統計實務

Spring 2024

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第四週：定義問題

如何定義決定解決方案

- Rittel and Webber (1973) suggests that

→The process of formulating the problem and of conceiving a solution..... are identical, since every specification of the problem is a specification of the direction in which a treatment is considered.

註：A problem’s definition determines the solution space.

定義問題

蒐集資料

分析資料

詮釋結果

絕大多數的
(統計)教學重心

學習（統計）的幾個要素

- 解決問題大致有以下幾個要素：

→如何定義、測量？(e.g. Variable Format, Data Collection)

→如何判斷、取捨？(e.g. Estimation, Prediction, Testing)

→如何詮釋、增加附加價值？(e.g. Utility, Decision)

幾本有趣的參考書籍

- 你管別人怎麼想：科學奇才費曼博士(2005)，天下文化出版。
- 阿基米德的浴缸－突破性思考的藝術與邏輯(2001)，究竟出版社。
- Strategies for Creative Problem Solving (2013), by Fogler and LeBlanc
- 頭腦體操系列，多湖輝著，商兆文化出版。

定義問題(Problem Definition)

「正確問題的近似答案，遠比錯誤問題的精確答案有價值。」

“An approximate answer to the right question is worth a great deal more than a precise answer to the wrong problem.”

--- the first golden rule of applied mathematics

有趣(或殘酷)的範例

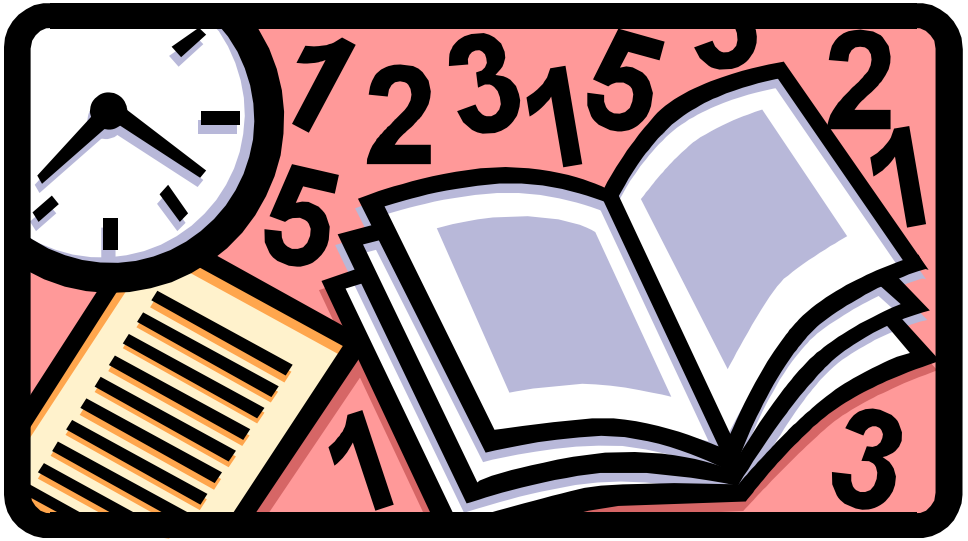
- 一位教授及其學生到阿拉斯加探勘，在一望無際的冰原上被北極熊追殺。眼看即將被追到，學生趕緊換上球鞋，教授說：「換上球鞋也跑不過北極熊。」學生卻說：「我不必跑贏北極熊，只要跑贏你就夠了。」

→ 真正的問題是甚麼？

統計的第三型誤差

- Type III error (error of the third kind):

  → Giving the “right” answer to the wrong question (Kimball, 1957)



統計研究的首要步驟

- 獲取研究問題的相關背景知識
- 確立問題的目標(研究目的)
- 以統計的語言定義問題

→如果與其他人合作，儘量「多發問」！

另一個定義問題的範例

- 某家旅館重新整修內部，將客房數增為原先的1.25倍，但電梯數維持不變，房客因等待時間增長而抱怨連連。

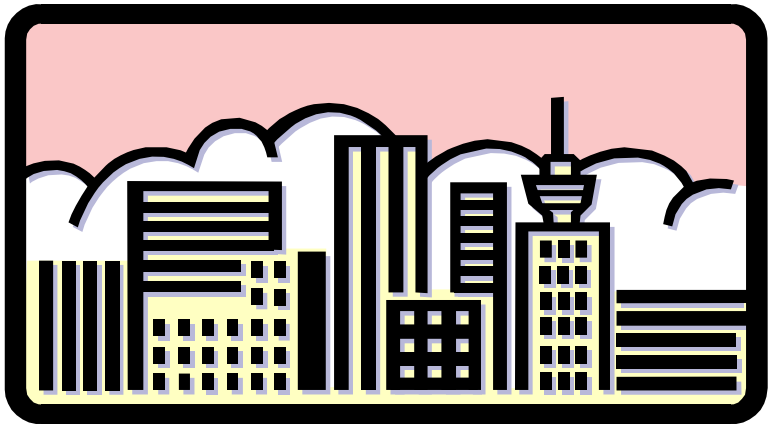
解決方案：

→ 增加電梯數？

→ 加快電梯速度？

→ 電梯門加設鏡子？

註：戶外電梯？



政治大學商學院電梯改善方案

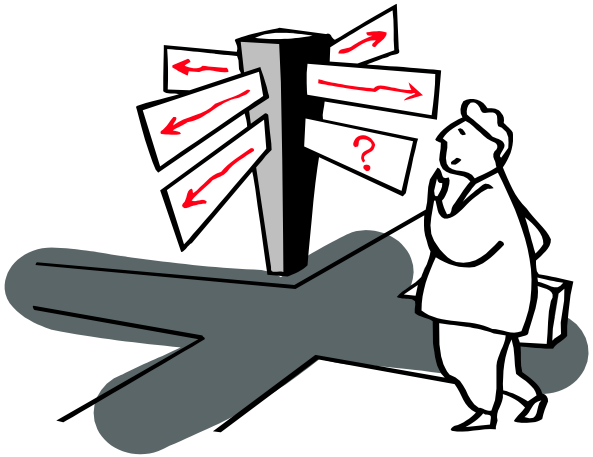
- 對於商學院電梯使用的缺點，有47%的同學認為「未顯示樓層」是最大缺點，其次是「速度太慢」，有29%的比例。

→樓層顯示版整棟總價至少約50萬台幣(需再加大理石牆壁施工費用)

→電梯速度無法調整加快

- **哪些問題可能改善？**

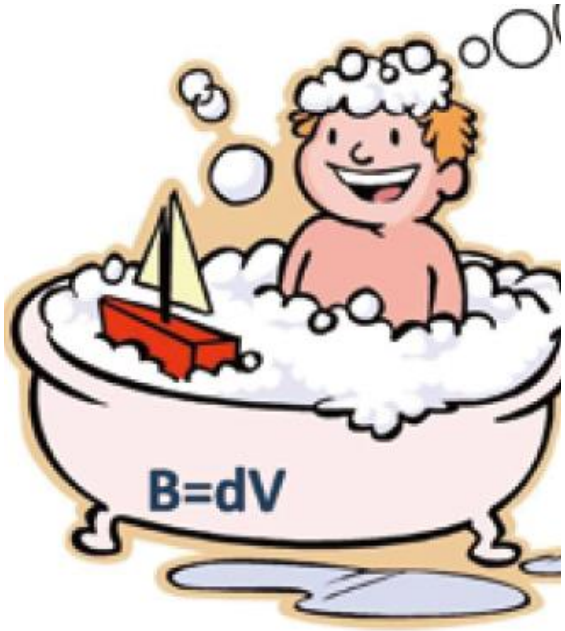
註：科技也會改變限制！



真正的問題在哪裡？

- 有時呈現在表面的因素並非造成問題的實際原因，解決方案需從另一方向或結合專業知識去探索。
- 討論：阿基米德的浮體原理。

→古今中外的突破與發展，許多藉助於變換思考方向(Paradigm Shift)，換個角度思考有意想不到的驚喜。



Bargain Prices

The Situation: A local merchant on Main Street in Ann Arbor was having difficulty selling a health food mix from the rain forest called Rain Forest Crunch, which was a hot selling item in other stores. Part of the attractiveness of Rain Forest Crunch was that it was indeed from the Brazilian rain forest and part of the proceeds of the sale went to protect the rain forest. The instructions given by the store manager: *"Lower the price of the item to increase sales."* Rain Forest Crunch still did not sell. The manager lowered the price further. Still no sales. After lowering the price two more times to a level that was well below the competitors', the item still did not sell. Finally, the manager walked around the store, and studied the display of Rain Forest Crunch. Then the real problem was uncovered. The problem was not the high cost of the item; the **real problem** was that it was not in a prominent position in the store to be easily seen by the customers. Once the item was made more visible, sales began to soar.[4]

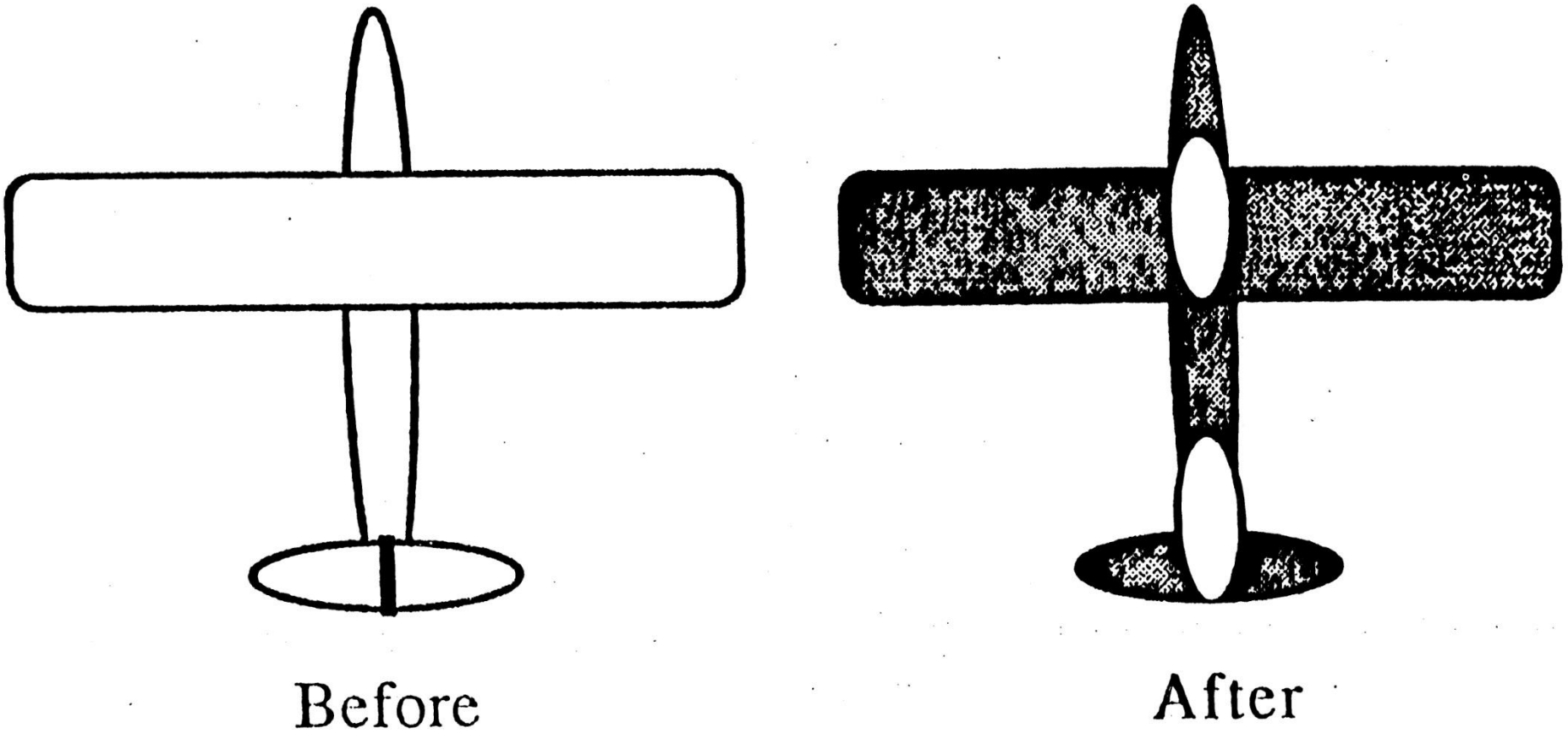
Price Reduced

~~$14.99~~

~~$12.99~~

~~$10.99~~

$9.99



A graphical depiction of Wald's bullethole data.

Face the Reality?

- 美國某家石油公司以管線的方式將阿拉斯加的天然氣輸往本土，但因天然氣中含有腐蝕性物質(二氧化硫)，連接管線間的測量表常遭腐蝕，造成天然氣外洩，該公司必須派人不定時檢修量表。

→該公司希望研發耐腐蝕的量表，但橡膠墊片會與二氧化硫作用。

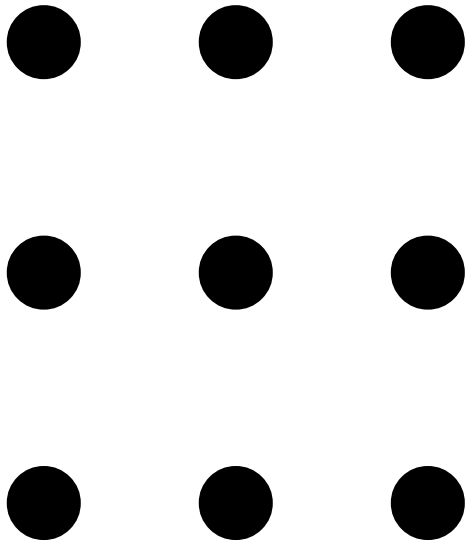
"Uh, yeah, Homework Help Line? I need to have you explain the quadratic equation in roughly the amount of time it takes to get a cup of coffee."

Definition of Problem (定義問題)

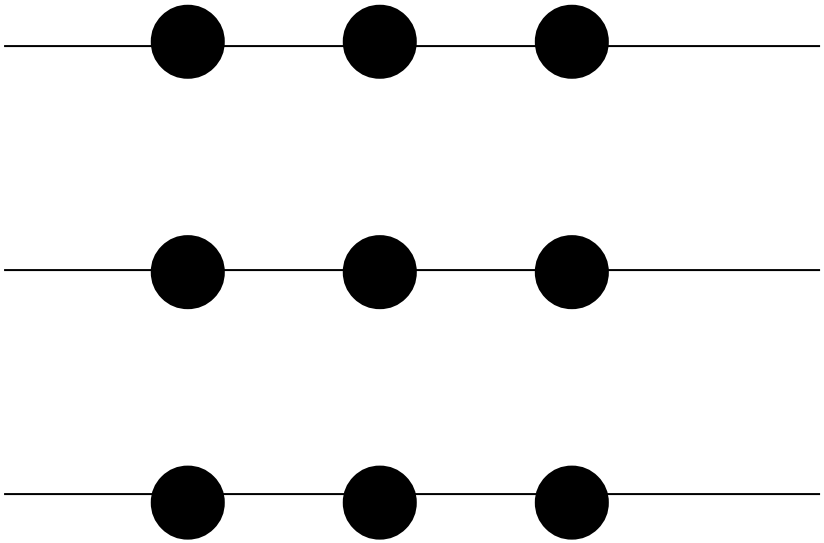
- A problem is decided by purposes. For example, manufacturing managers are usually evaluated with line-operation rate, which is shown as a percentage of operated hours to potential total operation hours. Therefore manufacturing managers sometimes operate lines without orders from their sales division. This operation may produce more than demand and make excessive inventories. The excessive inventories may be a problem for general managers. But for the manufacturing managers, the excessive inventories may not be a problem.
- Therefore, in order to identify a problem, problem solvers such as consultants must clarify the differences of purposes.

定義問題範例之一

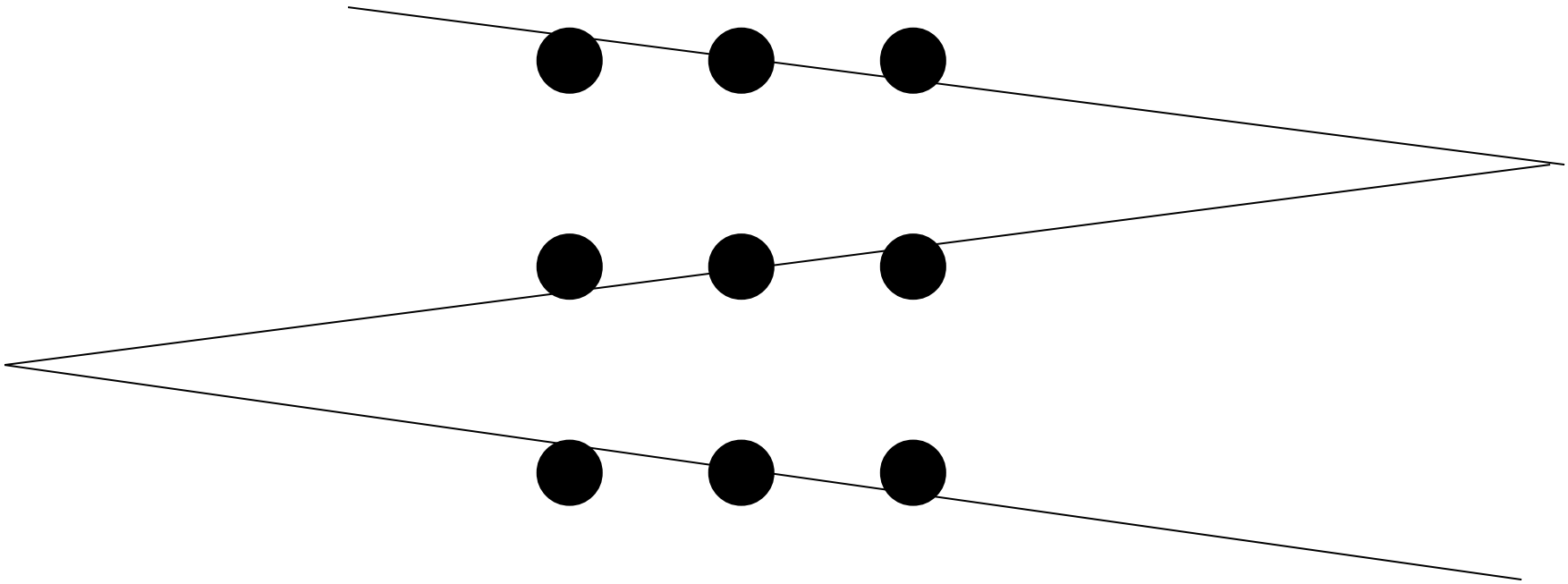
- 請以三條直線連接以下互相平行的九個點：



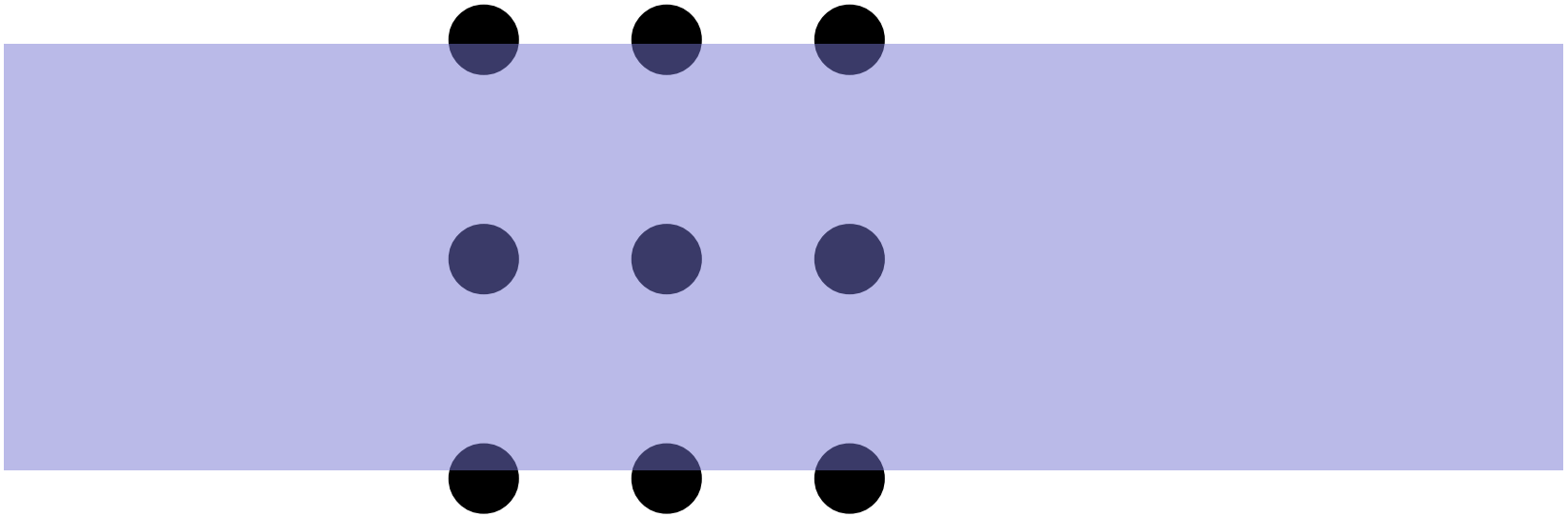
- 一般的想法可能是：



- 如果點有大小之分：



- 如果線也有粗細之分：



Three steps to a good decision

- Define the problem
- Set the decision criteria
- Choose the right analytical methods to satisfy the criteria

- “The formulation of a problem is often more essential than its solution.”

  — Albert Einstein

- Exploratory research is often required to help in the formulation of the research problem.

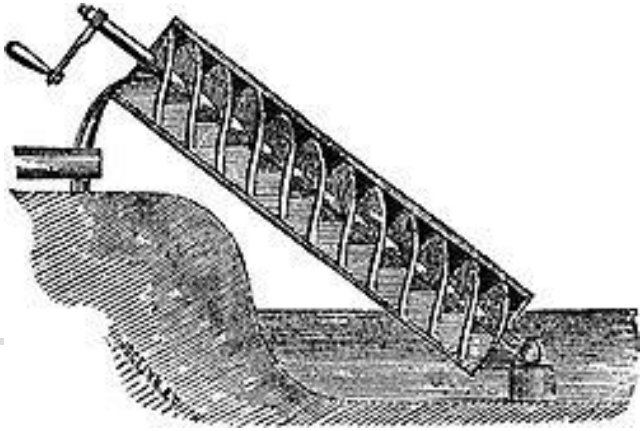
→All research is based on a set of assumptions or factors that are presumed to be true and valid. (It is called “hypothesis” in science.)

→But be careful not to give too many assumptions.

Ten ways to murder creativity

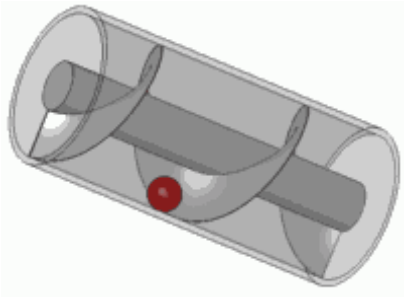
- Always pretend to know more than everybody around you.
- Get employees to fill in time sheets.
- Run daily checks on progress of everyone's work.
- Ensure that highly qualified people do mundane work for long periods.
- Put barriers up between departments.
- Don't speak personally to employees, except when announcing increased targets, shortened deadlines and tightened cost restraints.
- Ask for a 200-page document to justify every new idea.
- Call lots of meetings.
- Place the biggest emphasis on the budget.
- Buy lots of computers.

突破性思考的特色



- 長期探索(Long search)
- 沒有明顯的進展(Little apparent progress)
- 突發事件(Precipitating event)
- 靈光一閃(Cognitive snap)
- 轉換(Transformation)

→歷史上幾位著名人物的例子：阿基米德、孟德爾、達爾文、費曼。



定義問題前四個步驟(準備工作)

- Collect and analyze information and data
- Talk with people familiar with the problem

→請教專家、尋求專業建議

- If at all possible, view the problem first hand

→不只紙上談兵(費曼的太空梭調查！)

- Confirm all findings

定義問題的後續四個步驟

- Determine if the problem should be solved
- Continue to gather information and search the literature
- Form simple hypotheses and quickly test them
- Brainstorm potential causes and solution alternatives

過去的習慣不見得有道理

A little girl was watching her mother prepare a fish for dinner. Her mother cut the head and tail off the fish and then placed it into a baking pan. The little girl asked her mother why she cut the head and tail off the fish. Her mother thought for a while and then said, “I’ve always done it that way – that’s how babicka (Czech for grandma) did it.”

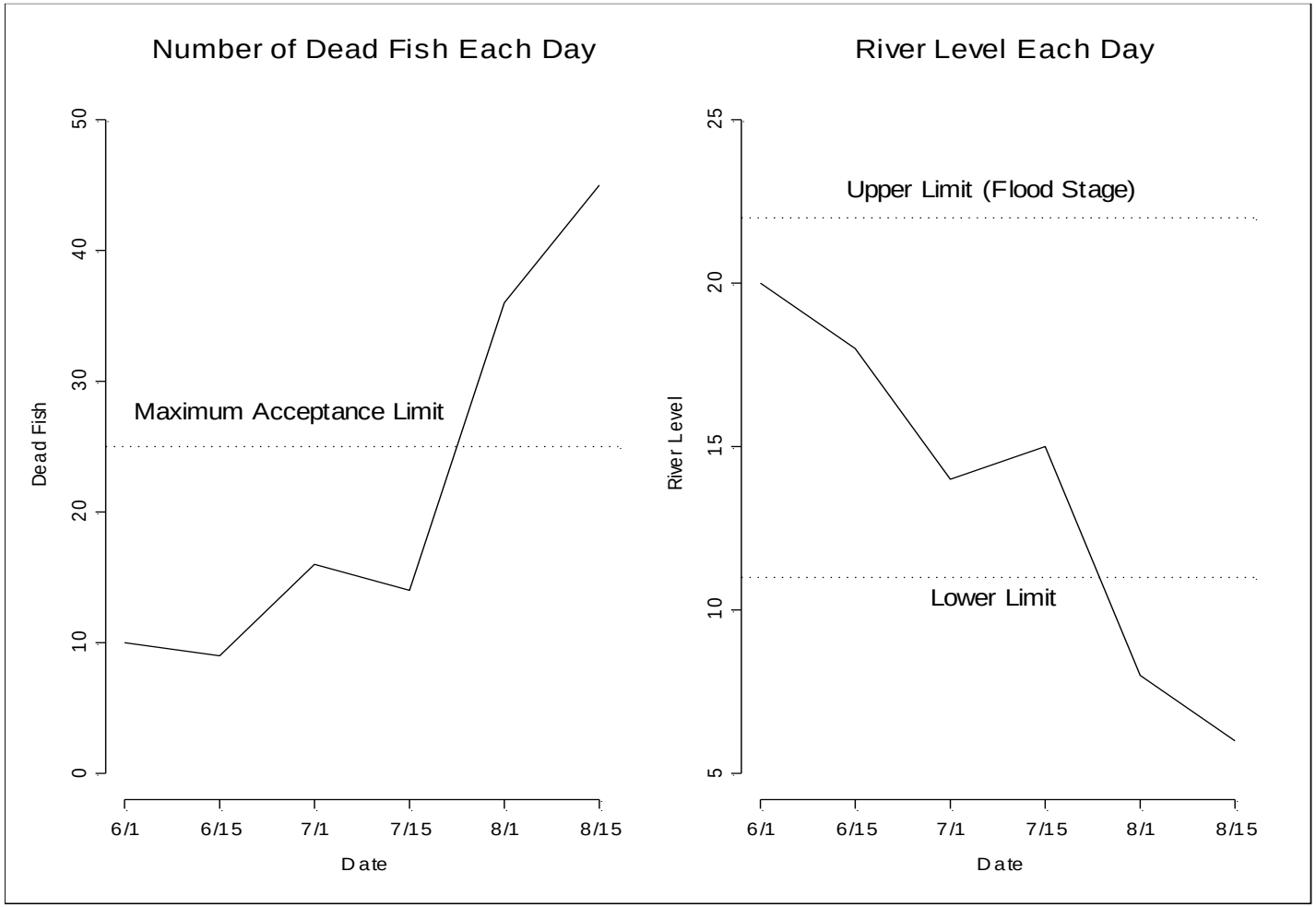
Not satisfied with the answer, the little girl went to visit her grandma to find out why she cut the head and tail off the fish before baking it. Grandma thought for a while and replied, “I don't know. My mother always did it that way.” So the little girl and the grandma went to visit great grandma to find ask if she knew the answer. Great grandma thought for a while and said,

“**Because my baking pan was too small to fit in the whole fish.**”

定義問題範例一

- 某化學工廠將處理過(低毒性)的廢棄物，排放到一條流量相當大的河川，該工廠聘任專家觀察河川生態，以確保安全性。今年夏天專家發現以下現象：

Time Series Plot→



Control Chart ←

相關訊息：

- 8月1日及15日死魚總數超過可接受範圍。

→工廠在7月29日排放了一批較大量的廢水，但過去這樣的量並未造成任何問題。

→然而過去的經驗都是在水位較高時，無法確定水位低時是否一樣沒問題。

- 如何解決死魚的問題？

定義問題的幾個技巧

- Finding out where the problem came from
- Explore the problem
- Present/Desire state technique
- Duncker diagram
- Statement-restatement technique

The sweet old couple (dangers of making assumptions, understand before you intervene)

A little old couple walked into a fast food restaurant. The little old man walked up to the counter, ordered the food, paid, and took the tray back to the table where the little old lady sat. On the tray was a hamburger, a small bag of fries and a drink. Carefully the old man cut the hamburger in two, and divided the fries into two neat piles. He sipped the drink and passed it to the little old lady, who took a sip and passed it back. A young man on a nearby table had watched the old couple and felt sorry for them. He offered to buy them another meal, but the old man politely declined, saying that they were used to sharing everything. The old man began to eat his food, but his wife sat still, not eating. The young continued to watch the couple. He still felt he should be offering to help. As the little old man finished eating, the old lady had still not started on her food. “Ma’am, why aren’t you eating?” asked the young man sympathetically.

The old lady looked up and said politely,

"I'm waiting for the teeth.."

當初的問題來源

- Where does the problem originate?
- Who did pose the problem statement in the first place?
- Can that person explain the reasoning as to how they arrived at that particular statement?
- Are the reasoning and assumptions valid?
- Has that person considered the situation from a number of different viewpoints before?
- Have you used the first fours steps?

釐清問題的幾個相關疑問。。。

- 實際問題未必清楚定義，尤其是問題的陳述及其來源值得探究：

→疑問一：誰（最先）提出這個問題？

→疑問二：為什麼會以這種方式定義？

→疑問三：有助於理解問題的相關知識？

→疑問四：假設條件及邏輯推論合理嗎？

→疑問五：問題可從其他角度切入嗎？

定義問題範例一(續)

- 管理部門將死魚問題定義為「研發可降低廢棄物毒性的(化學)配方」
- 針對管理部門的建議，我們可以詢問

→Who posed the problem?

→Can reasons for arriving at the problem statement be explained?

→Are the assumptions and reasoning valid?

→Has sufficient data/information been collected?

進一步探索問題

- Recall or learn the fundamental principles related to the problem
- Carry out an order-of-magnitude calculation
- Hypothesize what could be wrong
- Guess the result

定義問題範例一(續)

- 進一步探索問題，步驟包括：

→Identify available information

→Learn Fundamental

(What would cause more dead fish?)

→Missing information

(A fungus was found in near by areas.)

→Hypothesis

(The fungus is the cause.)

→More information (Proof!)

→Define the real problem (Cure of the fungus!)

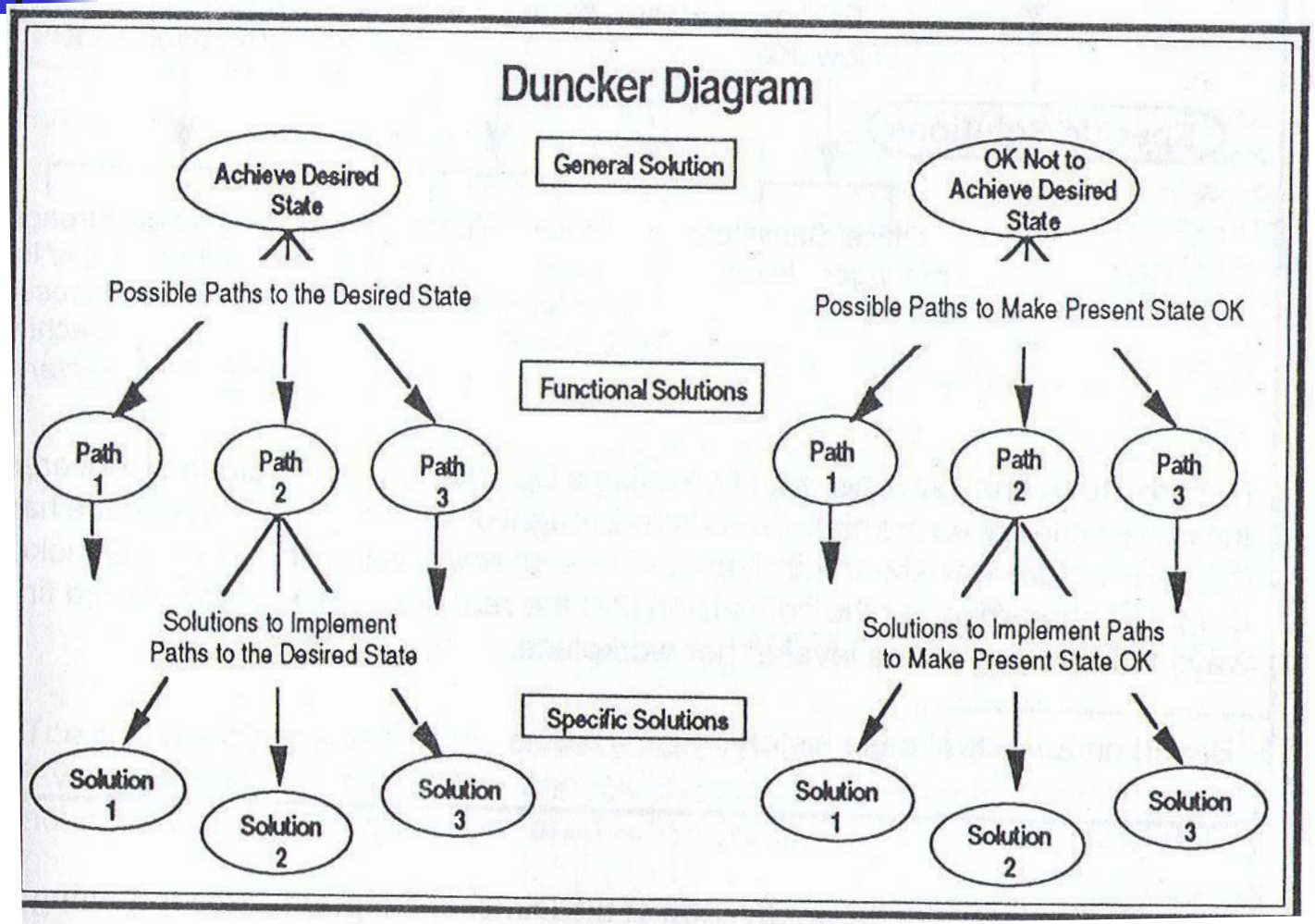
- Present state/Desire state

→Write a statement of where you are and a statement of what you want to achieve.

- 在設計問卷時經常遭遇這種問題，如果無法獲得某些問項的答案時，應該如何因應？(例如：收入)
- 定義問題時盡量避免模糊或是模擬兩可的措辭，例如：「非常」、「相當」等。(英文中則有best, minimal, within a reasonable time, more efficient等)

- Duncker diagram

→Devise a pathway that make it OK to solve the problem posed to you.



Functional Solutions: What to do.

Specific Solutions: How to do it.

- Statement-Restatement

→Use the six triggers to restate the problem in a number of different ways.

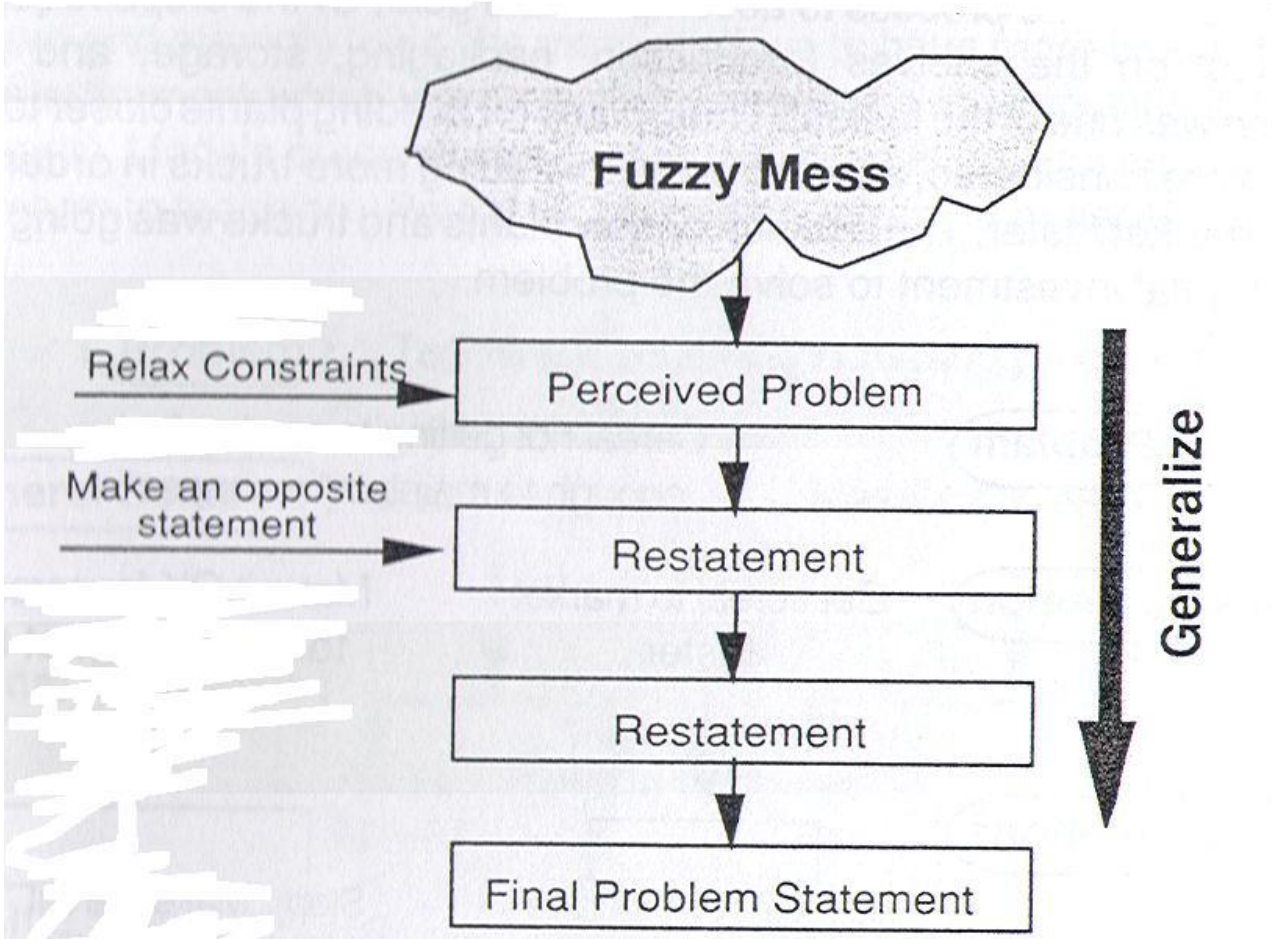


Figure 3-2. Stating the Real Problem

定義問題參考講義

- Einstein’s Secret to Amazing Problem Solving (and 10 Specific Ways You Can Use It).pdf
- Systems Approach to Problem Solving.pdf
- Effective Problem definition.doc
- Process of organizational problem definition: how to evaluate and how to improve.pdf

定義問題練習一

- 家庭中常見的意外之一是嬰幼兒誤食藥品而中毒，如何解決這個問題？
- 可能的問題定義是嬰幼兒自己打開藥瓶。

→解決之道為設計較難打開的瓶蓋。

- 然而仍有許多幼兒誤食藥物的案件發生。

→真正的問題是甚麼？

(有許多人用藥後忘了蓋上蓋子。)

- 如果在這個例子中以改變結果為目標，也就是減少嬰幼兒藥物中毒的案例為標準，或許問題會更為直接。

→如何減少嬰幼兒自己拿到藥品的機會？

- 如此可將問題分為兩個方向：

(1)在藥瓶上增加警示說明，提醒成年人不讓嬰幼兒有機會拿到藥品。

(2)即使嬰幼兒拿到藥品，他們不見得有機會食用。

定義問題練習二

- 高速公路因為駕駛使用手機的比例增加，因而發生交通事故的案件也逐年上升。

→如何降低手機相關的交通意外？

- 建議先查閱現有關於使用手機與交通意外的研究結果；再比較哪些因素與使用手機類似，也會造成意外事故。

→你/妳的問題定義？

定義問題練習三

- 政大商學院後門最近才剛改裝完成的殘障專用道，採用類似貪食蛇的路線設計，（商學院前門與行政大樓採類似設計）

→優點：減低殘障專用道的坡度

→缺點：路線加長為三倍、180度的轉角

- 問題：殘障步道的只要求坡度平緩嗎？

→對輪椅使用者而言（類比推車），轉彎和坡度兩者哪一個較吃力。

- 商院的坡道設置僅考量了『如何降低坡度』，而學思及研究大樓除了達到降低坡度的條件外，更顧及了『如何使輪椅使用者的負擔最小』。

延伸問題定義練習

- 2009年10月教育部提出為避免學童上體育課後，全身濕淋淋地吹風容易感冒，研議設置在各中小學淋浴設備。

→需要額外的淋浴時間、儲物櫃空間！

- 1966年時美國國會抨擊汽車業者生產的車輛不夠安全，希望強化汽車結構。

→「駕駛人」vs.「汽車結構」，何者較容易改善？

延伸問題定義練習(續)

- 捷運通車但新莊區中正路依舊塞爆，朱立倫市長於二月十五日視察輔大站，要求公車路線整併、考量減少班次、調整候車站位置，別讓所有車流都擠在中正路。

→為什麼輔大站前公車反而更為擁擠？

參考：輔大站怪象 等同向公車差百米(20120310)

- 中和淡水捷運分流-公共電視台(20120229)
- 誰殺了師大夜市-新新聞(20120222)

- 一有徵兆顯示可能造成異常現象，或出現有違常理的事件時，有效的決策者總是主動進行測試。他們總會一一寫下，在既有定義之下，他們預期哪些事情會發生（例如：預期交通意外的發生率降為零）？並定期測試是否真會出現自己所預期的情況。
- 愛因斯坦：「陳述一個問題、尋找一個問題，往往比解答一個問題更重要，解答所需要的可能只是數學或實驗的技巧而已，提出新的問題、新的可能性或從新的角度思考舊問題，需要的是創意的想像，才是科學真正的內涵。」