Creative Thinking

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Topics

- How innovations start
- Tools for creativity
- Tools for evaluation

- Leadership
- Good researcher, Good research

Expectation

Good
- Creator
- Inventor
- Innovator
- Researcher
- Implementer

… who can produce …

Meaningful
- Patent
- Paper publication
- Dissertation
- Viable prototype
- Software program

Creativity is just connecting things.

– Steve Jobs, 1995

HOW INNOVATIONS START

Dominant Designs Dominate History

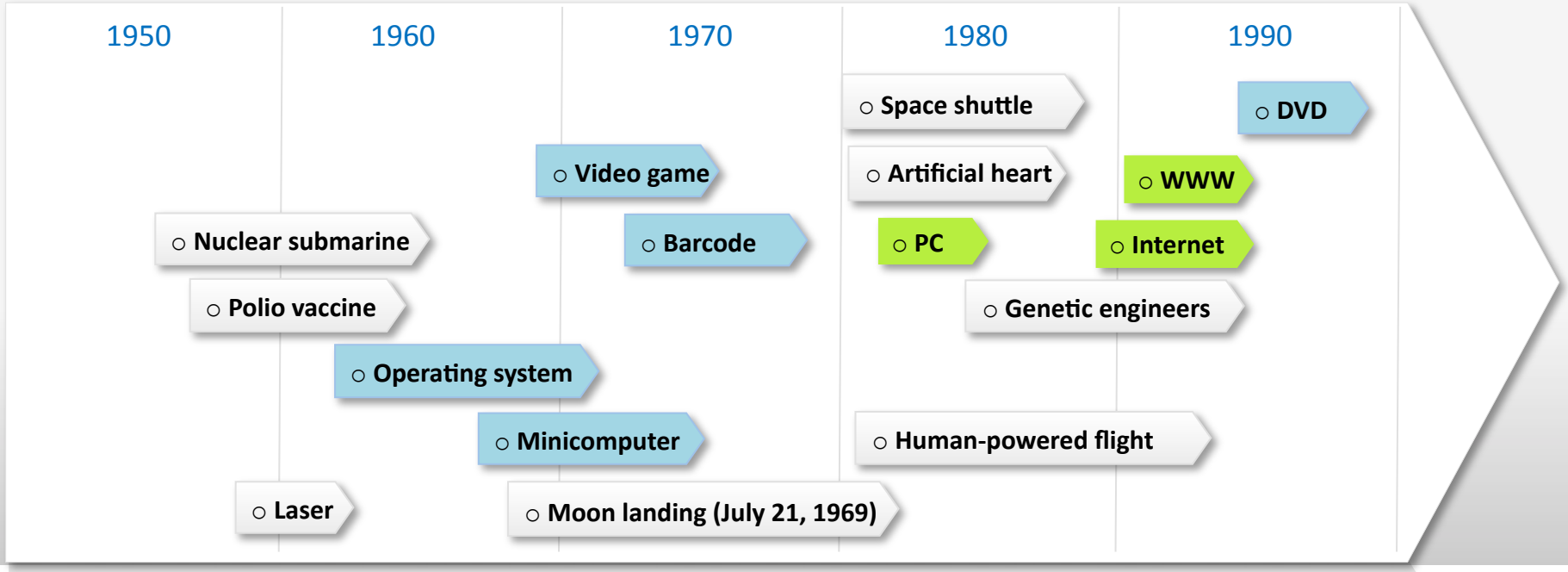
- It would be tempting to think that there is some predetermination to the emergence of dominant design – that automobiles with internal combustion engines were somehow exactly what the gods of transportation always meant for us to have, and that earlier experiments with electric and steam powered cars were misguided aberrations destined to go nowhere. The emergence of a dominant design is not necessarily predetermined, but is the result of the interplay between **technical and market choices** at any particular time.

James Utterback, Mastering the Dynamics of Innovation, Harvard Business School Press, 1996

About History

- **History** is written by those who win and those who dominate. – *Edward Said*
- **History** is the lie commonly agreed upon. – *Voltaire*
- **History** is a damn dim candle over a damn dark abyss. – *W. S. Holt*
- **History** is indeed the witness of the times, the light of truth. -- *Cicero*

A Typical Technology Timeline



1973 (Alto), 1977 (Apple II), 1979 (Atari 400), 1982 (Man of the Year, in TIME mag.)
1983 (IBM PC was the true dominant design)
Late of 1980s (The first Internet service provider (ISP) companies were formed)
Dec 1990 (Publicly introduced by Sir Tim Berners-Lee)

The myths of Innovation, Scott Berkun, O'Reilly, 2007
http://en.wikipedia.org/wiki/Timeline_of_historic_inventions/

History [edit]

http://en.wikipedia.org/wiki/Personal_computer

Main article: History of personal computers

See also: Microcomputer revolution

The Z3 by German inventor Konrad Zuse from 1941 was the first working programmable, fully automatic computing machine. Thus, Zuse is often regarded as the *inventor of the computer*.[3][4][5][6]

The Programma 101, released in 1965, was the first commercial "desktop computer",[7] but today it would usually be considered as a printing programmable calculator.

The Soviet MIR series of computers was developed from 1965 to 1969 in a group headed by Victor Glushkov. It was designed as a relatively small-scale computer for use in engineering and scientific applications and contained a hardware implementation of a high-level programming language. Another innovative feature for that time was the user interface combining a keyboard with a monitor and light pen for correcting texts and drawing on screen.[8]

In what was later to be called The Mother of All Demos, SRI researcher Douglas Engelbart in 1968 gave a preview of what would become the staples of daily working life in the 21st century - e-mail, hypertext, word processing, video conferencing, and the mouse. The demonstration required technical support staff and a mainframe time-sharing computer that were far too costly for individual business use at the time.

By the early 1970s, people in academic or research institutions had the opportunity for single-person use of a computer system in interactive mode for extended durations, although these systems would still have been too expensive to be owned by a single person.

Commodore PET in 1983 (at American Museum of Science and Energy)

In 1973 the IBM Los Gatos Scientific Center developed a portable computer prototype called SCAMP (Special Computer APL Machine Portable) based on the IBM PALM processor with a Philips compact cassette drive, small CRT and full function keyboard. SCAMP emulated an IBM 1130 minicomputer in order to run APL\1130.[9] In 1973 APL was generally available only on mainframe computers, and most desktop sized microcomputers such as the Wang 2200 or HP 9800 offered only BASIC. Because SCAMP was the first to emulate APL\1130 performance on a portable, single user computer, *PC Magazine* in 1983 designated SCAMP a "revolutionary concept" and "the world's first personal computer".[9][10] This seminal, single user portable computer now resides in the Smithsonian Institution, Washington, DC. Successful demonstrations of the 1973 SCAMP prototype led to the IBM 5100 portable microcomputer launched in 1975 with the ability to be programmed in both APL and BASIC for engineers, analysts, statisticians and other business problem-solvers. In the late 1960s such a machine would have been nearly as large as two desks and would have weighed about half a ton.[9]

Another seminal product in 1973 was the Xerox Alto, developed at Xerox's Palo Alto Research Center (PARC), it had a graphical user interface (GUI) that later served as inspiration for Apple Computer's Macintosh, and Microsoft's Windows operating system. Also in 1973 Hewlett Packard introduced fully BASIC programmable microcomputers that fit entirely on top of a desk, including a keyboard, a small one-line display and printer. The Wang 2200 microcomputer of 1973 had a full-size cathode ray tube (CRT) and cassette tape storage. These were generally expensive specialized computers sold for business or scientific uses. The introduction of the microprocessor, a single chip with all the circuitry that formerly occupied large cabinets, led to the proliferation of personal computers after 1975.

Early personal computers — generally called microcomputers — were sold often in kit form and in limited volumes, and were of interest mostly to hobbyists and technicians. Minimal programming was done with toggle switches to enter instructions, and output was provided by front panel lamps. Practical use required adding peripherals such as keyboards, computer displays, disk drives, and printers. Micral N was the earliest commercial, non-kit microcomputer based on a microprocessor, the Intel 8008. It was built starting in 1972 and about 90,000 units were sold. In 1976 Steve Jobs and Steve Wozniak sold the Apple I computer circuit board, which was fully prepared and contained about 30 chips. The first successfully mass marketed personal computer was the Commodore PET introduced in January 1977. It was soon followed by the Apple II (usually referred to as the "Apple") in June 1977, and the TRS-80 from Radio Shack in November 1977. Mass-market ready-assembled computers allowed a wider range of people to use computers, focusing more on software applications and less on development of the processor hardware.

IBM Personal Computer XT in 1988

During the early 1980s, home computers were further developed for household use, with software for personal productivity, programming and games. They typically could be used with a television already in the home as the computer display, with low-detail blocky graphics and a limited color range, and text about 40 characters wide by 25 characters tall. One such machine, the ZX Spectrum introduced at 1982, totaled 8 million unit sold. Following came the Commodore 64, totaled 17 million units sold, making it the best-selling single personal computer model of all time.[11][12] Another such computer, the NEC PC-98, sold more than 18 million units.[13]

Somewhat larger and more expensive systems (for example, running CP/M), or sometimes a home computer with additional interfaces and devices, although still low-cost compared with minicomputers and mainframes, were aimed at office and small business use, typically using "high resolution" monitors capable of at least 80 column text display, and often no graphical or color drawing capability.

Workstations were characterized by high-performance processors and graphics displays, with large local disk storage, networking capability, and running under a multitasking operating system.

Eventually, due to the influence of the IBM PC on the personal computer market, personal computers and home computers lost any technical distinction. Business computers acquired color graphics capability and sound, and home computers and game systems users used the same processors and operating systems as office workers. Mass-market computers had graphics capabilities and memory comparable to dedicated workstations of a few years before. Even local area networking, originally a way to allow business computers to share expensive mass storage and peripherals, became a standard feature of personal computers used at home.

In 1982 "The Computer" was named Machine of the Year by *Time* Magazine.

How Innovations Start

- **Luck** is a part of life, and everybody, at one point or another, gets lucky. But luck is a big part of business life and perhaps the biggest part of entrepreneurial life.

The myths of Innovation, Scott Berkun, O'Reilly, 2007

The formula for success is deceptively simple:

success = time × effort × luck × ability

It's hard to use. It requires that you've got every single variable—a deficiency in any one will lead to failure. But it also means that in time, with hard, skilled work and a bit of luck, you can enjoy great success.

http://contrast.ie/blog/the-formula-for-success/

Imagination is more important than knowledge.

For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand.

— Albert Einstein

The myths of Innovation, Scott Berkun, O'Reilly, 2007

Paths to Innovation

- Hard work in a specific direction

  DNA (Watson and Crick, 1953), Google (Page and Brin, 1998), mouse (Englebart, 1968), television (Farnsworth, 1938), cell phone (Cooper, 1983)

- Hard work with direction change

  Post-it Notes (weak glue), Teflon (a mechanical lubricant), tea bag (first used as packaging for loose tea samples), microwave (unexpected discharge from a radar system)

- Curiosity

  Velcro (in response to the burrs found on clothes after hike), Linux (started as a hobby)

- Wealthy and money

  Edison's invention (ambition of a tycoon), Google tried to sell to Yahoo! and Alta Vista, Apple to HP and Atari

- Necessity

  McDonald developed a system for fast food production to simplify the management

- Combination

The myths of Innovation, Scott Berkun, O'Reilly, 2007

Eight Challenges Innovations Confront

1. Find an idea
2. Develop a solution

   The idea is one thing; a working solution is another
3. Sponsorship and Funding
4. Reproduction

   Scale up issue:- HW vs SW
5. Reach your potential customer

   Wheel, steam engine, and freeze-dried foods were innovations that existed before 100 BCE, but it took centuries for innovators to position each of them in ways the average person could use
6. Beat your competitors

   The wise innovators keeps an eye on his peers' work for purposes of collaboration, inspiration, or tactical recognizance
7. Timing

   Why automobiles are rated in horsepower and electric lights in candles. As great as your idea is, will the culture be ready when it's finished?
8. Keep the lights on

The myths of Innovation, Scott Berkun, O'Reilly, 2007

Finding Paths of Innovation

- Self-knowledge
- Be intense, but step back
- Grow to size
- Honor luck and the past

The bright innovators who failed but refused to quit are more worthy of emulating than the "magic" success stories of those who claim false dominion over things they fear.

The myths of Innovation, Scott Berkun, O'Reilly, 2007

The best not always wins: Secondary Factors of Innovation

- Secondary factors of innovation
  - Culture
    - Innovations do change societies, but they must first gain acceptance by aligning with existing values e.g. Japanese invented firearms years before Europeans, but their culture saw the sword as a symbol of their values
  - Dominant design
    - Better design might follow, but to gain acceptance, they must improve on the dominant idea by a sufficient margin to justify the costs of the switch e.g. QWERTY keyboard
  - Inheritance and tradition
    - The U.S. rejection of the metric system is tied to tradition
  - Politics who benefits?
    - The interests of those in power influenced the adoption, or rejection, of every innovation in history
  - Economics
    - Innovation is expensive: will the costs of changing to the new this be worth it? Dominant designs are expensive to replace
  - Goodness is subjective
    - A key factor in the success of VHS was tape length (three hours, enough for a feature film, to Beta's one hour), which was more important to customers than Beta's superior video quality
  - Short-term vs. long-term thinking
    - How long does this innovation need to be used for? E.g. trolleys and tram systems were replaced by new lanes for cars, but today many cities regret these changes and approximate trolleys with new light-rail system

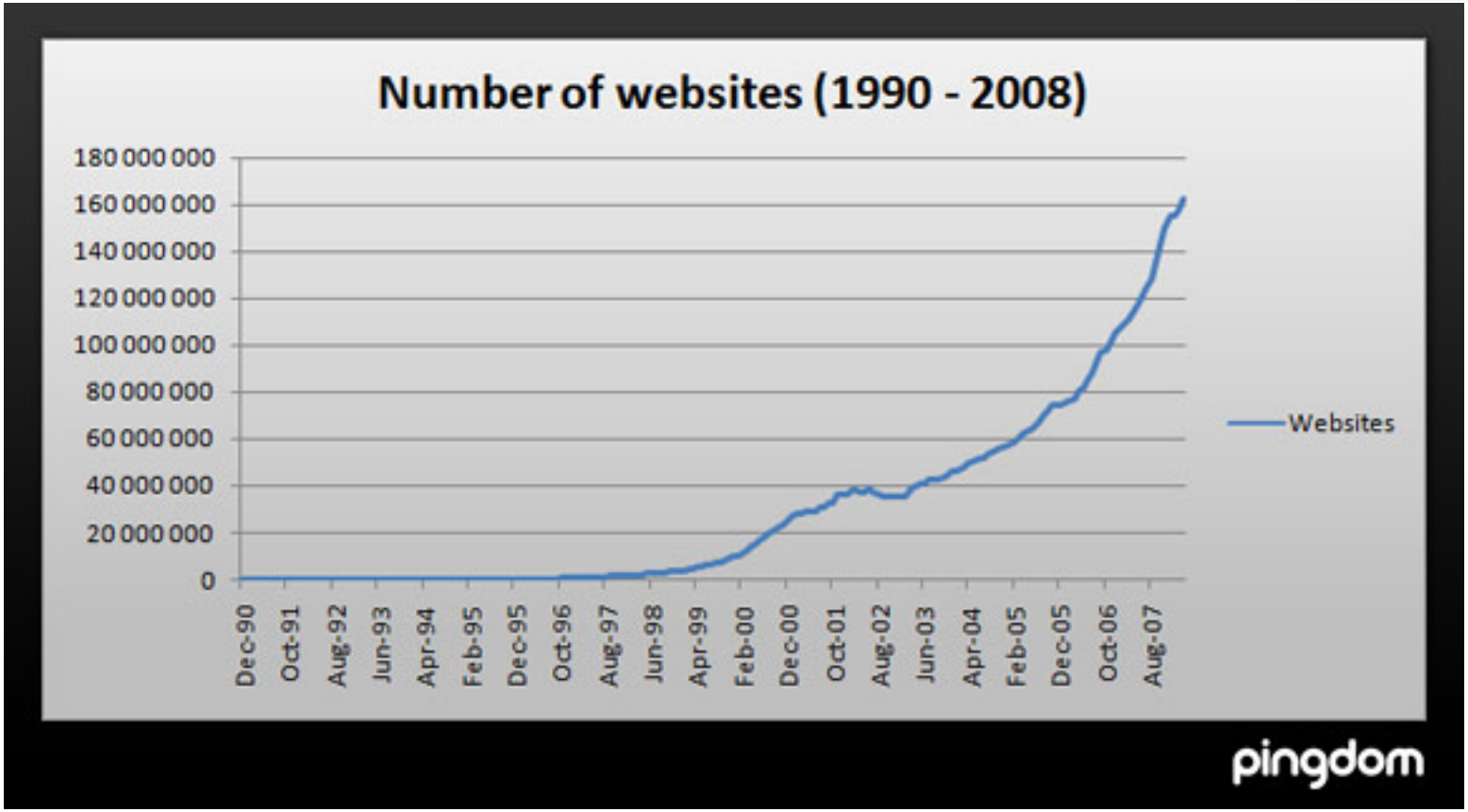
The myths of Innovation, Scott Berkun, O'Reilly, 2007

World Wide Web

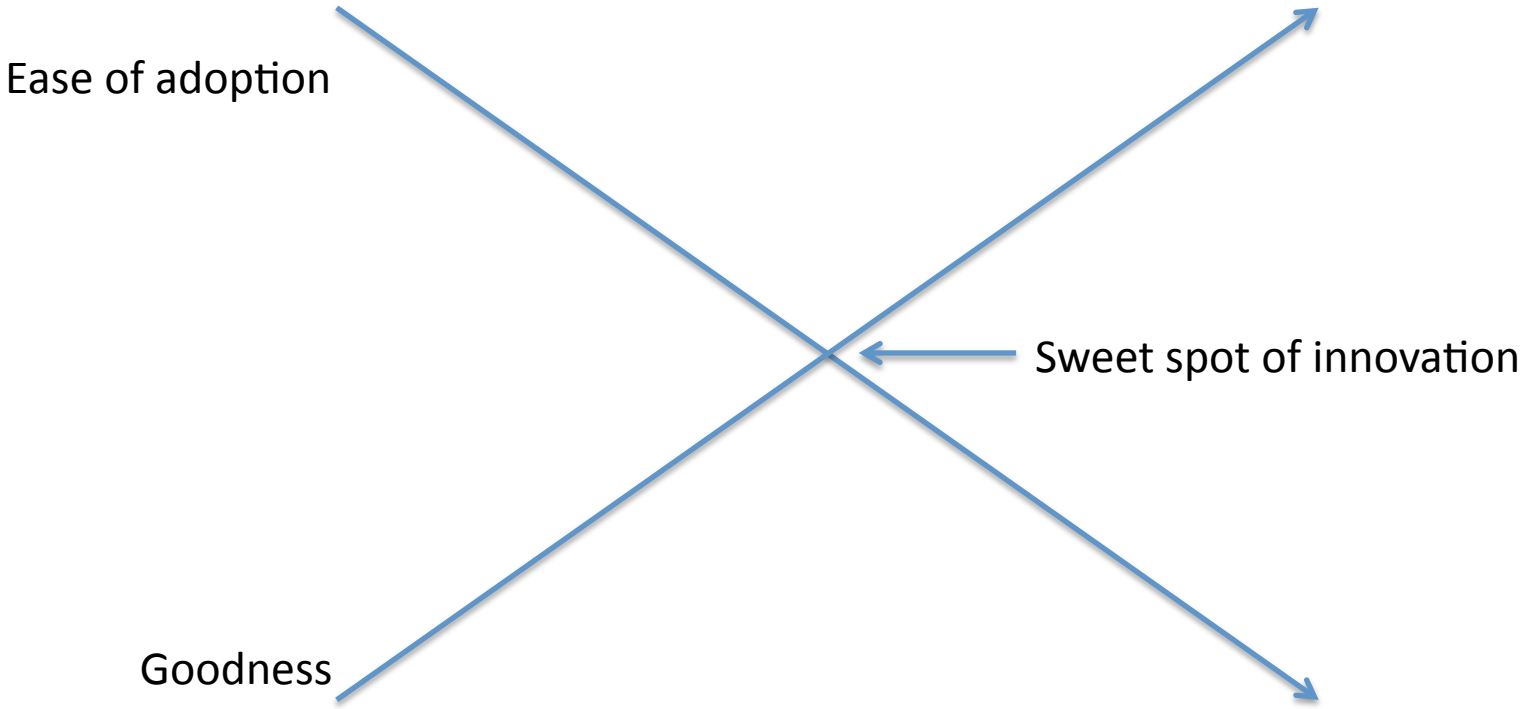
Number of websites, Dec 90 to Jan 96

Date	Number of websites
Dec 90	1
Dec 91	10
Dec 92	50
Jun 93	130
Sep 93	204
Oct 93	228
Dec 93	623
Jun 94	2,738
Dec 94	10,022
Jun 95	23,500
Jan 96	100,000

http://royal.pingdom.com/2008/04/04/how-we-got-from-1-to-162-million-websites-on-the-internet/



Goodness/Adoption Paradox



The myths of Innovation, Scott Berkun, O'Reilly, 2007

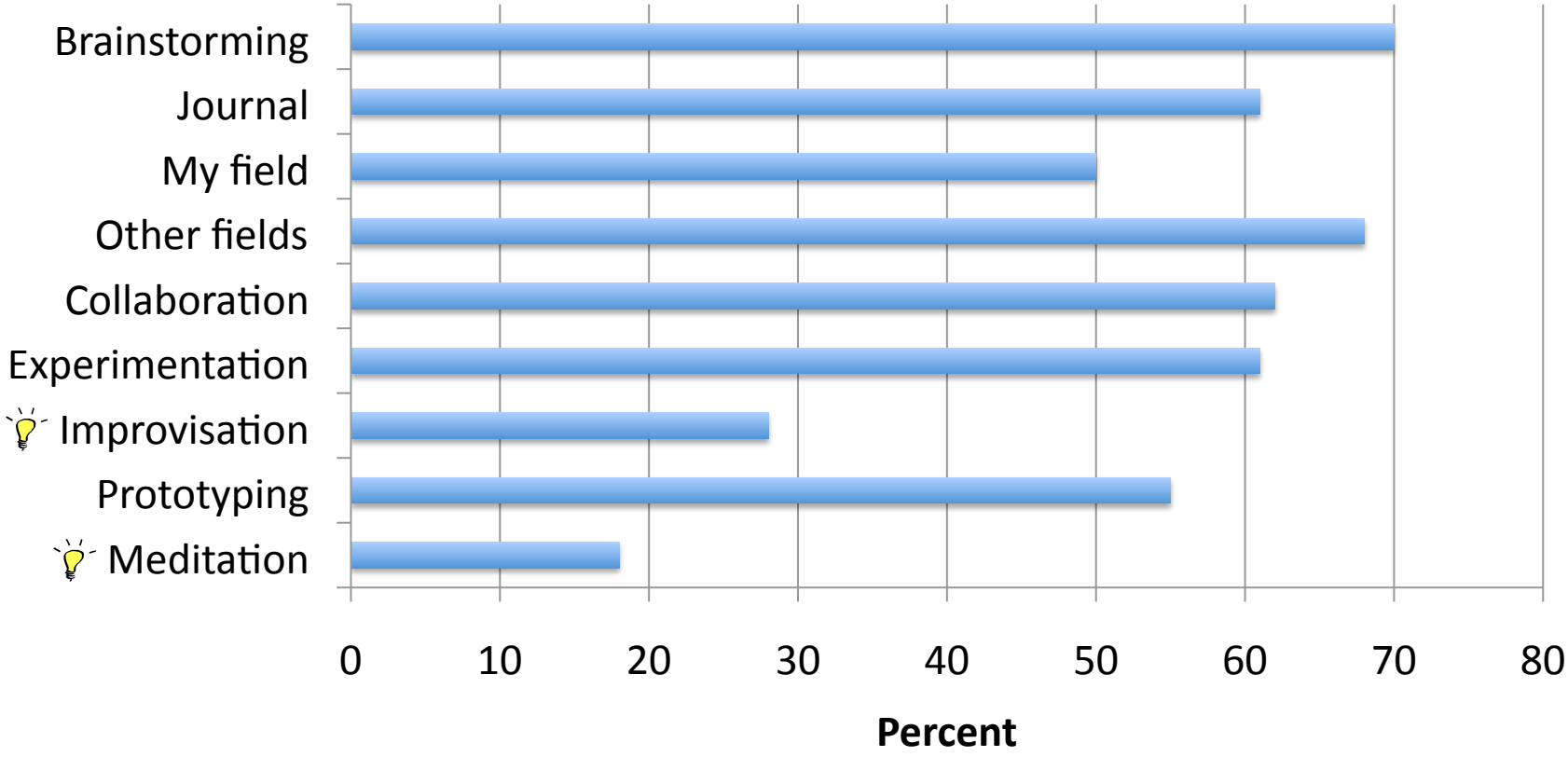
Problem solving is not nearly as important as **Problem Finding**

Project	Problem Definitions/Goals
Apple IIe	Reduce costs Simplify manufacturing Modernize Look like the Apple II
Original IBM PC	Beat Apple Do it in one year
Palm Pilot	Fits in shirt pocket Sync with PC Fast and easy to use Not more than $299

The myths of Innovation, Scott Berkun, O'Reilly, 2007

Idea-finding Techniques Used by Innovators

Based on a survey of over 100 self-identified innovators in various fields



The myths of Innovation, Scott Berkun, O'Reilly, 2007

TOOLS FOR CREATIVITY

Tools for Creativity

- Mindmap
- SWOT analysis
  (Strength, Weakness, Opportunity, Threat)
- TRIZ
  (Teoriya Resheniya Izobreatatelskikh Zadatch
  —Russian for the Theory of Inventive Problem Solving (TIPS)—)

What are Mind Maps?

- A mind map is a way to visually organize notes, thoughts, ideas, and conversations.
- Tony Buzan has largely tried to take credit for inventing modern mind mapping. (he's a British psychologist)
- In reality different forms of mind mapping have been used over many centuries – Buzan really just popularized it and offered some theories around why they work so well to capture thoughts and are compatible with the thought process.
- A Mind Map is created around a single word or text, placed in the center, to which associated ideas, words and concepts are added.
- Mind Maps have many uses including business situations where you could use Mind Maps to document conversations, general note taking, brainstorming, or to parse out a strategy or a particularly complicated situation you may face.
- In business mind maps are most frequently used collaboratively – but it is possible to use mind mapping on your own, as an individual.

Source: Michael Years, Market Development Consulting

Mind Map Uses

- You can use a Mind Map for:
  - Problem solving/decision making
  - Strategy development
  - Outline a proposal
  - Create a timeline
  - Defining roles at an organization
  - Collaboration technique
  - Expression of creativity
  - Condensing your thoughts onto one page
  - As a SWOT analysis
  - Create a framework
  - Put visuals and text together
  - Develop keyword phrases

Source: Michael Years, Market Development Consulting

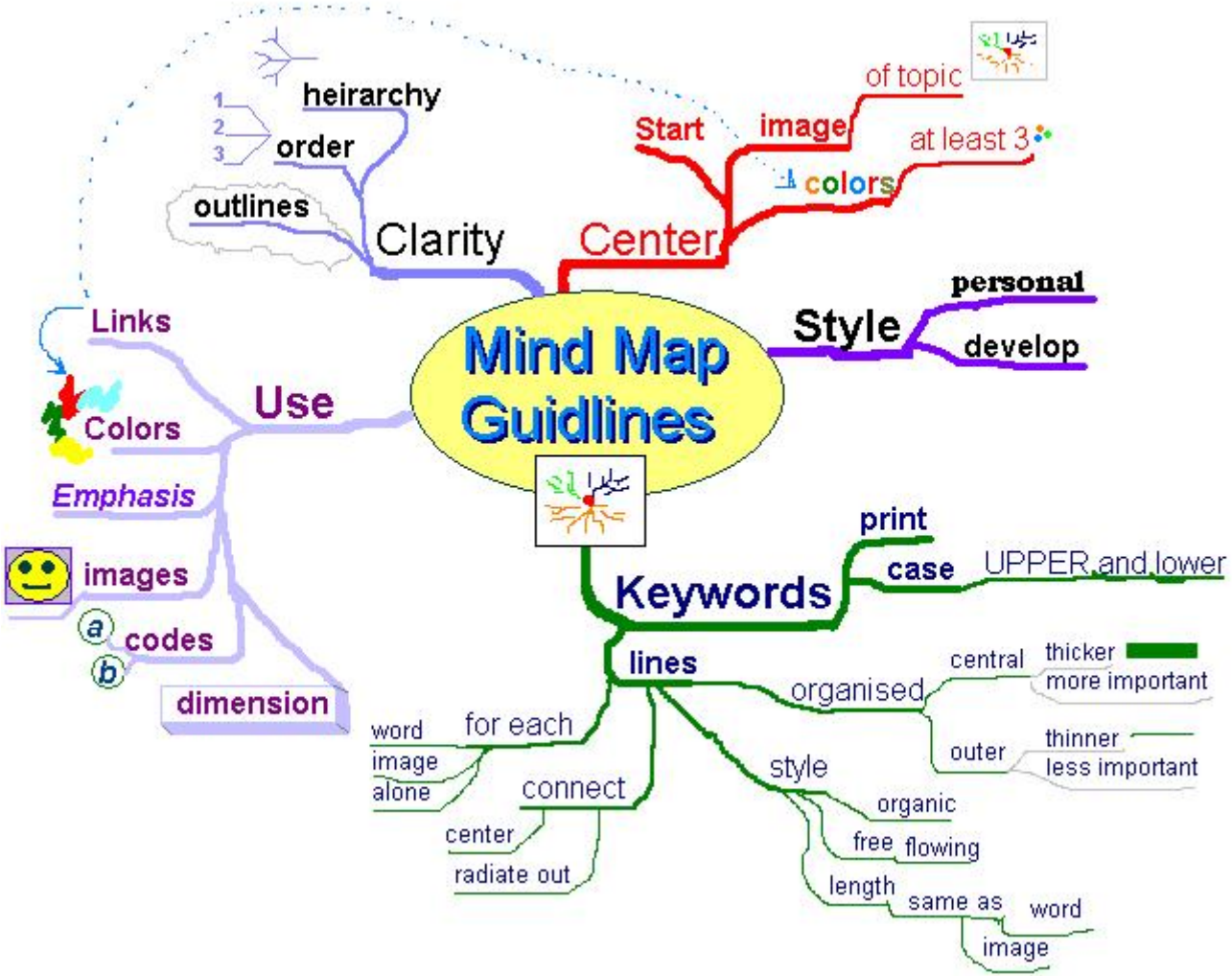
Mind Map Guidelines

In his books on Mind Maps author Tony Buzan suggests using the following guidelines for creating Mind Maps:

- Start in the center with an image of the topic, using at least 3 colors.
- Use images, symbols, codes, and dimensions throughout your Mind Map.
- Select key words and print using upper or lower case letters.
- Each word/image is best alone and sitting on its own line.
- The lines should be connected, starting from the central image. The central lines are thicker, organic and thinner as they radiate out from the centre.
- Make the lines the same length as the word/image they support.
- Use multiple colors throughout the Mind Map, for visual stimulation and also to encode or group.
- Develop your own personal style of Mind Mapping.
- Use emphasis and show associations in your Mind Map.
- Keep the Mind Map clear by using radial hierarchy, numerical order or outlines to embrace your branches.

Source: http://en.wikipedia.org/wiki/Mind_map

Mind Map Guidelines



Source: http://en.wikipedia.org/wiki/File:MindMapGuidlines.JPG Author: Danny Stevens

What is SWOT Analysis?

- A method for analysing a business, its resources, and its environment
- Often used as part of strategic planning
- Looks at
  - Internal strengths
  - Internal weaknesses
  - Opportunities in the external environment
  - Threats in the external environment

Source: tutor2u@slideshare.net

SWOT's Aim

- The aim of any SWOT analysis is to identify the key internal and external factors that are important to achieving the objective
- SWOT analysis groups key pieces of information into two main categories:
  - Internal factors – The 'strengths' and 'weaknesses' internal to the organization
  - External factors – The 'opportunities' and 'threats' presented by the external environment

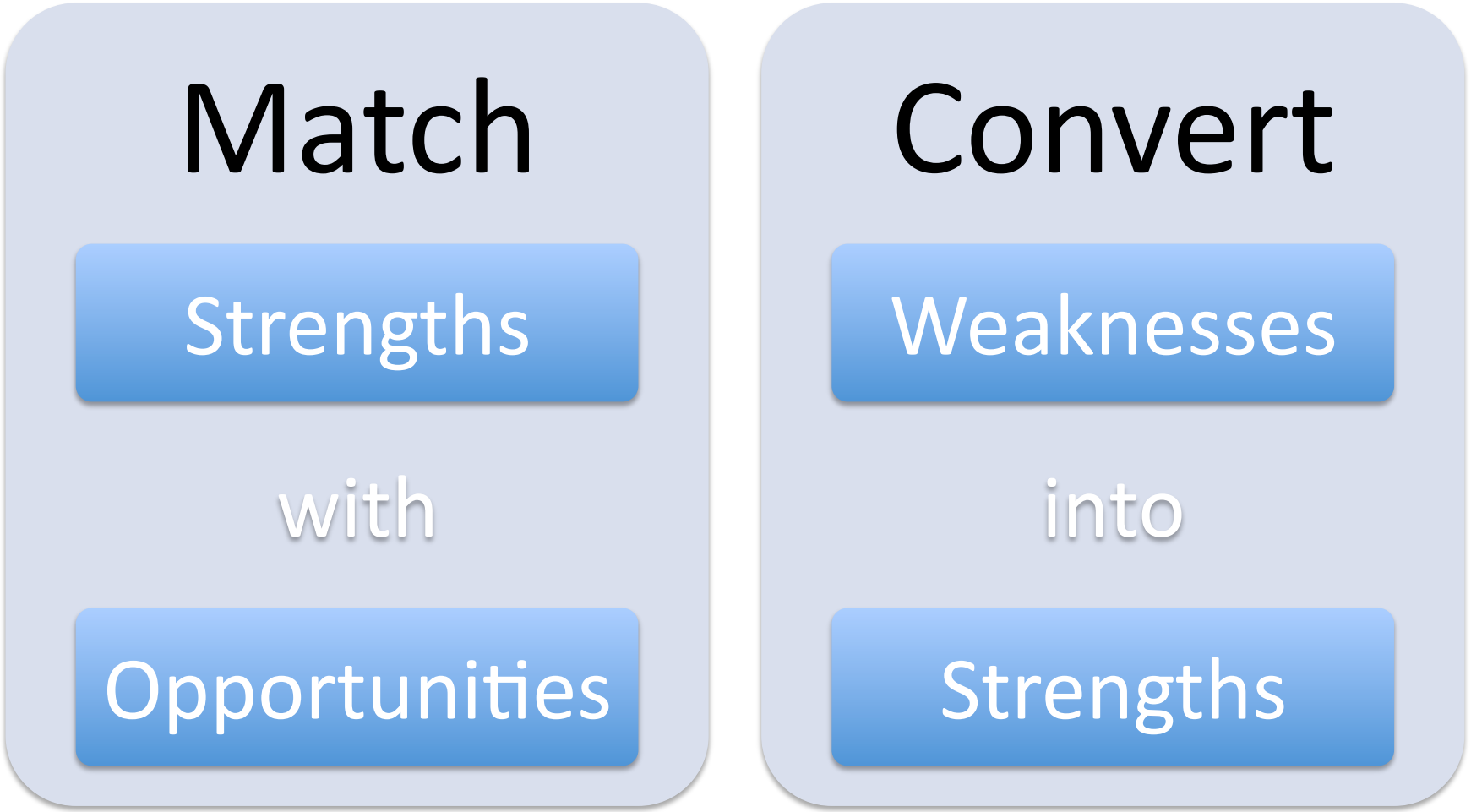
Source: swotsummary@slideshare.net

The SWOT Matrix

	Positive factors	Negative factors
Internal factors	Strengths	Weaknesses
External factors	Opportunities	Threats

Source: tutor2u@slideshare.net

Match and Convert



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Convert weaknesses into strengths

Weakness	Possible Response
Outdated technology	Acquire competitor with leading technology
Skills gap	Invest in training & more effective recruitment
Overdependence on a single product	Diversify the product portfolio by entering new markets
Poor quality	Invest in quality assurance
High fixed costs	Examine potential for outsourcing or offshoring

Source: tutor2u@slideshare.net

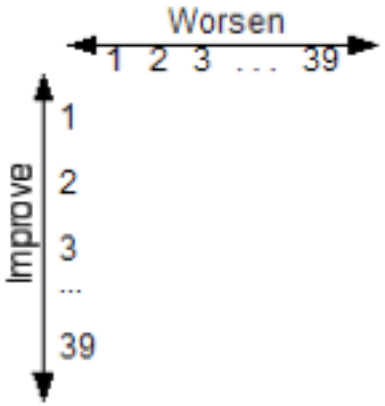
TRIZ

- **TRIZ** = "Teoriya Resheniya Izobreatatelskikh Zadatch" and is Russian for the "**Theory of Inventive Problem Solving (TIPS)**"
- The brainchild of Russian engineer and scientist Genrich Altshuller who studied tens of thousands of patents to look for similarities and innovations in the patents.
- The TRIZ process recognizes that technical systems evolve towards the increase of ideality by overcoming contradictions mostly with minimal introduction of resources. http://www.triz40.com/TRIZ_GB.php

39 TRIZ Features

39 TRIZ Features

1: Weight of moving object	14: Strength	27: Reliability
2: Weight of stationary object	15: Durability of moving object	28: Measurement accuracy
3: Length of moving object	16: Durability of non moving object	29: Manufacturing precision
4: Length of stationary object	17: Temperature	30: Object-affected harmful
5: Area of moving object	18: Illumination intensity	31: Object-generated harmful
6: Area of stationary object	19: Use of energy by moving object	32: Ease of manufacture
7: Volume of moving object	20: Use of energy by stationary object	33: Ease of operation
8: Volume of stationary object	21: Power	34: Ease of repair
9: Speed of object	22: Loss of Energy	35: Adaptability or versatility
10: Force (Intensity)	23: Loss of substance	36: Device complexity
11: Stress or pressure	24: Loss of Information	37: Difficulty of detecting
12: Shape	25: Loss of Time	38: Extent of automation
13: Stability of the object	26: Quantity of substance	39: Productivity



Interactive tools:
http://www.triz40.com/TRIZ_GB.php

TRIZ Contradiction Matrix

Improving Feature \ Worsening Feature	1: Weight of moving object	2: Weight of stationary object	3: Length of moving object	4: Length of stationary object	5: Area of moving object	6: Area of stationary object
1: Weight of moving object	*	-	15, 8 29, 34	-	29, 17 38, 34	-
2: Weight of stationary object	-	*	-	10, 1 29, 35	-	35, 30 13, 2
3: Length of moving object	8, 15 29, 34	-	*	-	15, 17 4	-
4: Length of stationary object	-	35, 28 40, 29	-	*	-	17, 7 10, 40
5: Area of moving object	2, 17 29, 4	-	14, 15 18, 4	-	*	-
6: Area of stationary object	-	30, 2 14, 18	-	26, 7 9, 39	-	*
7: Volume of moving object	2, 26 29, 40	-	1, 7 4, 35	-	1, 7 4, 17	-
8: Volume of stationary object	-	35, 10 19, 14	19, 14	35, 8 2, 14	-	-
9: Speed of object	2, 28 13, 38	-	13, 14 8	-	29, 30 34	-
10: Force (Intensity)	8 1 37 18	18 13 1 28	17 19 9 36	28 10	19 10 15	1 18 36 37
11: Stress or pressure	10 36 37 40	13 29 10 18	35 10 36	35 1 14 16	10 15 36 28	10 15 36 37
12: Shape	8 10 29 40	15 10 26 3	29 34 5 4	13 14 10 7	5 34 4 10	-
13: Stability of the object	21 35 2 39	26 39 1 40	13 15 1 28	37	2 11 13	39
14: Strength	1 8 40 15	40 26 27 1	1 15 8 35	15 14 28 26	3 34 40 29	9 40 28

Altshuller's 40 Principles of TRIZ

Altshuller's 40 Principles of TRIZ

1. Segmentation	15. Dynamics	28. Mechanics substitution
2. Taking out	16. Partial or excessive actions	29. Pneumatics and hydraulics
3. Local Quality	17. Another dimension	30. Flexible shells and thin films
4. Asymmetry	18. Mechanical vibration	31. Porous materials
5. Merging	19. Periodic action	32. Color changes
6. Universality	20. Continuity of useful action	33. Homogeneity
7. "Nested doll"	21. Skipping	34. Discarding and recovering
8. Anti-weight	22 "Blessing in disguise"	35. Parameter changes
9. Preliminary anti-action	23. Feedback	36. Phase transitions
10. Preliminary action	24. 'Intermediary'	37. Thermal expansion
11. Beforehand cushioning	25. Self-service	38. Strong oxidants
12. Equipotentiality	26. Copying	39. Inert atmosphere
13. The other way around	27. Cheap short-living	40. Composite material films
14. Spheroidality		

Two Basic Principles of TRIZ by Domb

- Somebody, someplace, has already solved your problem or one similar to it. Creativity means finding that solution and adapting it to the current problem.
- Don't accept contradictions. Resolve them.

TOOLS FOR EVALUATION

Tools for Management and Evaluation

- Gantt chart
- **NSDB**
  Needs-Solution-Differentiation-Benefits
- PDCA
  Plan-Do-Check-Act
- Gatekeeper
- **Valley of Death**

NSDB

(Needs-Solution-Differentiation-Benefits)

- Based on NABC analytical model (customer/ market Needs, compelling Approach, customer Benefits, worldwide Competition) put forward by SRI (Stanford Research International).
- Based on ITRI's 32-year experience, it seeks to convert the NABC model into NSDB method, which is closer to Taiwan's local economic value creation. In other words, it produces maximum benefits by providing solutions that meet market needs through differentiation of competitors.

NSDB

The way how we think determines our fate!

- Thinking as suppliers: We sell what we make.
- Thinking as customers: We offer what customers need.

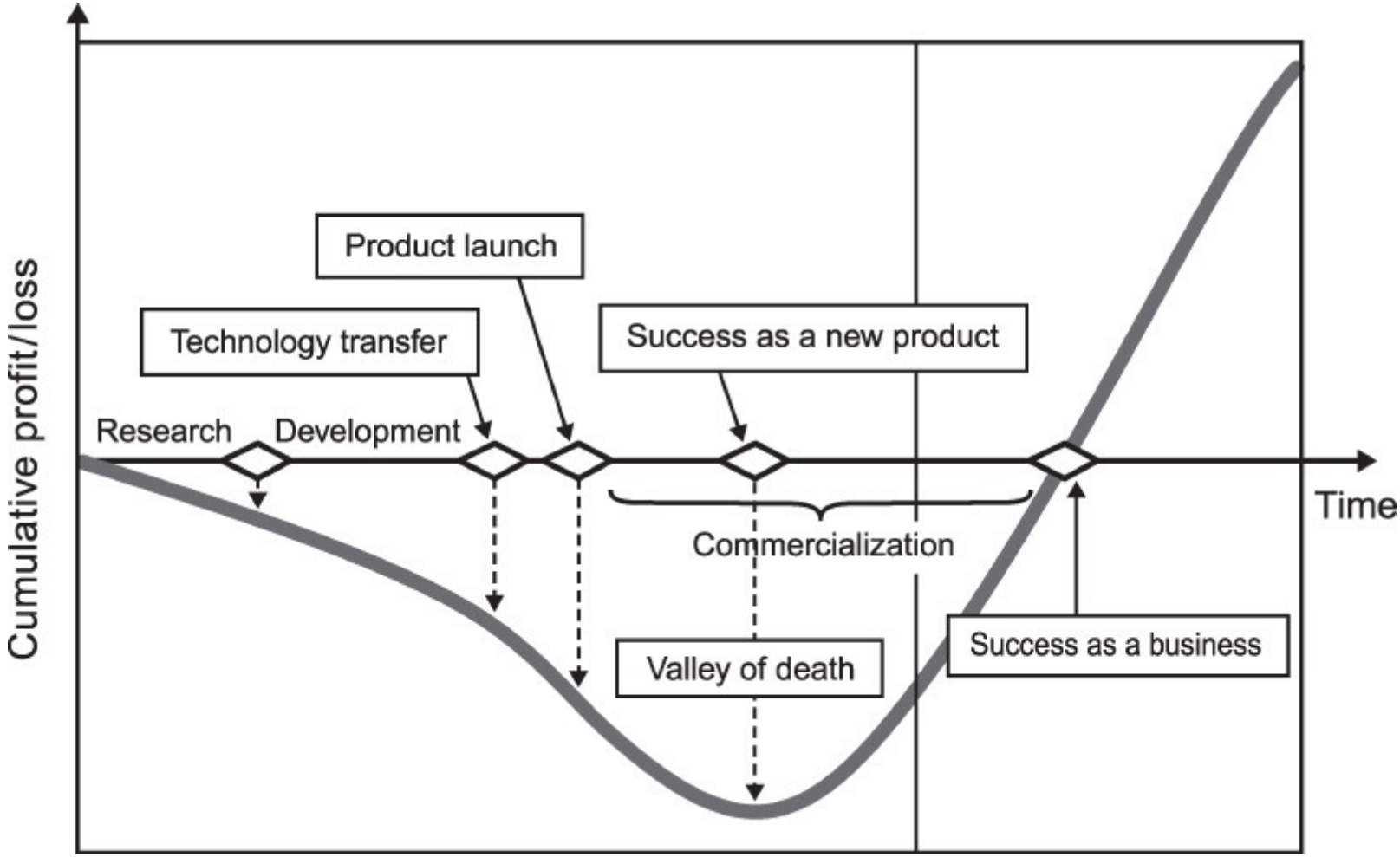
NSDB is the core of "Value Innovation" that Dr. Yeh mentioned in the workshop.

- N (Needs): Find out the real needs of customers and markets
- S (Solution): Offer a compelling solution
- D (Differentiation): The solution is differentiated from the competitor's
- B (Benefits): Create maximum benefits that meet customers' needs

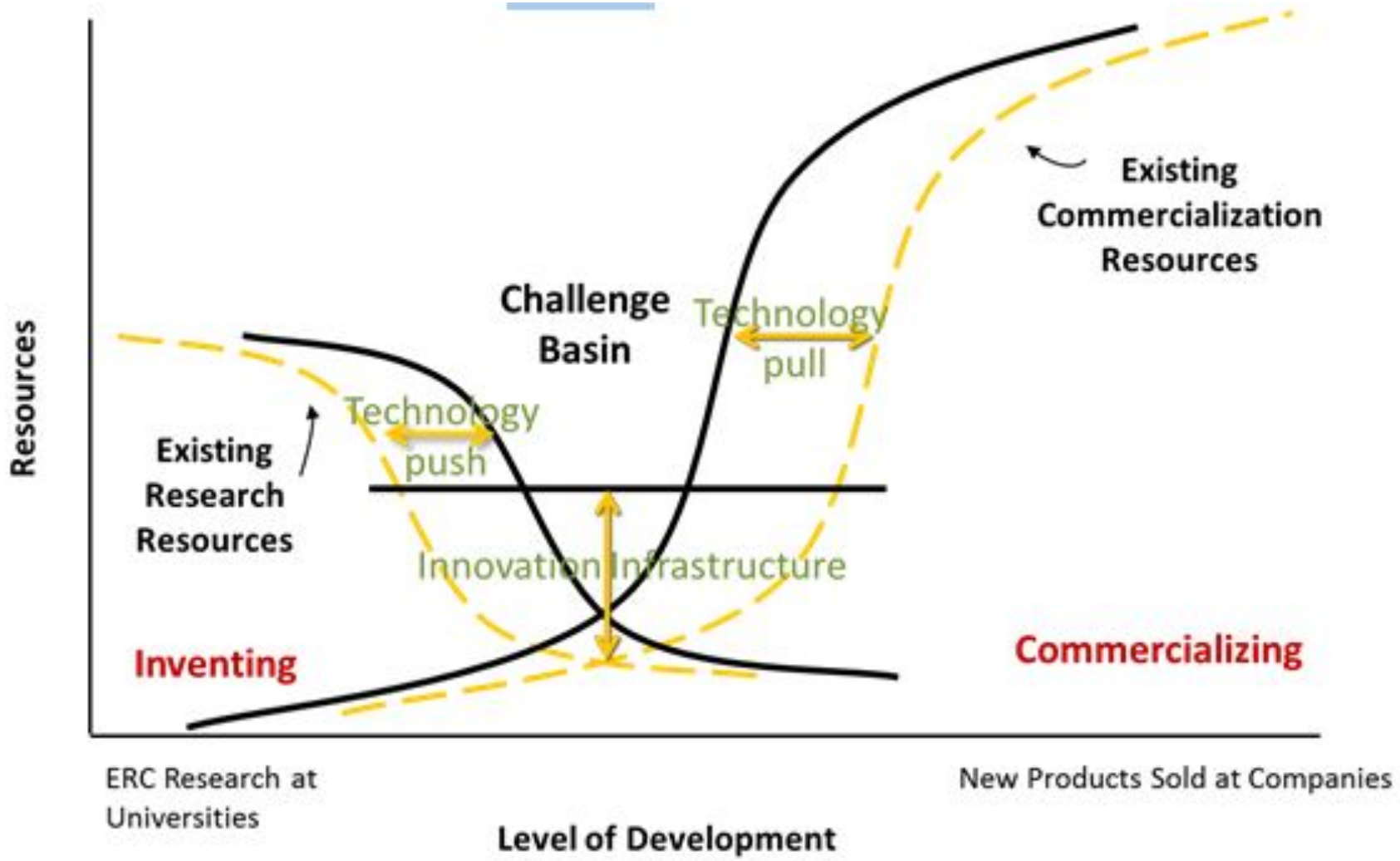
Of the four elements, N (Needs) is a fountainhead. Find out customers' pain (real needs) and offer a painkilling solution.

2010.06.23 (Wed.) JC Journal – Innovation of Products & Services - NSDB
http://www.hybrex.com/BlogEntry.aspx?BlogID=1&Locale=en-US&EntryID=2208

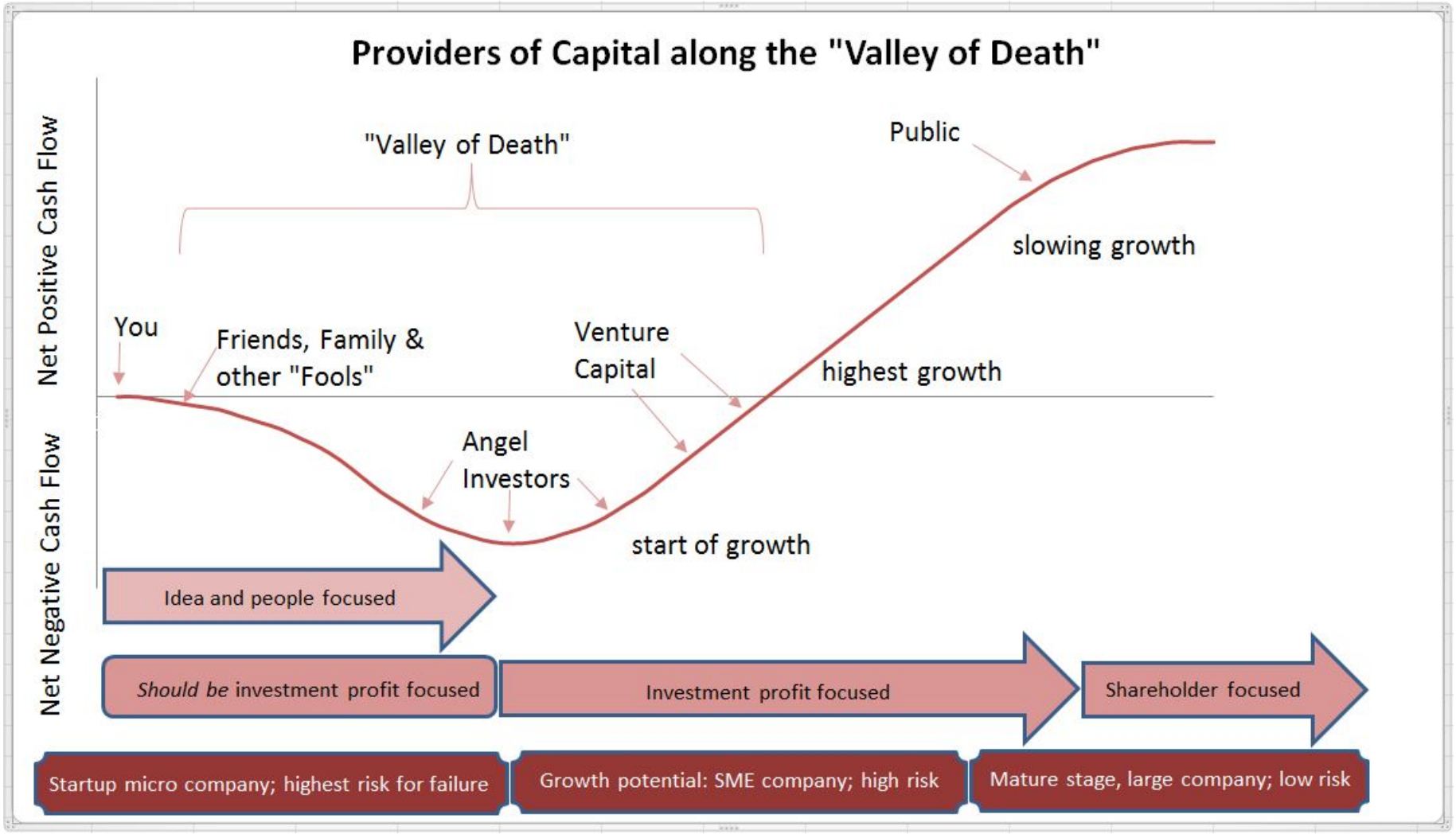
Valley of Death
--Commercialize R&D--



Valley of Death
--Shallowing the Valley--



Valley of Death
--It's all about money--



Tools for Management and Evaluation (others)

- BSC (Balanced Scorecard)
- WIG (Widely Important Goal)
  - Lag measure
  - Lead measure
- Logic Model (short-term, medium-term, long-term impact)
  - Input (man, machine, money)
  - output (paper, patent, prototype)
  - outcome (income, impact)

Productivity & Creativity

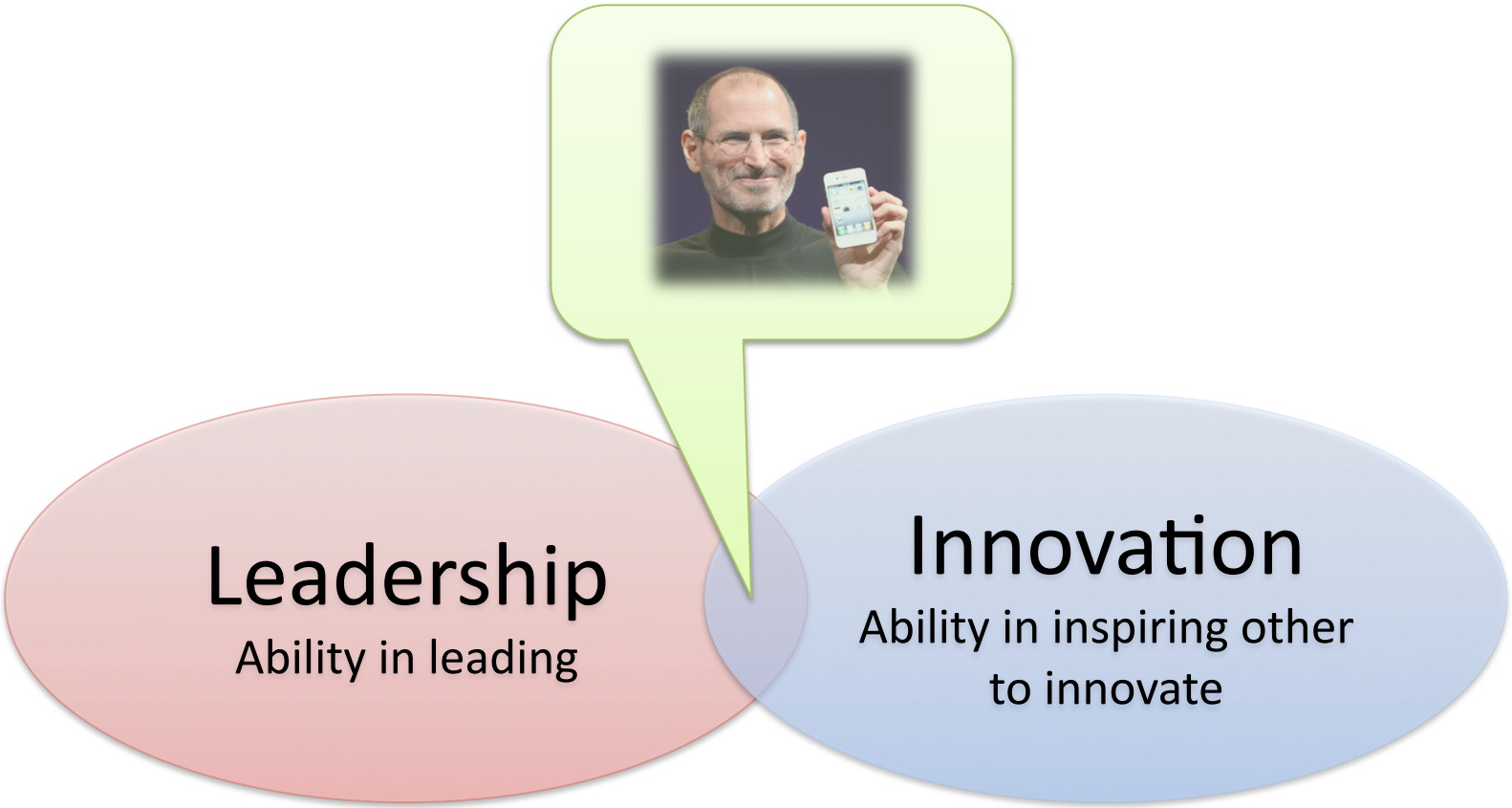
⟹ Concentration on work rather than tools

> Simple tools, less burden

> Get used to them as early as possible

LEADERSHIP

Leader in New Era



Stay hungry. Stay foolish.

Your time is limited,
so don't waste it living someone else's life.

Connecting the dots

Creativity is just connecting things.

When you ask creative people how they did something, they feel a little guilty because they didn't really do it, they just saw something. It seemed obvious to them after a while. That's because they were able to connect experiences they've had and synthesize new things....

– **Steve Jobs**, Wired, February, 1995

Raw Data

Raw data now!

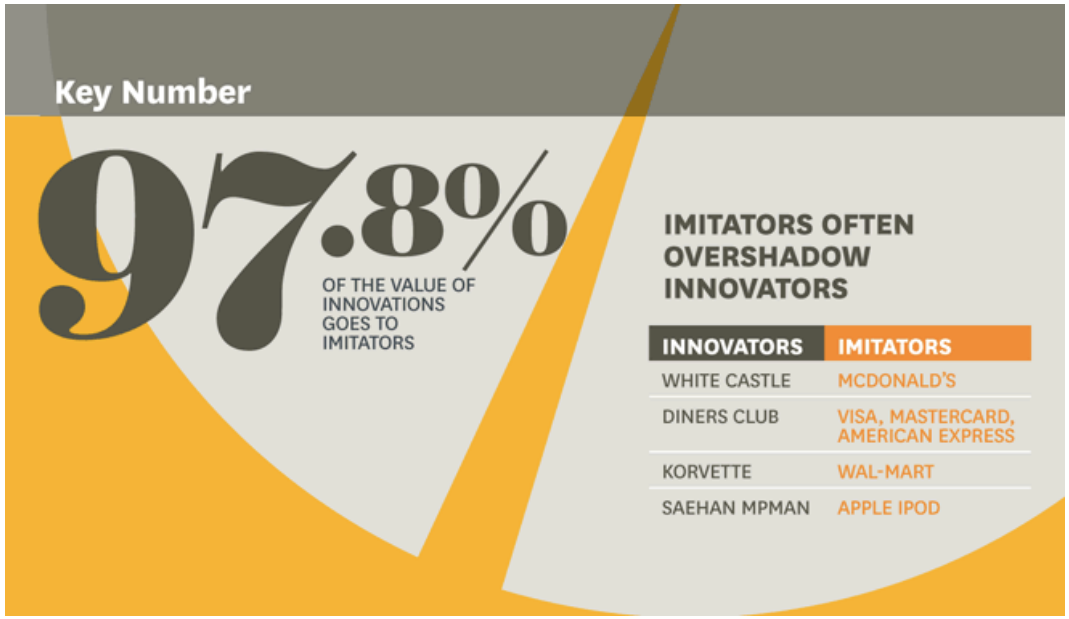
– **Tim Berners-Lee** on the next Web, TED Talks
At TED2009

Copy and Imitation

Picasso had a saying –

'Good artists copy, Great artists steal'

- and we have always been shameless about stealing great ideas." — Walter Isaacson, Steve Jobs



http://hbr.org/2010/04/defend-your-research-imitation-is-more-valuable-than-innovation/ar/1

Samsung

Lee Kun-Hee, Chairman

Analysis

Cost reduction & Competitor trend

Fighting spirit by leader

Production & marketing

GOOD RESEARCHER, GOOD RESEARCH

Aiming for the Top

- What makes a good leader?
- What makes a good researcher?
- What makes good research?
- What makes not so good research?
- Worrying trends

By Prof. Chung Low, GESL Symposium 2013, Keio Univ.

What Makes a Good Leader in Science & Technology?

- Need to have a strong technical foundation yourself
- Confident
- Consultative but decisive
- Inspirational
- Visionary
- Lead by example
  - High technical standard. Demands the best
  - Personal qualities – ethics
- Caring
- Ready with deserved praise
- Clear but gentle criticism
- Never hurt a subordinate's confidence

What Makes a Good Researcher? (1/2)

- Education
  - Strong in basics
  - Broad in knowledge
- Personality traits
  - Creative (but principled)
  - Curious (but disciplined)
  - "Rebellious" (but with reason)
  - Bold (but cautious)
  - Intuitive (but thorough)
  - Thorough (but not stifling)
  - Persistent (but not stubborn)
  - Optimistic (but self critical)

What Makes a Good Researcher? (2/2)

- Working habits and attitudes
  - Dedicated and hardworking
  - Passionate and obsessive
- Additional factors
  - Timely and substantial publications
  - Good oral and written communication skills

Characteristics of Good Research

- Logical
- Significant Impact
  - Revision of basic concepts
  - Discovery of new phenomena and processes
  - Generalization of principles
- Simple and elegant results

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Characteristics of Not So Good Research

- Sterile “fundamental” research
- Uncontrolled and unguided experimental mapping
- Mindless computational data generation
- “Garbage in, garbage out” in computation
- Useless research is at least better than misleading research

Worrying Trends

- Decrease in academic rigor and standard at undergraduate and graduate levels
- Decrease in dedication by both students and faculty
- Excessive reliance on computation; reduced emphasis on mathematical and analytical skills
- Too much hand-holding in textbooks and lectures; inhabits independent thinking
- Emphasis on new areas (bio, nano, info, materials) at the expense of fundamentals and traditional areas (e.g. aero and auto)