香港大學教育學院 教育應用資訊科技發展研究中心 (CITE)

知識交流工作坊系列｜知識交流工作坊(一)

如何透過 STEAM 課程培養學生的科學探究素養

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Problem Solving in STE(A)M Education

STE(A)M 教育與二十一世紀能力

21 Century Skills (二十一世紀能力)

- Creativity and innovation (創新能力)
- Applying knowledge and skills (應用知識和技術的能力)
- Using technology (IT, Media, etc.) (使用科技的能力)
- Communication (溝通能力)
- Collaboration (協作能力)
- Critical thinking (批判思維能力)
- Problem-solving (解難能力)

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- **Problem-solving (解難能力)**

What is the aims of STEM Education in HK ?

- Is STEM Education a mean or an end ?
- STEM Education is a mean to ……

"**APART** from cultivating students' interest in Science, Technology and Mathematics, and developing among them a solid knowledge base, we **AIM** to ***strengthen*** students' ability to ***integrate and apply*** **knowledge and skills across different S.T.E.M disciplines**, and to ***nurture*** their **creativity, collaboration and problem-solving skills**, as well as to ***foster*** their **innovation and entrepreneurial spirit** as required in the 21st century."

(Report on Promotion of STEM Education – Unleashing Potential in Innovation, EDB Hong Kong, 2016, p.i)

What are S.T.E.M ? (3 Key Terms– From NGSS)

- 3 key terms defined in broad ways (Putting the E in STEM in Teaching and Learning, p.3)

- Science is usually defined as both knowledge of how the natural world works as well as the practices we employ to determine those understanding

- Engineering is a *systematic and often iterative approach* to *designing objects, processes, and systems* to meet human needs and wants. (NRC,2012 p.202)

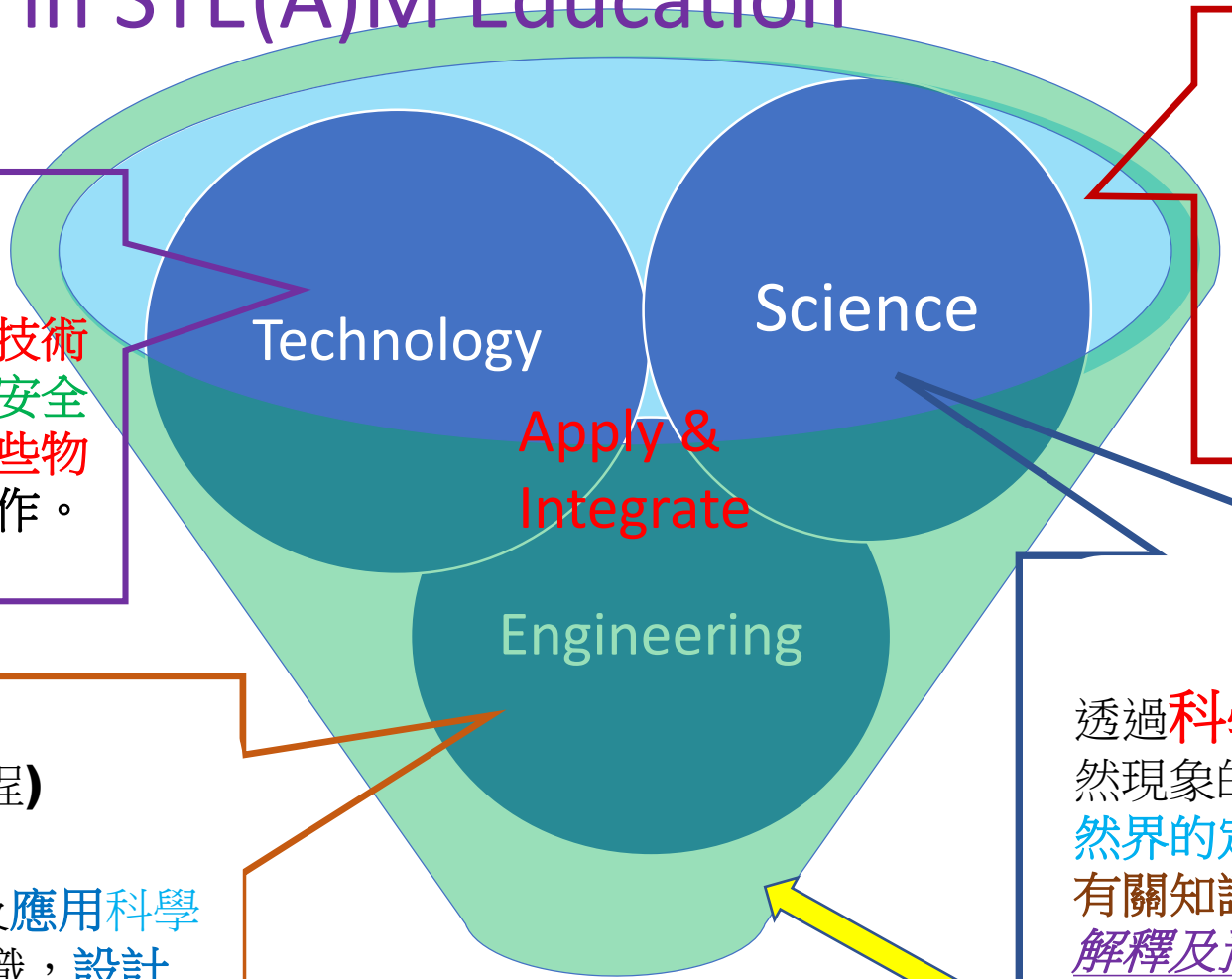
- **Technology is the *product of engineering***. Technologies result when engineers *apply their understanding of the natural world* and of *human behavior* **to design ways** to satisfy human needs and wants. (NRC, 2012,p.12)

Science Practices and Engineering Practices

Simplified version:

- Asking questions (for science) *and defining problems* (for engineering)
- Developing and using models (models should contain organized science ideas)
- Planning and carrying out investigation
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) *and designing solutions* (for engineering) (explanation should based on accepted theories/models)
- Engaging in argument from evidence
- Obtaining, evaluating and communication information

Problem Solving in STE(A)M Education



Technology (技術)

包括有關物料、工具、程序、技術系統、軟件系統的知識；以及安全地、有效地、具創意地使用這些物料、工具及系統完成面對的工作。

Mathematics (數學)

透過邏輯思維處理數量、數據、關係和空間等的變化及其關係，可支援科學探究或工程設計等過程.

Science(科學)

透過科學探究(SI)過程找出有關自然現象的解釋，從而找出相關的自然界的定律，建立科學理論和梳理有關知識讓我們能就自然現象*作出解釋及預測*

Engineering (工程)

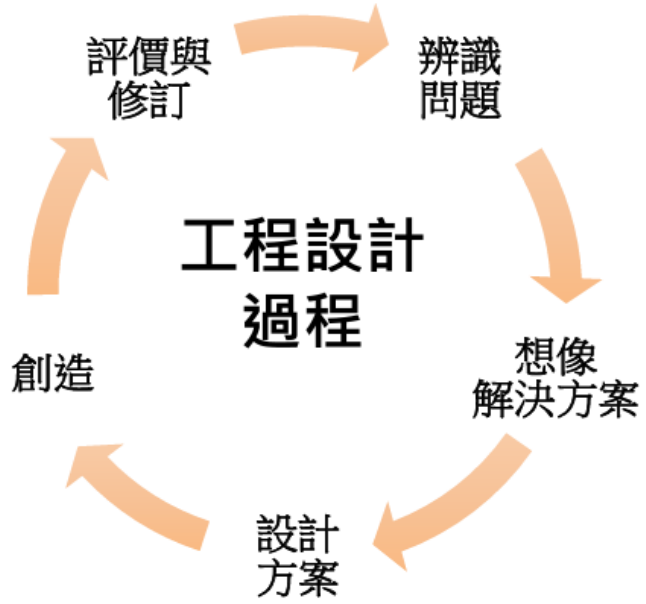
透過工程設計(E)的理念及應用科學(S)、技術(T)及數學(M)的知識，設計及製造產品以解決所面對的實際問題

Values

現實問題的背景及要求:
文化、經濟、藝術(Arts)方面

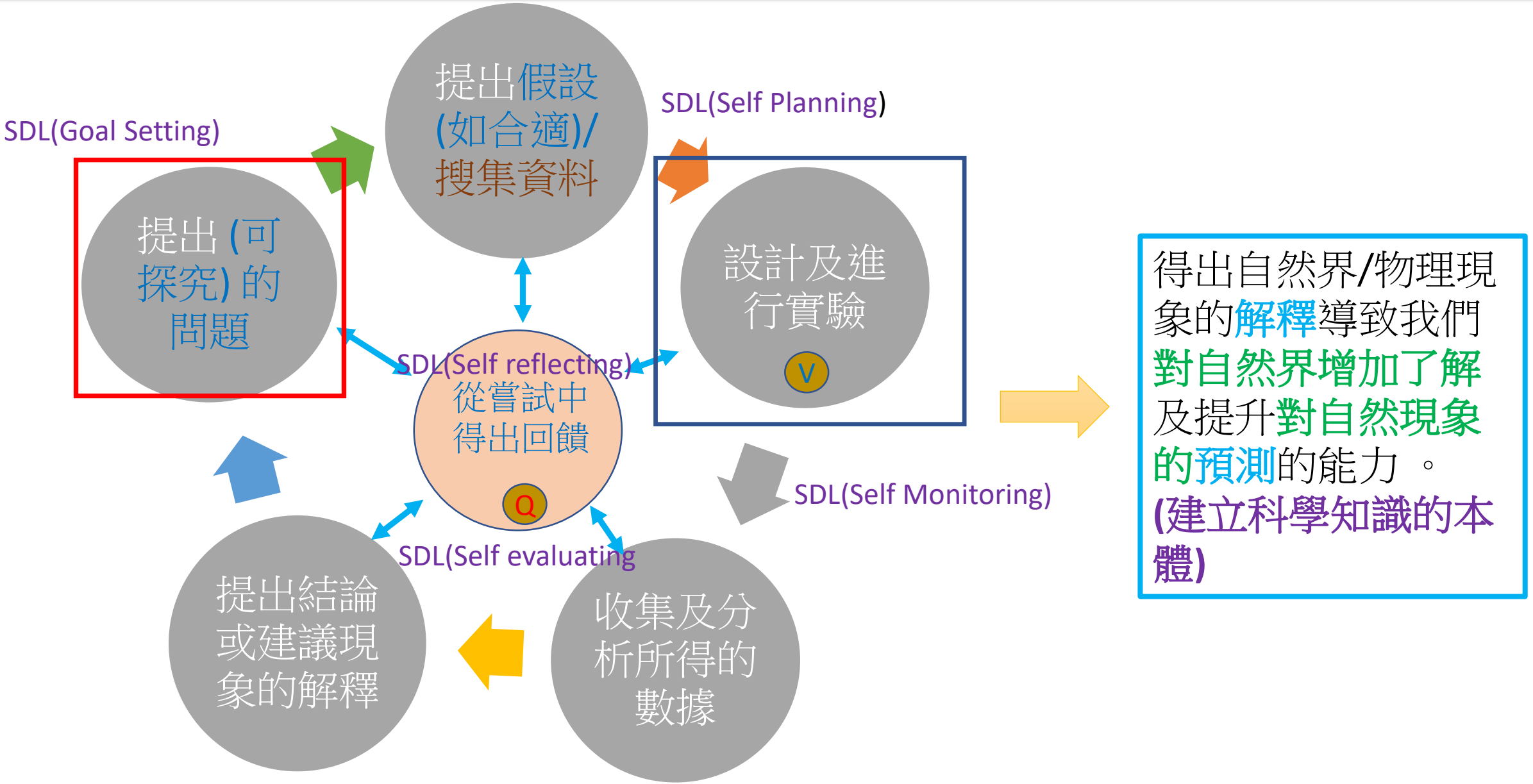
Solving authentic Problems(解決現實問題)

Models for SDL, SI and ED adopted by In-STEM Project, CITE,HKU



Adapted from In-STEM Project, CITE, School of Education, HKU

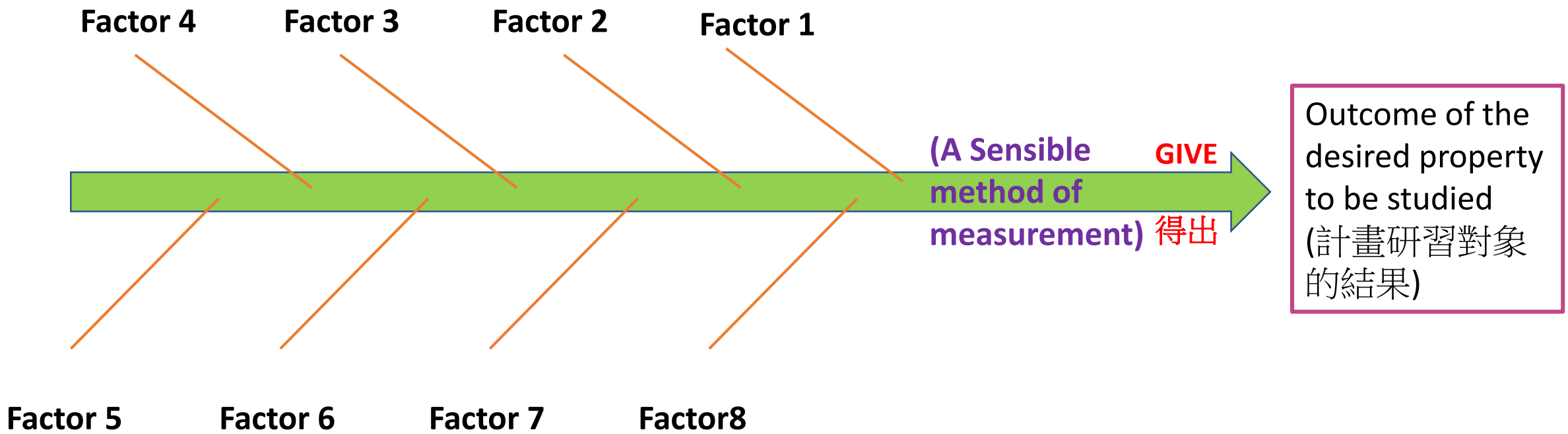
A Science Inquiry Process (一種科學探究過程)



得出自然界/物理現象的**解釋**導致我們**對自然界增加了解**及提升**對自然現象的預測**的能力 。
(建立科學知識的本體)

A Thinking Tool for scientific investigation (To find 'Cause and Effect' (因果關係))

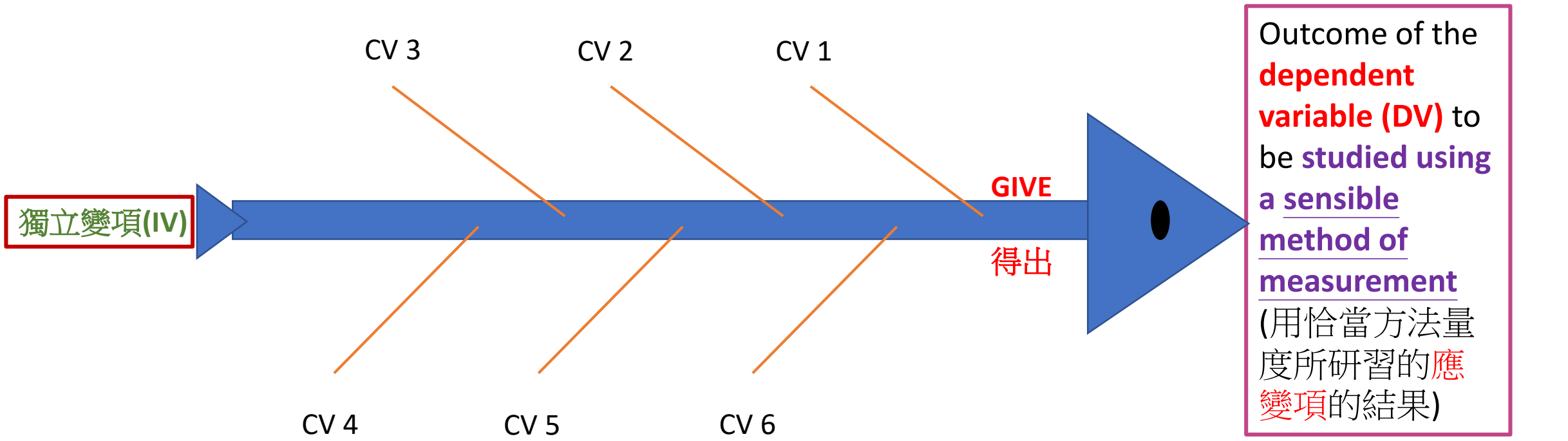
This thinking tool help plan of an experiment to give scientifically sound results



Factors that affect the experimental outcomes(影響實驗結果的各種因素)

(1) One type of scientific investigation: Experimental Investigation

(To find 'Cause and Effect' in science inquiry (於科學探究中找出因果關係)



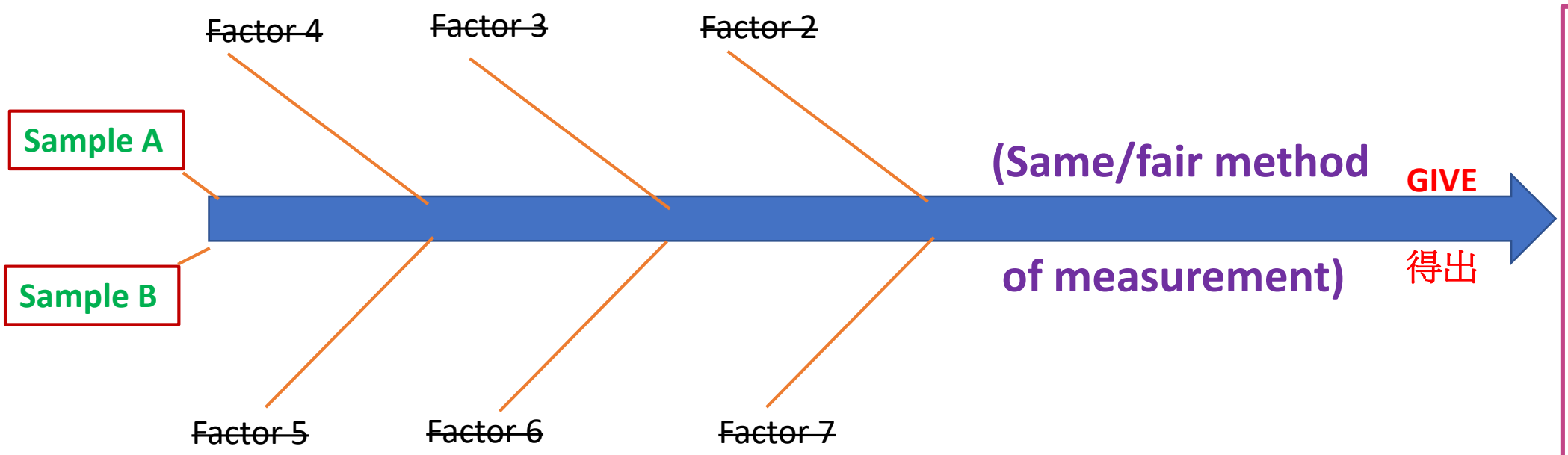
Independent variable (IV) 獨立變項

Controlled variable (CV)控制變項

Dependent variable (DV) 應變項

(2) Another type of scientific investigation : A Comparative Investigation

例子: 消委會的產品測試



Compare the outcomes of the desired property to be studied from the two samples in a fair way.
(公平地比較計畫研習對象的結果)

(3) Another type of scientific investigation : A descriptive Investigation

To provide factual, accurate and systematic descriptions of phenomena based on accepted method without attempting to infer causal relationships (e.g. a detail record of the structure of a plant through observation)

A few words on FAIR TESTS

Refer to the following example:

https://www.instagram.com/p/CQaLvAJlsUh/

Conclusion from the experimental results (從實驗數據所得的結論):

(1) 果皮的吸油能力: 柚子皮> 橙皮> 荔枝皮> 西瓜皮

(2) 天然原裝果皮的吸油能力: 柚子皮 > 橙皮> 荔枝皮> 西瓜皮

(3) 同一面積的天然原裝果皮的吸油能力: 柚子皮> 橙皮> 荔枝皮> 西瓜皮

*Conclusion/Method of inquiry depends on the inquiry question asked

(結論/探究方法取決於所探究問題)

針對香港較潮濕的情況，測試在恆溫和恆濕的環境搭建一個模擬浴室的小空間，窗口式及天花式樣本（**#1至#9**）以乾衣模式吹乾**相同數量的濕衣物**，包括**5**條棉質面巾、**5**件**T**袖及**2**條牛仔褲。

測試前**先量度每件衣物的重量，再把衣物浸濕，然後用離心脫水機以相同的特定速度和時間脫水，務求做到衣物於每次乾衣測試前的濕度大致相同。掛上濕衣物待乾前，試驗人員會量度濕衣物的總重量，然後把衣物按特定次序掛在樣本的出風口位置，其後持續監察濕衣物重量的變化，直至衣物達到97%乾才結束測試。**

浴室暖風機測試結果

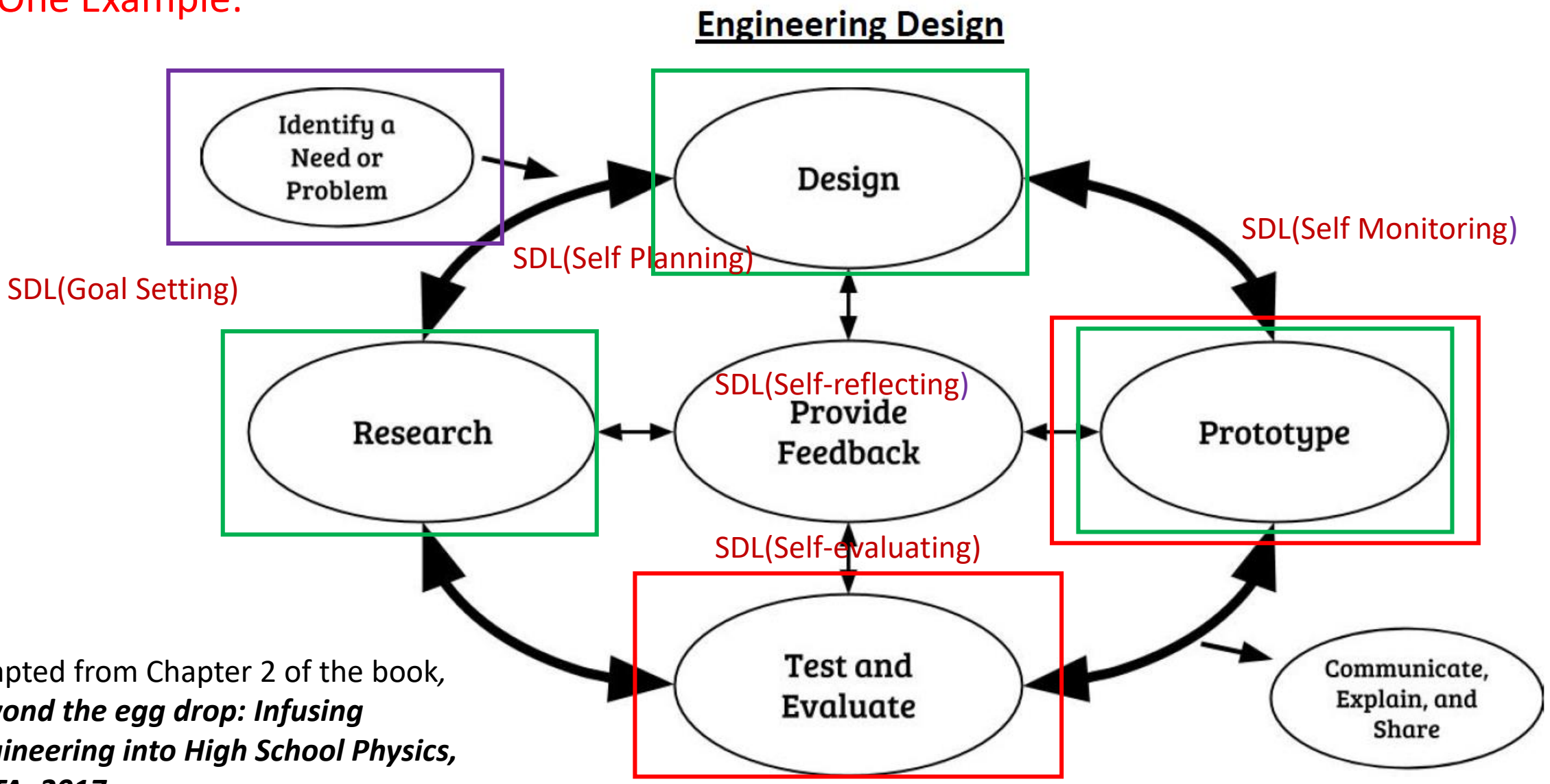
樣本編號	牌子及型號	售價[1]	安裝費[1]	聲稱原產地[2]	型號資料[2]							安全程度[3]					
					重量(kg)	體積大小(高x闊x深)(cm)	最高氣流量(m^3/hr)	額定功率(W)	暖風設定數目	保用期(年)	續保年費[1]	結構及防水效能	功率偏差	標示說明	整體	乾衣速度(小時:分鐘)	
窗口式																	
1	**樂聲 Panasonic** FV-23BWN2H	$3,580	$500	中國	4.8	28x28x28.6	220	1,400	2	1	$580	●●●●●	●●●●●	●●●●●	●●●●●	●●●●	3小時44分鐘
2	**新朗 Cinetron** CV-88W	$2,090	$500	中國	4.6	28x28x22.3	123	1,500	2	2	$430	●●●●●	●●●●●	●●●●●	●●●●●	●●●	5小時38分鐘
3	**草津 Kusatsu** KBF-331RGSC	$3,680	$500	日本	4	28x30x25	190	1,270	2	2	$580	●●●●●	●●●●●	●●●●●	●●●●●	●●●	5小時8分鐘
4	**金章 Zanussi** ZBH1015	$2,580	$380	中國	4	25.4x25.4x21.8	110	1,350	2	1	—	●●●●●	●●●●◖ d	●●●●●	●●●●◖	●●◖	6小時23分鐘
5	**卓爾 Summe** SBH-103	$1,180	—	中國	4	28.2x28.2x21.2	—	1,350	2	1	—	●●●●◖ a	●●●●●	●●●●●	●●●●◖	●●◖	6小時6分鐘
6	**金瑞典 JEE** JBH20	$798	—	中國	3	26.7x26.7x21	120	1,160	1	1	—	●●●●◖ b	●●●●●	●●●●●	●●●●◖	●◖	8小時△
天花式																	
7	**三菱電機 Mitsubishi Electric** V-251BZ-HK	$3,980	—	日本	7.4	36x36x22.7	180	2,100	2	2	—	●●●●●	●●●●●	●●●●●	●●●●●	●●●●	3小時24分鐘
8	**KDK** 30BGCH	$2,980	—	中國	4.9	36x36x21.9	170	1,650	1	1	$780	●●●●●	●●●●●	●●●●●	●●●●●	●●●●	3小時41分鐘
9	**Kohler** K-77316H-MZ	$4,350	—	中國	7.4	30x30x20	132	2,100	1	3	—	●●●●●	●●●●◖ e	●●●●◖ f	●●●●◖	●●●●	3小時17分鐘
移動式																	
10	**德國寶 German Pool** HTW-330	$1,420	—	中國	2.1	39x25x12.5	—	2,000	2	1	—	●●●●●	●●●●●	●●●●◖ g	●●●●◖		
11	**樂信 Rasonic** RA-BH205FY	$980	—	中國	2.2	38.3x24x12.7	—	2,050	2	1	—	●●●●●	●●●●●	●●●●●	●●●●●		
12	**伊瑪 Imarflex** INB-2023R	$799	—	中國	3.1	28.5x16.5x43.1	—	2,050	2	2	—	●●●●●	●●●●●	●●●●◖ g h	●●●●◖		
13	**Thomson** TM-SHT-BH10	$699	—	中國	2.5	14.5x24.4x14.5	—	2,000	2	1	—	●●●●◖ c	●●●●●	●●●●●	●●●●		

There are a lot of representations for Engineering Design Processes (EDP)

A generalized model from NGSS (2013)

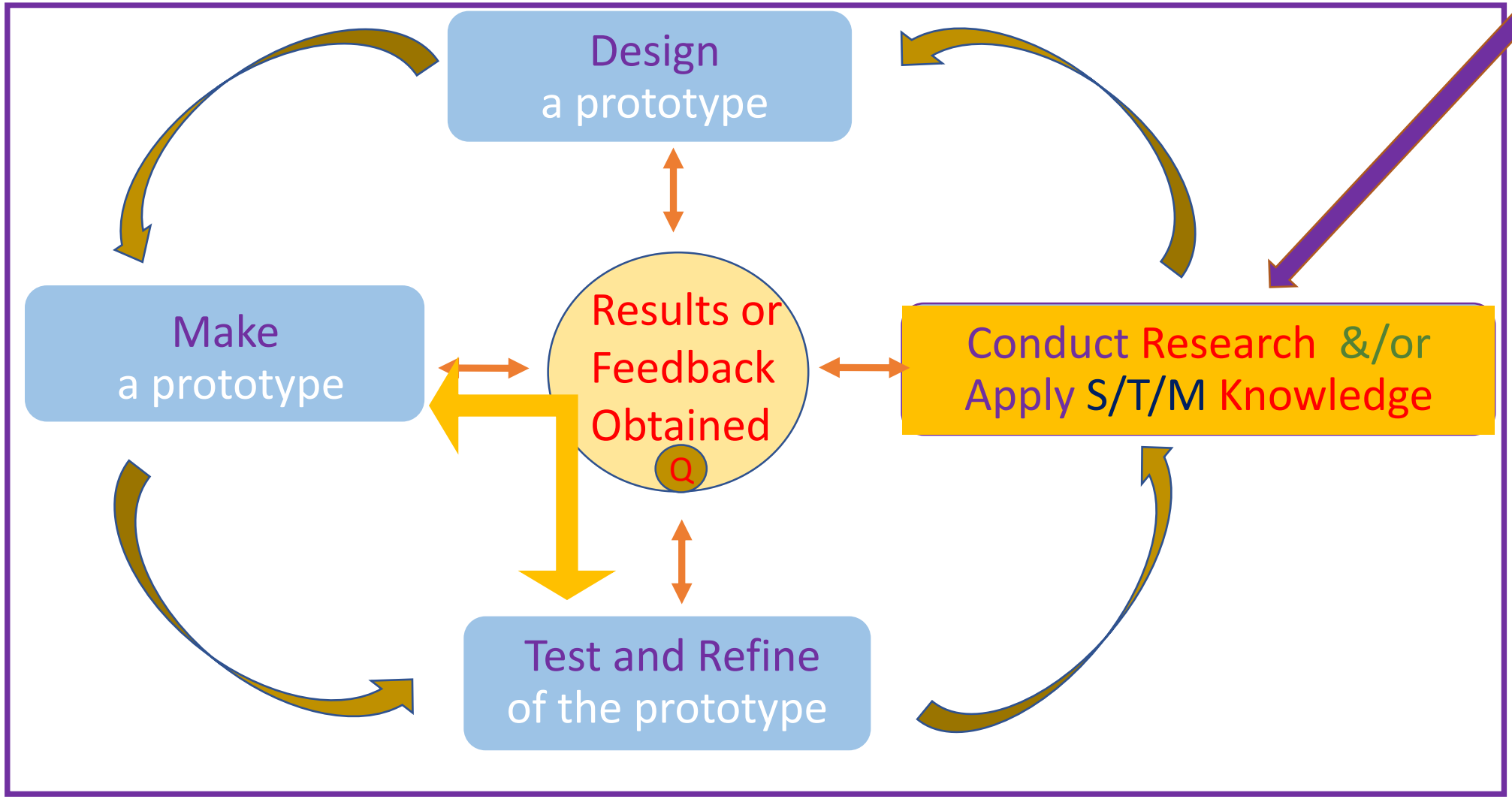
There are a lot of representations for Engineering Design Processes (EDP)

One Example:



Adapted from Chapter 2 of the book,
Beyond the egg drop: Infusing Engineering into High School Physics, NSTA, 2017

Engineering Design Process

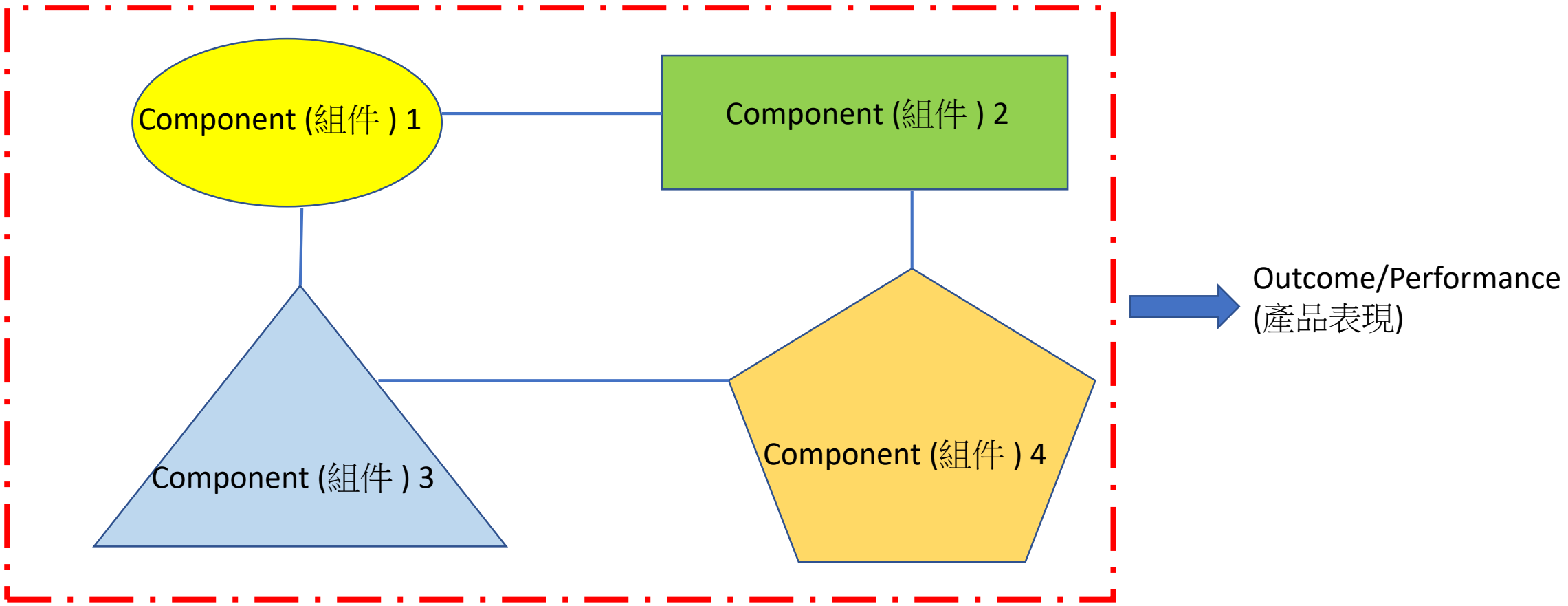


Modified from Chapter 2 of the book, ***Beyond the egg drop: Infusing Engineering into High School Physics, NSTA, 2017***

A Useful Tool for Engineering Design

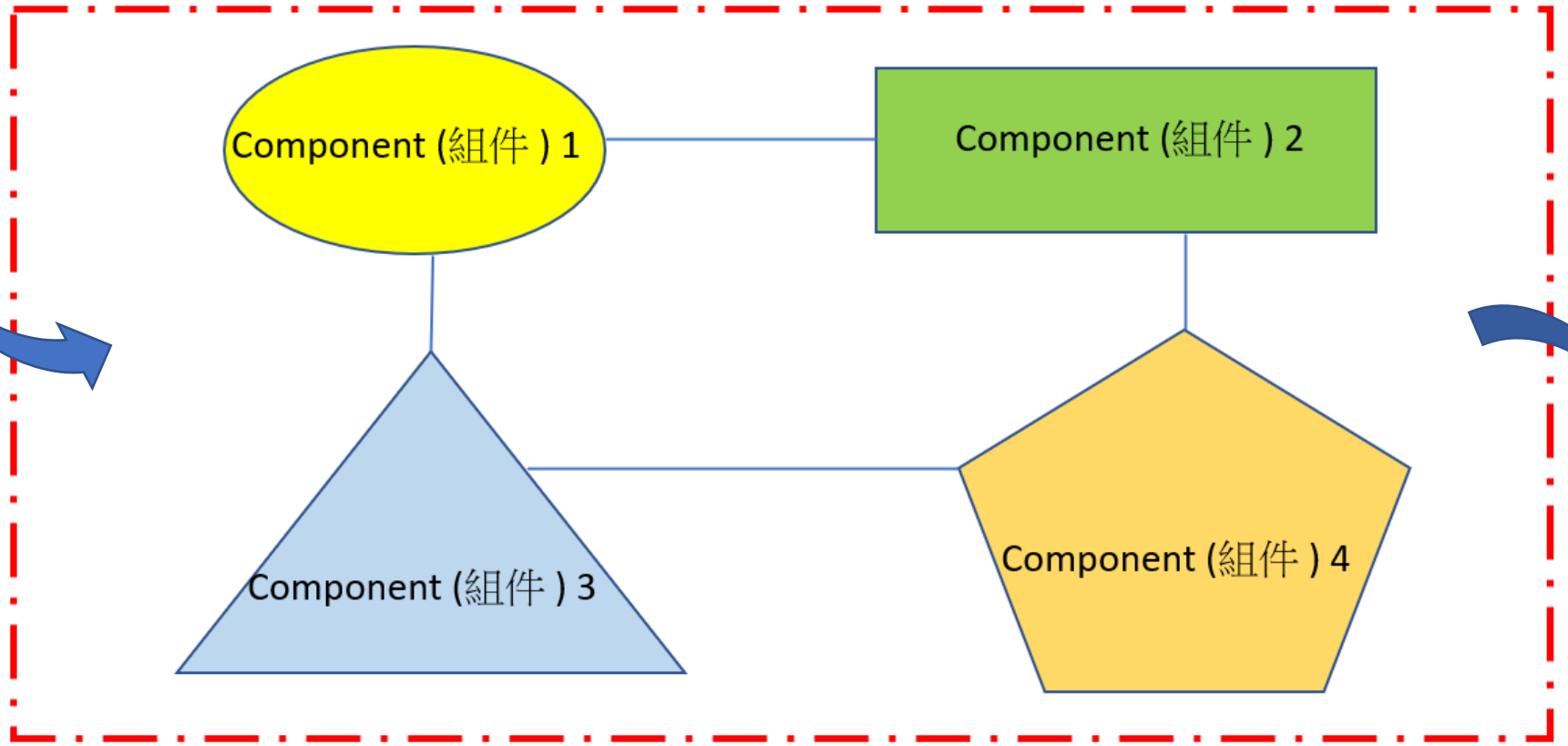
Component/Structure Diagram of the Product/Artifact (產品組件/結構圖)

A representation of a system (系統的表示)



Energy Input (能量輸入)
Material Input (物料輸入)

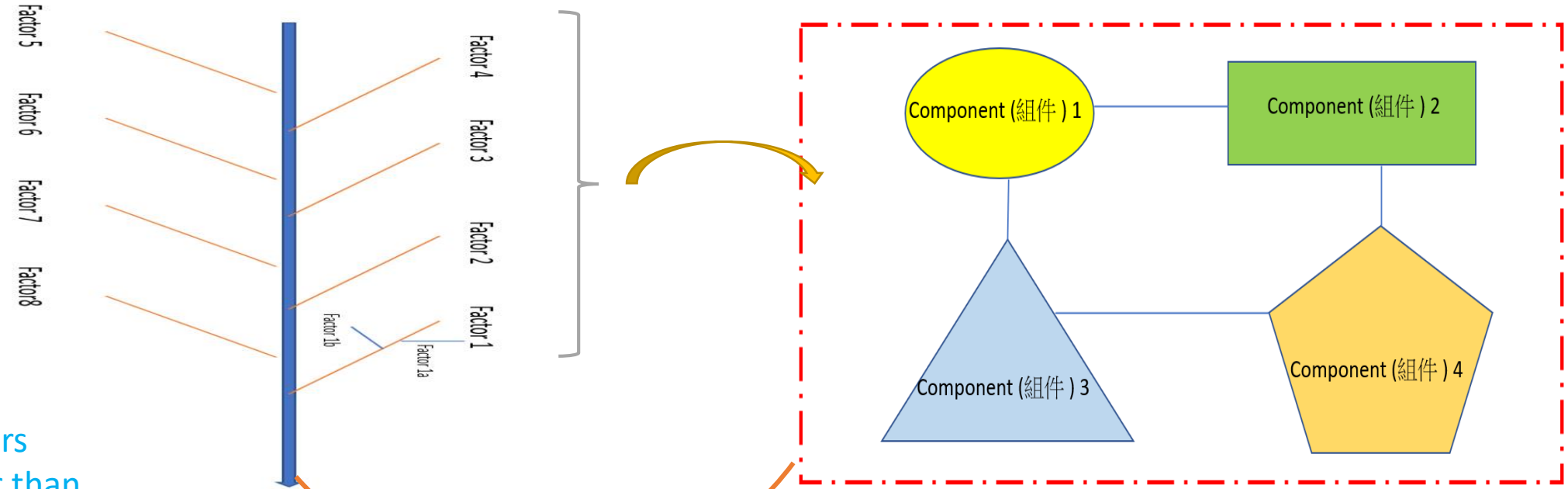
A representation of a system (系統的表示)



Outcome(產出), such as
Energy Output (能量輸出)
New Material Output (物料輸出)

A method to help design/refine the product and generate creative ideas:

DESIGN Stage (設計階段)



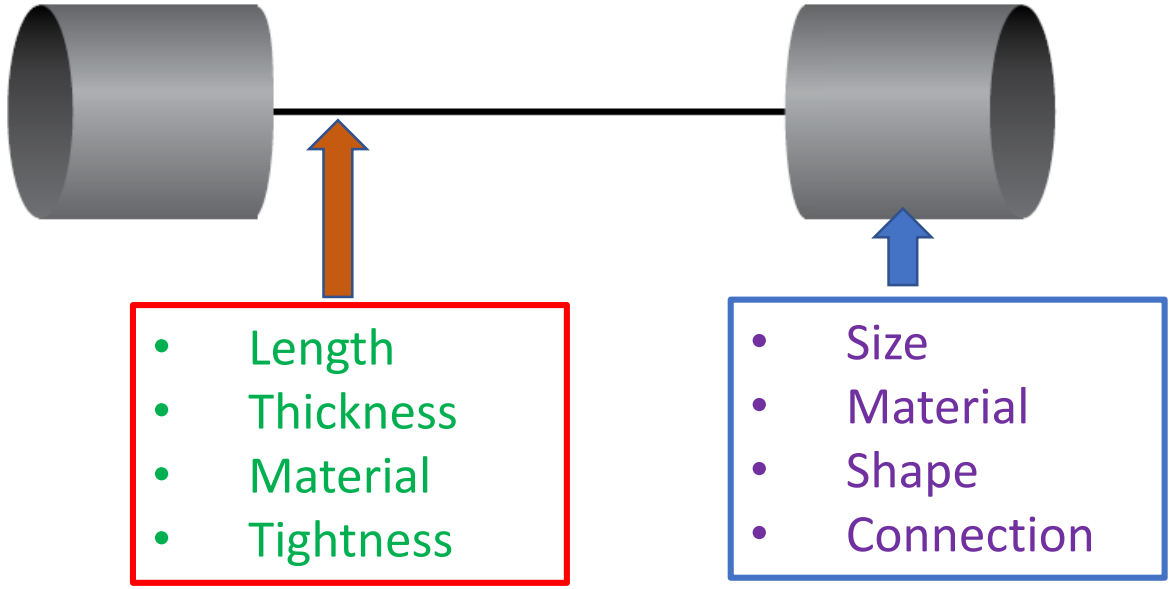
Factors other than that from the components

Outcome/Product Performance(產品表現)

S.C.A.M.P.E.R https://digitalyoming.com/scamper/

Refined Product Performance(改良產品表現)

Example: A Toy Phone



1. The volume of the voice of speaker
2. The method/instrument to measure the volume of sound received.
3. The closeness of speaker's mouth to the can

This Variable Might Be Important.	Reason for Inclusion
How loudly we talk	The louder you talk, the louder the phone should sound.
The length of the string	The phone should sound louder the closer you are together.
How tightly we pull the string	The phone may work better if the string is tight.
The size of the cans	The size of the cans might amplify the sound.
The shape of the cans	Different shapes might work better.
If we use something else besides cans (like paper cups)	Maybe other materials will make the sound louder.
The thickness of the strings	Thicker strings might work better.
Use something else besides string (such as wire).	String might not be the only material that works well.

The figure and table was adapted from *Learning & Teaching Scientific Inquiry,* **NSTA**, 2011 (P.64 and 65)

Problem solving in STE(A)M Education

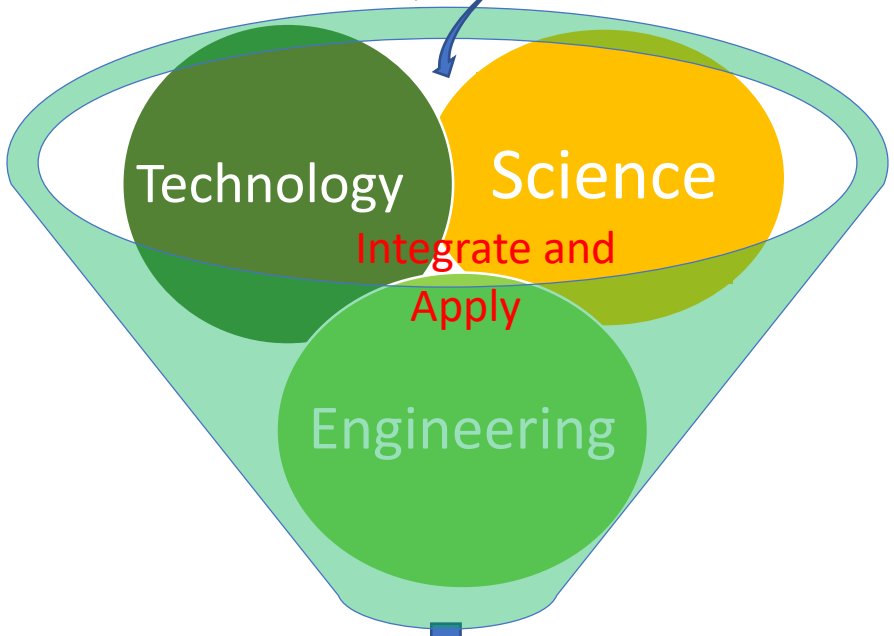
Identify a **Need** or **Problem(P)**

P → P1,P2,.....

Define the **problem (Pi)**
(with **success criteria** /**constraints**

Information Search for the specified **problems (Pi)**

Maths and Arts



Values

Authentic Problem solved through integrating and applying knowledge and skills in S.T.E.M. disciplines

Exploratory Learning

Directed Learning

Reflective Learning

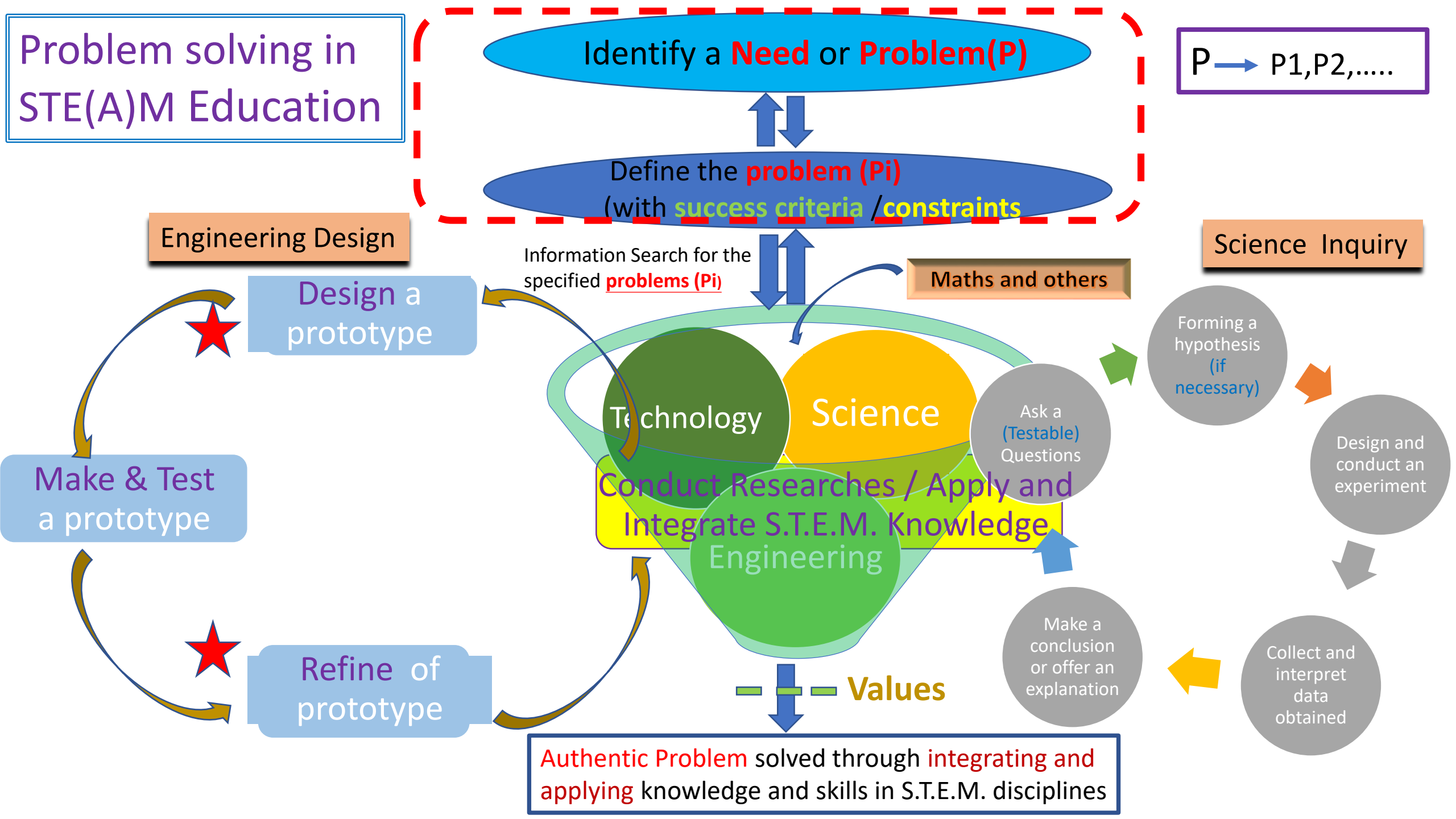
Productive Learning

Directed Learning	Receiving and interpreting information 信息接收及理解	Practice 指定練習/操練	Test/Assessment 測驗/老師評核
Exploratory Learning	Information exploration 信息探索	Exploration through conversations 通過對話探索	Explorations through tangible/immersive investigations 探索 (實體/虛擬情景)
Productive Learning	Construction: conceptual/visual artefacts 建構概念化/視覺化成品	Construction: tangible/manipulable artefacts 建構有形/可操作的成品	Presentations Performances Illustrations 演講, 表演, 說明
Reflective Learning	Reflection 反思	Revision 修訂	Self-/Peer-assessment 自我/同儕評估

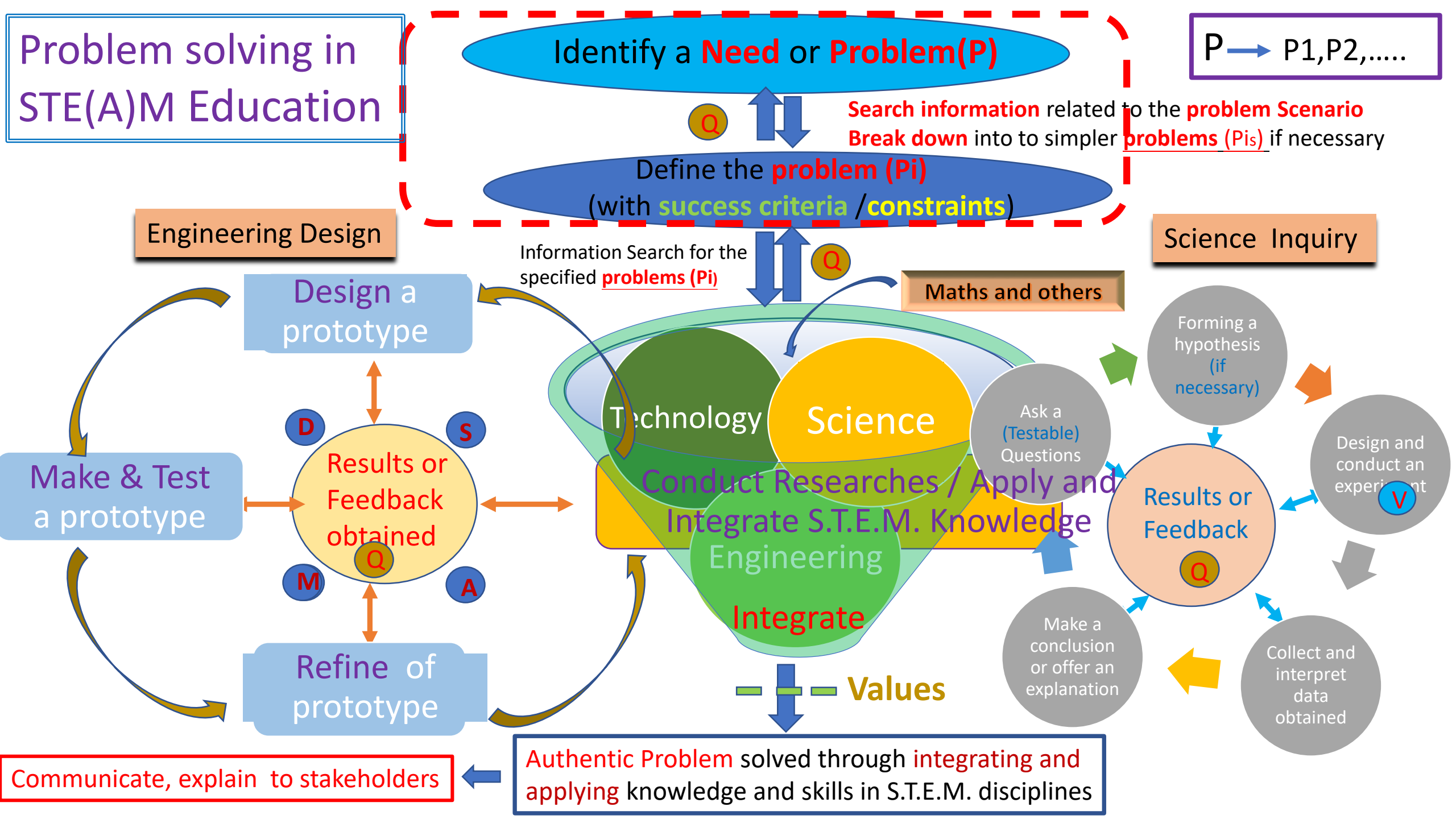
Adapted from Professor Law, CITE, School of Education, HKU

Reference: Nancy Law and co-authors, A pattern language based learning design studio for an analytics informed inter-professional design community. *Interaction Design and Architecture(s),* ***33*** , (2017), 92-112

Problem solving in STE(A)M Education



Problem solving in STE(A)M Education



A summary:

- The key element in STE(A)M education is to integrate and apply the knowledge and skills students have learned in the S.T.E.A.M. disciplines.
- The method of inquiry designed (as well as the conclusion) must match the inquiry question raised.
- The concept of fairness in designing an experiment can be introduced through comparative investigations (such as the comparison of a property of several objects under certain conditions) in elementary grades. In senior grades, when students can handle the idea of 'variable', the concepts of independent variables, dependent variables and controlled variables can be introduced in a more vigorous sense. "魚骨圖" is a helpful tool for students to handle the concept of fair tests.
- The engineering design process (EDP) and Science inquiry can be integrated into a STE(A)M curriculum. The components in an artifact to be produced can be considered as variables in the inquiry process; this practice can help to inform the 'design' and 'refine' stages of the associated EDP. This practice can help strengthen the science process skills as well as the innovation in product design.

THANK YOU