Overcoming Innovation gaps:

Technology Management & Entrepreneurship Initiatives

Professor C C Hang
Head, Div. of Engg & Technology Management,
Faculty of Engineering & Exe Director,
Institute for Engineering Leadership

Contents

- Examples of Innovation Challenges
- Innovation Gaps
- Management of Technology (MOT) Education – Example of Singapore
- Entrepreneurship Education: A New Attempt by Singapore

- Contrary to some dominant logic, there was actually little success by the Venture Capital industry to nurture breakthrough innovation, especially in recent years. Many high-tech start-ups indeed either failed rapidly or struggled to survive in crossing the valley of death.

Example 1: The invention of **carbon nanotubes** in the early 1990s was thought to be a major breakthrough with many potential applications – hence large amount of public funding was provided by government funding agencies globally. After 18 years, with more than 50,000 publications (still increasing annually now), many early start-ups based on nanotube technology with VC backing failed to create any impactful product!

[from Eugene Fitzgerald, et. al "Inside Real Innovation", Nov 2010]

Example 2: Segway Human Transporter

- In early 2000s, DECA R&D Corp spent more than US$100M to develop the Segway Human Transporter – an engineering marvel involving the use of advanced control techniques, sophisticated microprocessors (x10), aviation-grade gyros, an accelerometer, etc. It has no brakes, no throttles, no gear-shift and no steering wheel!

- **VC firm Kleiner Perkins (which launched Netscape, Amazon.com, etc) invested US$38M for a 7.5% stake – valuing DECA at US$500M!**

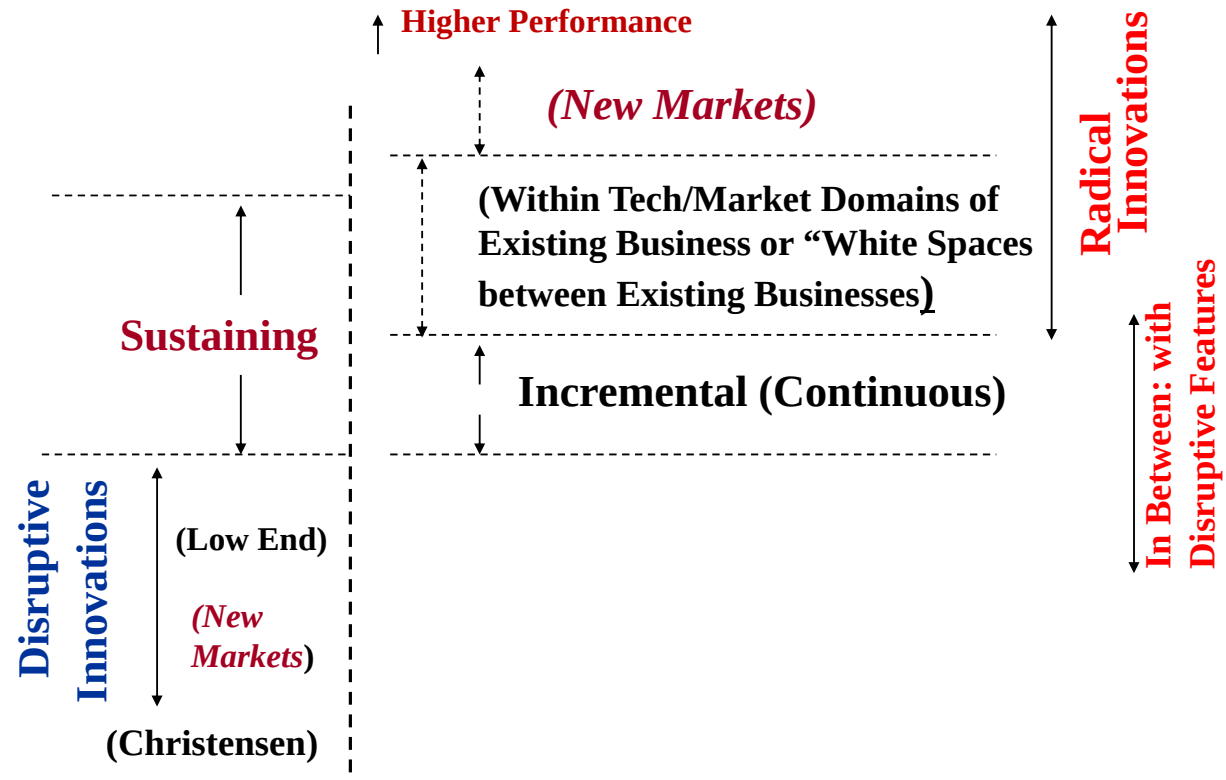
-- Individual investors included Paul Allaire, CEO of Xerox

-- Intel Chairman Andy Grove gave it a thumbs up

- Big expectations: e.g. "Segway will be to the car what the car was to the horse and buggy"; DECA prepared a large factory to produce 40,000 Segways/month.

- Problem: *Would customers pay US$3000 for each Segway??*

Radical vs Disruptive Innovations



What Is the Innovator's Dilemma?

Good/Innovative Firms understand :

Old Technologies		**New Technologies**
(vacuum tube)	(eventually) → replaced by	(transistor)
(minicomputer)		(microcomputer)
(laser-jet printing)		(ink-jet printing) ??
(TV tube)		(flat-panel display)

Yet most of the established firms failed when attacked by new entrant firms using ***certain*** technologies with initially ***inferior*** performance!

(1997 Book by Harvard's Professor Clayton Christensen,
*"**The Innovator's Dilemma** : Why New Technologies Cause Great Firms to Fail? ")*
*(**"certain"** & **"inferior"** refer to "disruptive" but not 2nd rate technologies)*

A Long List of Such Failures

RCA	Its Consumer Electronics Div was a leader in vacuum tubes + products.
DEC	A US $7.6 B giant in 1986 and a model in the book " In Search of Excellence").
Xerox	Missed the chance in tabletop photocopiers; failed to commercialise many of its PARC inventions.
IBM	Missed the advent of mini-computers; successful initially in the PC business but eventually pulled out.

The Dilemma: These leading companies were innovative and well-run; they also had sophisticated market knowledge and distribution channels. Yet the way decisions were made, when confronted with *disruptive* changes in technology and market structure, sowed the seeds of eventual failure!

Disruptive Innovation/Technology

New technologies are developed continuously to foster improved product performance. They are known as *Sustaining Technologies* as they are responsible for improved performance of established products. They could be either incremental or discontinuous (radical/break-through) in character. (Same marketplace → little organizational impact; some people may need to learn new skills.)

→ *Sustaining Innovation*

Occasionally, *Disruptive Technologies* emerge. They result in worse product performance, at least in the near-term. Hence they under-perform established products in mainstream markets. But they have other features that a few fringe (and new) customers value (they are typically cheaper, simpler, smaller and frequently more convenient to use).

→ *Disruptive Innovation*

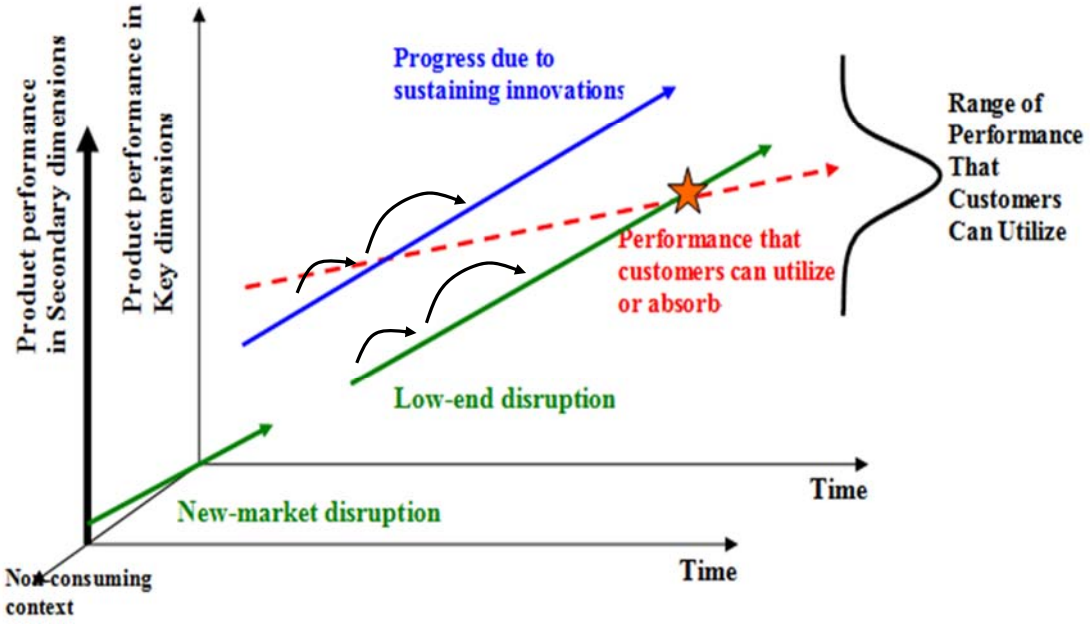


Figure 2 The Disruptive Innovation Model

Example 3 : GE's Portable Ultrasound Business

Back in 2002, GE served the Chinese ultrasound market with machines developed in the US and Japan. But the expensive *($100K)* bulky devices sold poorly. Then a local team in China leveraged GE's global resources to develop a cheaper, portable machine using a laptop computer enhanced with a probe and sophisticated software. Its *$30K ~ $40K* price was more acceptable and some rural clinics bought it.

In late 2007, GE introduced a model that sold for as low as $15K, which became a hit in rural clinics, where doctors used it for simple applications such as spotting enlarged livers and gallbladders and stomach irregularities.

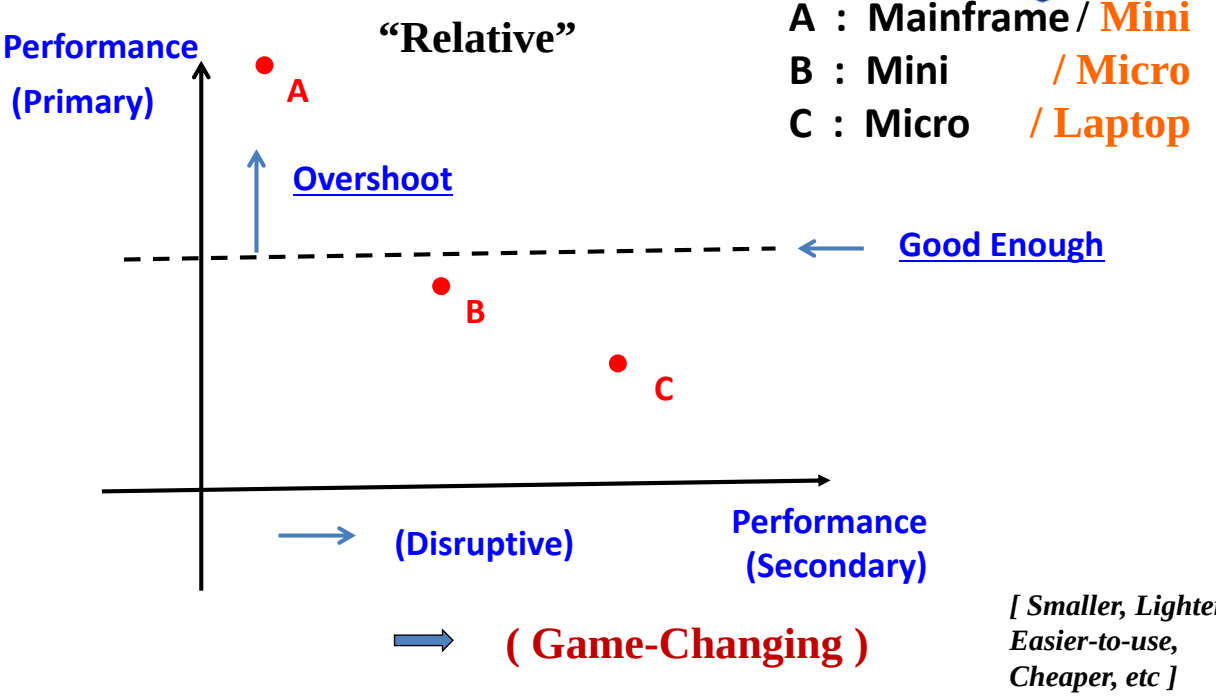
Even more exciting, the innovation found new applications in the US, where portability is critical or space is constrained, such as at accident sites where the portable machines are used to diagnose problems like pericardial effusions (fluid around the heart); in emergency rooms where they are used to identify conditions such as ectopic pregnancies; and in operating rooms, where they aid anaesthesiologists in placing needles and catheters.

[6 years after their launch, the sales of portable ultrasounds grew from $4 M in 2002 to $278 M in 2008 *(50 to 60% growth per year !)*]

-- What can we learn from the above GE example?

Example of an Innovation with just good enough performance but very affordable; also a candidate to emerge first in the developed market and then find its way to create a new application in the advanced market – Strategy of Disruptive & Reverse Innovation.

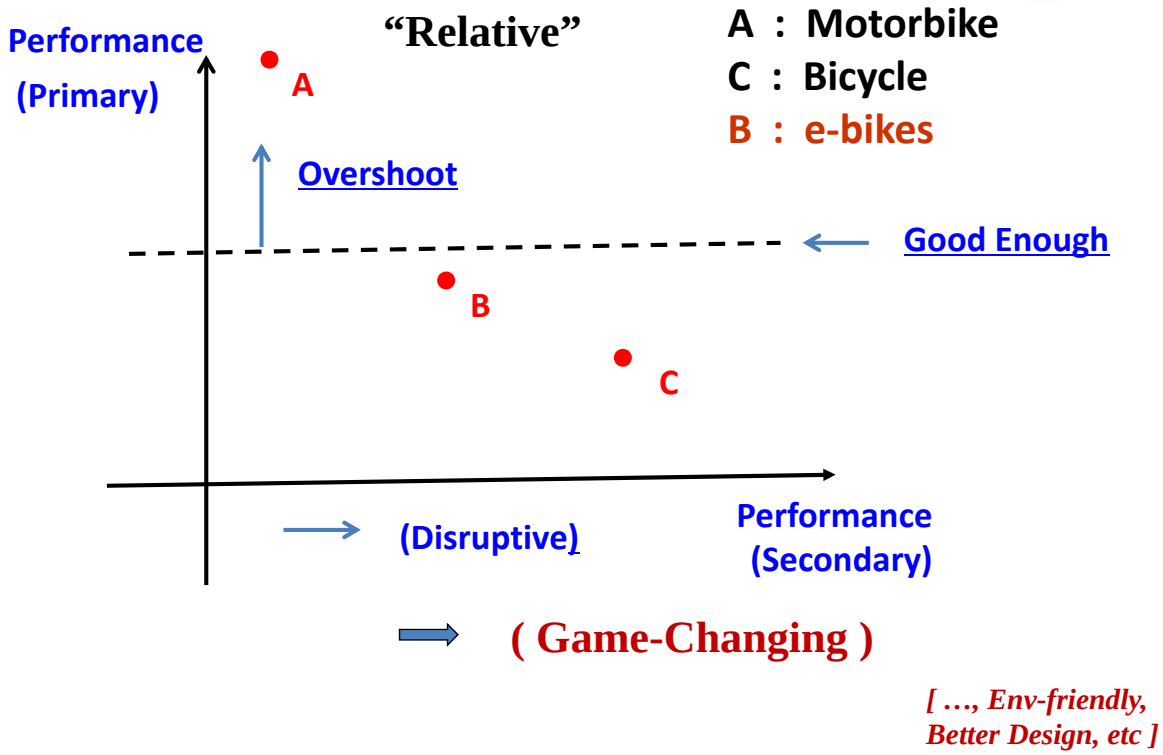
(Reverse flow: from 3rd to 1st world!)



A : Mainframe / Mini
B : Mini / Micro
C : Micro / Laptop

(Game-Changing)

[Smaller, Lighter, Easier-to-use, Cheaper, etc]



Role of Universities in Innovation Education

- Recognizing the above "**Innovation Gap**", Universities globally have tried to extend their missions to cover *Management of Technology (MOT)*.

  MBA : too long, too general (and for CEOs)

  MOT : started by MIT in 1981;
  > 200 programmes worldwide (still very few in Asia)

- In the National University of Singapore, we have experience in two different paths:
  -- 1st attempt for 8 years in the Business School;
  then stopped for 4 years;
  -- *Revived in 2004 in the **Faculty of Engineering**!*

Modules from MSc(MOT)

Core Modules	Code
▪ Management of Technological Innovation	MT5007/ BMA5115
▪ Finance for Engineering & Technology Management	MT5011
▪ IP Management	MT5001
▪ Management of Industrial R&D	MT5002
▪ Creativity and Innovation	MT5003
▪ Systems Engineering Project Management	SDM 5004
▪ Marketing of High-Tech Products & Innovation	MT5012

[An optional 2-day foundation module on Marketing and Strategy will be offered in July/August.]

Electives

Strategic Aspects	▪ Decision Analysis	IE5203
	▪ Knowledge Management	SDM5003
	▪ Creativity and Innovation	MT5003
	▪ Strategic and New Product Development	MT5006
	▪ Technology Intelligence & IP Strategy	MT5010
	▪ The Financial & Business Aspects of IP	MT5015
Organization & Systems Aspects	▪ Management and Organization (2 MCs)	BMA5004
	▪ Systems Engineering	SDM5002
	▪ Systems Architecture	SDM5001
	▪ Systems Approach to Tech & Innov Management	MT5014

Electives

Entrepreneurship Aspects	▪ Corporate Entrepreneurship	MT5008/BMA5404
	▪ Technopreneurship	BMA 5108
	▪ Analyzing High-Technology Opportunities	MT5009
	▪ User-centred Engineering & Product Development	MT5004
	▪ Business Models for High-Tech Products	MT5016
Operational Aspects	▪ Managing Operations	BMA 5010
	▪ Quality Planning and Management	IE5121
	▪ Industrial Logistics	IE5401
	▪ *MOT Research Project (8 MCs)*	*MT5900*
	▪ IP Laws for Scientists and Engineers	MT5005
	▪ Management Practicum	MT5900 & MT5901

- Each module is 4 MCs (3 hrs/week x 13 weeks)
- Need 40 MCs to graduate (either 10 modules or 8 modules + research project)
- At least 16 MCs from the core modules

2 years (part-time)

[Graduate Certificate in MOT – 4 Modules]

[Being adapted to become Executive Education modules]

Strength

- Drawing modules from both Engineering and Business Depts
- Mixed pedagogy of lectures and case discussions (60/40 to 50/50)
- Balance: Scholar-Teachers/Adjunct Professors from industry
- Balance: global perspectives from Visiting Professors

Role of Universities in Innovation & Enterprise

- In recent years, there is a recognition of a **second "Innovation Gap"**, in that large % of patents from universities and public Research Institutes research remain un-utilized. Universities and RIs globally have responded by extending their missions to cover *Innovation & Enterprise*.
- In the Institute for Engineering Leadership in NUS, we have created a process to iterate through Technology, Market and Implementation so that potential start-ups will improve the odds of survival
  → *a kind of realistic innovation education with the help of experienced business angels as mentors.*

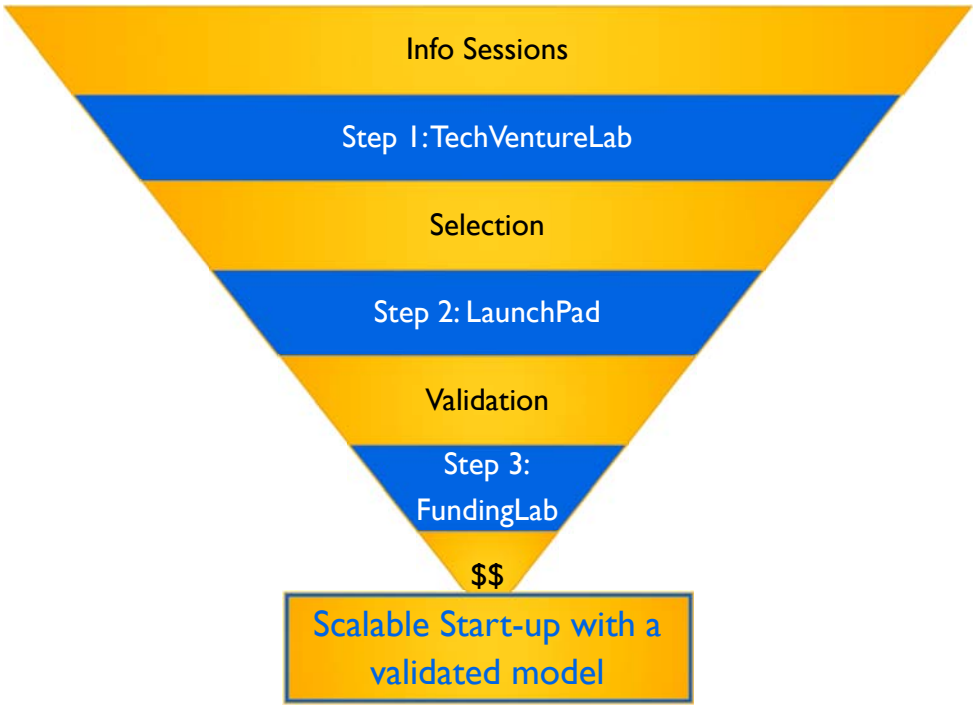
Entrepreneurship Defined

It's ALL about IMPACT!

(TECHNOLOGY → MARKET = IMPACT)

(TECHNOLOGY ← MARKET = IMPACT)

From Technology to Market – Company Pipeline Creation



Imperative #1:

Create a mental shift in the mind of the inventor

Inventor vs Investor

- WOW!
- Look at this – no one has done this before!
- The world will die for it!

- How is this unique?
- Who cares?
- How can we make money on it?
- How good is the team?

Bridging the 'Innovation Gap'

Technology ⟷ Business

- Inventors need to be exposed to how investors and business people look at the world

TechVentureLab

- Objective – exposes NUS FoE researchers to the process of creating a commercialization strategy for their technologies
- Action learning weekend experience
- Industry experts supervise small groups of researchers
- Requires presentation to a group of industry experts/investors at the end of the Lab
- End Result – ability to articulate technology's commercial potential and societal impact

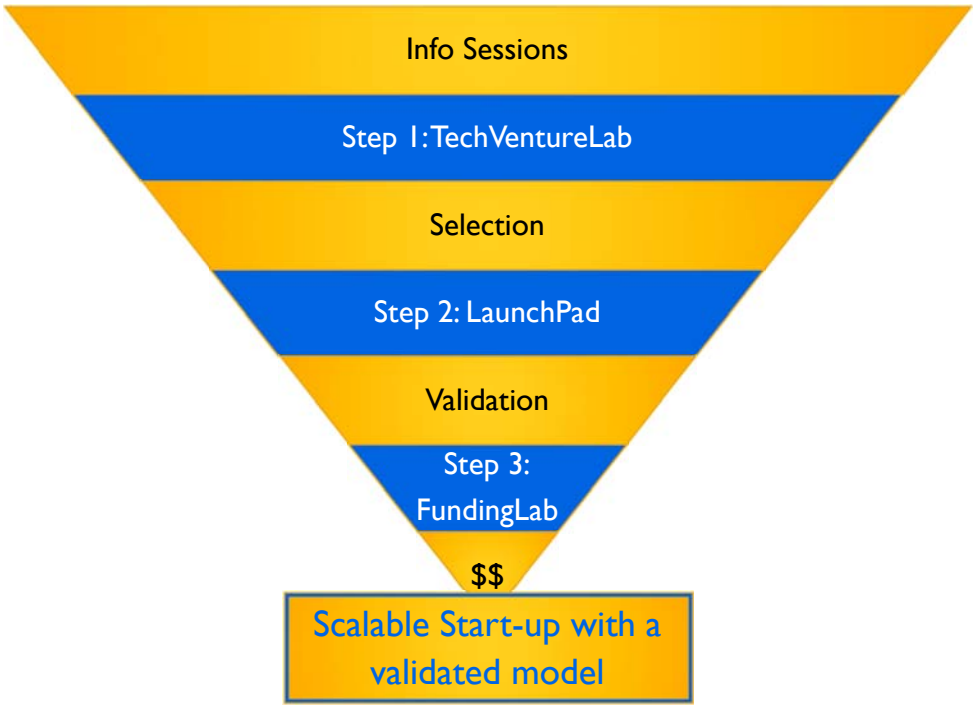
What did you like most about the TechVenture workshop?

This weekend was a real eye-opener for me.

I got a clearer picture of how to create market value.

Bridge between tech and market, better understanding of what customers are looking for.

From Technology to Market – Company Pipeline Creation



Imperative #2:
Build a team around the inventor

LaunchPad Project Course (8MCs)

- Objective – to create companies based on pre-selected NUS technologies
- Assemble teams of engineering and business (MBA/MOT) graduate and PhD students (4-6 per team)
- Industry experts supervise each team
- Academic inventor designates a PhD or graduate student to provide technical input about the innovation
- End Result – a potential company with a validated business model

Principle 1:

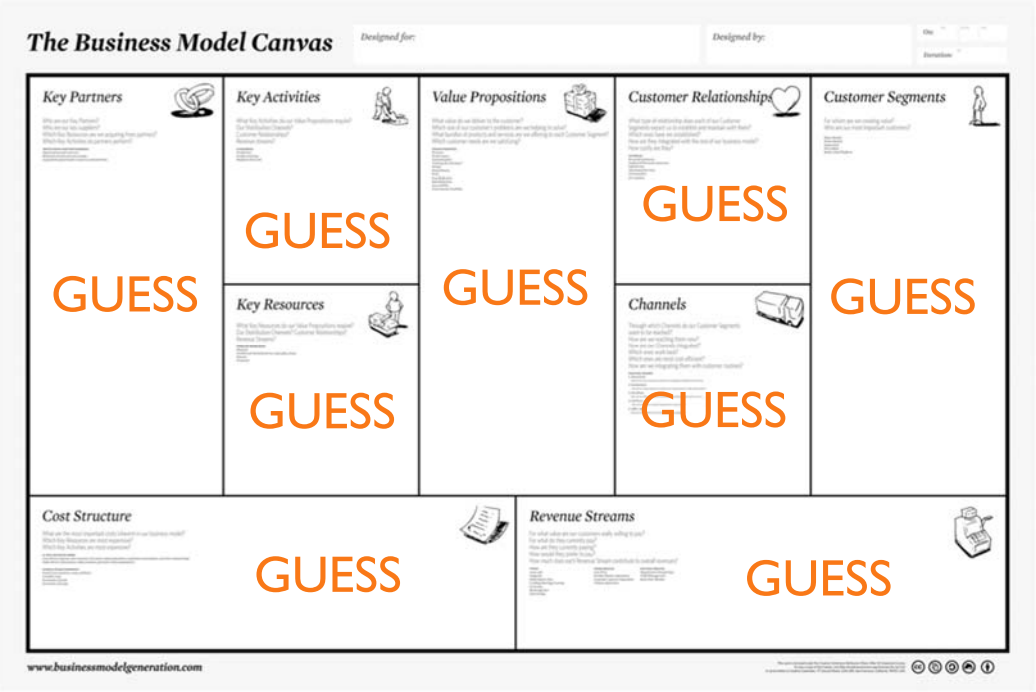
Entrepreneurship

=

Management

of EXTREME uncertainty

Business Model Canvas



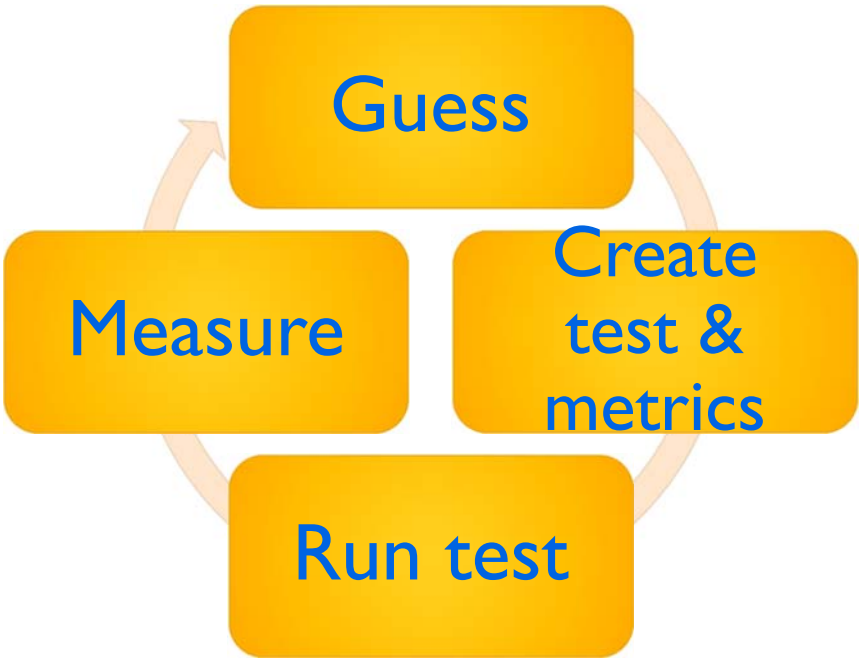
Principle 2:

Entrepreneurship
=
Elimination of Guesses
=
Validated Learning

Principle 3:

Entrepreneurship
=
Disciplined Method
of
Build-Measure-Learn

Build-Measure-Learn



Principle 4:

Entrepreneurship requires special metrics to be successful

What are the main assumptions to be tested?

- Value
  - How is this unique?
  - Who cares?
- Scalability
  - How big is the market?
  - Can we build a large company?
- How can we make money on it?
  - What is the margin per unit?

→ **Business Model**

LaunchPad Results

- Out of eight teams
  - Seven identified viable business models and secured Letters of Interest from Customers
  - One identified viable markets but requires more research for the technology to be ready
- 4-7 investor follow-up meetings per team!

LaunchPad Graduates

- **DOT Medical** - a disruptive mammography diagnostic device without radiation
- **InnoMem** – high performance dye removal water membrane for textile and other industries
- **EasyArray** – a revolutionary protein research platform with high specificity, ease of use and low cost
- **FlexNano** – flexible, low cost TCO layer for solar and electronics markets
- **Digi Surgical** – next generation digital microscope
- EnerCap – new material for energy storage
- **CentoFlow** – oil removal water membrane
- **Gene&Health** – drug efficacy and toxicity prediction

What did you like most about LuanchPad?

Hands-on experience, industry exposure, freedom to be creative

It is a life-changing class for me.

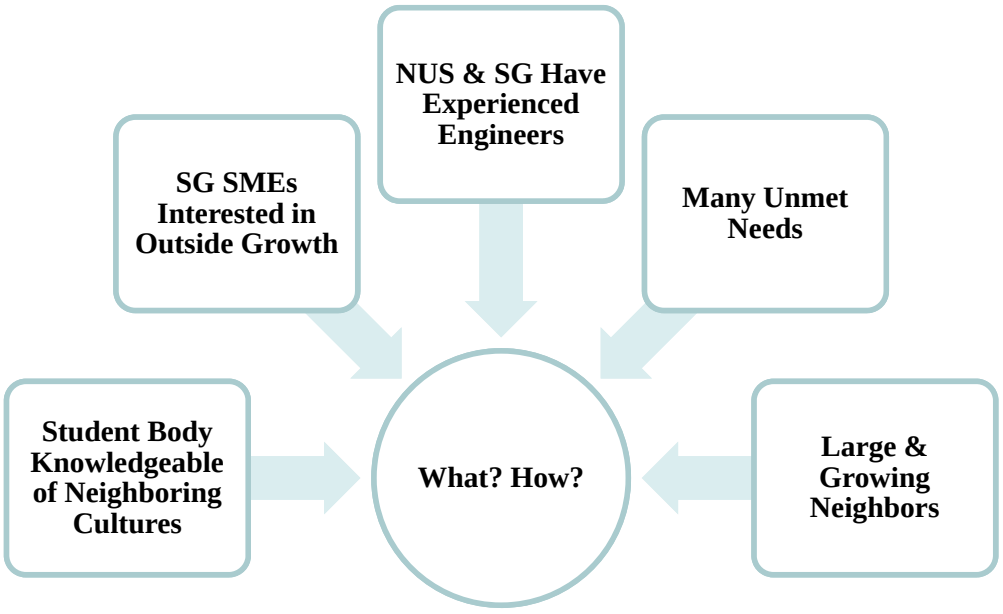
Being thrown into the real world and talking to real customers – cannot learn this in business school

- # VENTURE FUNDING LAB

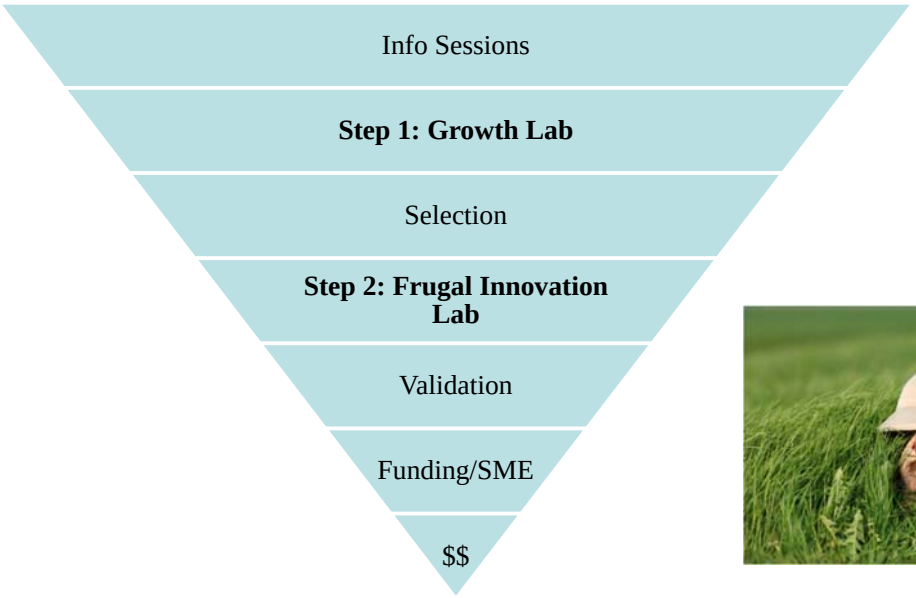
Objective – focuses on start-up equity funding.

- Challenge the teams to identify creative ways to fund the company by getting out into the market and 'pounding the pavement'.
- Teams/companies that are selected for the Funding Lab satisfy four criteria:
  1. Know their customers and their needs and have validated that their product addresses them.
  2. Offer unique value and have proof to this effect.
  3. Have validated assumptions in their business model and can prove that the product will make money.
  4. Have a great team that is passionate about the start-up.

From Market to Technology: Unique Opportunity for NUS/SG



Creating Impact in Emerging Markets



- GROWTH LAB:

Objective – identify issues and define problem statements for emerging market needs in SE Asia.

- "On the ground" assessment in identified markets based on prior market research of potential interest areas.
- Defining industry problem statements based on this research.
- Identifying technical partners both within and outside NUS.

- FRUGAL INNOVATION LAB:

  Objective – create prototypes to address Emerging Market needs in SE Asia based on problem statements defined in Growth Lab

- Undertaken by teams of engineering and business graduate students.
- Students prototype, then test in local markets.