준, 정지원
과제명 / 도식화	비수면적 극대화를 위한 비수방법(장치) 설계 최적화
1. 목표상황 / IFR	물을 최대한 넓은 면적에 살수한다
2. 자원	물 (압력, 온도), Pipe 길이/형상, Pump 능력
3. 기능	물의 비산 (각도, 압력, 속도)를 변경한다 물의 상태 (Spray → Mist)를 바꾼다 비수 노즐의 형상 (각도 내경)을 변경한다
4. 모순	<ul style="list-style-type: none"> <li>관리적 모순: pipe 노즐을 돌리면 비수면적은 넓어지지만 pipe 무게와 에너지가 증가한다</li> <li>기능적 모순: <ul style="list-style-type: none"> <li>pipe 노즐이 돌다 → 비수면적 증가</li> <li>pipe 노즐이 돌다 → 에너지 소모 증가</li> <li>pipe 무게가 낮다 → 에너지 소모 감소</li> <li>pipe 무게가 낮다 → 비수면적 감소</li> </ul> </li> </ul>

발명원리	개별 발상 아이디어	발명원리 10	발명원리 4	발명원리 12	발명원리 24
System					
Function					
Resource					
Effect					

### 1조

#### [아이디어 도출]

- 비수면적 확대 위한 비수방법 변경 (Spray → Air Mist)  
(발명원리 10. 예비조치) 
- 물의 분사 압력을 높이기 위해서 pipe 형상을 비대칭으로 설계 (베르누이 원리 활용)  
(발명원리 4. 대칭/비대칭)
- 살수 분포 영역 확대 위한 지형 변경  
(발명원리 12. 단계동위) 
- RC 비행기 사용을 통한 비수 실시  
(발명원리 24. 매개체)



# Products of the trainees -3

## ➤ Task #3

3조

1. 목표(IFR)  
안정적 안장 / 용이  
페달링이 용이하고 편안한 안장

2. 자원  
안장, 페달, 스프링, 바퀴, 사람의 무게  
동력(인력), 자석, 쿠션, 실리콘

3. 기능

```

    graph LR
      A[사람] -- 회전 --> B[페달]
      B -- 권력 --> C[자전거]
      D[안장] -- 지탱 --> E[사람]
      F[스프링] -- 충격 --> G[안장]
      G -- 편안함 --> H[안장]
      I[페달의 힘 전달 어려움] --> J[편안함]
      K[너운 안장] --> L[편안함]
      M[페달링 불편] --> N[편안함]
    
```

4. 모순

```

    graph LR
      O[스프링] -- 충격 --> P[안장]
      P -- 편안함 --> Q[안장]
      R[페달의 힘 전달 어려움] --> S[편안함]
      T[너운 안장] --> U[편안함]
      V[페달링 불편] --> W[편안함]
    
```

개인별 발상 아이디어	발명 권리	발명원리 & 실용성을 위한 아이디어
	S	
	F	
	R	
	E	

아이디어

1. 실리콘 수축/팽창  
실리콘 안장에 팽창/수축 기능을 겸비한 다기능 안장.

2. 안장에 유압 쇼바를 장착하여 충격 흡수.  
← oil, 스프링

3. 충전식 에너지를 활용하여 MOTOR 구동함으로써 계속적인 자동 페달링...

# Conclusion

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➤ So far,

- This research proposes SFRE grouping and its usage.

➤ In conclusion,

- SFRE grouping is a complementary method.
- This method is simple and practical. It will improve the skill of using the inventive principles.
- This research expects this method spreads widely in TRIZ education and application.