

# A Study of Conceptual Design Process For An Ideal Design Way

2014,9/11(Thursday )-12(Friday)

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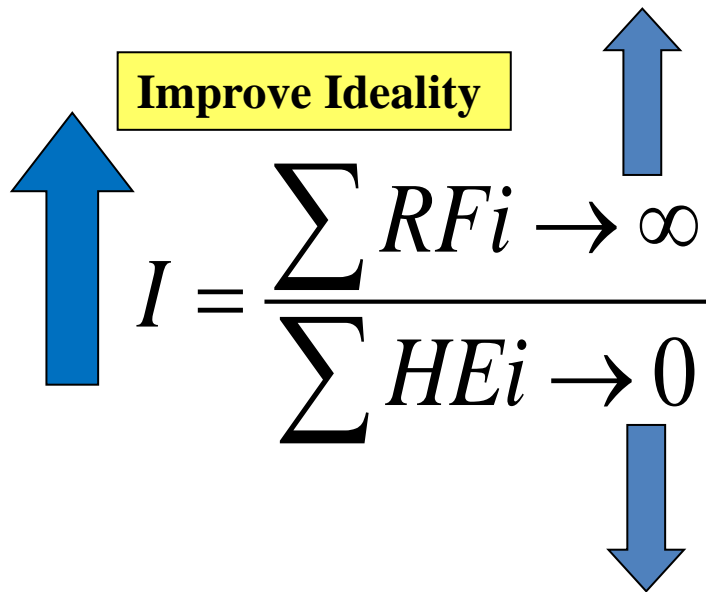
# 1. Preface

1) The product development activity plays a pivotal role in their corporate management for manufacturing companies.

2) The upstream stages such as product planning and design development work is vitally important for materializing customers' required functions economically and also for the speedy product development activity.

3) The purpose of this study is to consider “a conceptual design process” with less interference among numerous functions required by customers and to chase ideal design.

# Aim for ideal design



The diagram illustrates the Ideal Design equation,  $I = \frac{\sum RFi \rightarrow \infty}{\sum HEi \rightarrow 0}$ . A large blue arrow on the left points upwards, indicating the goal of increasing the numerator. A yellow box labeled "Improve Ideality" is positioned above the equation. A blue arrow above the numerator points upwards, and a blue arrow below the denominator points downwards, indicating the goal of decreasing the denominator.

$$I = \frac{\sum RFi \rightarrow \infty}{\sum HEi \rightarrow 0}$$

- Realize required functions for customers
- Improve inadequate required functions for customers
- Improve required functions for customers
- Enforce required functions for customers

- Eliminate harmful effects
- Prevent harmful effects
- Reduce harmful effects

$RF_i$  (Required Function) : Required Function  $i$  for customers

$HE_j$  (Harmful Effect) : Harmful Effect  $j$  while realizing  $RF_i$

# 2. Outline of design process

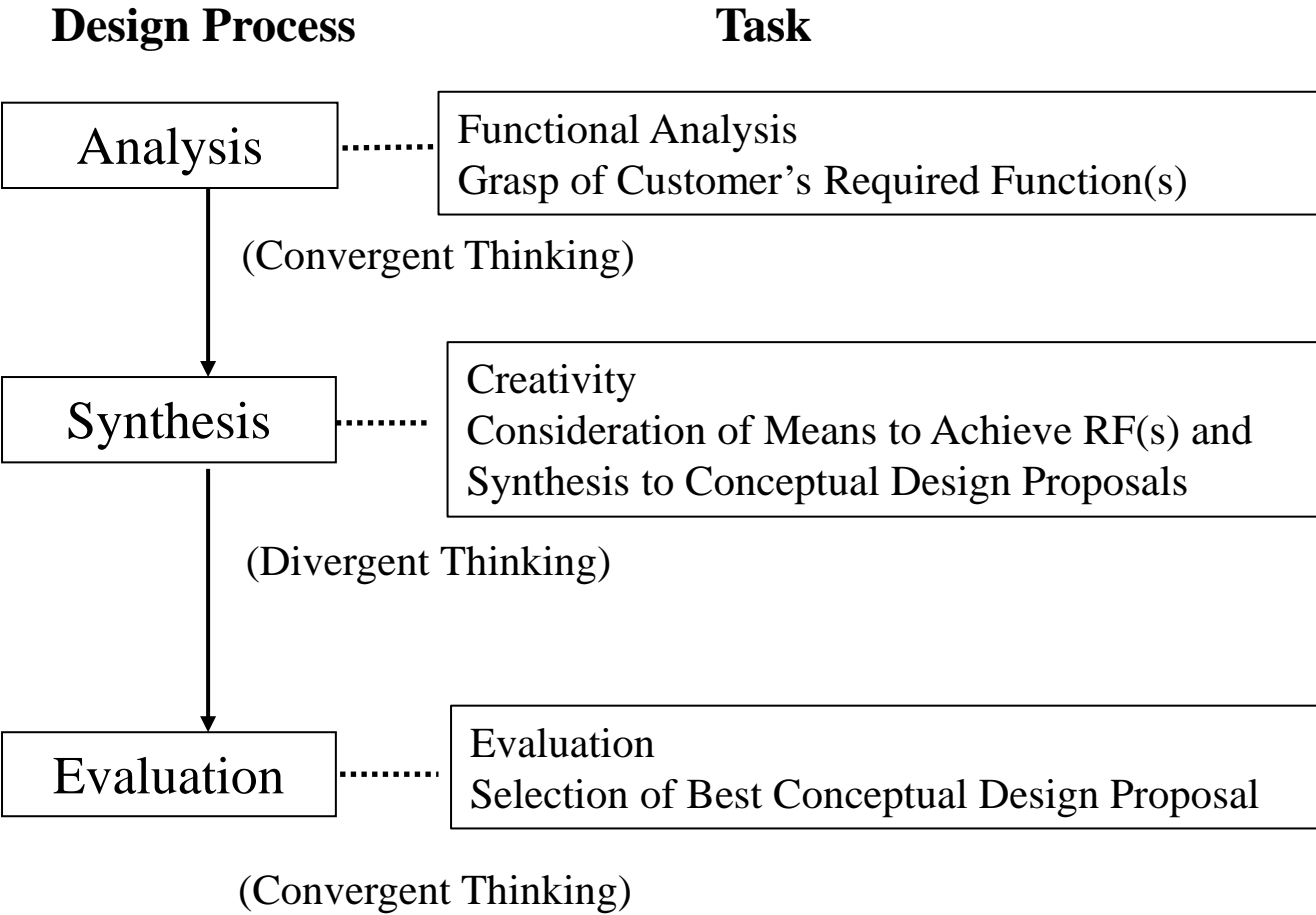
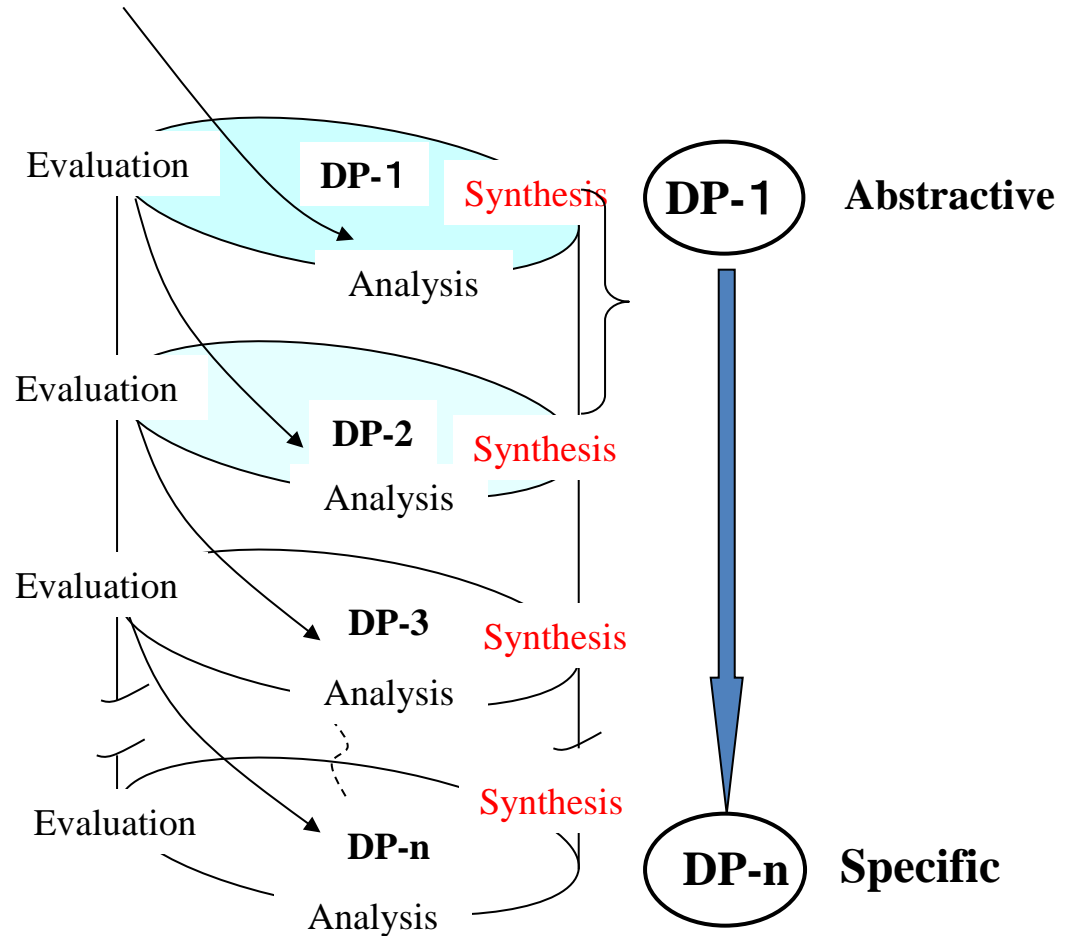
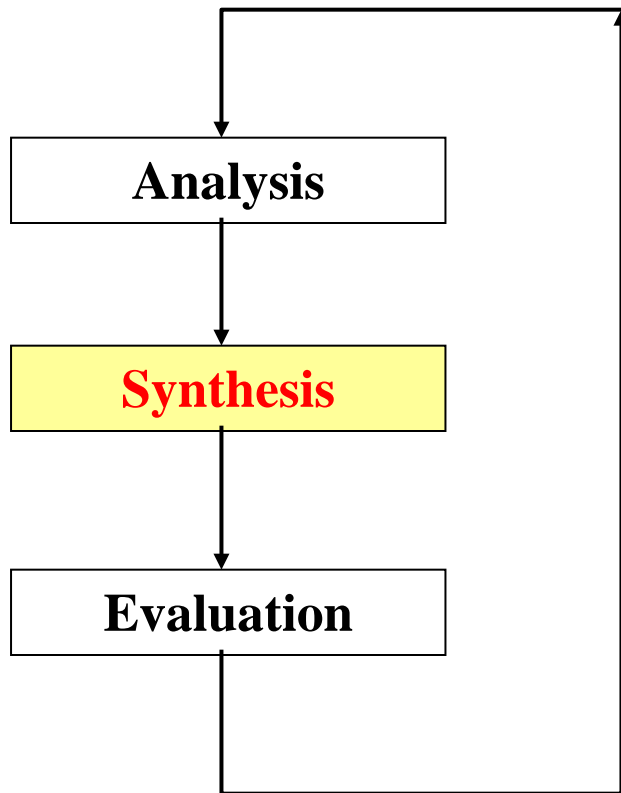


Fig.1. Three stages about design process

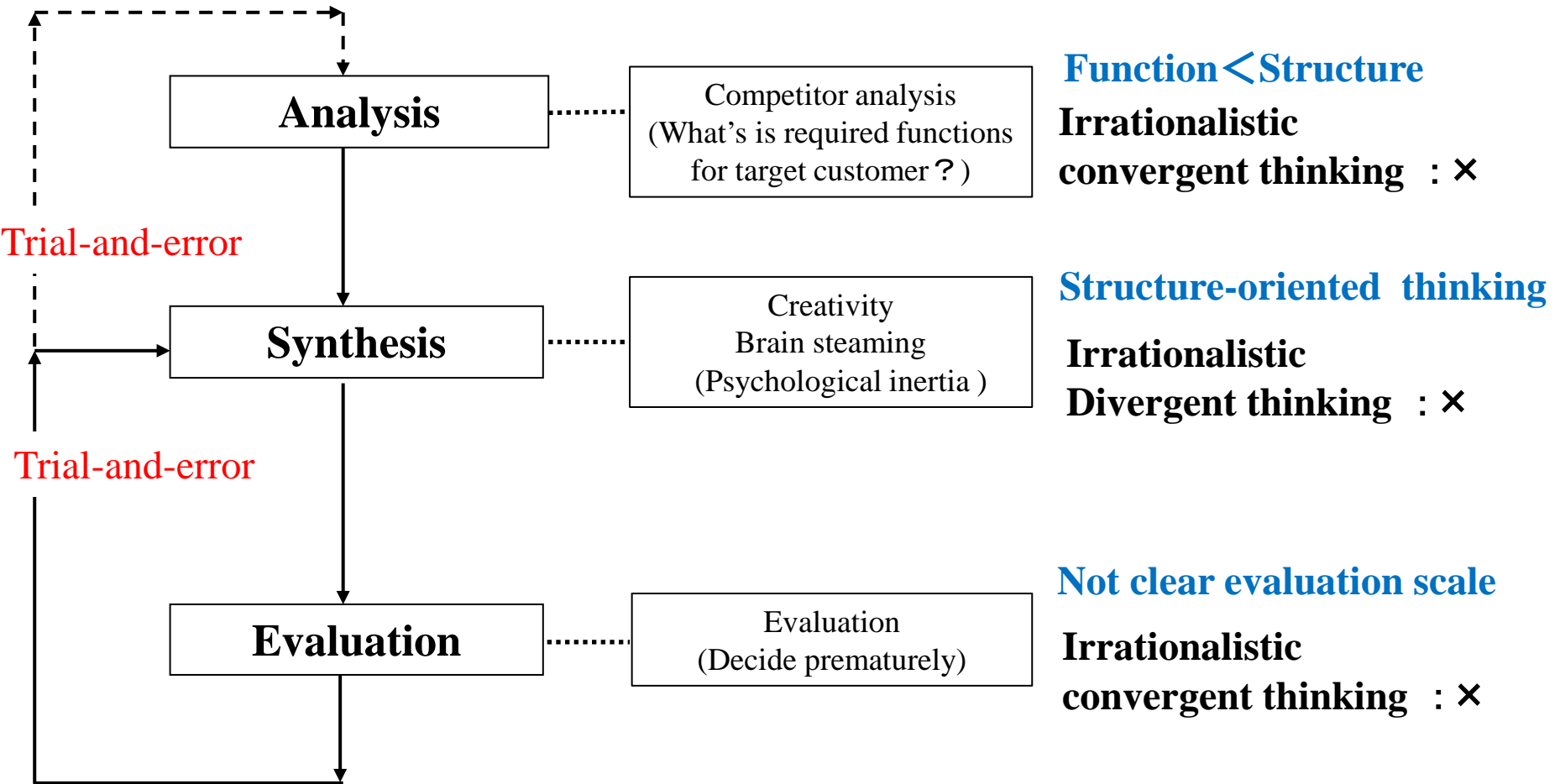
# Spiral of DP(Design process)



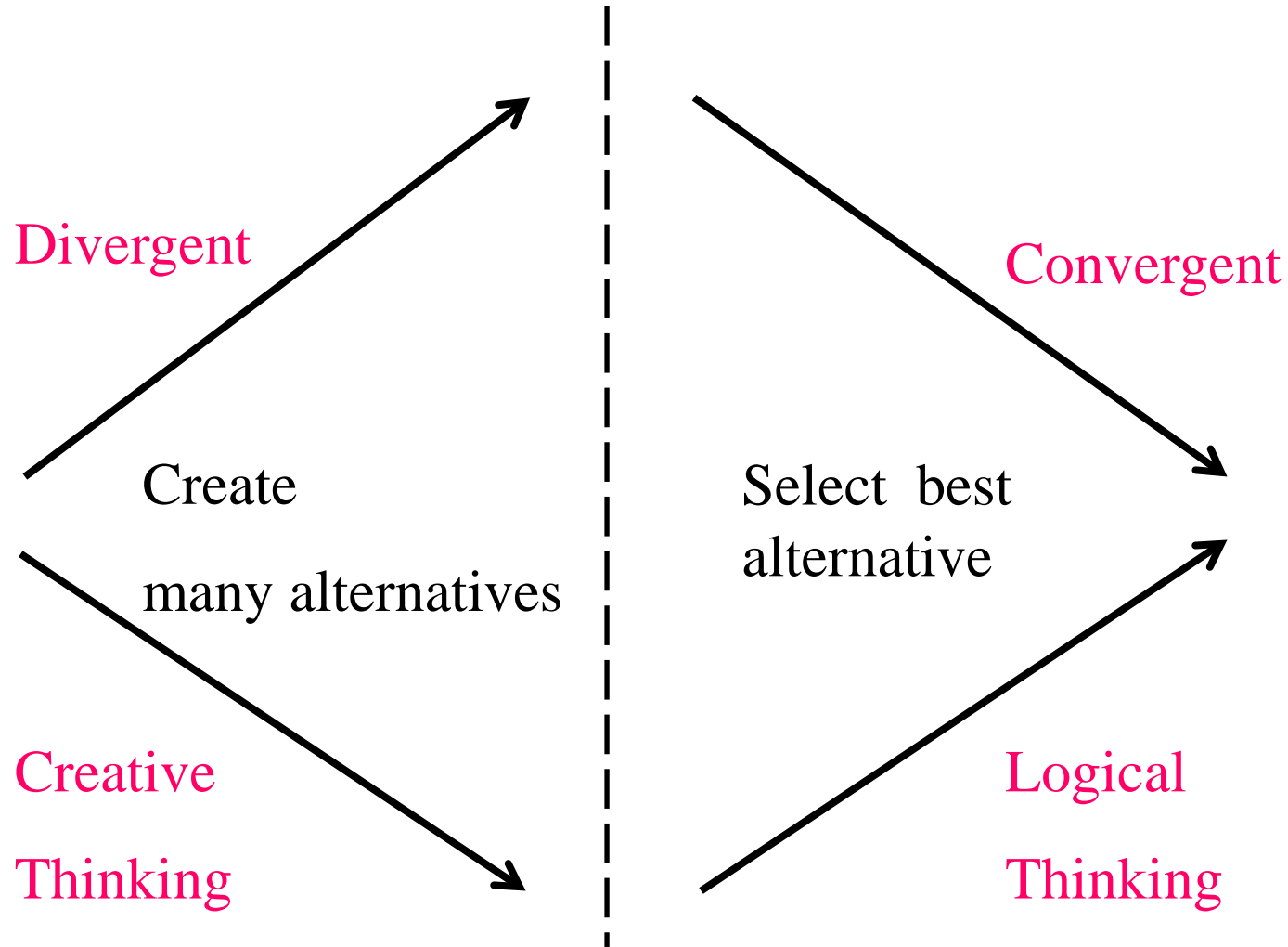
# 3. Conventional process for considering design proposals

## Design Process

## Contents

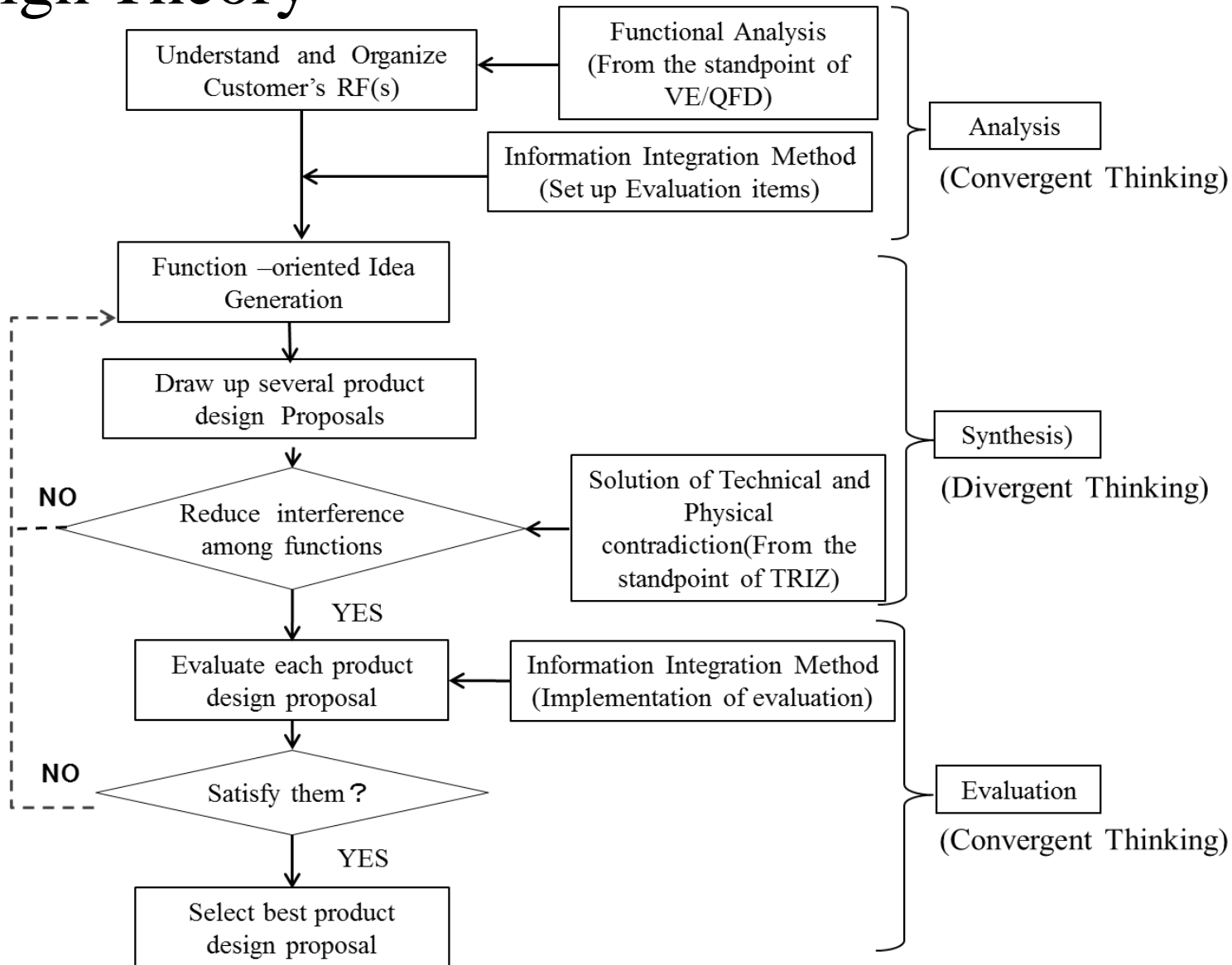


# Convergent and Divergent thinking





# 4. Design process for ideal design and the “Axiomatic Design Theory”



Design Process for Ideal Design

# Axiomatic Design Theory

## Axiom1 : The Independent Axiom

The independence between two or more functions, not physical parts, shall be maintained.

## Axiom2 : The Information Axiom

The design with minimum content of information shall be the best among those satisfying the Independence Axiom.

# A case example about Axiom1 : The Independent Axiom

$RF$ : required function     $DP$ : Design parameter

$[A]$ : Design Matrix

$$\{FR\} = [A]\{DP\}$$

Design Equation

$RF_1$ : take the foods in and out at refrigerator

$RF_2$ : minimize the loss of energy

<A case about decoupled design >

$$DP_1: \text{open sideways door} \quad \begin{pmatrix} RF_1 \\ RF_2 \end{pmatrix} = \begin{pmatrix} X & 0 \\ X & X \end{pmatrix} \begin{pmatrix} DP_1 \\ DP_2 \end{pmatrix}$$

$DP_2$ : Adiabatic material for door



To ideal design for realizing axiom 1



<Uncoupled design (solution of contradiction) >

$$DP_1: \text{horizontally-moving door} \quad \begin{pmatrix} RF_1 \\ RF_2 \end{pmatrix} = \begin{pmatrix} X & 0 \\ 0 & X \end{pmatrix} \begin{pmatrix} DP_1 \\ DP_2 \end{pmatrix}$$

$DP_2$ : Adiabatic material for door



# Axiom2: The Information Axiom

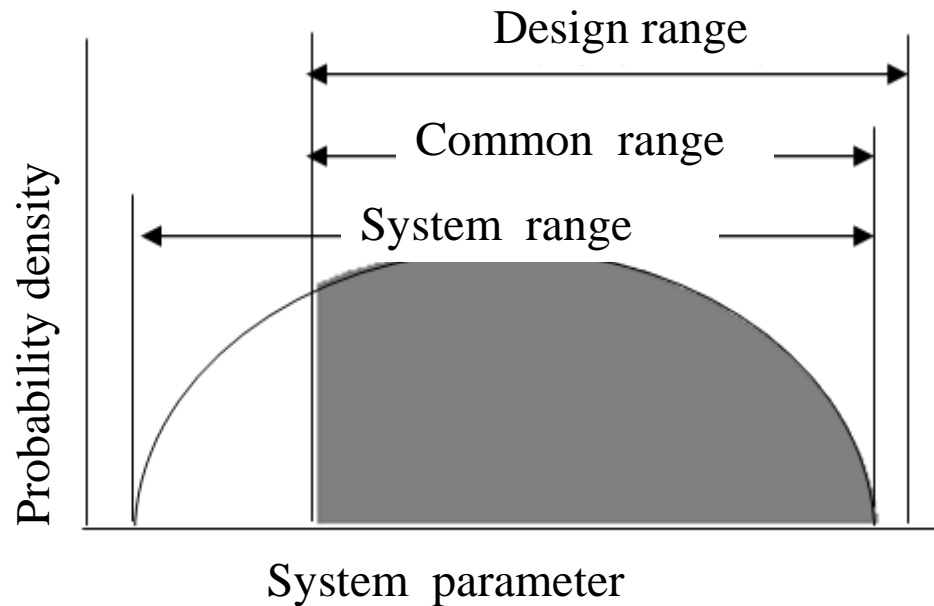
Evaluation method developed by Hiromu Nakazawa

- All features are evaluated using a common measure called Information based on Shannon's information theory
- IIM expands this concept to measure the difficulties (Information, energy, or effort) required to satisfy the requested features in products design.

Information (I) for communicating the status of feature a, which is associated with probability  $P_a$ , is given as follows

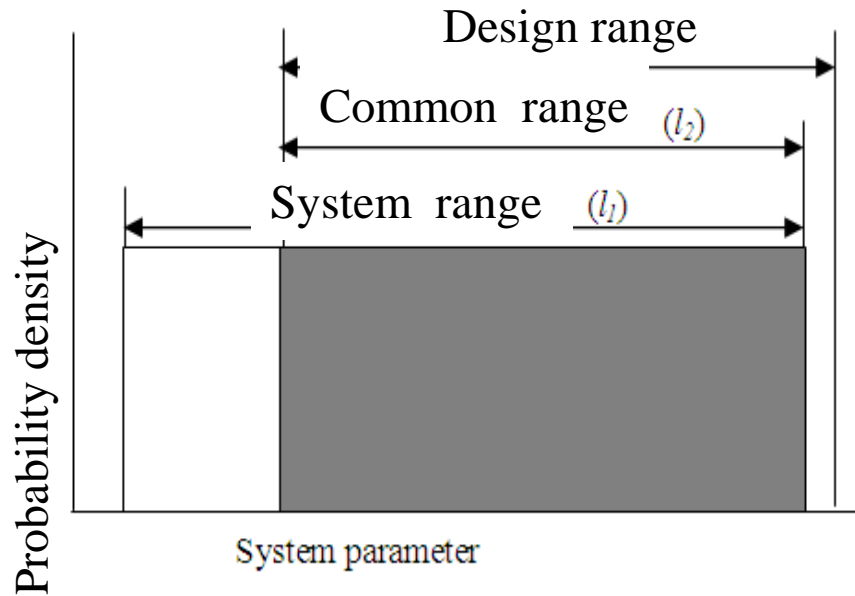
$$I = \ln \frac{1}{P_a} \quad (1)$$

Information Integration method(IIM) is based on the concept of Shannon's information



Probability distribution of a system parameter

# Application to the evaluation method for product design



$$I = \ln \frac{1}{P_c} = \ln \frac{\text{System range } (l_1)}{\text{Common range } (l_2)} \quad (2)$$

# 5. Case study-Paper cups for hot coffee

(First half )-----Past analysis

#1:Set up evaluation items

#2:Experiment and survey condition

#3:Subject of this study –paper cup

#4:Compute the features' information content

#5:The evolution of paper cups from the viewpoint of resolving contradictions



(Latter half )----- New product planning for a next generating paper cup

#1:Interview on the present coffee cups

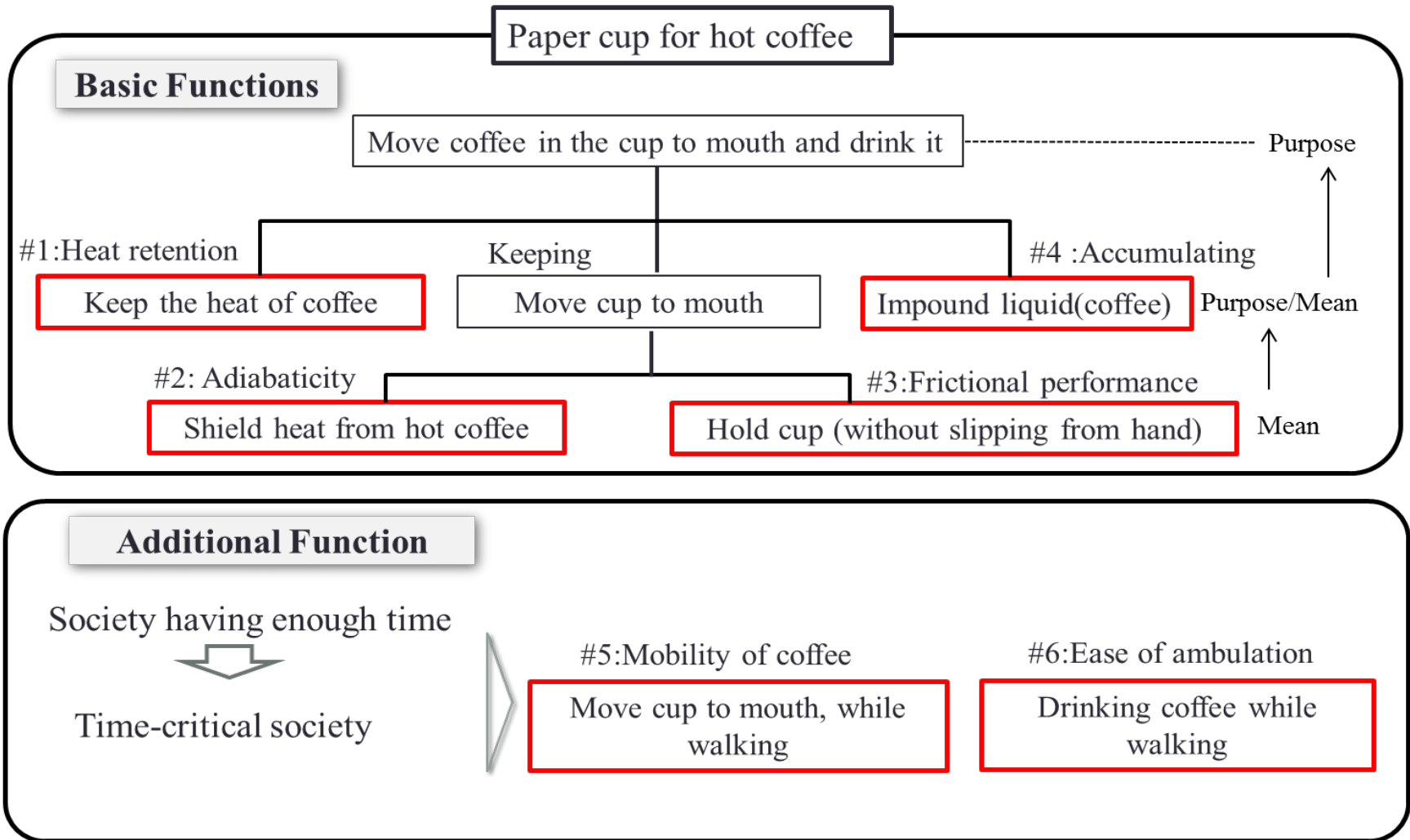
#2:Localization of problems

#3:Idea creation by resolving contradiction

#4:Effectiveness of the next generation paper cup

# Past analysis(First half)

## #1:Set up evaluation items



Functional analysis and evaluation items about coffee cup



## #2: Experiment and survey condition

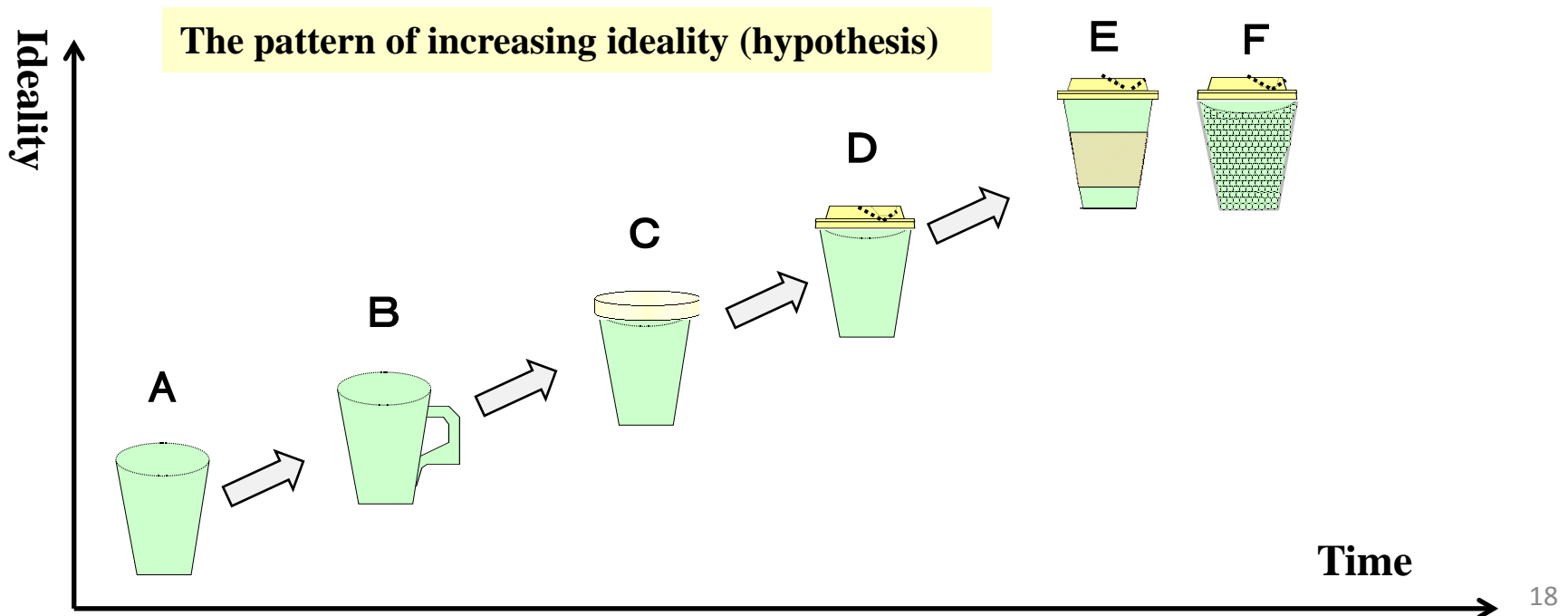
Maximum score of each sensitivity item and minimum value of Design Range

	#2 Adiabaticity	#3 Frictional performance	#4 Accumulating	#5 Mobility of coffee	#6 Ease of ambulation
Scoring	5-point	3-point	5-point	5-point	3-point
Design Range	4.14-	4.33-	3.00-	4.14-	2.57-

### #3: Subject of this study –paper cup

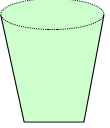
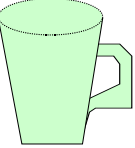
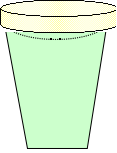
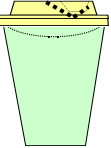
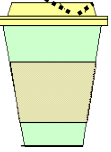
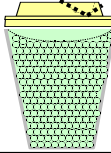
Table2 The features of each paper cup for hot coffee

A	Usual paper cup
B	Paper cup with assist handle
C	Paper cup with lid
D	Paper cup with solo lid (lid with small hole for drinking)
E	Paper cup with solo lid and insulating sleeve
F	Paper cup with solo Lid and its adverse side with embossed effect



## #4: Compute the features' information content

Table3 The amount of each evaluation item's Information for each coffee cup and its total score

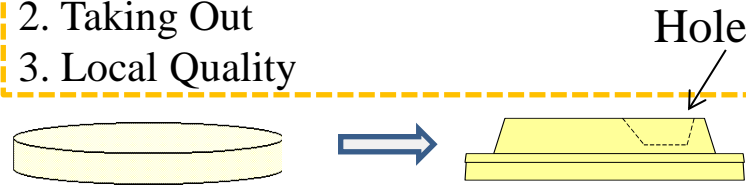
	#1Heat retention	#2Adiabaticity	#3 Frictional performance	#4 Accumulating	#5Mobility of coffee	#6 Ease of ambulation	Total
A 	1.61	$\infty$	0.922	0	$\infty$	3.33	$\infty$
B 	1.61	0.003	1.56	0	$\infty$	$\infty$	$\infty$
C 	0.159	$\infty$	0.922	0	0	$\infty$	$\infty$
D 	0.311	$\infty$	0.922	0	0.024	0.381	$\infty$
E 	0.069	0	0.499	0	0.024	0.381	0.97
F 	0.143	3.55	0.081	0	0.024	0.381	4.18

# #5: The evolution of paper cups from the viewpoint of resolving contradictions

We need lid for heat retention. However, we don't need it for drinking

## Separation in space

1. Segmentation
2. Taking Out
3. Local Quality

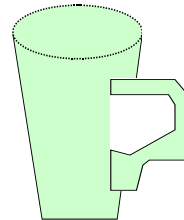
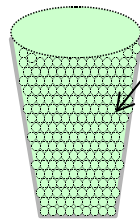


**Make a hole on the lid**

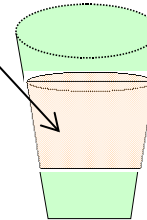
**Improving Feature (13line) Stability of object VS  
Worsening Feature(31row)Harmful side effects**

- 27. Cheap short –living objects
- 35. Parameter changes
- 39. Inert atmosphere
- 40. Composite materials

Adverse side with  
embossed effect



Insulating sleeve



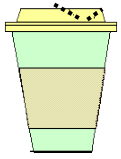
# New product planning for a next generating paper cup (Latter half)

## #1: Interview on the present coffee cups

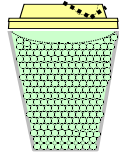
### Main problems against type E and F

Functional problems	number of times	The concrete contents
Ease of disassembly	7	It's very hard to take off lid for pouring sugar and milk , or for disposal
Stability of sleeve	3	Slippery sleeve
Ease of scramble up	2	Putting sugar or milk in sticky coffee like cafe latte, it's hard to run together each other
Easiness to drink	2	It's very hard to run sticky liquid like café latte from small hole on lid.
design sensibility	1	Sleeve of corrugated paper is frumpy

## #2: Localization of problems



Type E



Type F

Table5 The amount of each evaluation item's Information for Type E and F and their total score

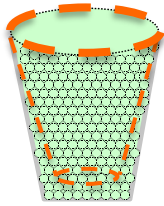
	#1 Heat retention	#2 Adiabaticity	#3 Frictional performance	#4 Accumulating	#5 Mobility of coffee	#6 Easiness to drink	#7 Ease of disassembly	Total
Type E	0.069	0	0.499	0	0.024	2.19	3.81	6.592
Type F	0.143	3.55	0.081	0	0.024	2.19	2.34	8.328

# #3:Idea creation by resolving contradiction

*Idea 1*

**Improving Feature (17line)Temperature VS  
Worsening Feature(13 row) Stability of object**

- ① Segmentation
32. Color Changes
35. Parameter changes



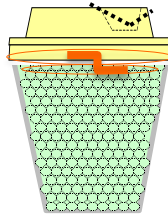
- Hanging superior portion of inner cup on superior portion of external cup
- Change the angle of edge of both inner and external cup.
- Use each different color to discriminate between inner and external cup
- Use adverse side with embossed effect to be stable to hold cup



## *Idea 2*

**Improving Feature(12line)Shape VS  
Worsening Feature (22row )Waste of energy**

### 14. Curvature

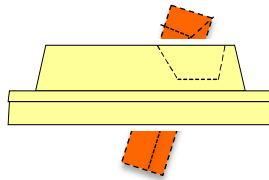


- Lid should be improved as rotary lid
- Put the clamp between lid and cup

### *Idea 3*

**Improving Feature (15 line) Durability of moving object VS Worsening Feature (31 row) Harmful side effects**

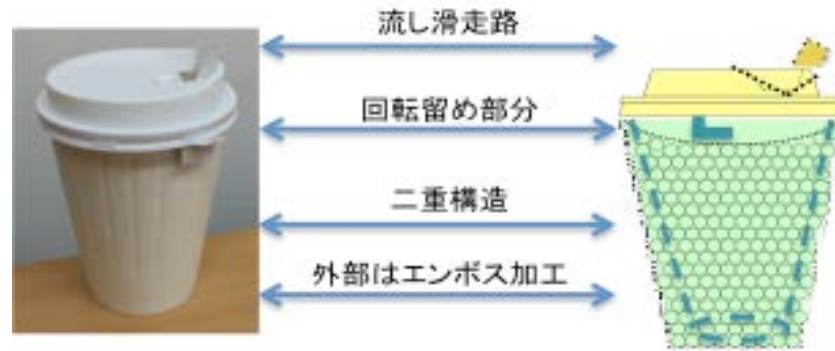
- 16. Partial or excessive actions
- 21. Skipping
- 22. "Blessing in disguise"
- 39. Inert atmosphere



- Make angle to drink smoothly near facet (hole) on the cup
- Make landing field to move liquid (coffee) smoothly to one's mouth

# #4: Effectiveness of the next generation paper cup(idea1+2+3)

## Proto-type fabrication



\*Make angle to drink smoothly near facet (hole) on the cup

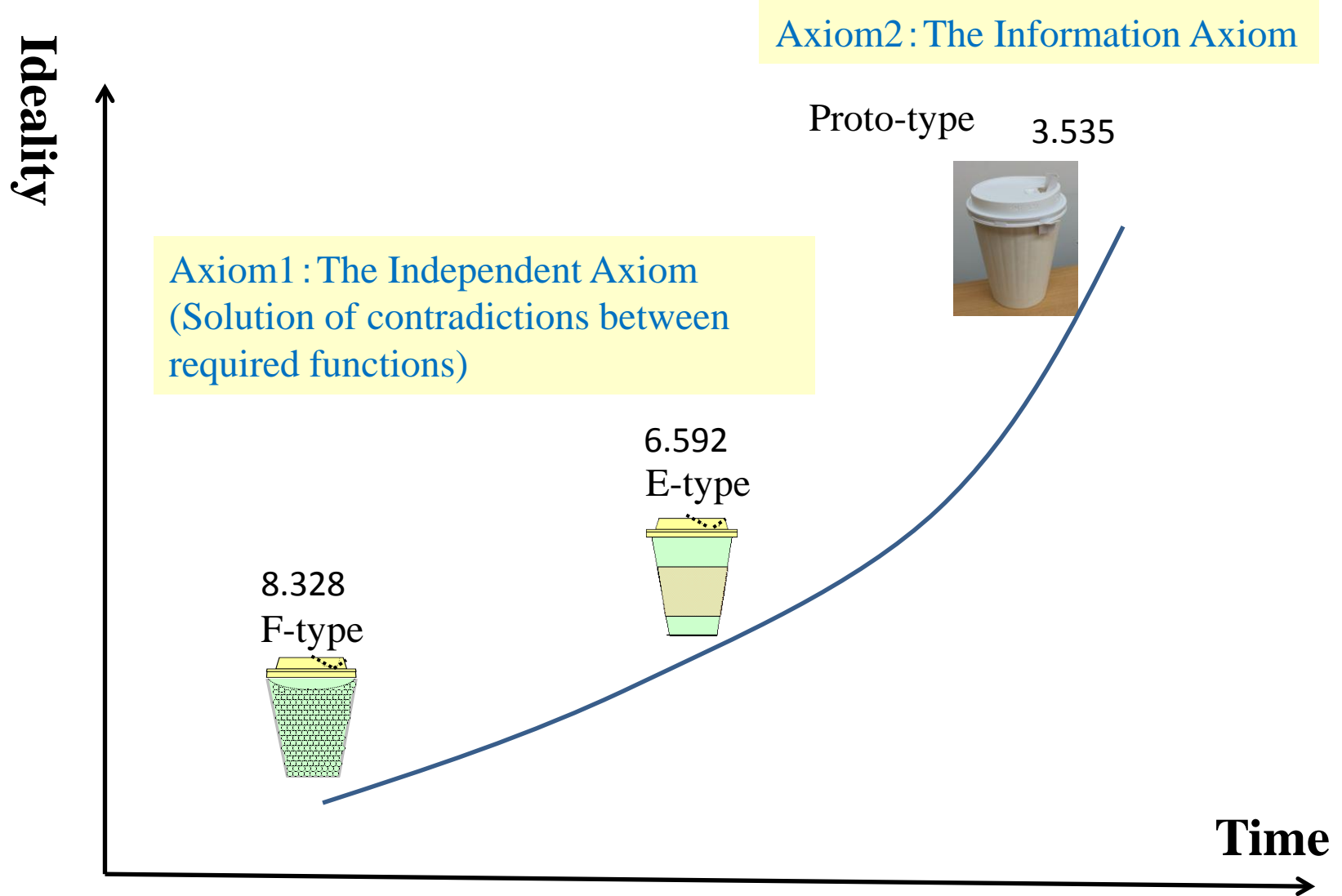
\*Put the clamp between lid and cup

\*Hanging superior portion of inner cup on superior portion of external cup

\*Use adverse side with embossed effect to be stable to hold cup

	#1 Heat retention	#2 Adiabaticity	#3 Frictional performance	#4 Accumulating	#5 Mobility of coffee	#6 Ease of ambulation	#7 Ease of disassembly	Total
Type E	0.069	0	0.499	0	0.024	2.19	3.81	6.592
Type F	0.143	3.55	0.081	0	0.024	2.19	2.34	8.328
New paper Cup	0	0	0.081	0	0.024	1.54	1.89	3.535

# 6. Conclusion



## 6. Conclusion

1) We made clear that **axiom 1** is for **solving contradictions** and **axiom 2** is for **reducing the amount of features' Information** through analysis of paper cups (first half).

2) We made clear that **ideality of proto-type** is **increased** through Idea generation by TRIZ (Contradiction Matrix).

3) We basically proved that **proposed design process** is for direction to the **idea design**.

# Thank for your attention

