#### Hong Kong Society for Quality (香港品質學會)



# Recent Applications of Extension Intelligence (可拓智能的最新應用)



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#### Content



- Introduction of Extenics
- Extension Intelligence
  - Extension Innovation Method (4 steps)
- Application Case Studies
  - Mainland China cases
  - Hong Kong cases

## Extenics (可拓學)



- From 1976, Prof. Cai started to study the law, theory and method for dealing with incompatible problems. The paper "Extension Set and Incompatible Problem", which was published in 1983, marked the birth of new science Extenics (originally called Matter-element Analysis).
- Using formal model to research the extension possibility of things, the rules and methods of innovation, and applying all of them to solve contradictory problems.

Extenics = Extension Theory + Extension Method + Extension Engineering



"Extenics: China original theory" organized by HKCIE (香港中國工程師學會), HKIE - MIE, HKSQ, TQM and SZIPS on 29 Feb 2016.



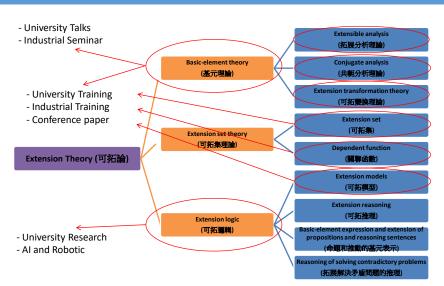
The 1st World Summit for Chinese Quality was organized by WACQ (全球華人 品質聯盟(籌), co-organized by HKSQ & SEKM, CityU on 8 July 2016. Prof. Cai Wen and Prof. Yang Chunyan gave a keynote speech named "China Original Science Subject – Extenics" (中國原創的學科可拓學).

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## Extension Theory (可拓論)

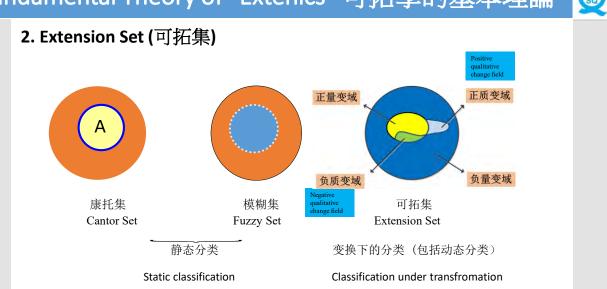




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#### Fundamental Theory of "Extenics" 可拓學的基本理論

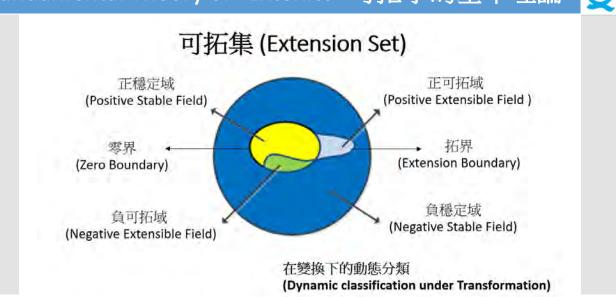




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## Fundamental Theory of "Extenics" 可拓學的基本理論



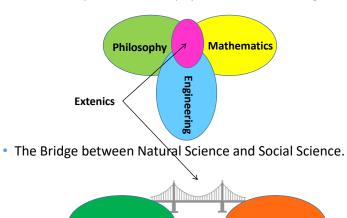


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## Fundamental Theory of "Extenics" 可拓學的基本理論



• A Cross-discipline of Philosophy, Mathematics & Engineering.



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**Social Science** 

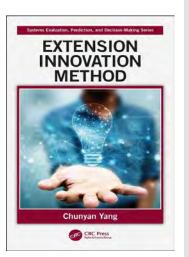
**Natural Science** 

#### **Extension Innovation Method**









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#### Extension Innovation Method Trainer Course Lv1-5



	Lv (級)	Content (内容)	Model (建模)	Extension (拓展)	Transformation (變換)	Selection (選擇)		
(	L1	Fundamental 基礎知識 Creative Method 產品創意生成	Basic-element 基元 The 2 <sup>nd</sup> Creative Method 第二創造法	Divergence 發散樹	5 Basic Transformation 5 基本變換 4 Basic Operation 4 變換的運算	Introduction 簡介		
	L2	Fundamental 基礎知識	Model, Core Problem, Compound Element, Parametric Basic Element & Conjugate Part	Correlative 相關網 Implication 蘊含系	Conductive Transformation 傳導變換	Fundamental Step 基礎步驟		
		Creative Method 產品創意生成						
	L3	Fundamental 基礎知識	Incompatible Problem 不相容問題 Antithetical Problem 對立問題	Opening-up 分合鍵 Conjugate 共軛對	Conjugate Transformation 共軛變換	Dependent Function 關聯系數		
		Creative Method 產品創意生成	The 1 <sup>st</sup> & 2 <sup>nd</sup> & 3 <sup>rd</sup> Creative Method 第一及第二及第三創造法					
		Creative Sol'n 解決問題創意生成	Extension Strategy Generating Method,可拓策略生成方法,轉換橋方法	Transforming Brid	dge Method			
	L4	Extension Marketing Method & Extension Strategic Planning Method 可拓營銷方法,可拓策劃方法						
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## **Product Quality Innovation**



- Extenics established three creative methods to conceiving a new product or service.
- The first creative method is called "Create from Nothing" or "0 to 1".
- •第一創造法名為「無中生有」。
- The second creative method named "Change in Existing".
- 第二創造法可名為「有中求變」。
- The third creative method named "Change from Demerits".
- 第三創造法又名為「改缺成優」。

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#### **Contradiction Problem**



- In extenics model, there are two types of contradiction problem.
- They are "Incompatible Problem" (不相容問題) and "Antithetical Problem" (對立問題);.
- Problem is that our requirement /target (G Goal) cannot be fulfilled under certain condition (L – Condition/Limitation).
- The model of contradiction problem is P = G \* L, where P = Problem,
   G = Goal and L = Limit or Condition
- Contradictory problems' model are showed below:
- (i) "Incompatible problems" (不相容問題) P = G 个 L
- (ii) "Antithetical problems" (對立問題) P = (G1^ G2) 个 L

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#### Extension Intelligence (可拓智能)



- Extension Intelligence is a new kind of AI which can deal with contradictions intelligently by extending and transforming information and knowledge based on the theory and methods of Extenics especially extension set.
- It can intelligently extend the relevant information from the initial conditions and objectives by the multi-dimensional extension and transformation methods in order to build comprehensive base of elements for problem solving. Furthermore, based on the massive data, the rule knowledge of the transformation is obtained by the algorithms such as extension data mining.

Xingsen Li, et al., (2020) "Extension Intelligence for Process Manufacturing" J. Phys.: Conf. Ser.

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## Extension Intelligence vs Artificial Intelligence



No.	Content	Current artificial intelligence	Extension intelligence
1	Research objects	Explicit data and information	Explicit and latent data, information and knowledge
2	Theoretical Basis	Computer science, Cantor set of mathematics, psychology, philosophy and linguistics	Extesion Set in Extenics, System science, complexity science, philosophy
3	Implementation methods	1)Programming, such as expert system; 2)Modeling approach, such as generic algorithm and artificial neural network, etc	<ol> <li>Institutionalism, process oriented systematic approach, such as strategy generation system;</li> <li>Modeling approach, such as basic- element extension, transformation and extension data mining</li> </ol>
4	The goal	Identification, search, prediction, game, translation, etc	Transformation, contradictions resolution, problem solving
5	Algorithms	Training models that rely on large amounts of data	Extend information from small data or even no data

Xingsen Li, et al., (2020) "Extension Intelligence for Process Manufacturing" J. Phys.: Conf. Ser.

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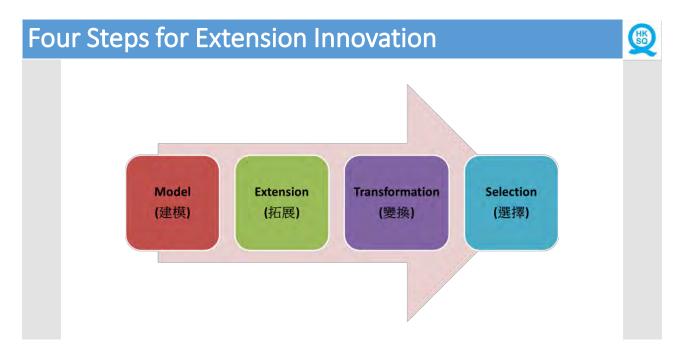
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## 按一下以編輯母片標題樣式



# Extension Innovation Method (4 steps)

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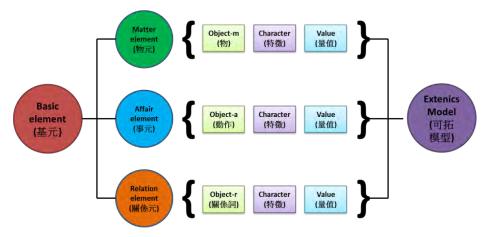


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## Basic-element (基元)



Basic element is logic cells of extenics used for formalized description of matter, affair and relation.



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# Matter-element (物元)



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 Using matter-element to describe a 10ml Class A Cole-Parmer glass beaker D and its size

Matter- element	Object	Characteristic	Value
M (Beaker) =	Beaker D,	Capacity,	10ml
		Material,	Borosilicate glass
		Outer diameter,	2.54cm
		Total height,	3.4925cm
		Brand,	Cole-Parmer
		Level,	A

(Note: Beaker D refers to a specific beaker.)

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## Matter-element (物元)



- What changes can be made to a beaker used in the laboratory?
- The size, capacity, material and quality of the beaker can be changed. In addition, its characteristics can also be changed.



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## Matter-element (物元)



- When I was a guest speaker at a secondary school, I collected a cup made of beaker. It just adds a cup handle to the beaker and then changed from laboratory beakers to home cups!
- HKQF Career Talk on Testing & Certification Industry 2016
- https://qualityalchemist.blogspot.com/2016/10/hkqf-career-talk-on-testing.html

Matter- element	Object	Characteristic	Value
M (Beaker) =	Beaker D,	Capacity,	10ml
		Material,	Borosilicate glass
		Outer diameter,	2.54cm
		Total height,	3.4925cm
		Brand,	Cole-Parmer
		Level,	Α



Object	Characteristic	Value
Cup Handle E,	Material,	Borosilicate glass
	radius,	X cm

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#### Affair-element (事元)



- Generally, the characteristics of Action include dominating objects, acting objects, receiving objects, time, place, degree, method, tools, and so on.
- The following example illustrates the affair-element of a washing machine.

Affair- element	Object (O <sub>a</sub> )	Characteristic (c <sub>a</sub> )	Value (v <sub>a</sub> )
A(Wash) =	Wash E,	Dominating object , (支配對象) (For What)	Cloth
		Acting object , (施動對象) (Who to do)	Mother
		Receiving object , (接受對象) (To Whom)	Child
		Time,	Day time
		Location,	Home
		Tools,	Washing machine

(Note: Washing E refers to a specific action.)

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## Affair-element (事元)

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- If the action "wash" is changed to "dry", the function of the product is to dry clothes and the tool is changed to a clothes dryer.
- When we want to combine two functions into one, using extensible analysis in Extenics describes that one thing can be combined with other things to produce new product, thereby providing the possibility of solving contradictory problems.



## Affair-element (事元)



• The two affair-elements are combined into one are expressed as follows.

Affair-element	Object (O <sub>a</sub> )	Characteristic (c <sub>a</sub> )	Value (v <sub>a</sub> )
A(Wash) =	Wash E,	Dominating object, (支配對象) (For What)	Cloth
		Acting object, (施動對象) (Who to do)	Mother
		Receiving object, (接受對象) (To Whom)	Child
		Time,	Day time
		Location,	Home
		Tools,	Washing machine



Object (O <sub>a</sub> )	Characteristic (c <sub>a</sub> )	Value (v <sub>a</sub> )
Dry E,	Dominating object, (支配對象) (For What)	Cloth
		Mother
	Tools,	Clothes dryer
	Dry E,	Dry E, Dominating object, (支配對象) (For What) Acting object, (施動對象) (Who to do)



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# Relation-element (關係元)



• The relationship between product parts are explained as follows.

Relation- element	Relationship name	Characteristic	Value
	Up and down relation,	Antecedent,	Bottle cap
R(Ketchup bottle)=		Consequent,	Bottle body
		Maintaining mode,	Spiral

# Relation-element (關係元)



• When the elements of the relation-element are changed, different ideas can be generated, which can eventually become new products and business models.





Relation-element - Bottle Body and Cap of Tomato Sauce Bottle

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## Extension (拓展)

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• The second step of the Four-step Extension Innovation Method is named "Extension". It contains "Divergence", "Correlative", "Implication" and "Opening-up". The following is a brief introduction to these four extension analysis.

「發散樹」 Divergence 「相關網」 Correlative



「蘊含系」Implication

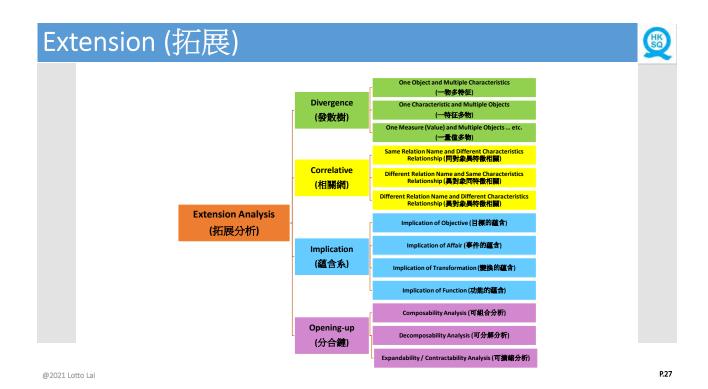


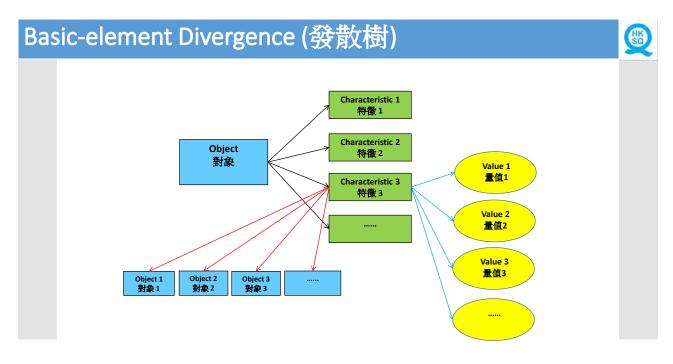
「分合鏈 」 Opening-up



 Using the above four extension analysis methods, it is not limited by the few characteristics of the thing itself, and it truly achieves creativity without limits.

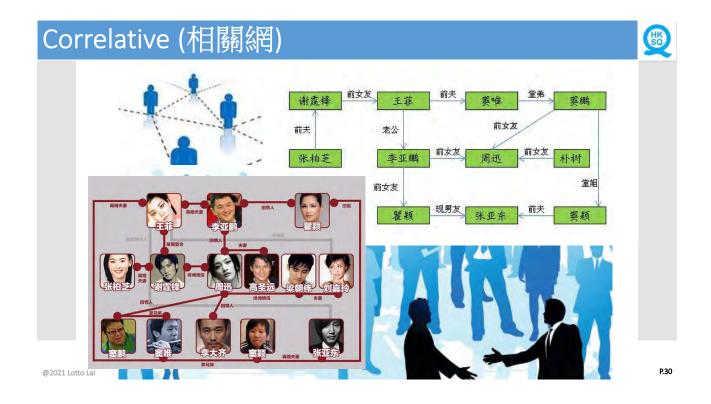
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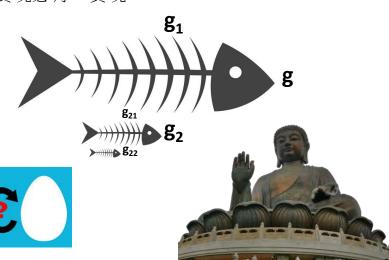




## Implication (蘊含系)



- 「若p則q」(p→q)。
- 若B1實現必有B2實現, B1 => B2。

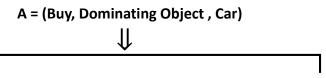


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# Implication Analysis (蘊含關係方法)





 $A_1$  = (Buy, Dominating Object, Petrol)

A<sub>3</sub> = (Buy, Dominating Object, Insurance)

 $\parallel$ 

A<sub>11</sub> = (Go, Dominating Object, Petrol Station)

A<sub>31</sub> = (Go, Dominating Object, Insurance Company) A<sub>2</sub> = (Buy, Dominating Object, Parking Space)

 $\Downarrow$ 

A<sub>21</sub> = (Go, Dominating Object, Car Park)

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## Opening-up (分合鏈)





## **Opening-up Analysis**

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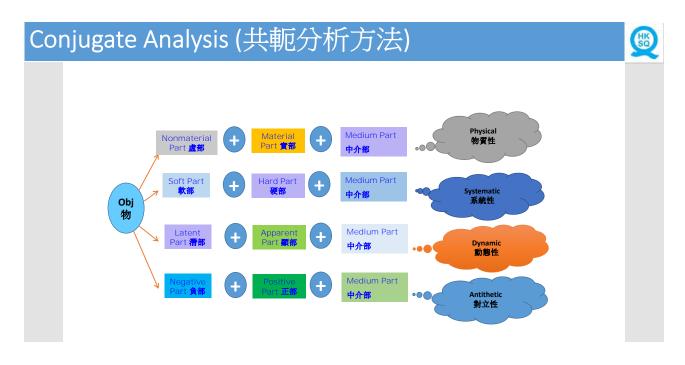


- Both " Breaking up the whole into parts" 「化整為零」 and " Assembling the parts into a whole "「化零為整」 can generate ideas.
- "Breaking up the whole into parts" can turn complex things or problems into simple things or problems to deal with.
- "Assembling the parts into a whole" is about combining complicated things or problems from clutter and fragmentation to achieve a more complete form of expression to solve the problem of contradiction.

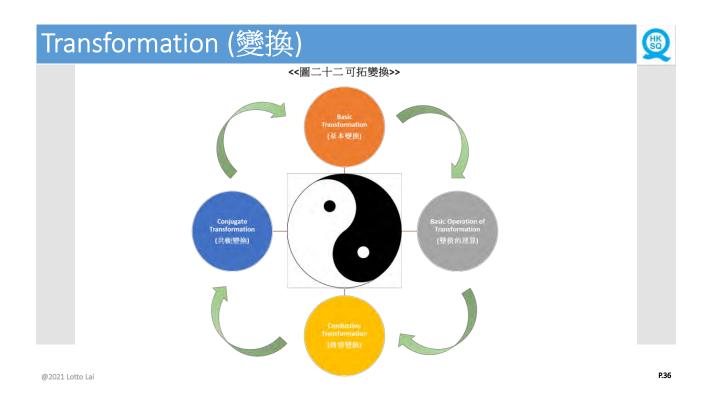




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## Basic Transformation (基本變換)



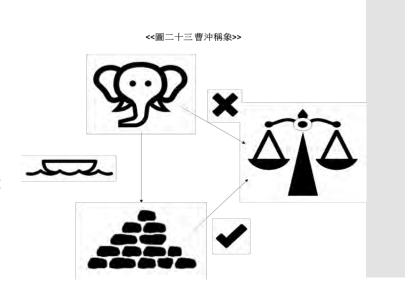
	B(Object)			TB'(Object)		
	Object (對象)	Char (特徵)	Value (量值)	Object (對象)	Char (特徵)	Value (量值)
Substitution (置換)	O <sub>m</sub>			$O_{m}$		
Increase (增)	O <sub>m</sub>			O <sub>m</sub>		
Decrease (減)						
Expansion (擴)	O <sub>m</sub>			O <sub>m</sub>		
Contraction (縮)						
Decomposition 分解)						
Duplication (複制)						

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# Cao Chong weighs the elephant (曹沖稱象)



- Use Cao Chong's story to weigh elephant to describe "Substitution Transformation" 「置 換變換」 with basicelement.
- Using a scale that can only weigh 100 kg to weigh an elephant that more than 100 kg has become an incompatibility issue (Contradiction).



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# Cao Chong weighs the elephant (曹沖稱象)



• The elephant replaces into stone, and the boat acting as an intermediary, it can be extended from weight to buoyancy, which solves this incompatibility problem.

物元 Matter-element							
對象 Object	特征 Char	量值 Value					
Elephant E	Weight	x kg					
Balance D	Scale	100 kg					

事元 Affair-element								
對象 Object	特征 Char	量值 Value						
Weight	Dominating object, (支配對象)	Elephant E						
	Tool	Balance D						

Before Transformation											
對象 Object	特征 Char	量值 Value									
Weight	Dominating object, (支配對象)	Elephant E									
	Tool	Balance D									

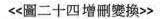
After Transformation											
對象 Object	特征 Char	量值 Value									
Weight	Dominating object, (支配對象)	Stone S									
	Tool	Balance D									

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## Increase Transformation (增加變換)



- 1) Increase Transformation (Action · Characteristic · Value)
  - (Pack · Dominating Object · Milk) ⊕ (Measure · Dominating Object · Temperature) = Temperature Indicated Milk Bottle













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## Decrease Transformation (減刪變換)



- 2) Decrease Transformation (Object · Characteristic · Value)
  - (Mobile \ Function \ Call  $\oplus$  Camera  $\oplus$  App)  $\Theta$  (Mobile \ Function \ Camera  $\oplus$  App) = Elderly Mobile

#### <<圖二十四增刪變換>>







删除模塊的顯 示,比如日曆, 音樂,圖庫, 計算器等等。





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# Expansion Transformation (擴大變換)



1) In entertainment, the giant is by expanding of the human.





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## Contraction Transformation (縮小變換)



2) In entertainment, Ant-Man is to shrink human.

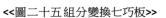


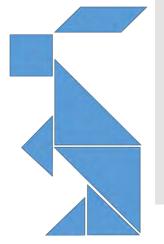
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#### Composition & Decomposition Transformation (組分變換)



 In terms of generating creativity, the simplest example is Tangram. It is a square made up of seven boards.
 Due to different combinations and transformations, these seven boards can be assembled into ever-changing graphics





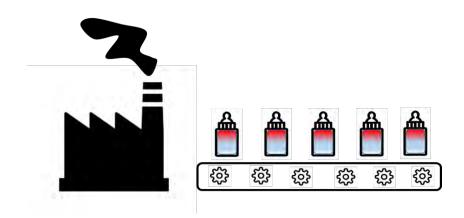
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#### Duplication Transformation (複製變換)



 Production is often used multiple duplication. There is a prototype product, and then a large number of copies for production.

<<圖二十六複製變換>>



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#### Selection (選擇) - Superiority Evaluation Method (優度評價方法)



- Determining measuring indicator according to the practical
- Selecting the type of superiority
- Determining the weight coefficient of measuring indicator
- First evaluation by the indispensable indicator
- Establishing dependent function and calculating dependent degree
- Calculating standard dependent degree
- Calculating the superiority
- Selecting the scheme with higher superiority

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## Selection (選擇) - Example



- Using Quality Innovation Engineering Course M(QIE) as example:
- Dependent Functions (關聯函數)

The 3 credit course of Quality Innovation Engineer (QIE) has 39hr and the range is <36,42>. (X = <36,42>; M = 39)



Use Simple Dependent Function (簡單關聯函數) X = <a,b> and (a,b) a M

$$k(x) \begin{cases} \frac{x-a}{M-a,} & x \leq M \\ \frac{b-x}{b-M} & x \geq M \end{cases}$$

$$k(x) \begin{cases} \frac{x-36}{39-36}, & x \le 39 \\ \frac{42-x}{42-39}, & x \ge 39 \end{cases} = k(x) \begin{cases} \frac{x}{3} - 12, & x \le 39 \\ 14 - \frac{x}{3}, & x \ge 39 \end{cases}$$

When x = 30 hr, k(30) = -2 When x = 33 hr, k(33) = -1 When x = 36 hr, k(36) = 0 When x = 38 hr, k(38) = 0.67 When x = 39 hr, k(39) = 1 When x = 41 hr, k(41) = 0.33 When x = 42 hr, k(42) = 0 When x = 48 hr, k(48) = -1

Use Discrete Dependent Function (離數型關聯函數) for Trainer Qualification shown as follow.

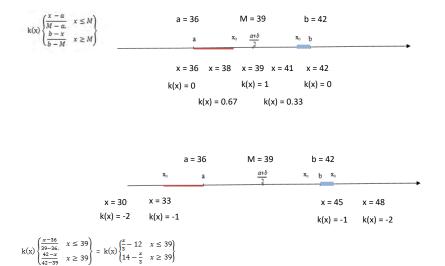
$$k(x) = \begin{cases} 2, & x = Excellence \\ 1, & x = Good \\ 0, & x = Average \\ -1, & x = Bad \\ -2, & x = Very \ Bad \end{cases}$$

The Trainer Qualification should be at least Average where  $k(x) \ge 0$ .

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## 1D - Dependent Functions (關聯函數)





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#### 案例分析:适合背少年的选优评价表

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第一步: 填写创意名称、创意评价要点,并分配重要级别

创意名称	评价要点	重要级别(★分配方案)
21/2/ H M	71712711	±2,40,71 (7,7 H2,7 ),7,7





第一步: 填写创意名称、创意评价要点,并分配重要级别。

创意名称	评价要点	重要级别(★分配方案)	评价标准
	新颖性	***	****
一种防滑	实用性	***	请根据评价要点重要程度,将这 10 颗★分到左边的 3 个空格里,★越多则
**	制作成本	****	该评价要点越重要, 你会如何分配呢?

可拓创新方法在深圳的普及推广及应用-鄞汉藩 (2018)



#### 案例分析。适合青少年的选优评价表

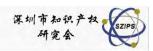
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第二步: 填写创意方案, 并给每个方案的各个评价要点打分。

方案	评分要点	评分(分)	评分标准				
磁铁柄勺子	新颖性	2					
	实用性	1					
	制作成本	1					
不倒翁勺子	新颖性	3	很好(3分)				
人。	实用性	3	好(2分) 一般(1分)				
	制作成本	1	差(0分)				
带钩勺子	新颖性	1					
	实用性	3					
	制作成本	2					

# 第 案例分析: 适合背少年的选优评价表



#### 第三步: 计算优层(优度=第1重要级别×分数+第2重要级别×分数+第3重要级别×分数)。

评分要点	重要级别(★)	评分(分)	列算式	总分(分)
新颖性	3	2	3×2+3×1+4×1	
实用性	3	1	=6+3+4	13
制作成本	4	1	=13	
新颖性	3	3	3×3+3×3+4×1	
实用性	3	3	=9+9+4	22
制作成本	4	1	=22	
新颖性	3	1	3×1+3×3+4×2	
实用性	3	3	=3+9+8	20
制作成本	4	2	=20	
	新颖性 实用性 制作成本 新颖性 实用性 制作成本 新颖性	新颖性 3     实用性 3     制作成本 4     新颖性 3     实用性 3     制作成本 4     新颖性 3     实用性 3     制作成本 4     新颖性 3     实用性 3	新颖性     3     2       实用性     3     1       制作成本     4     1       新颖性     3     3       实用性     3     3       制作成本     4     1       新颖性     3     1       实用性     3     3	新颖性     3     2     3×2+3×1+4×1       实用性     3     1     =6+3+4       制作成本     4     1       新颖性     3     3×3+3×3+4×1       实用性     3     3     =9+9+4       制作成本     4     1       新颖性     3     1     3×1+3×3+4×2       实用性     3     3     3×1+3×3+4×2       实用性     3     3     3×1+3×3+4×2       三次日性     3     3     3×1+3×3+4×2

## Summary on Extension Innovation Table (可拓創意生成表)



			e Ana			jugate				Exte	nsion	Trans	forma	ation (	可拓!	變換)				ation	
		(可狂	· 			(共軛	分析)		Ва	sic Tr (基	ansfo 本變		on			perati 扚運算			(評	(評價)	
Objective or Condition (目標或條件)	Divergence (發散)	Correlative (相關)	Implication (蕴含)	Extensible (可據)	Nonmaterial / Material (虛實)	Soft / Hard (軟硬)	Latent / Apparent (潛順)	Negative / Positive (負正)	Substitution (置換)	Increase & Decrease (增減)	Expansion & Contraction (擴縮)	Decomposition (分解)	Duplication (複制)	Product (積變換)	AND (與變換)	OR (或變換)	Inverse Operations (逆雙換)	Idea (主意)	Feasibility (可行性)	Superiority (優度)	Innovation (創意)
Object (對象)																					
Characteristic (特徵)																					
Value (量值)																					
Criterion (準則)																					
Universe of Discourse (論域)																					

#### Extension Innovation Method Training and Certification Exam





- 20170331: Extension Innovation Method Trainer Course Level 1 https://qualityalchemist.blogspot.hk/2017/03/extension-innovation-method-trainer.html
- 20170409: Extension Innovation Method Trainer Course Level 2 https://qualityalchemist.blogspot.hk/2017/04/extension-innovation-method-trainer.html
- 20170514: Extension Innovation Method Trainer Course Level 3 Part 1 https://qualityalchemist.blogspot.hk/2017/05/extension-innovation-method-trainer.html
- 20170528: Extension Innovation Method Trainer Course Level 3 Part 2 https://qualityalchemist.blogspot.hk/2017/05/extension-innovation-method-trainer\_28.html

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## Application Case Study (I)



#### Mainland China cases

- 1. "Intelligent Fitting Model of Emotional Basic-Element" (仝小冬、尚会超 情感化造型基元的智能拟合模型).
- 2. "Research on the Innovative Design of Baoshui Village Reconstruction in Fangshan District, Beijing based on Extension Theory" (王涛、李文杰 基于可拓理论的北京市房山区宝水村改造创新设计研究).
- 3. "The Interior Design of Driverless Car based on Extension Theory" (王体春、许枫魁 基于可 拓理论的无人驾驶汽车内饰设计).
- 4. "The Shelf Structure Design of Automated 3D Warehouse based on Extension Innovation Method" (郭恒发、李兴森 基于可拓创新方法的自动化立体仓库的货架结构设计).

2021年8月15日

腾讯会议

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#### Application Case Study (II)



#### Hong Kong cases

- Extenics + Quality Startup Management System (2017)
- 2. Extension Business Innovation Model Approach in Covid-19 Outbreak Situation (2020)
- 3. A Case Study of Extenics Six Sigma (ExSS) Approach - The Automation Process of Pills Package for Elders (可拓六西格玛(ExSS)方法的案例研究 - 药板包裝自动化过程) (2018)
- 4. Preliminary Study on QMS based Innovation Management System (QInnoMS) with Extension Innovation Methodology (2019)

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Value a

Customer C1

10:30pm

On Street

Taxi driver

Customer C1

Taxi driver

PolyU

CityU

Value

Taxi

Taxi

(施動對象) (Who to do) Customer C1

#### New business model / service for Startup



#### **Example: Car Rental**

Dominating object,

(支配對象) (What)

Acting object,

Start Location

End Location

(支配對象)

(施動對象)

(施動對象)

Acting object,

Acting object,

Dominating object,

Method

<u>Driver</u> Object Extension Char Extension

Time

Receiving object,

(接受對象) (To Whom)

Object a

Booking B1

Sitting S1

Driving



Value - Extension

Taxi

Customer C1

Customer C1

Taxi driver

Value - Extension

Customer C1 +

(Lady only)

Taxi driver

10:30pm

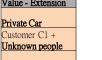
PolyU

CityU

Taxi

八折的士

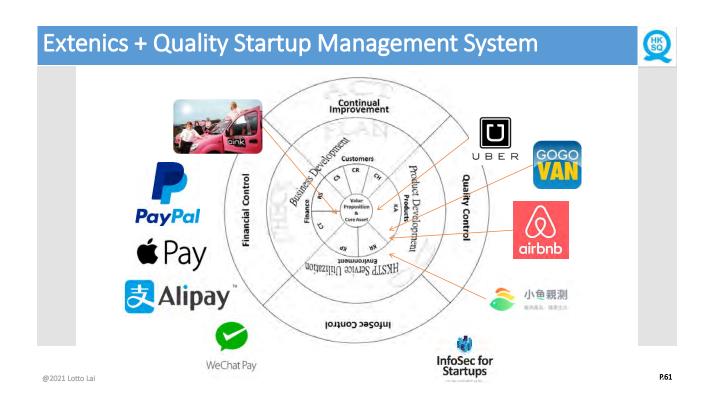






Car owner

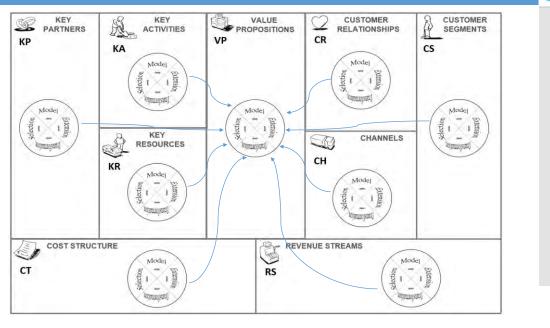
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#### The Business Model Canvas





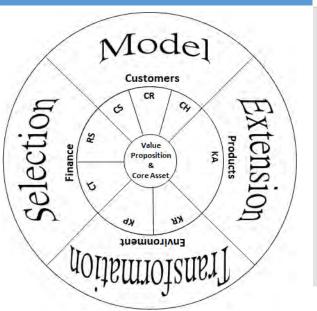
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## Extension Business Innovation Model (ExBIM)



 The overall model could be presented by integrated all blocks into one model for four group and under a big METS Cycle. The final approach named Extension Business Innovation Model (ExBIM).



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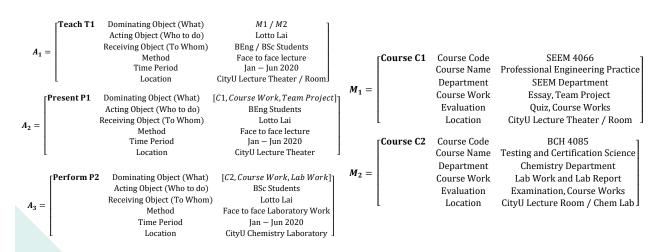
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#### Using CityU degree teaching as example

- For BMC, Customer Value Infrastructure is focused for this study that "CS to VP to CH (plus KA) to CR to RS".
- We provide quality education service through the Channel (CH) included face-by-face teaching, group discussion, technical visit and laboratory workshop those are our Key Activities (KA).
- Using METS to describe the key process, the first step is Modelling. Affairelement and Matter-element are employed to demonstrate the problem (P), goal (g) and condition (1) in this case study.

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#### Model Phase:



#### Condition / Limitation (1)

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#### Core Problem: P = g₀ ↑ 1₀

Goal (g):

• 
$$A_1 = \begin{bmatrix} \text{Teach T1} & \text{Dominating Object (What)} & M1 / M2 \\ & \text{Location} & \text{CityU Lecture Theater / Room} \end{bmatrix}$$

• 
$$A_2 = \begin{bmatrix} \text{Present P1} & \text{Dominating Object (What)} & [C1, Course Work, Team Project] \\ & \text{Location} & \text{CityU Lecture Theater} \end{bmatrix}$$

• 
$$A_3 = \begin{bmatrix} Perform P2 & Dominating Object (What) & [C2, Course Work, Lab Work] \\ Location & CityU Chemistry Laboratory \end{bmatrix}$$

Condition (1):

Condition (1):

• 
$$A_4 = \begin{bmatrix} \text{Isolate I1} & \text{Dominating Object (What)} & \text{Infection chain} \\ & \text{Location} & \text{At home} \end{bmatrix}$$

#### Extension Analysis Phase

```
A_1 = (\textbf{Teach T1} \quad \text{Method} \quad \text{Face to face lecture}) - |
\left\{ \begin{array}{l} A_1' = (\textbf{Teach T1} \quad \text{Method} \quad \text{Online Lecture}) \\ A_1'' = (\textbf{Teach T1} \quad \text{Method} \quad \text{Recorded Video Lecture}) \end{array} \right.
T_{11}A_1 = A_1' \text{ and } T_{12}A_1 = A_1''
A_2 = (\textbf{Present P1} \quad \text{Method} \quad \text{Face to face lecture}) - |
\left\{ \begin{array}{l} A_2' = (\textbf{Present P1} \quad \text{Method} \quad \text{Online Lecture}) \\ A_2'' = (\textbf{Present P1} \quad \text{Method} \quad \text{Video Presentation}) \end{array} \right.
T_{21}A_2 = A_2' \text{ and } T_{22}A_2 = A_2''
A_3 = (\textbf{Perform P2} \quad \text{Method} \quad \text{Face to face Laboratory Work}) - |
\left\{ \begin{array}{l} A_3' = (\textbf{Perform P2} \quad \text{Method} \quad \text{Video Demonstration}) \\ A_3'' = (\textbf{Perform P2} \quad \text{Method} \quad \text{Using Past Data Set}) \end{array} \right.
T_{31}A_3 = A_3' \text{ and } T_{32}A_3 = A_3''
```

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#### Transformation Phase:

- $Z_1 = T_{11}A_1$  (Online Lecture)
- $Z_2 = T_{12}A_1$  (Recorded Video Lecture)
- $Z_3 = T_{21}A_2$  (Online Presentation)
- $Z_4 = T_{22}A_2$  (Video Presentation)
- $Z_5 = T_{31}A_3$  (Perform Video Demonstration)
- $Z_6 = T_{32}A_3$  (Perform Using Past Data Set)
- $Z_7 = T_{11}A_1 \wedge T_{12}A_1$  (Online and Video Lecture)
- $Z_8 = T_{21}A_2 \wedge T_{22}A_2$  (Online and Video Presentation)
- $Z_9 = T_{31}A_3 \wedge T_{32}A_3$  (Video Demonstration & Using Past Data Set)

#### Selection Phase

The **indispensable indicator** is no risk for student to be inflected COVID-19 virus in university during teaching or laboratory practice activities.

Solution of Transformation	MI <sub>1</sub>	MI <sub>2</sub>	MI <sub>3</sub>	MI <sub>4</sub>	MI <sub>5</sub>	Total
i) $C(Z_1) = T_{11}A_1$ (Online Lecture)	0.2	0.4	0	0.4	0.4	1.4
i) $C(Z_2) = T_{12}A_1$ (Recorded Video Lecture)	0	0.4	-0.4	0.4	0.4	0.8
i) $C(Z_3) = T_{21}A_2$ (Online Presentation)	0	-0.2	0.2	0.4	0.4	0.8
i) $C(Z_4) = T_{22}A_2$ (Video Presentation)	0.2	0.2	-0.4	0.2	0.4	0.6
i) $C(Z_5) = T_{31}A_3$ (Perform Video Demonstration)	0.2	0.2	-0.4	0.2	0.4	0.6
i) $C(Z_6) = T_{32}A_3$ (Perform Using Past Data Set)	0.2	0.2	-0.2	0.2	0.4	0.8
i) $C(Z_7) = T_{11}A_1 \wedge T_{12}A_1$ (Online and Video Lecture)	0.4	0.4	2	0.4	0.4	1.8
i) $C(Z_8) = T_{21}A_2 \wedge T_{22}A_2$ (Online and Video Presentation)	0.4	0.4	0.4	0.4	0.4	2
i) $C(Z_9) = T_{31}A_3 \wedge T_{32}A_3$ (Video Demonstration & Using Past Data Set)	0.4	0.4	0.0	0.4	0.4	1.6

(I<sub>n</sub> = Knowledge Transferability, Practicability, Interactive Level, IT Facility Support and Safety Responsible to Students & Staff)

#### Three strategies

- Campus-wide and real-time online teaching for postgraduate and undergraduate students according to schedule using Zoom and recorded in video also provided under Zoom for student re-study afterward.
- In order to keep the Student team project presentation management smoothly, it suggests to ask students prepared video and playing during the lecture for discussion. It will achieve both time management and interaction.
- Laboratory workshop is most challenge. It suggested to use video for calibration demonstration first and then using past data set for calculating the result



# A Case Study of Extenics Six Sigma (ExSS) Approach - The Automation Process of Pills Package for Elders

可拓六西格玛(ExSS)方法的案例研究-药板包裝自动化过程

> Lotto Lai Chairman of HKSQ

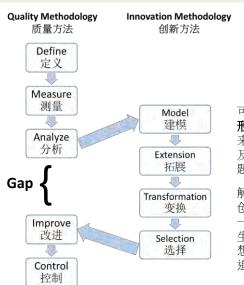


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#### Extenics Six Sigma (ExSS) model - "DMA-METS-IC"



观察到"分析阶段"和"改进阶段"之间的差距,头脑风暴不是一個系统方法去思考创造性和创新性解决方案。



可拓学使用 **形式化语言** 来表达问题 及找出核问 题。

解决问题的 创新思想是 一步一步产 生的,这个 想法是可以 追溯的。

# 7x4 rectangular drug board (矩形七天药板)



• A 7x4 rectangular drug board with twenty-eight spaces contains the dosage around one week for a patient.

有28个空格的7x4长方形药盒包含一名患者约一周的剂量。





自动包装系统的流程如下:

- 1. 手动将药丸放入容器中
- 2. 检查剂量(如果药丸的 剂量是一半然后切丸)
- 3. 机器拿起药丸,放入矩 形七天药板
  - 检查矩形七天药板中药 丸的种类和药丸的剂量 (药剂师)
- 5. 如果通过检查,密封七 天药板
- 6. 交付给老人

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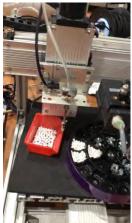
# Problem Statement and Scope (问题陈述和范围)



Failure rate of the machine is too high because the robotic suction cup cannot pump the pill successfully.

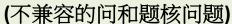
该机器的故障率太高,因为机器吸盘不能成功地泵送药丸。







#### **Incompatible Problems & Core Problems**







A1 =

Goal (g<sub>0</sub>): 对象 量值 拾起 E1 药物 D1 支配對象 (What) 精准度 低 Condition (l<sub>0</sub>): 对象 量值 特征 很多 药物 D1 药物的数量 状态 重叠

M1 =

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#### Extension Phase (拓展阶段)



#### Extensible Analysis (可拓分析)



#### Vibration



#### Rotation



#### Transformation Phase (变换阶段)



- Part 1 Change the goal (g<sub>o</sub>):
  - Transformation 1 (T1) is substitution from Pick (E1) to Vibrate (E2). It expresses as T1A1 = A1'
  - Transformation 2 (T2) is another substitution from Pick (E1) to Rotate (E3) that aims to enhance the accuracy of picking medicine. It expresses as T2A1 = A1"
- Part 2 Change the condition  $(I_0)$ :
  - Transformation 3 (T3) is decreased the number of medicine from "Many" to "Middle", and then to "Little" and finally to "One". It expresses as T3M3 = M3'.
  - Transformation 4 (T4) is increased the size of medicine case from X cm<sup>2</sup> to X+Y cm<sup>2</sup>. It expresses as T4M3 = M3".
- Finally, Transformation 5 (T5) is conductive transformation that T1, T2, T3 and T4 that cause to change the status from Drugs Overlapping to Flat. It expresses as T5M1 = ωM1'.

		对象	特征	量值	扩展量值
σM1'	=	药物 D1	状态	重叠	平坦 (T5)

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#### **Basic Operation of Transformation**

(变换的基本运算)

#### 与变换 (AND)

The proposed solutions are showed as follows.

- i) T1A1 (Vibrate E2)
- ii) T2A1 (Rotate E3)
- iii) T3M3 (Reduce no. of medicine)
- iv) T4M3 (Enlarge Drug tray size)
- v) A1 \( \text{T1A1} \) (Pick E1 and Vibrate E2)
- vi) T1A1 \(\times T2A1\) (Vibrate E2 and Rotate E3)
- vii) T3M3 ∧ T4M3 (Reduce no. of medicine and Enlarge Drug tray size)

viii)A1 ∧ T1A1 ∧ T3M3

Pick E1 and Vibrate E2 and Reduce no. of medicine



Vibrator

#### Selection Phase (选择阶段)



Discrete dependent function (k) criteria (關聯函數)

No.	Criteria	Weighting	Range					
			-2	-1	0	1	2	
k1	Size	0.1	Very Large	Large	Average	Small	Very Small	
k2	Cost	0.2	Very Expensive	Expensive	Average	Cheap	Very Cheap	
k3	Accuracy	0.5	Very Bad	Bad	Average	Good	Excellence	
k4	Efficiency	0.1	Very Bad	Bad	Average	Good	Excellence	
k5	Manufacturability	0.1	Very Bad	Bad	Average	Good	Excellence	

Summary of discrete dependent function (k) in each transformed solution

Solution of Transformation	k1	k2	k3	k4	k5	Total
T1A1	-2	0	-1	-1	1	-0.7
T2A1	-2	-1	-1	0	-1	-1
T3M3	0	-1	0	-1	1	-0.2
T4M3	-2	0	-1	-1	1	-0.7
A1^ T1A1	0	0	1	0	1	0.6
T1A1 ∧ T2A1	-2	0	-1	-1	-2	-1
T3M3 ∧ T4M3	-2	0	0	-1	1	-0.2
*A1 ^ T1A1 ^ T3M3	0	-1	2	1	1	1.0

 $<sup>\</sup>mbox{\ensuremath{^{\star}}}$  The combination of Pick A1 plus Vibrate and Reducing number of medicine is found the most superiority in the ranking

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#### Prototype to Final Machine (2018 – 2020)







#### 香港品質學會

#### **Hong Kong Society for Quality**





#### **Preliminary Study on QMS based Innovation Management System** (QInnoMS) with Extension Innovation Methodology

#### Dr. Lotto LAI

Chairman of Hong Kong Society for Quality (HKSQ) Adjunct Professor, SEEM Dept., CityU 中國人工智能學會可拓學專業委員會委員 廣東工業大學可拓學與創新方法研究所兼職研究員 及可拓學學術交流中心副主任

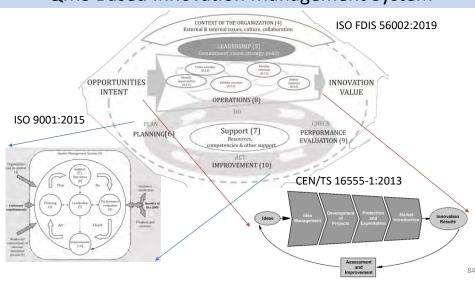


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#### QMS Based Innovation Management System



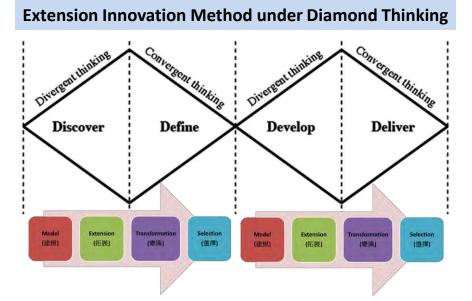


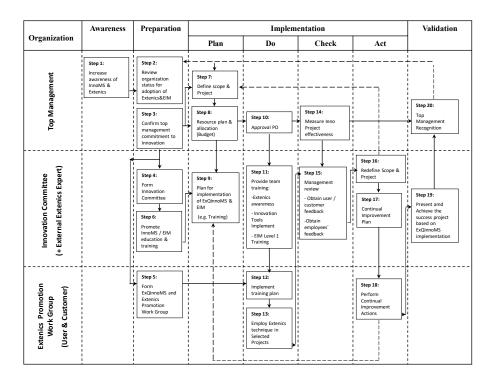
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#### My other conference papers & book



- Lai, Lotto K.H. (2020) "Extension Business Innovation Model Approach in Covid-19 Outbreak Situtation" Proceedings of the 18th ANQ Congress in Seoul, Korea, ANQ-023.
- Lai, Lotto K.H. (2019) "The Logic of Innovation: Extenics" (創新之理則一介紹中國原創學科「可拓學」), Hong Kong Society for Quality (香港品質學會), Dec 2019.
- Lai, Lotto K.H. (2019) "QMS based Innovation Management using Extension Innovation Methodology" *Proceedings of the 17th ANQ Congress in Bangkok, Thailand, ANQ1-003/HK-1*.
- Lai, Lotto K.H. (2018) "Quality Innovation using an Extenics Six Sigma (ExSS) Approach and a Case Study" Proceedings of the 16th ANQ Congress in Almaty, Kazakhstan, A6/HK-1.
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- Lai, Lotto K.H. (2017) "Quality Innovation: Extenics employed in Quality Startup Management System" The 2<sup>nd</sup> International Academy for Quality – World Quality Forum, Stream C, C2 session.

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# 創新之理則——介紹中國原創學科「可拓學」





**Extenics: The Logic of Innovation** 

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# Achieving a Culture of Innovation based on "Extenics"





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