

The Role of Engineering Education in Singapore's Economic Transformation

By

YT Chew

National University of Singapore



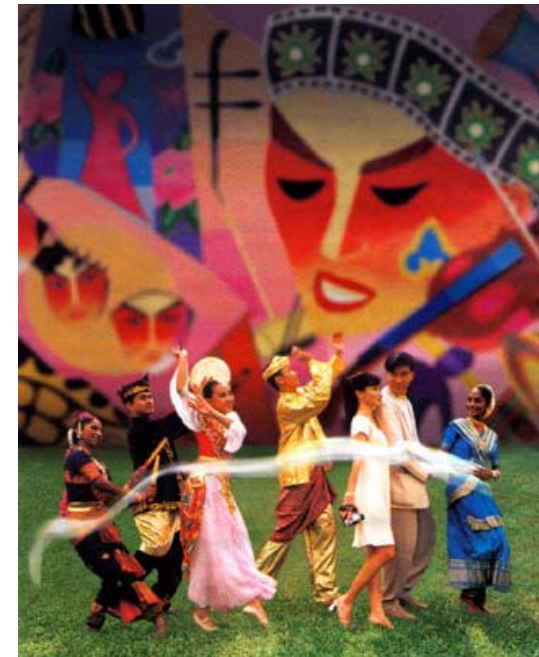
Singapore Vital Statistics



- ≈ 716 sq. km
- Cosmopolitan multi-cultural city-state



- Population of about 5.31m:
 - Chinese 74%
 - Malays 13%
 - Indians 9%
 - others eg, Arabs, Eurasians
- Singapore residents: 3.8 m
- A former British colony, now is an international city with a large expatriate community
- 13m visitors yearly



Land area before 1960: 581 sq. km





Economy and Trade

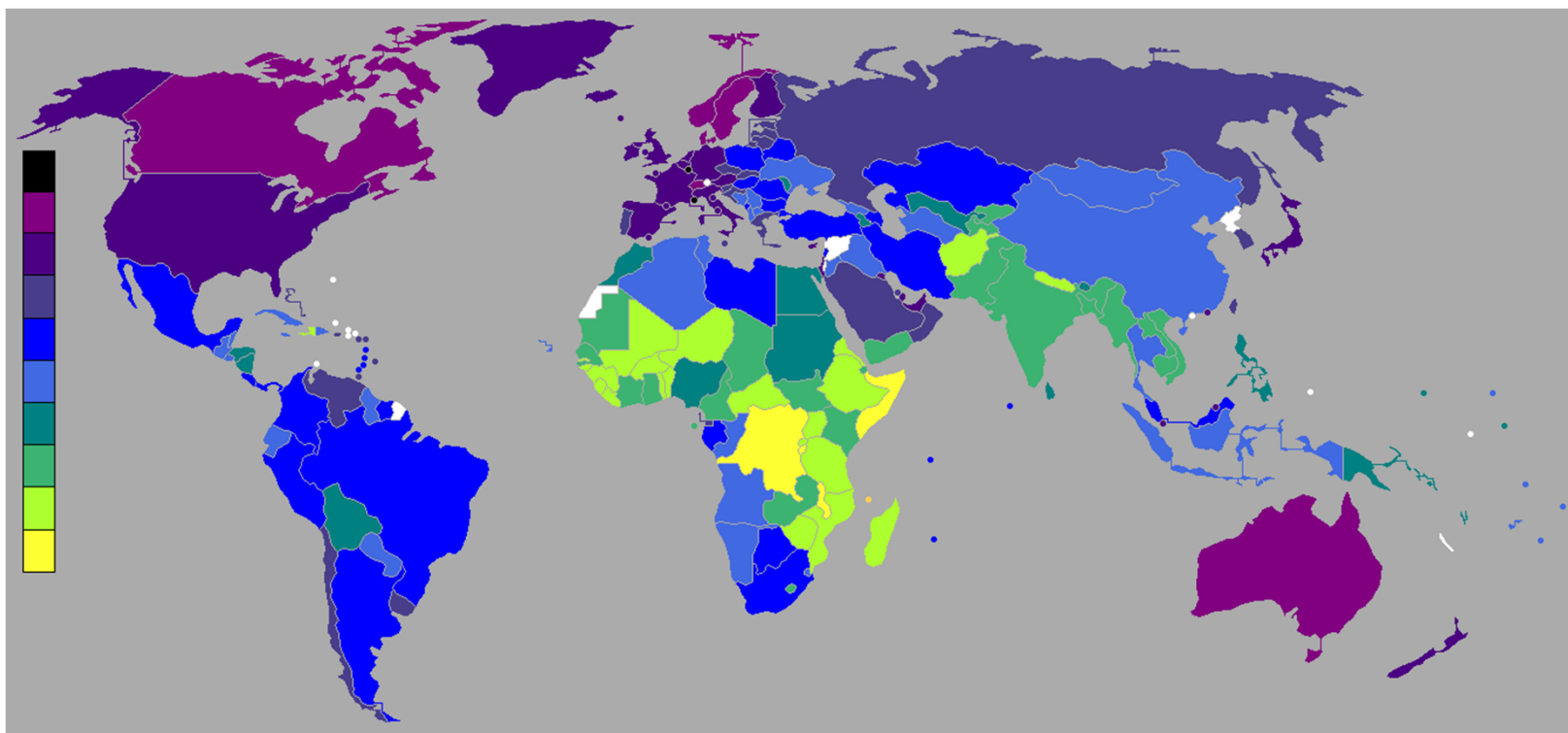
- High standard of living with nominal per capita income of **US\$53,1266** (IMF 2012) (US\$51,703 for US and US\$6,071 for China)
- Major industries: oil refining (3rd in world), pharmaceutical, electronics, precision engineering, offshore enrg
- Major services: wholesale/retail trade, hospitality, financial, business
- One of the 5 busiest port in the world, external trade is **3 times the size of GDP**
- Fourth biggest financial centre in the world
- **5,000 MNCs** use Singapore as a base for global operations
- Accounts for **40%** of ASEAN trade, and 40% of the investment in the region



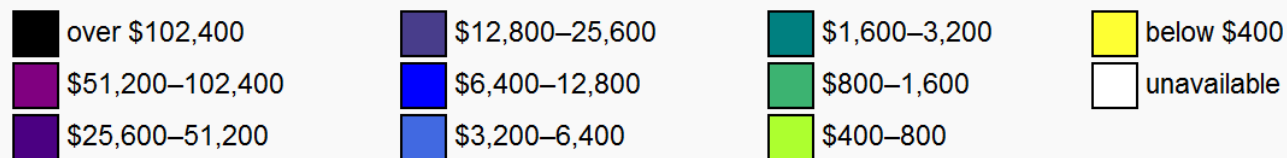


GDP(Nominal) Per capita

Singapore ranked 9th: 2012 GDP (Nominal per capita = USD \$52,052). USA (USD \$51,704), China (USD \$6,071)



Countries by 2012 GDP (nominal) per capita.^[1]



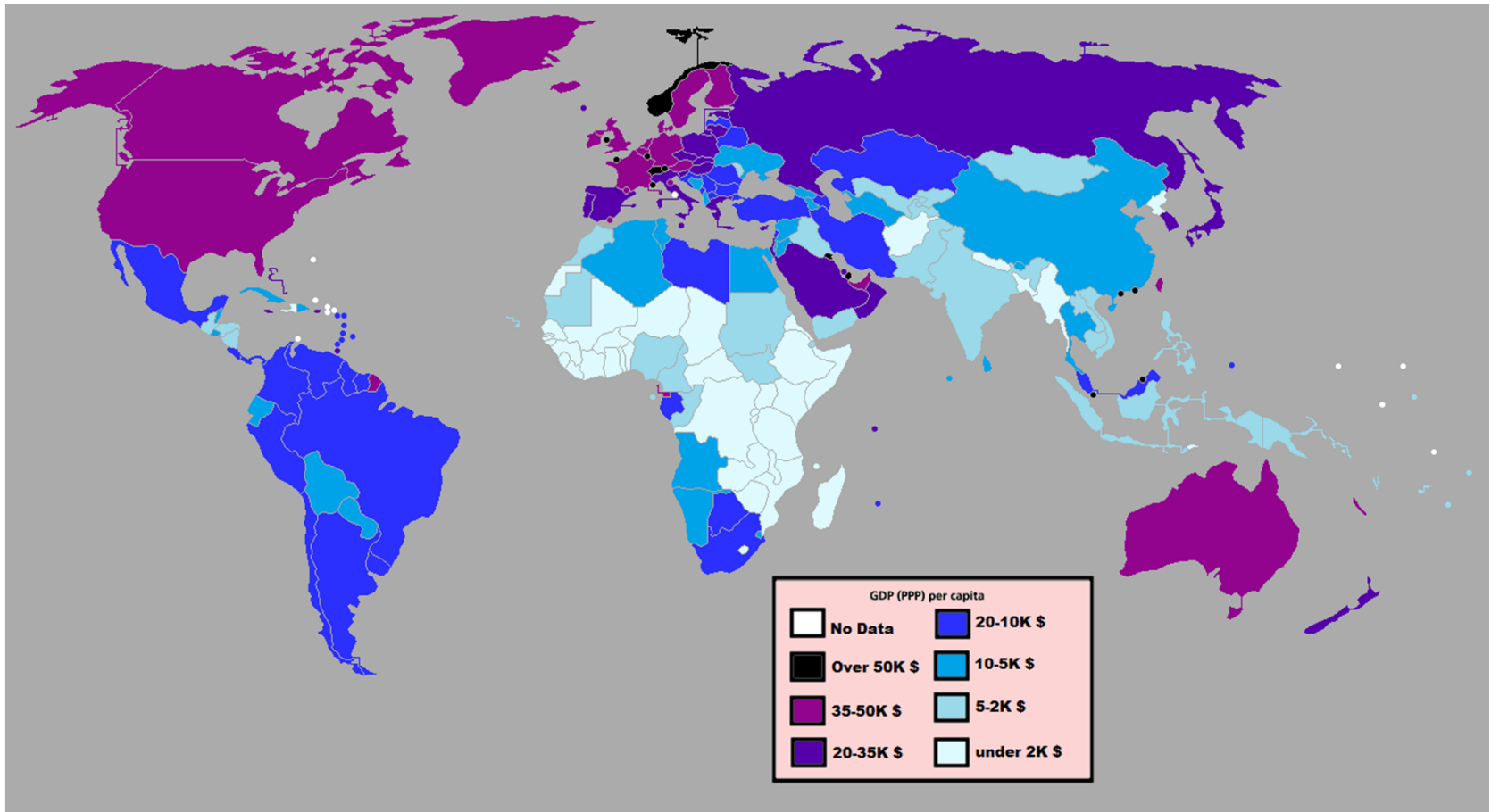
Source: Based on the IMF figures. If no number was available for a country from IMF, CIA figures were used.

URL: [http://en.wikipedia.org/wiki/List_of_countries_by_GDP_\(nominal\)_per_capita#cite_note-1](http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita#cite_note-1)



GDP(PPP) Per capita

Singapore ranked 3rd: 2012 GDP (PPP= USD \$60,799). USA (USD \$51,704), China (USD \$9,055)

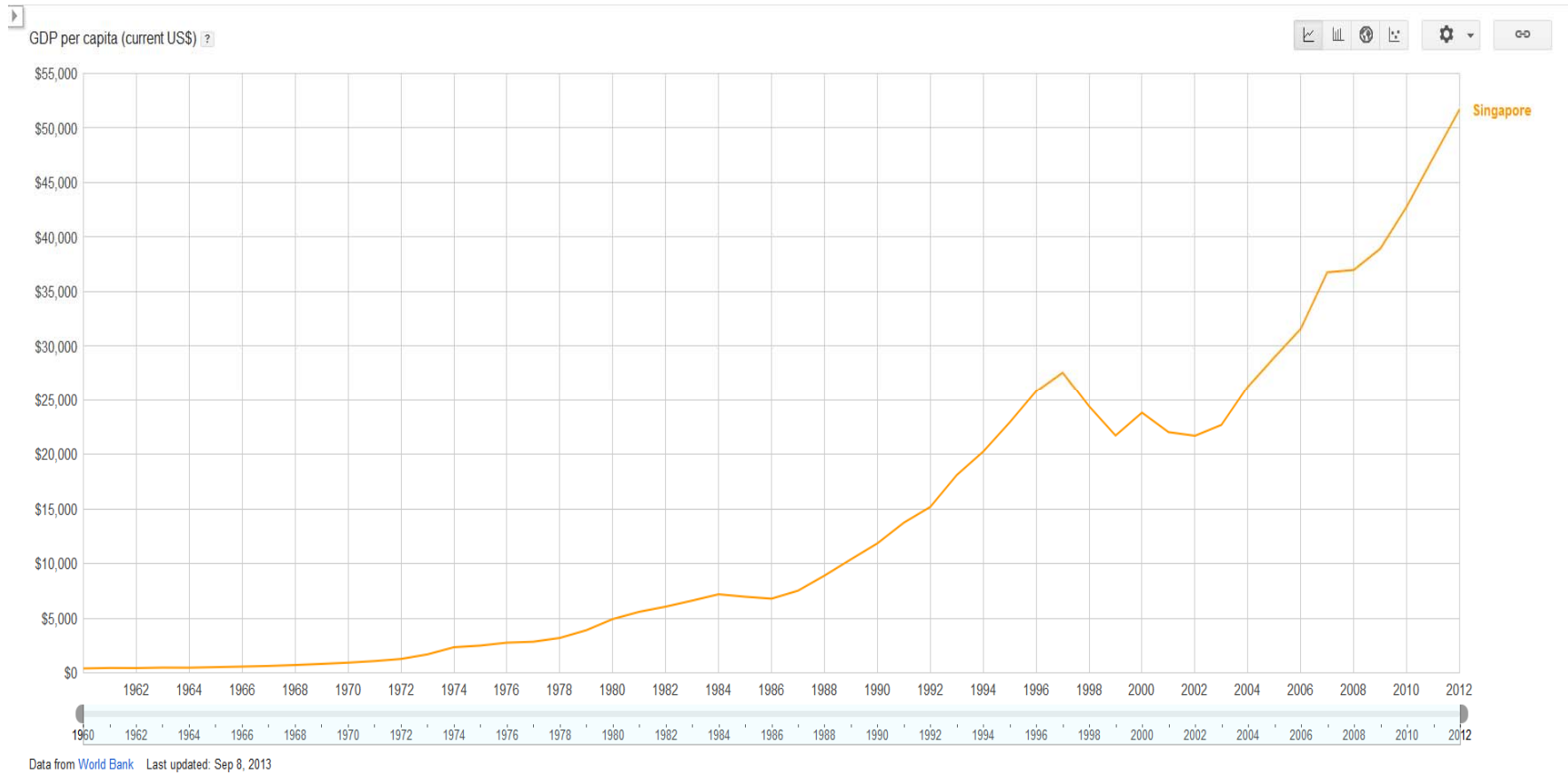


Countries by 2011 GDP (PPP) per capita, based on World Bank figures; if no IMF/World Bank figure was available for a country, the CIA figure was used.

URL: [http://en.wikipedia.org/wiki/List_of_countries_by_GDP_\(PPP\)_per_capita](http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP)_per_capita)

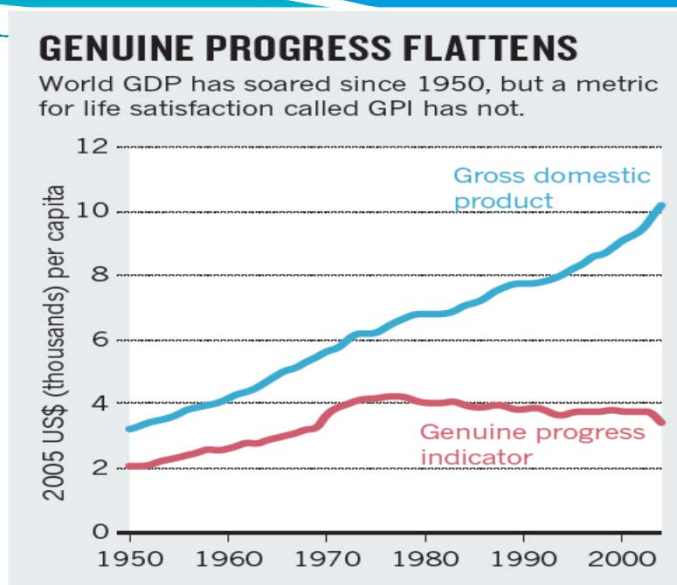


Singapore GDP per capita Trend



Source: World Bank

Caveat



- A country's gross domestic product (GDP) measures “**everything except that which makes life worthwhile**”.
- **GPI** (Genuine Progress Indicator), **a metric for life satisfaction** which includes subjective measures of well-being, may be more useful.

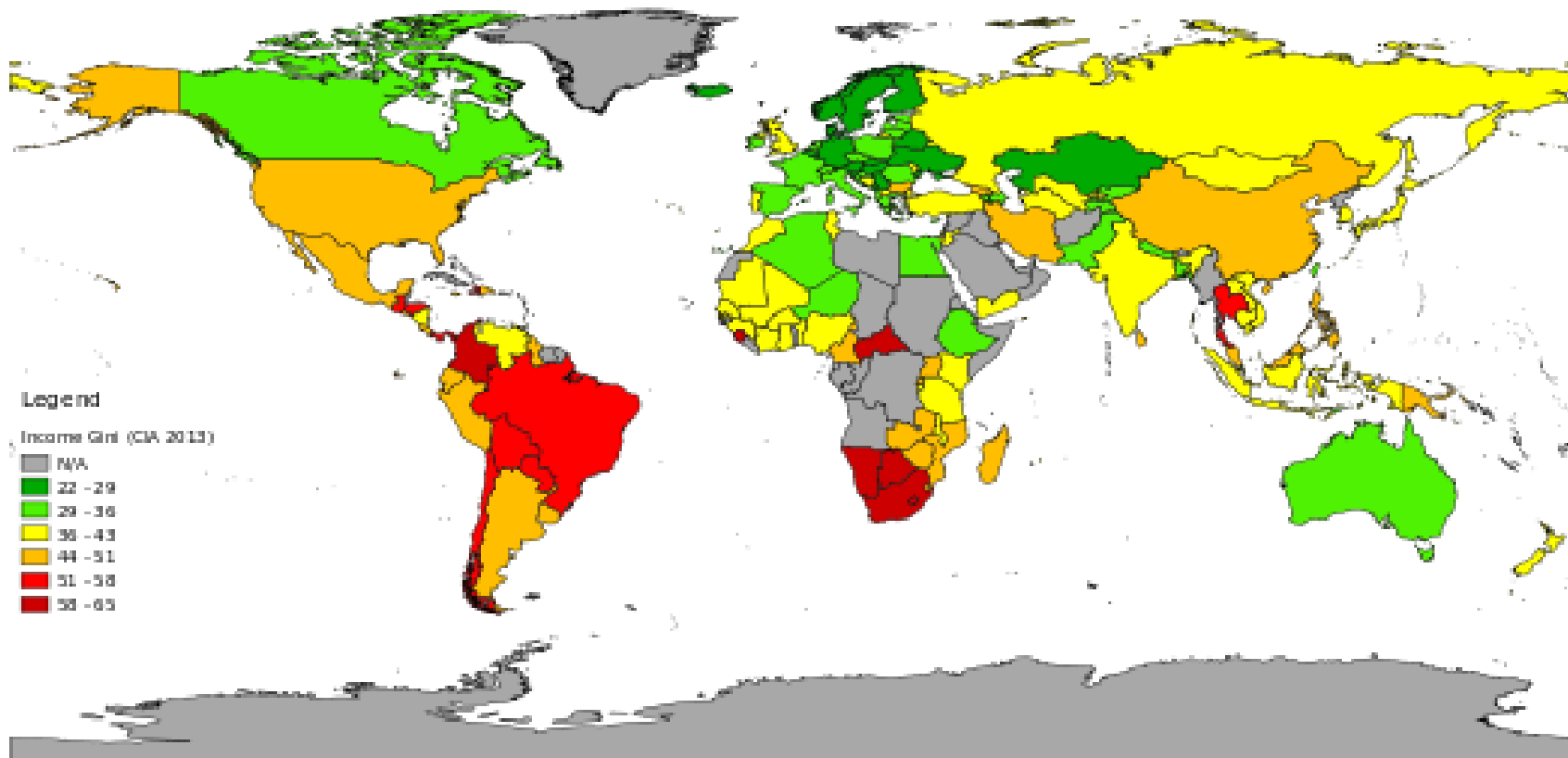
---Robert F. Kennedy



Possible Reasons for Divergence

- Wealth **Creation** vs Wealth **Management**
 - Wealth management increases GDP but not necessary wealth
 - **Engineers** are wealth creators but **insufficiently rewarded**
 - Efficiency = output/input: Comparison of TV and Property clearly shows the discrepancy
- **Unequal distribution** of wealth leads to widening of rich-poor gap and increase in Gini coefficient (**0.478** in Singapore, 0.256 in Norway in 2012), and **flattening of GPI**

World distribution of Gini Coefficient





Consequences of unequal reward system

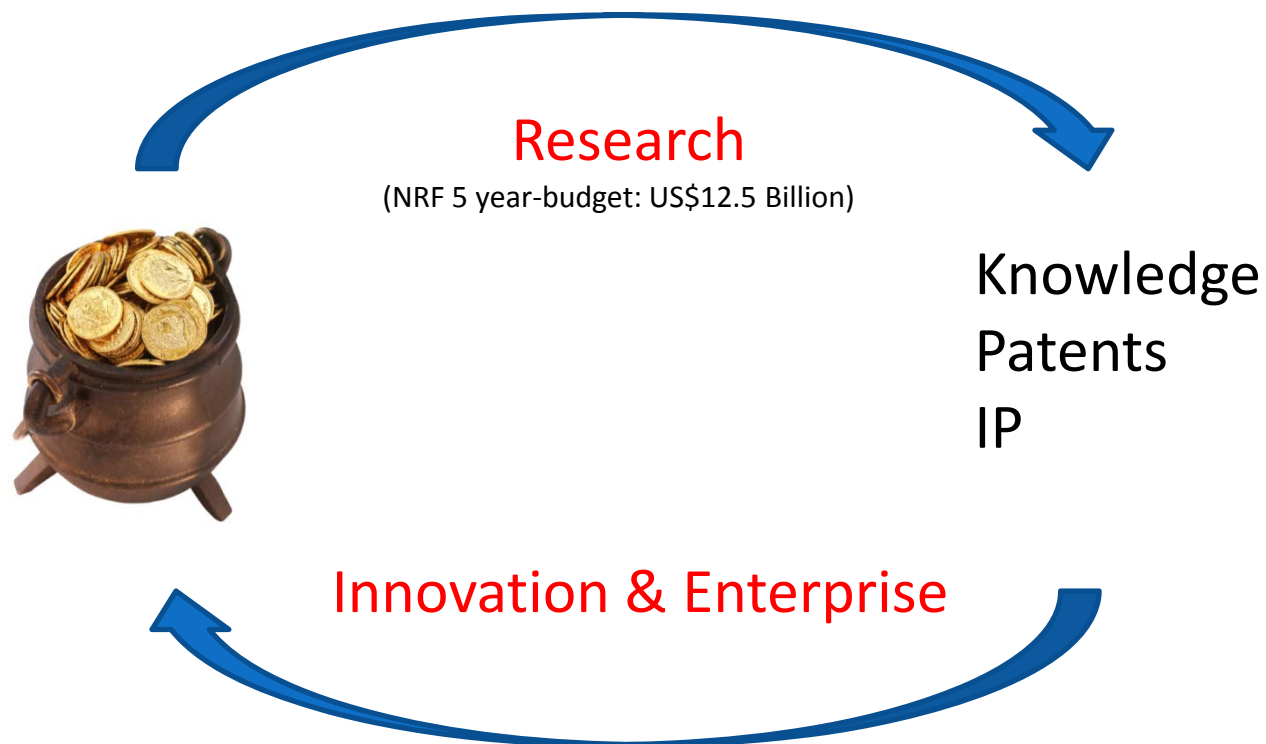
- Difficulty to attract good students to engineering as more are drifted towards finance
- Many engineering graduates do not stay in engineering profession
- Decline in manufacturing industries and rise of service sector
- The economy will suffer in the long term as it needs wealth creation to support wealth management



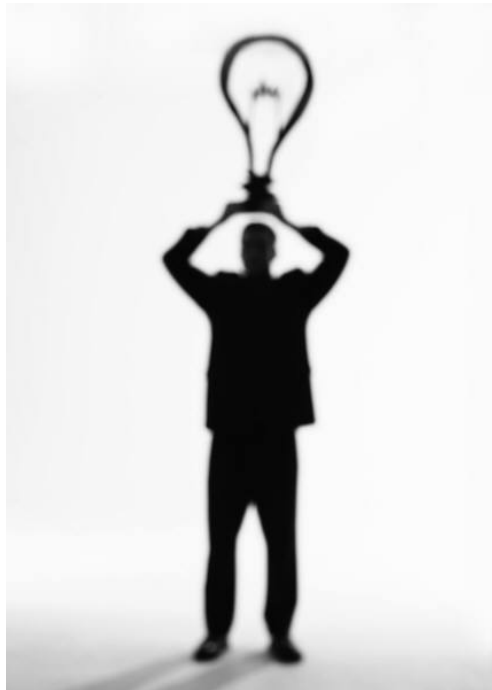
Possible Solutions

- Enhance wealth creation through **innovation and enterprise**
- At national level, a Research Innovation and Enterprise Council (**RIEC**) chaired by the Prime Minister was formed in 2006. It comprises Cabinet Ministers and distinguished local and foreign members from the business, science and technology community
- At faculty level, an Institute for Engineering Leadership (**IEL**) to promote innovation and enterprise was formed in 2011

Possible Solutions



IEL Supports National Strategies



Innovation



Entrepreneurship



**Productivity
(through innovation)**

What IEL wants to achieve



Supporting current opportunities



Creating new opportunities

A strong base of **engineer-leaders** that can support current opportunities and create new ones





Engineer-Leaders are ...

- *Individuals* who are **strategic systems thinkers** and **value creators**. They can **identify** market and technology **opportunities** and **engage people** around them to deliver **profitable growth** with **social impact**.
- *Enterprises* that are **differentiated**, fast growing, **scalable** and visible.

Engineer-Leaders have

Technical depth



Strategic outlook



Business savvy

Engineer-leaders can
generate....



... New ideas

Translate....



... Ideas to innovations

Transform....



... Innovations to wealth opportunities

Innovation and Enterprise Development

Objective:

Teaching students through action how to leverage technology into start-ups and unique products.

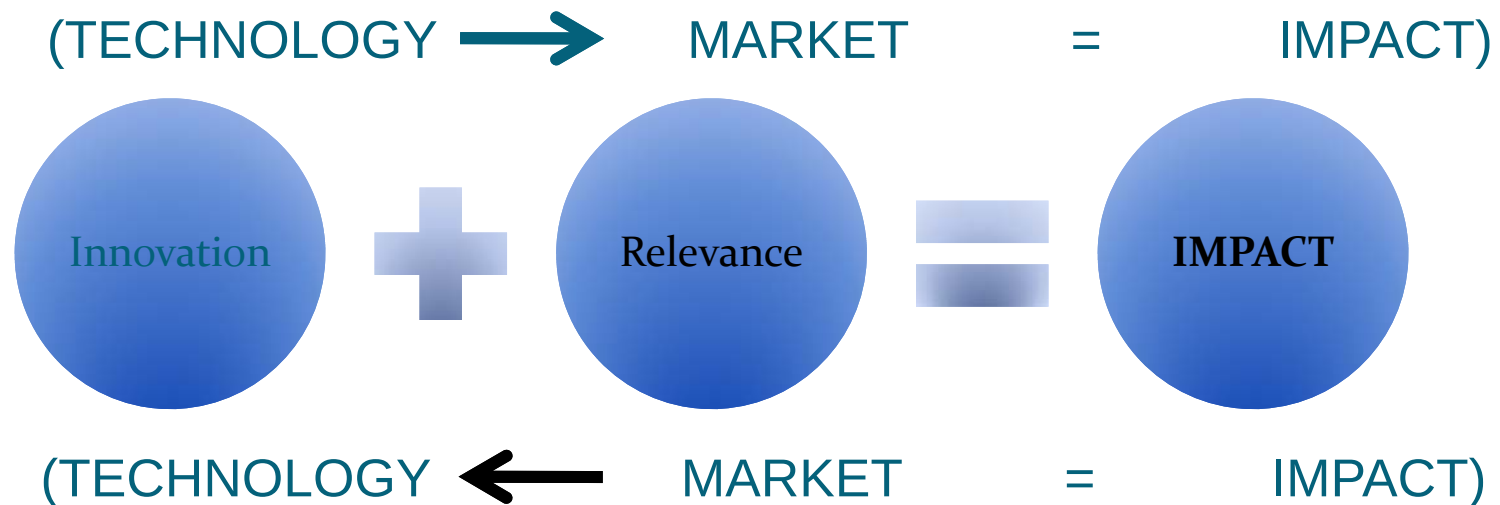
Implementing unit:

Enterprise Development Lab
(EDL)



Innovation and Enterprise Development

- Focusing on Value Creation
 - Nurtures both types of innovation & entrepreneurship
-





EDL's Modules: Experiential Learning for Leadership Development and Value Creation

Technology to Market

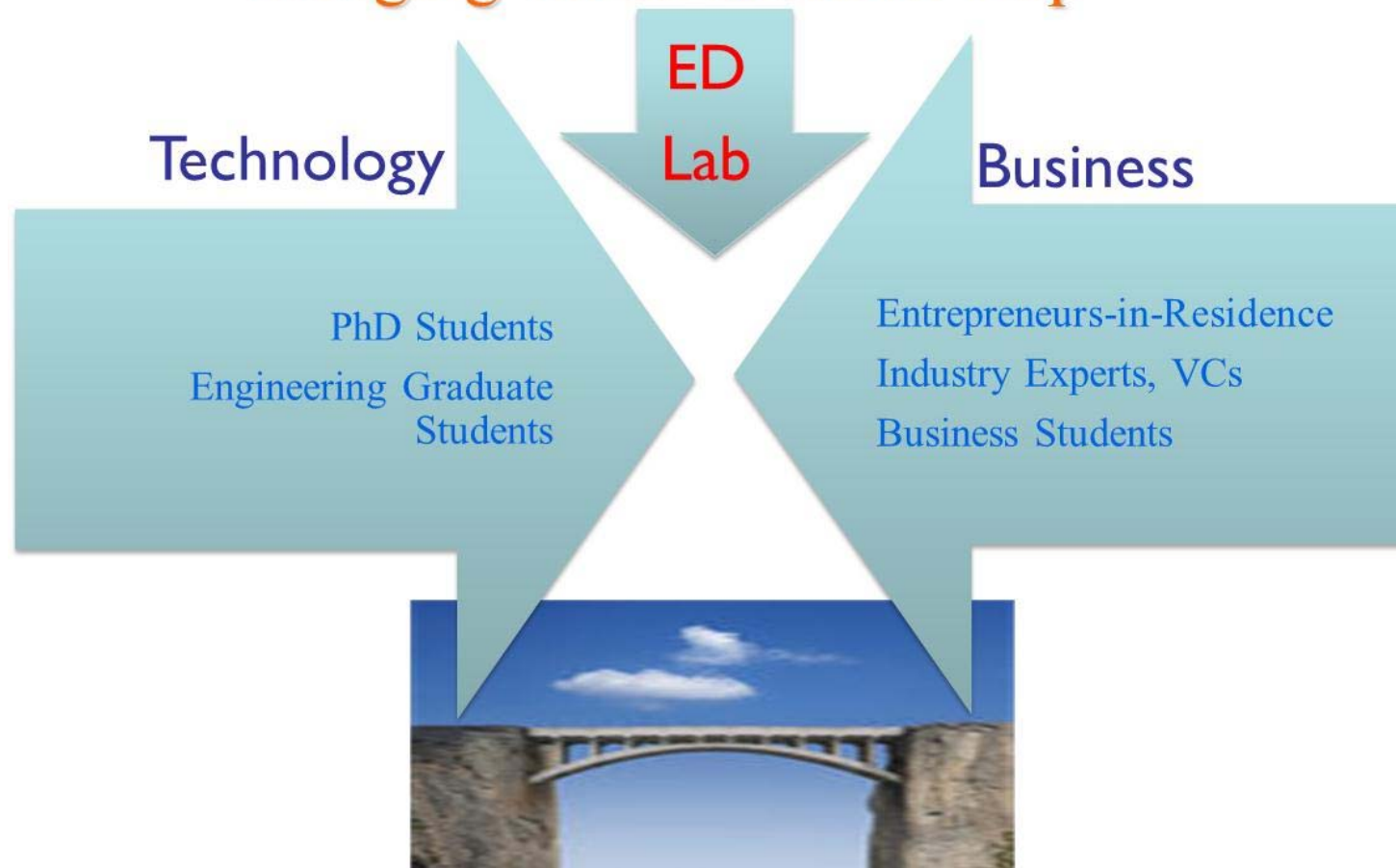
- **Technology Venture Lab:** Catalysing mindset change in researchers.
- **MarketZoom:** Strengthening commercialization strategies.
- **TechLaunch:** Finding and validating value for selected NUS technologies.
- **Venture Funding Lab:** Identifying ways to fund a new venture.

Market to Technology

- **Market Gaps:** Identifying and analyzing for potential technology application.
- **Frugal Innovation Lab:** Creating prototypes to address identified market needs.

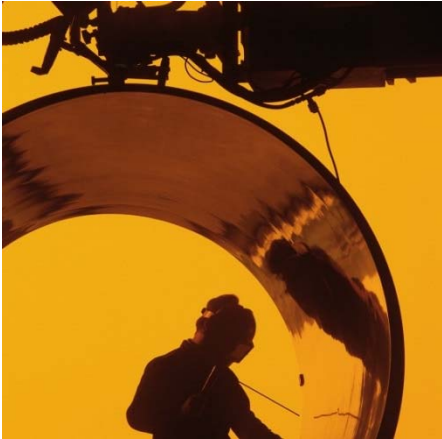
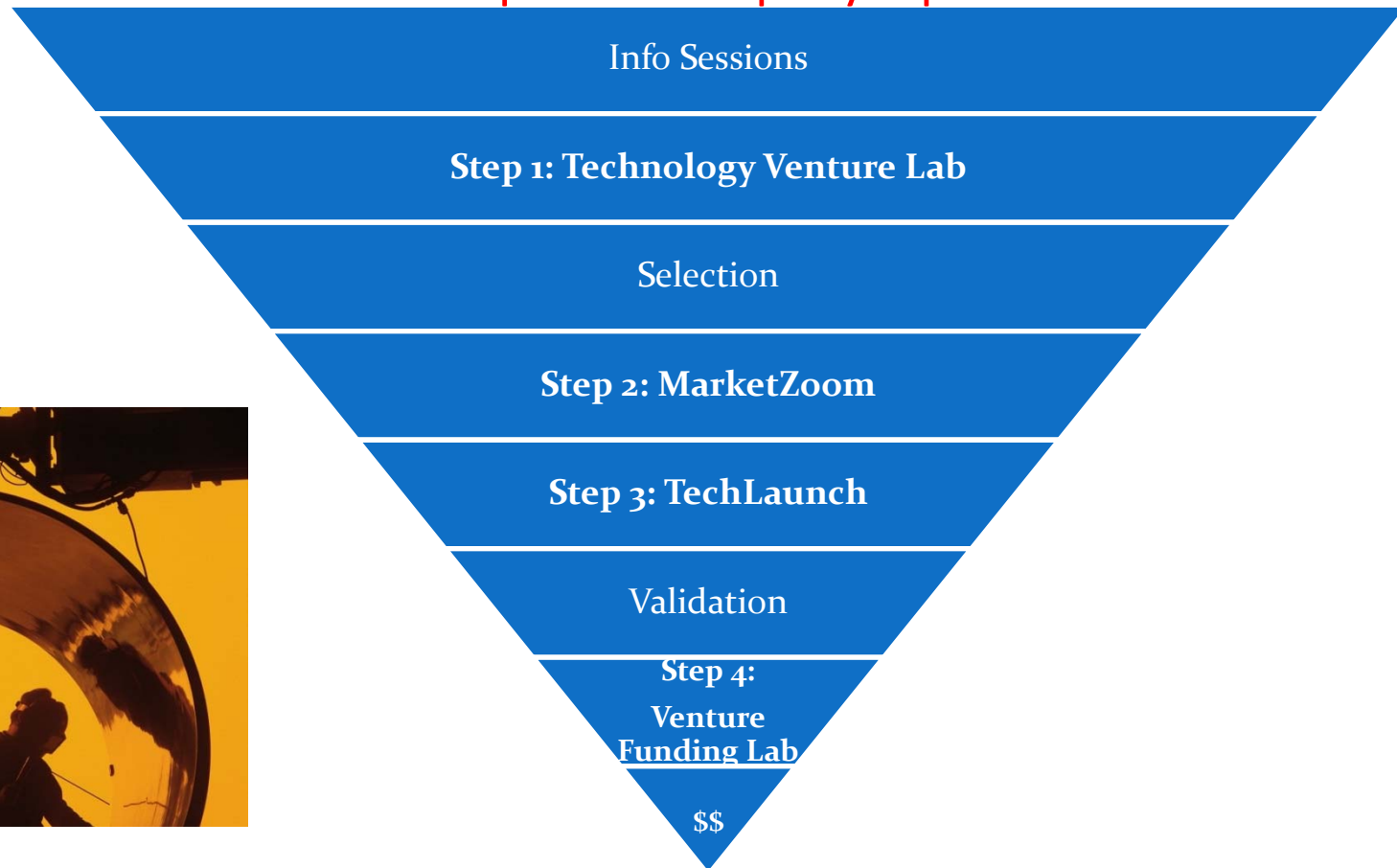
Innovation and Enterprise Development

Bridging the Innovation Gap



Innovation and Enterprise Development

From Idea to Impact – Company Pipeline Creation



Scalable Start-up with a validated model



Innovation and Enterprise Development

- **TECHNOLOGY VENTURE LAB**
- Objective – expose NUS researchers to the process of creating a commercialization strategy for their technologies
- Action learning weekend experience
- Industry experts supervise small groups of researchers
- Required presentation to a group of experts at the end of the lab
- Product – ability to articulate technology's commercial potential and societal impact

1. MINDSET CHANGE



Innovation and Enterprise Development

- **MARKETZOOM**
- Objective – strengthen commercialization strategies for technologies applying for Proof-of-Concept grants
- Action learning over 3 weeks
- Done by teams of engineering and business graduate & PhD students who go through value definition and validation, making money & business models, Go-to-Market strategies
- End Result – clear definition of technology's commercial potential and societal impact

2. CLARIFIES TECHNOLOGY DEVELOPMENT TARGETS



Innovation and Enterprise Development

- **TECHLAUNCH**

- Objective – develop & VALIDATE commercialization strategies for selected NUS technologies
- Done by teams of engineering and business graduate and PhD students (4-5 on each team)
- Industry experts supervise each team
- PI designates a PhD or graduate student to provide technical input about the innovation
- Created around “Management of Extreme Uncertainty” principles
- Business plan presentation to potential investors

**3. DEVELOP & VALIDATE
COMMERCIAL POTENTIAL**



More About TechLaunch

- About the Course:
- A unique experiential module in which students develop a start-up based on a selected technology created at NUS.
- Students work in cross-disciplinary teams of graduate and Ph.D. students from the Faculty of Engineering & School of Business.
- The *objective* is for students to learn how to search for the maximum value creation in an iterative manner as start-ups do in the real world.
- The *goal* is to get commitments, customers and orders at the end of the semester if at all possible.

Real experiences – pitching to industry and business experts



Some of the NUS Technologies in TechLaunch...

HumidFree provides a unique **membrane dehumidifier** system that decreases inlet air humidity by half thus dramatically reducing the energy required to cool a building.

Nusmetics is commercializing novel **micro-needles** developed at NUS. The first product is an effective overnight patch for reducing cellulite.

Structo revolutionizes rapid prototyping by providing a **3D printer** that is 10 times faster than current to the leaders of the manufacturing industry.

ReVoice equips surgeons with a medical device for in-office **tracheo-esophageal puncture** (TEP) surgeries for immediate voice restoration.

Greenus is commercializing a **patented bacteria** and simple process to convert organic feedstock into useful green products. The first product is bio-succinic acid produced out of sugarcane bagasse.

StemDerm revolutionizes **skin testing in cosmetics** and pharmaceutical industries by providing real life human skin derived from stem cells assuring consistency and thus speeding time-to-market for cosmetics products.

HomeRehab system enables patients to perform **prescribed rehabilitation exercises** from home and measures their progress. Therapists can focus on customizing treatment thus allowing them to see 3 times more patients than before.

BioCycle produces **bio diesel** made out of waste grease using a **unique patented biocatalyst** for the Asian emerging economies hungry for energy.

LuminiCell offers a **unique cell-tracing product** to the pharmaceutical industry that enables ten times higher visibility and dramatically longer tracing of cancer cells than any other product on the market today.

ReVoice

Providing a novel user-friendly medical device assisting surgeons to safely and efficiently restore patient's voice

Current Surgical Procedures and Problems



Traditional Placement of a Voice Prosthesis (VP)

The tracheo-esophageal speech (TES) provides the best recovery of voice and is the gold standard for voice rehabilitation. In order to achieve TES, tracheo-esophageal puncture (TEP) and voice prosthesis implantation are currently used, which causes problems

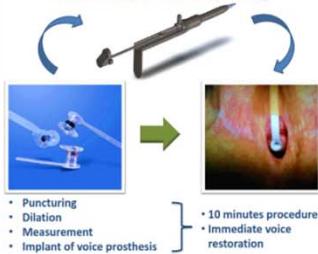
- Large trauma
- Difficulty in measurement of voice pitch
- Long procedure time
- Slower healing
- Discomfort for patients



Headline: Invention Revolution
Source: *The New Paper*, p16-17
Date: 24 March 2013

Solution and Value Proposition

Our Device Provides a Safe and Efficient Way

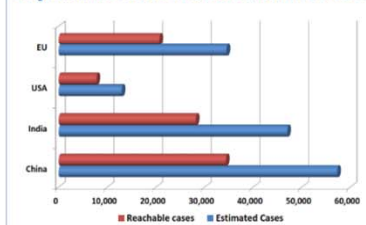


Key Benefits

- Immediate voice restoration
- Less discomfort

Market Size and Business Model

Projected Revenue of \$100 Million in 5 Years



ReVoice Business Model

- Device is reusable
- Sterilization is required before each use

Contact



Telephone: (65) 6516-1336
Fax: (65) 6779-1459
E-Mail: ReVoice@gmail.com
Post: EA-04-06, 10 Kent Ridge Crescent, 119260 Singapore



INVENTION REVOLUTION

Local universities have come up with innovations that could transform health care. **Cheow Sue Ann** takes a look at some of them

Say no to eye infections

By Professor Mary Chan, School of Chemical and Biomolecular Engineering, Nanyang Technological University (NTU)



Wearing contact lenses can lead to corneal infections, but the anti-bacterial coating invented by NTU means that eye infections can be prevented without the use of antibiotics. Using a special type of material known as a long-chain polymer, the coating attracts bacteria, so the contact lenses become more porous, rather than the bacteria and a piece of the bacteria's cell wall ends up being torn off, killing it in the process, says the scientist. The coating is already in commercial use by some companies.

World's smallest heart pumps



By NTU Deputy President and President Professor Freddy Boey

It's a mere 5mm, four times smaller than the average heart pump which weighs about 200g, but it can take over most of the pumping load from a diseased or weakened heart - allowing it to rest and recover, says its inventor. The small size of the device (it measures about 2mm in diameter) allows it to be inserted at various existing surgically made. A single incision operation is used either in the leg or armpit. The device is then inserted into the artery and pushed towards the heart. The pump is undergoing clinical trials.

The wireless vital signs monitor

By Professor Lim Yee, Department of Electrical and Computer Engineering, NUS



The patch is a wireless biomedical chip that is used to record vital signs including heart rate, brain activity, breathing rate, oxygen levels in red blood cells and body temperature. This single-chip can be worn on the body and is capable of wirelessly connecting to a doctor's mobile phone for early warning. It can be totally powered by the body's own heat allowing continuous monitoring of heart conditions without batteries. The EEG chip is being further developed.

Home-made scabs

By Assistant Professor Ng Kwee Wei, School of Materials Science and Engineering, NUS



The patches and gels are made using keratin, a protein found in hair and nails. The natural attraction of scabs that form after an injury. Keratin is a type of material that naturally occurs in the body, the patches will not be rejected, says its inventor. For diabetic patients and burn victims, the scab-like skin will not be harmed as it does not have to be removed at all. The patch will protect the wound, and as new skin forms, will be absorbed by the body. The patches have passed clinical tests and prototypes are being tested.

A voice for the voiceless

By Dr Chee Chuan Kang, Department of Mechanical Engineering, NUS, and Dr David Lee, consultant ENT surgeon at Raffles Hospital

It looks like a small rubber tube. But this seemingly ordinary tube holds the promise to restore voices for people who have lost their voice due to cancer and other diseases. Its inventors say the tube is inserted between the windpipe and oesophagus. To speak, the patient covers the stoma (the opening in the neck) with his or her thumb and forces air through the prosthesis into the oesophagus and out through the mouth. Dr Chee says this new system has merged all the steps into a single procedure and most significantly, ensures an immediate usage fit of the prosthesis.



Unlike older procedures, which usually took up to two weeks before the patient could speak, the new system takes a mere 10 minutes, after which the patient can speak quite readily, say its inventors. The system is now ready for human clinical trials.

The cancer tracker

By Professor Lim Chuan Teck, Department of Biomedical Engineering and Department of Mechanical Engineering, National University of Singapore (NUS)



This chip can potentially diagnose cancer better and faster. Only a tiny drop of blood - a 'teat' - is needed. The blood is 'fed' into the microfluidic chip, and the device is able to detect cancer cells for detection and isolation. This means that potentially, doctors can tell quickly if cancer is present, or to use if cancer treatment is working. The device may check if there is any decrease in the number of cancer cells in the course of treatment. For example, the biologists are being further developed.

'Suicide-bomber bugs'

By Assistant Professor Matthew Chang and Assistant Professor Pui Chui Lee, School of Chemical and Biomolecular Engineering, NTU



Many infections of the respiratory and gastrointestinal tracts and even the urinary tract are caused by a superbug, *Pseudomonas*. And it is resistant to antibiotics. NTU has biochemically engineered a strain of *E. coli* to create 'suicide-bomber' against the bad bug. The *E. coli*, upon detecting the superbug, will self-destruct, releasing molecules to kill the bad bug. These 'killing molecules' are toxic to the bug, but harmless to the human body. The *E. coli*, to be taken orally like a beverage or supplement, is meant to make its way into the gut, preventing infections by killing harmful bacteria before they attack. This is still in the research phase.

New and improved hernia meshes

By NTU Professor Freddy Boey



Hernia meshes are commonly used by doctors to repair tears in the abdominal walls caused by injury, pregnancy, operations or aging. These meshes are made from polypropylene, PDS or PDS, which is used in surgical sutures. The meshes are now compatible with the human body, reducing chances of rejection and inflammation.

The home-grown hernia mesh is being developed by NTU start-up company Medline Asia. This new patch is also stronger, hopefully reducing the need for follow-up operations, says the company.



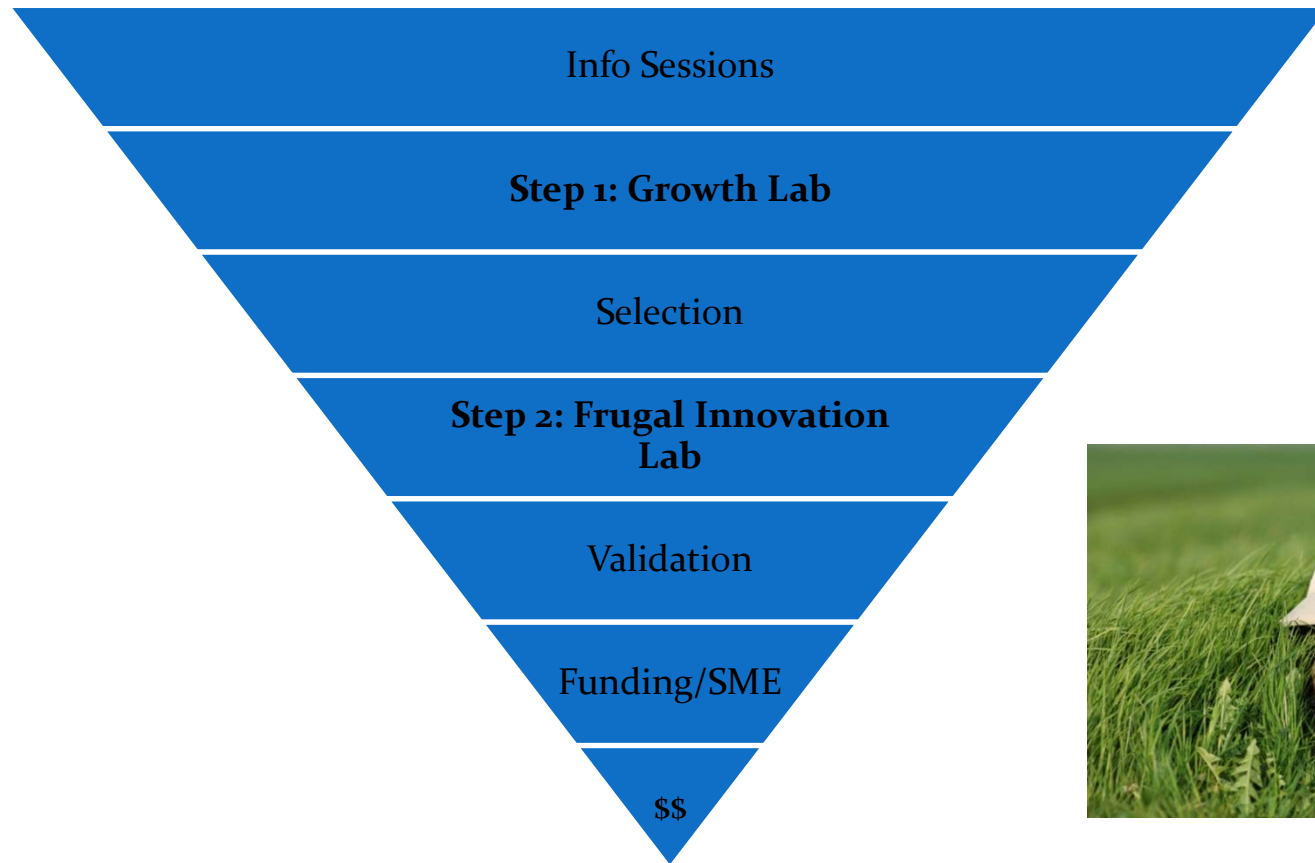
Innovation and Enterprise Development

- 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 (**customer desirability**).
 2. Offer unique value and have proof to this effect (**technology feasibility**).
 3. Have validated assumptions in their business model and can prove that the product will make money (**business viability**).
 4. Have a great team that is **passionate** about the start-up.

4. GET MONEY

Innovation and Enterprise Development





Innovation and Enterprise Development

- **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.



Innovation and Enterprise Development

- **FRUGAL INNOVATION LAB:**
- [Launched in Semester 1 AY 2012/2013]
- 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.



INNOVENTURE

DESIGN.CREATE.DISRUPT.

THE **TECHNOPRENEURSHIP** LEARNING PLATFORM BY STUDENTS, FOR STUDENTS.

www.innoventure.com.sg

- A flagship technopreneurship learning platform that aims to **nurture** a community that redefines **innovation and venture creation** in universities.
- Hosts challenges featuring **real industry problems** faced by organizations, institutions and companies around the world and bring together **passionate students** from diverse backgrounds to create **disruptive solutions**.

<http://innoventure.com.sg/>



InnoVenture

- Launch of the inaugural **InnoVenture competition**.
 1. A student competition run by students for students.
 2. Teams work on problems statement provided by companies.
 3. Undergo bootcamps on technopreneurship and prototyping.
 4. Winning teams get prototyping money and proceed to the next stage.
 5. Students get credits for their involvement; learning by doing.
- Hands-on, competitive, experiential learning module that is ideal for students to gain insight, confidence, and basic capabilities about the theoretical and practical aspects of technopreneurship.

InnoVenture



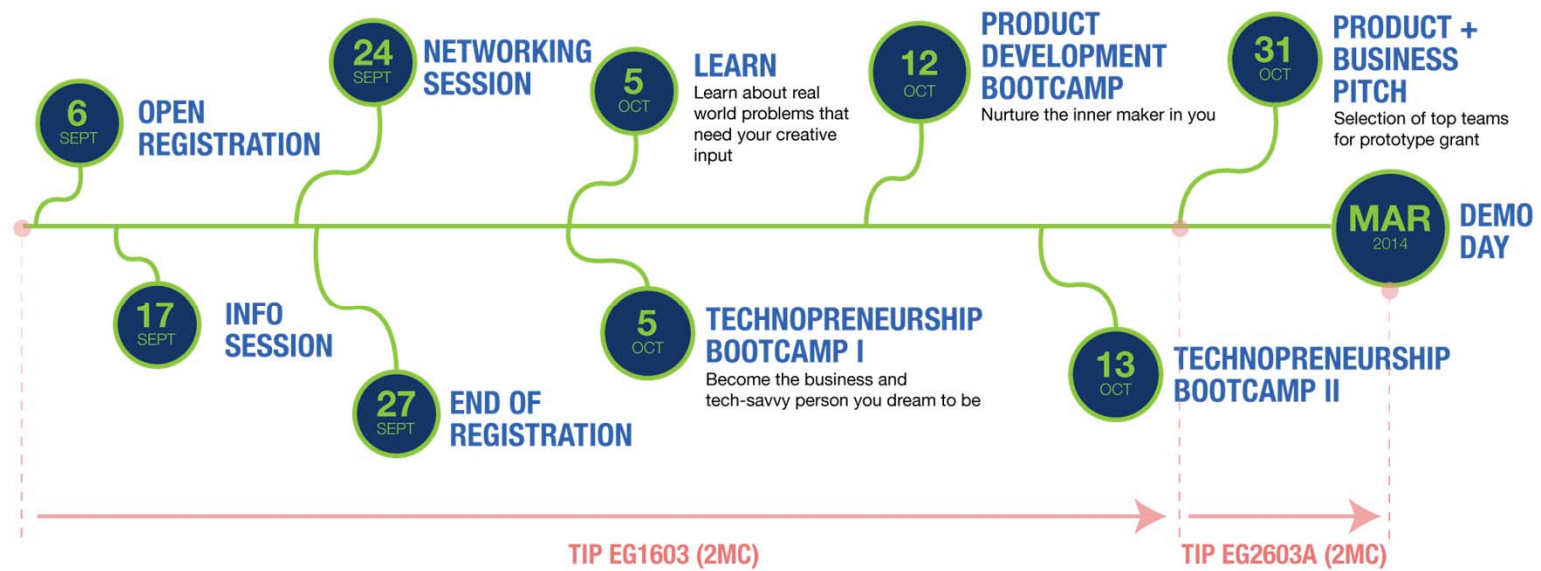
- Providing problem statements for the students to work on, expertise to guide the students along the way and sponsorship to support the student initiative.

HEALTHY NUTRITION ON-THE-GO NESTLÉ

Active adults between the ages of 55 to 65, aka Good Lifers, are interested in maintaining their energy and wellbeing. They know that they need to pay attention to their nutrition as much as possible. However, the normal fast paced life makes fulfilment of this objective difficult.

The challenge is to design a product or service that would allow these Good Lifers to enjoy the benefits of a healthy and balanced nutrition "on the go".





How were they impacted?



Learning to take risks



Getting hands dirty



Solving problems together

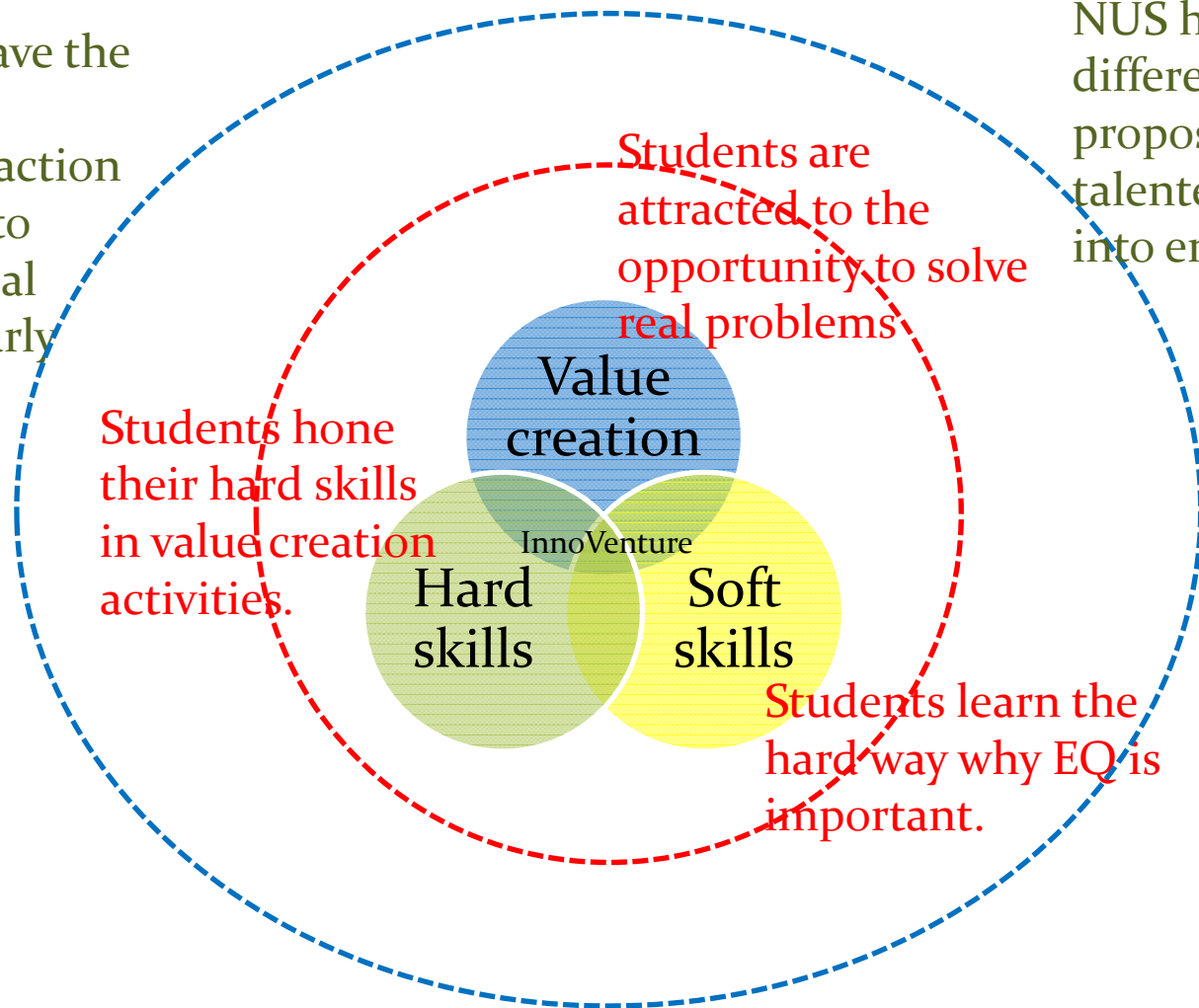


Becoming part of an entrepreneurial community

The InnoVenture “circles of influence”

Companies have the opportunity through interaction with student to assess potential talent at an early stage.

NUS has a differentiating proposition to draw talented students into engineering.





- 
- Observation 1:
 - Leadership potential is best developed through EXPERIENTIAL LEARNING
 - Not just project work
 - Leadership potential development requires situations that are
 - Real world cases
 - Where students **CAN TAKE CHARGE** of **DELIVERING SOMETHING OF VALUE**
 - Where they **HAVE VESTED INTEREST**; and
 - Have **POTENTIAL FOR CONTINUATION** not just learning

- 
- Observation 2:

REAL EXPERIENTIAL CASES & REAL
ENVIRONMENT

are required for practising REAL LEADERSHIP



LEADERS EMERGE

**Develop
Engineering
Leaders**

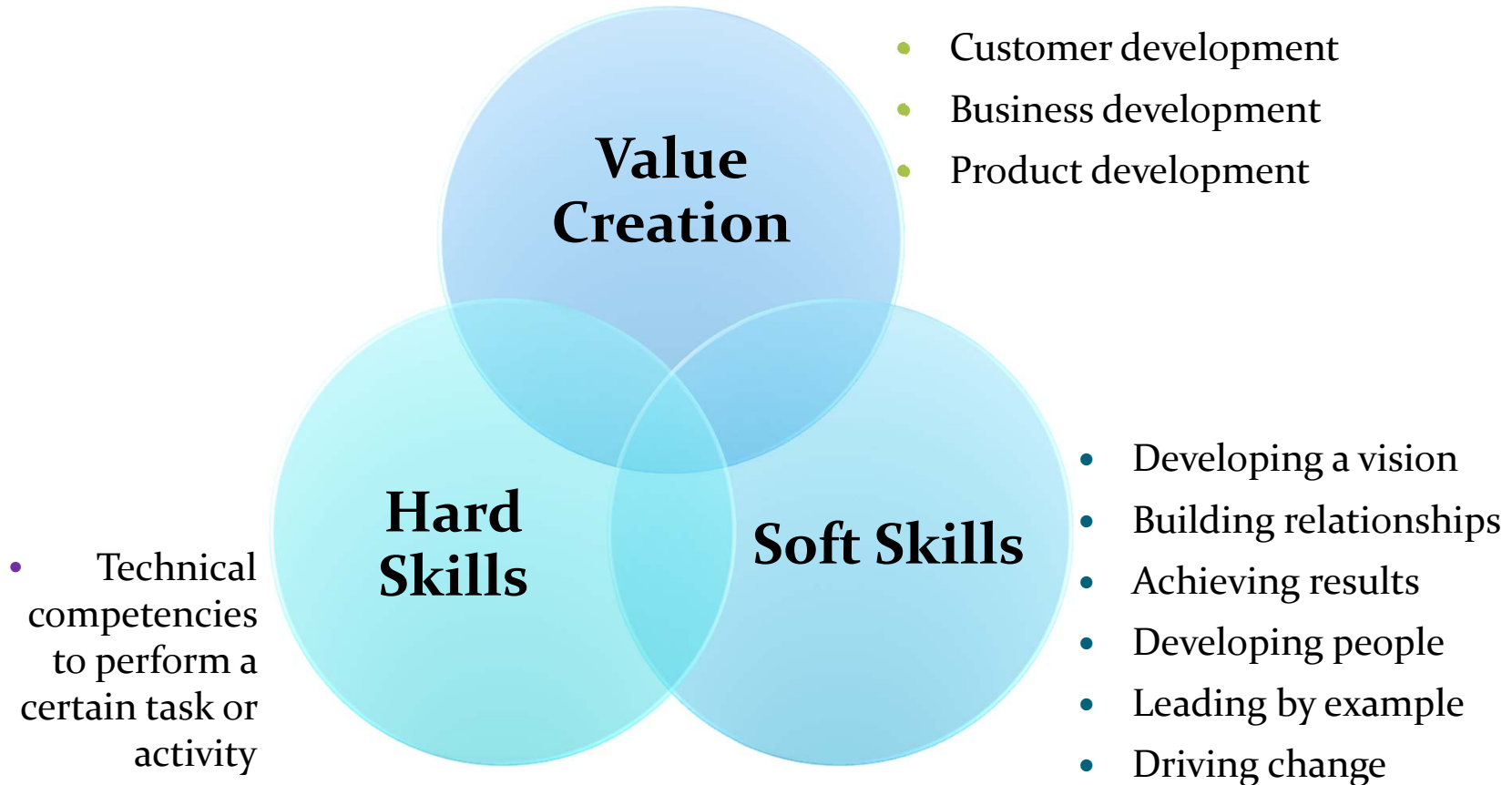
**IEL: Creating
experiential
cases &
environment**

- Safe to take risks
- Create value
- Take charge

**Develop &
Strengthen
Enterprises**

VALUE CREATED

- 
- Observation 3:
 - Leadership development has to provide SOFT and VALUE CREATION SKILLS in addition to hard (technical) skills



Engineer-Leader Skill Gaps IN VALUE-CREATION AND SOFT-SKILLS



IEL develops and provides a vibrant connected ecosystem for the development of engineer-leaders.



Thank You