Industry Transformation
Challenges and Opportunities for Engineering Education

14 March 2017

Lim Peng Hun

SINGAPORE POLYTECHNIC

SP joins CDIO

Industry Transformation

Enhancing CDIO

~Design Thinking

~FabLab

~Skills Framework

~Industry Value Exchange

Moving Forward

Outline

SP joins CDIO

Industry Transformation
Enhancing CDIO
~Design Thinking
~FabLab
~Skills Framework
Industry Value Exchange
Moving Forward

Singapore Polytechnic

- Established 27 October 1954
- 38 Hectares of Lush Greenery

Mission : Life Ready. Work Ready. World Ready

10 Academic Schools

- Design
- Business
- Mathematics and Sciences
- Chemical and Life Sciences
- Singapore Maritime Academy
- Electrical & Electronic Engineering
- Architecture and Built Environment
- Mechanical & Aeronautical Engineering
- Digital Media & Infocomm Technology
- Communication, Arts and Social Sciences

Students

Full-time Diploma
14,910

Continuing Education
19,452

Programmes

47 Full-time Diplomas
10 Part-time Diplomas
8 Advanced Diplomas
15 Specialist Diplomas
6 Diploma Conversion
36 Work Skill Qualification
128 short courses

Alumni
189,929

Staff
1683

SINGAPORE POLYTECHNIC

2004

We need to produce graduates who are more Creative, Innovative and Entrepreneurial (CIE)

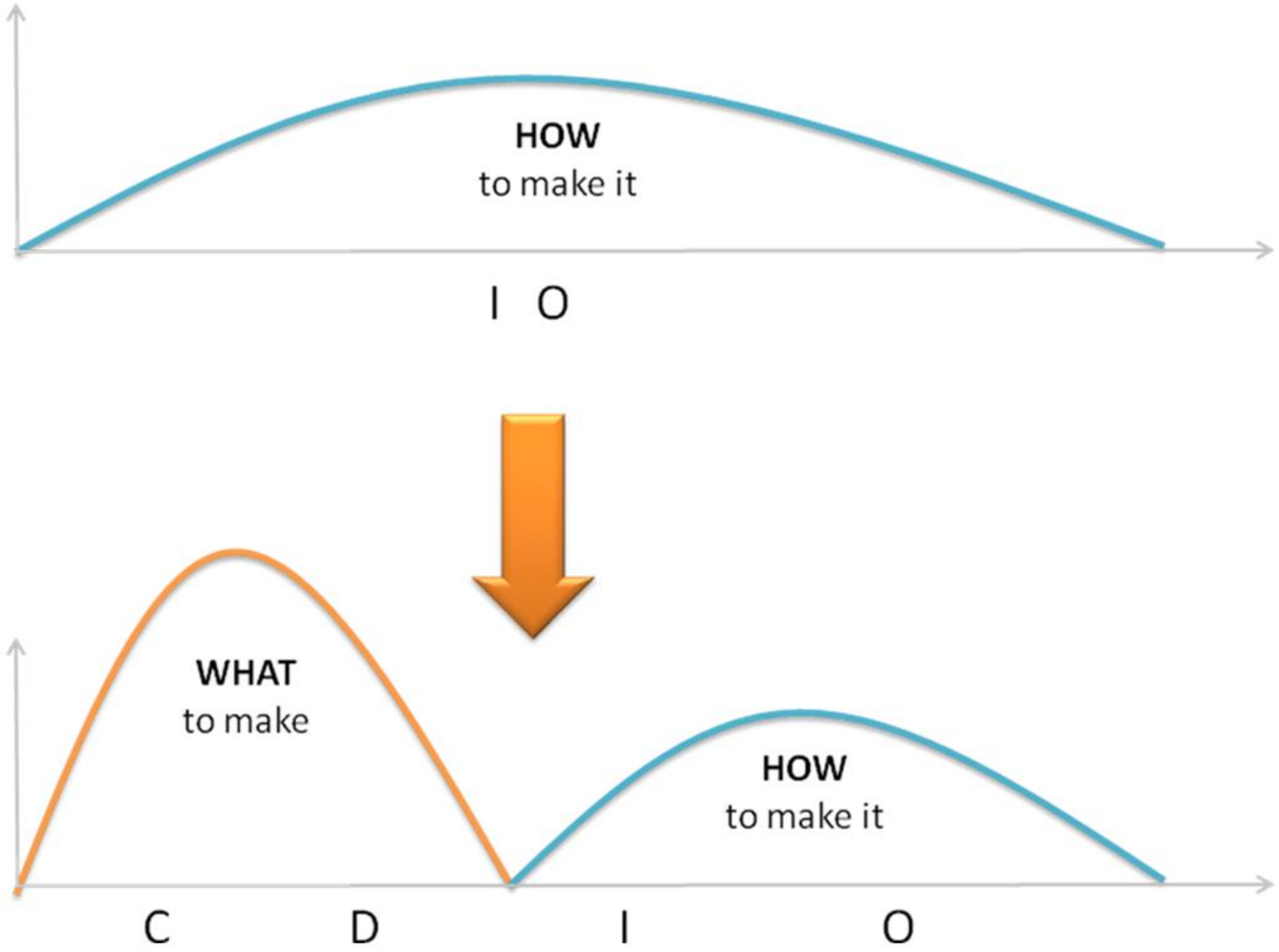
The Challenge

Education Model of the Future?

SINGAPORE POLYTECHNIC

Responding to *The Challenge*

- Pilot CDIO with 20 students
- Convince management
- Joined CDIO in 2004

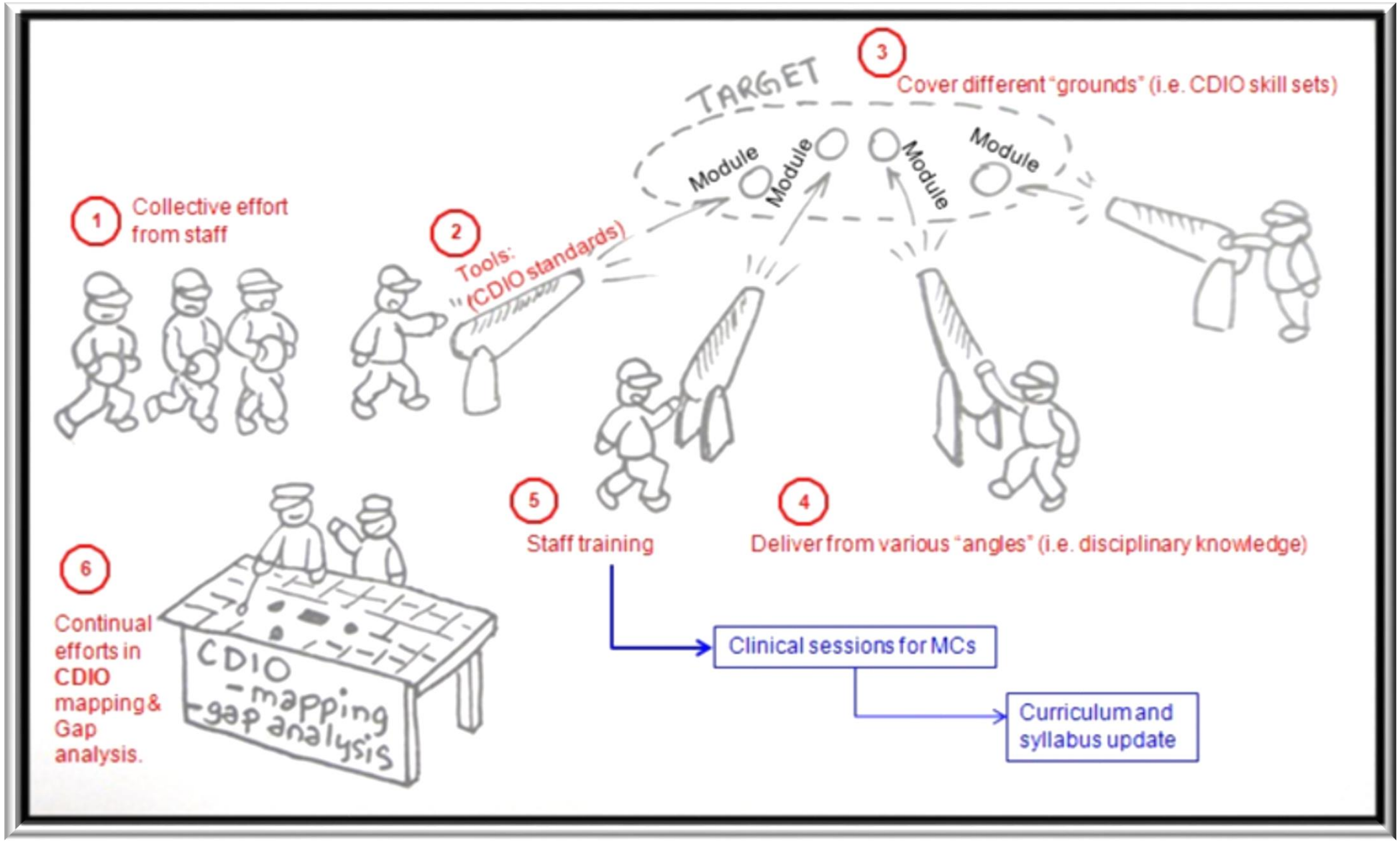


SINGAPORE POLYTECHNIC

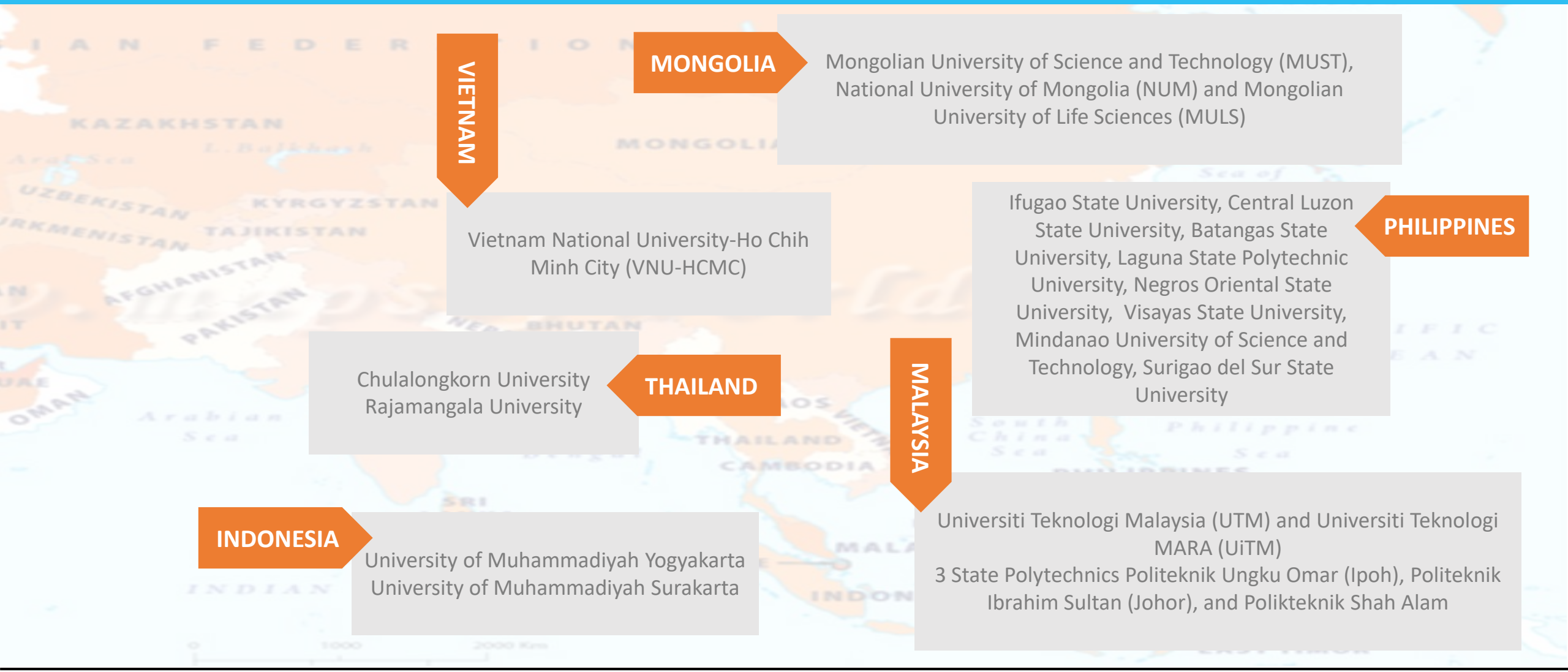
CONCEIVE - DESIGN - IMPLEMENT – OPERATE (CDIO) STANDARDS

1. CDIO as Context
2. CDIO Syllabus Outcomes
3. Integrated Curriculum
4. Introduction to Engineering
5. Design-Build Experiences
6. CDIO Workspaces
7. Integrated Learning Experiences
8. Active Learning
9. Faculty CDIO Skills
10. Faculty Teaching Skills
11. CDIO Skills Assessment
12. CDIO Program Evaluation

SINGAPORE POLYTECHNIC


1
Collective effort from staff
2
Tools: "(CDIO standards)
TARGET
3
Cover different "grounds" (i.e. CDIO skill sets)
Module
Module
Module
Module
4
Deliver from various "angles" (i.e. disciplinary knowledge)
5
Staff training
Clinical sessions for MCs
Curriculum and syllabus update
6
Continual efforts in CDIO mapping & Gap analysis.
CDIO
-mapping
-gap analysis

2012 - Singapore Polytechnic elected CDIO Regional Centre for Asia



CDIO In Action

Requirement:

- Minimal human intervention
- Zero error
- Compact
- Low noise

Achievement:

- High utilisation rate
- Operates 24/7
- Saves 8,760 man-hours annually
- Capable of storing more than 4,000 bottles
- Handles 80 different bottles' shapes and dimensions

The Making of the World's First Robotic Bottle Dispensing System (BDS)

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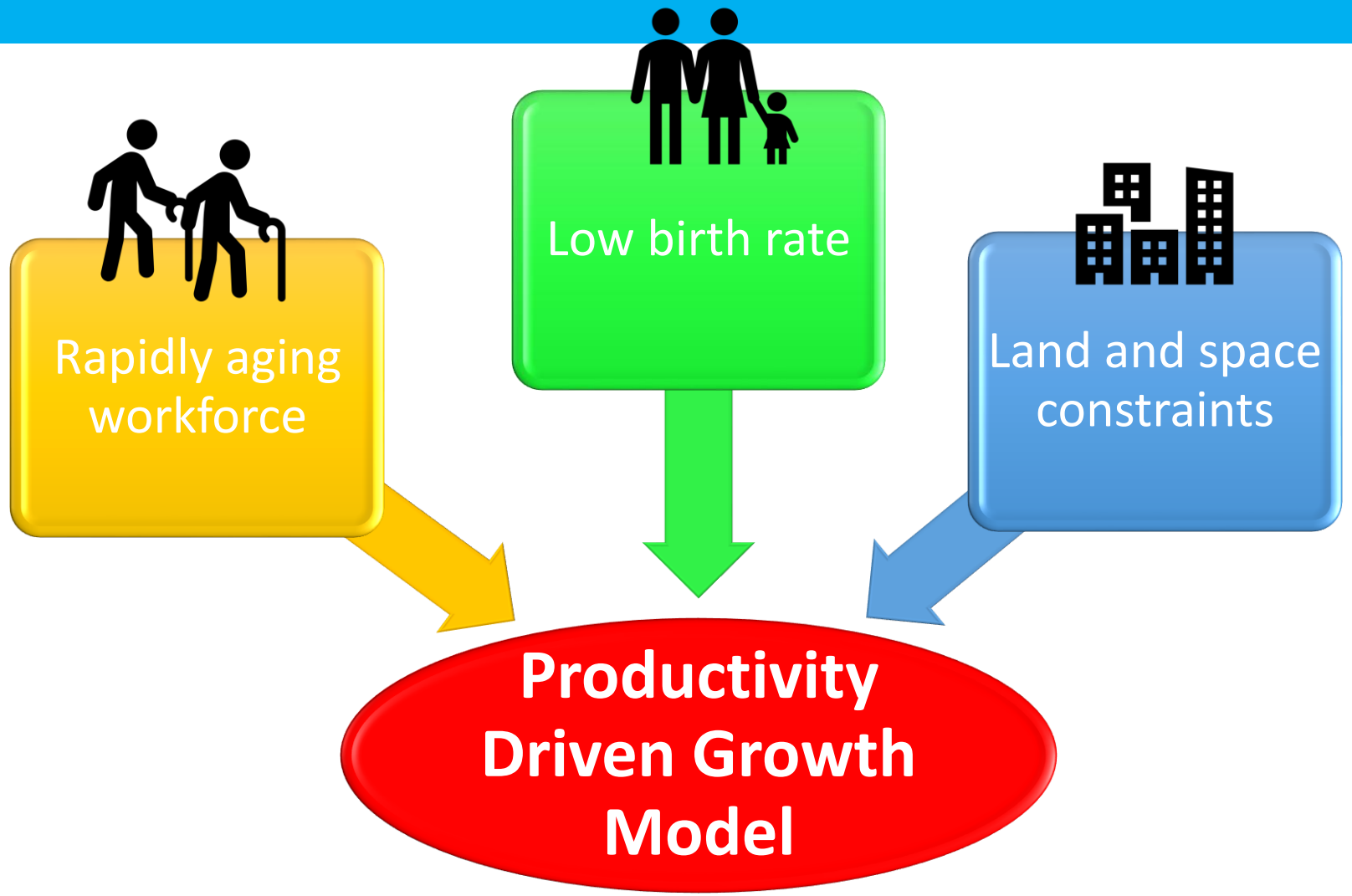
Singapore's Resource Constraints

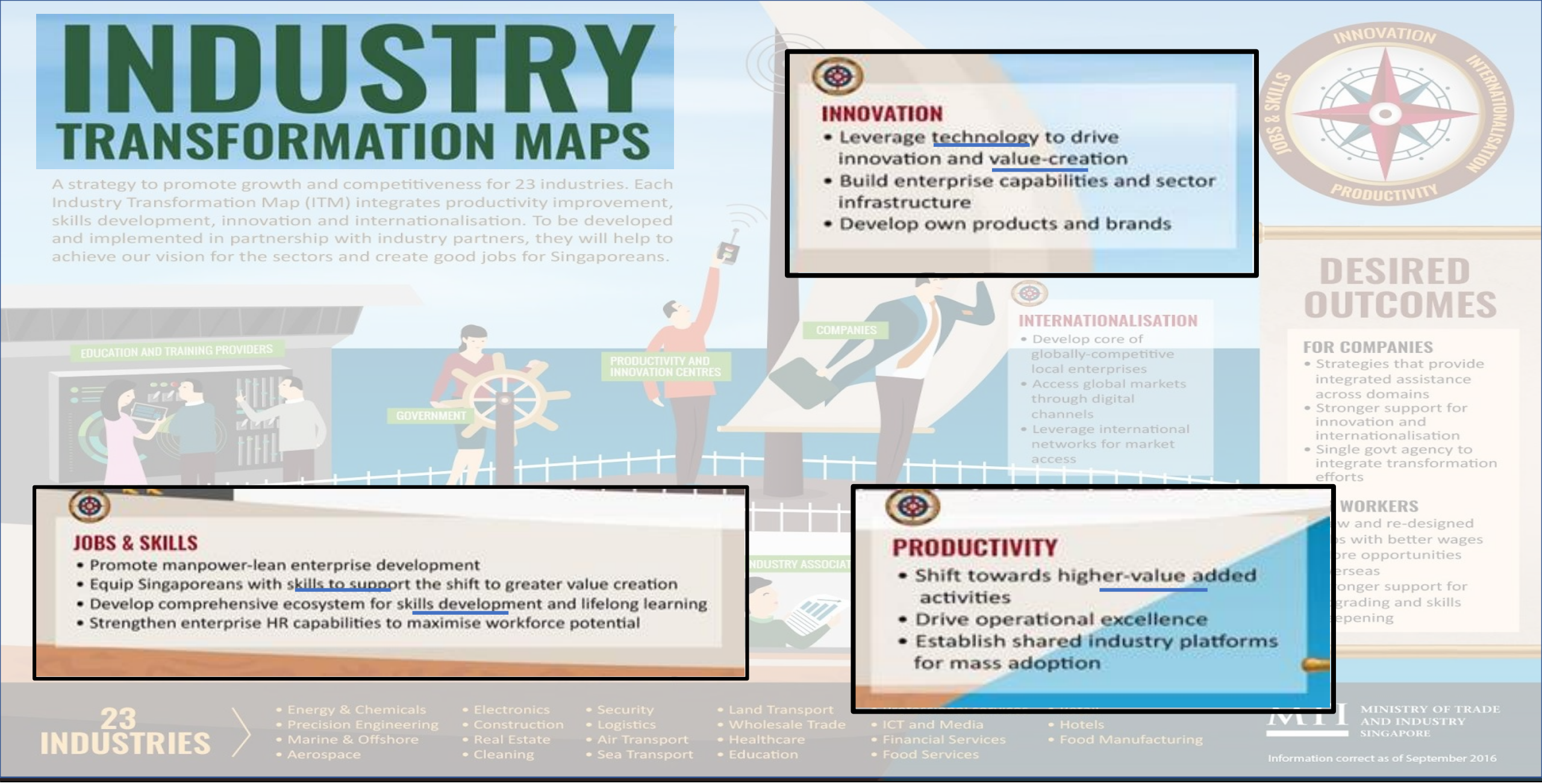


Nov 2014

SINGAPORE POLYTECHNIC

INDUSTRY TRANSFORMATION MAPS

A strategy to promote growth and competitiveness for 23 industries. Each Industry Transformation Map (ITM) integrates productivity improvement, skills development, innovation and internationalisation. To be developed and implemented in partnership with industry partners, they will help to achieve our vision for the sectors and create good jobs for Singaporeans.



INNOVATION

- Leverage technology to drive innovation and value-creation
- Build enterprise capabilities and sector infrastructure
- Develop own products and brands

INTERNATIONALISATION

- Develop core of globally-competitive local enterprises
- Access global markets through digital channels
- Leverage international networks for market access

JOBS & SKILLS

- Promote manpower-lean enterprise development
- Equip Singaporeans with skills to support the shift to greater value creation
- Develop comprehensive ecosystem for skills development and lifelong learning
- Strengthen enterprise HR capabilities to maximise workforce potential

PRODUCTIVITY

- Shift towards higher-value added activities
- Drive operational excellence
- Establish shared industry platforms for mass adoption

INNOVATION · INTERNATIONALISATION · PRODUCTIVITY · JOBS & SKILLS

DESIRED OUTCOMES

FOR COMPANIES

- Strategies that provide integrated assistance across domains
- Stronger support for innovation and internationalisation
- Single govt agency to integrate transformation efforts

WORKERS

w and re-designed
s with better wages
re opportunities
erseas
onger support for
grading and skills
epening

23 INDUSTRIES

- Energy & Chemicals
- Precision Engineering
- Marine & Offshore
- Aerospace
- Electronics
- Construction
- Real Estate
- Cleaning
- Security
- Logistics
- Air Transport
- Sea Transport
- Land Transport
- Wholesale Trade
- Healthcare
- Education
- ICT and Media
- Financial Services
- Food Services
- Hotels
- Food Manufacturing

MINISTRY OF TRADE AND INDUSTRY SINGAPORE

Information correct as of September 2016

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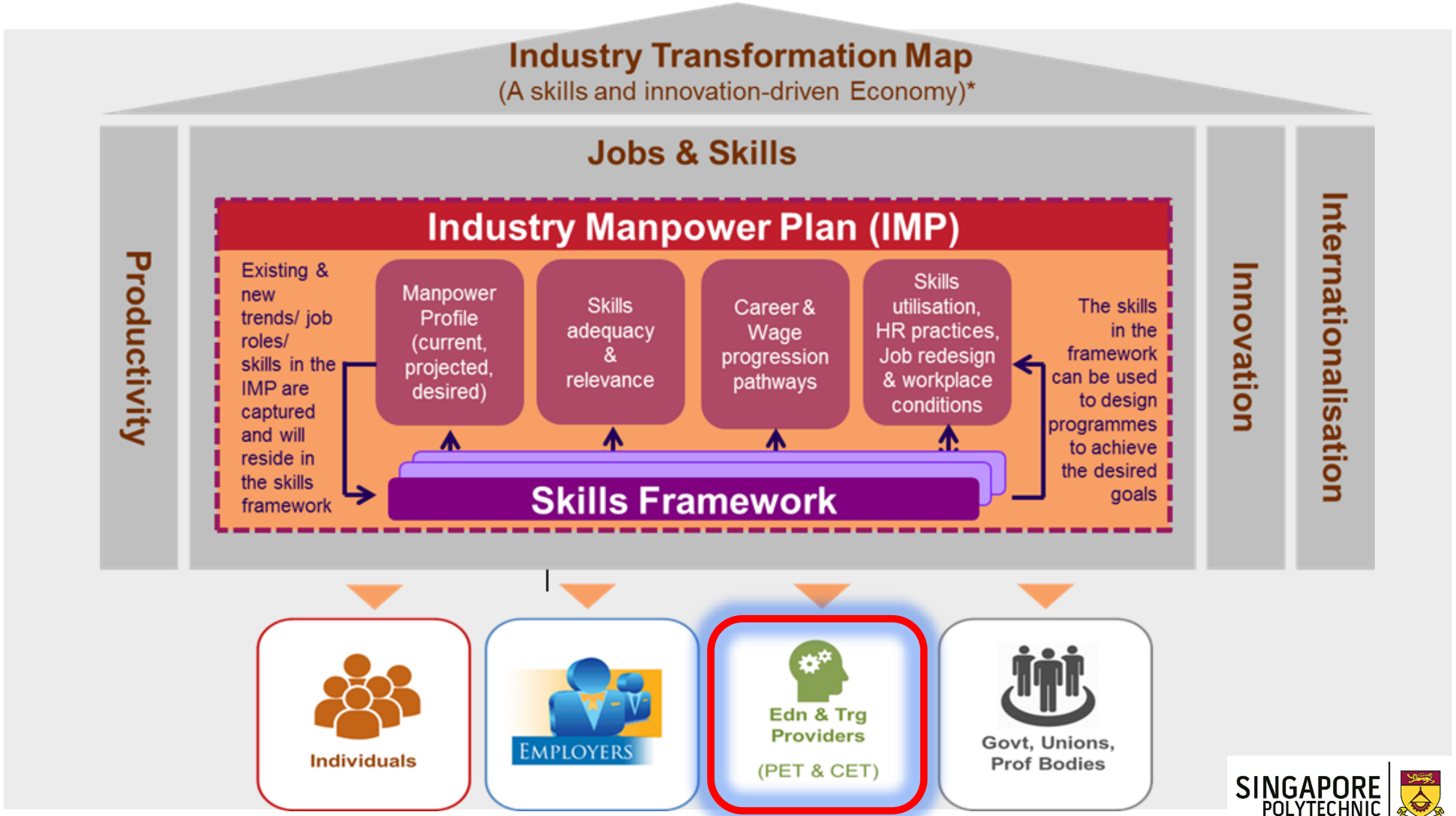

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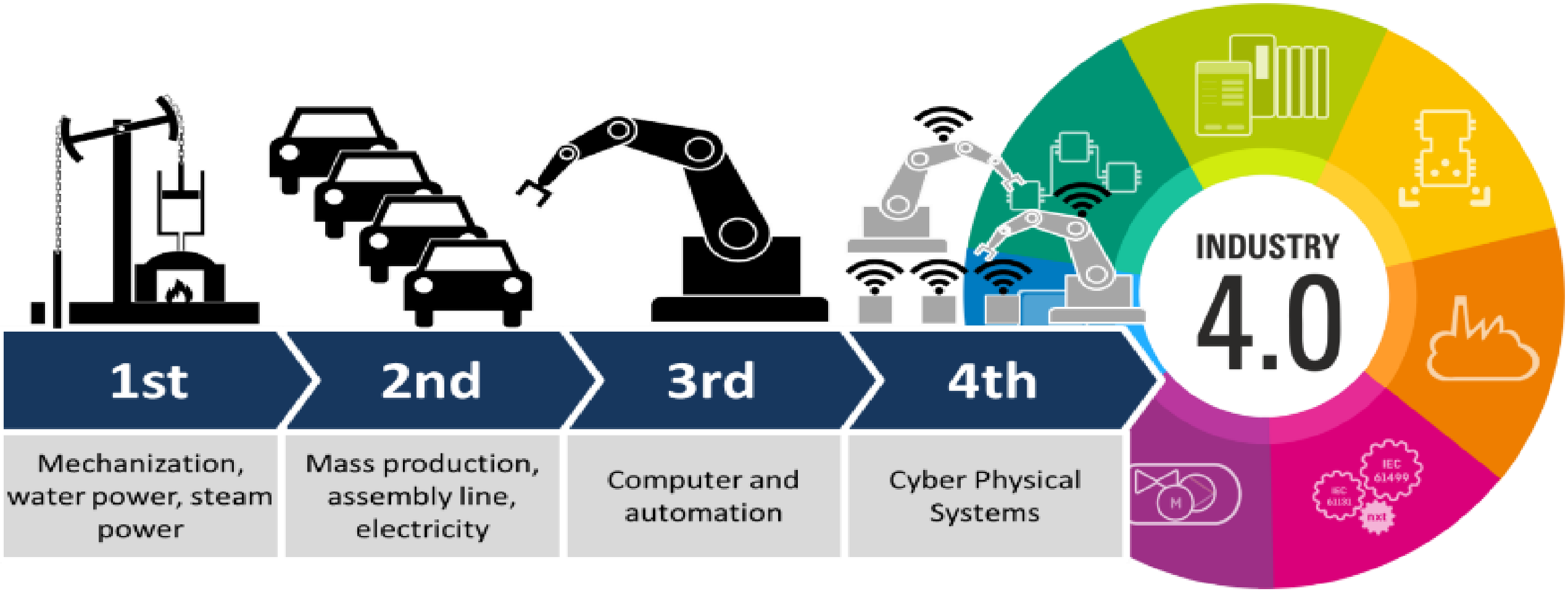
Megatrend

An information revolution where everybody & everything is networked



Additive Manufacturing

- From 3D design and simulation
- Produce desired components and parts
- Faster, more flexible and more precise
- Less prototype construction, fewer dies, less post-processing

Collaborative/ Autonomous Robots

- Adapt to real-world variability
- Change applications quickly
- Perform tasks like people do
- Detect people prior to contact

Education Reform to Support Economic Transformation

2014

We need to produce graduates who are Future Ready and Industry 4.0 Ready

The Challenge

Next Education Model?

SINGAPORE POLYTECHNIC

The New Norm for Polytechnic Education

Pre-Employment Training (PET)

Continuing Education & Training (CET)

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Moving Forward

Enhancing CDIO in Singapore Polytechnic

Design Thinking

Standard 1 – CDIO Context
Standard 7 - Integrated Learning Experiences

Industry 4.0 – future ready graduates

FabLab

Standard 5 - Design Implement Experiences
Standard 6 - Engineering Workspaces
Standard 1 – CDIO Context

cdio

Skills Framework

Standard 2 – Learning Outcome

Industry Value Exchange

Standard 8 - Active Learning

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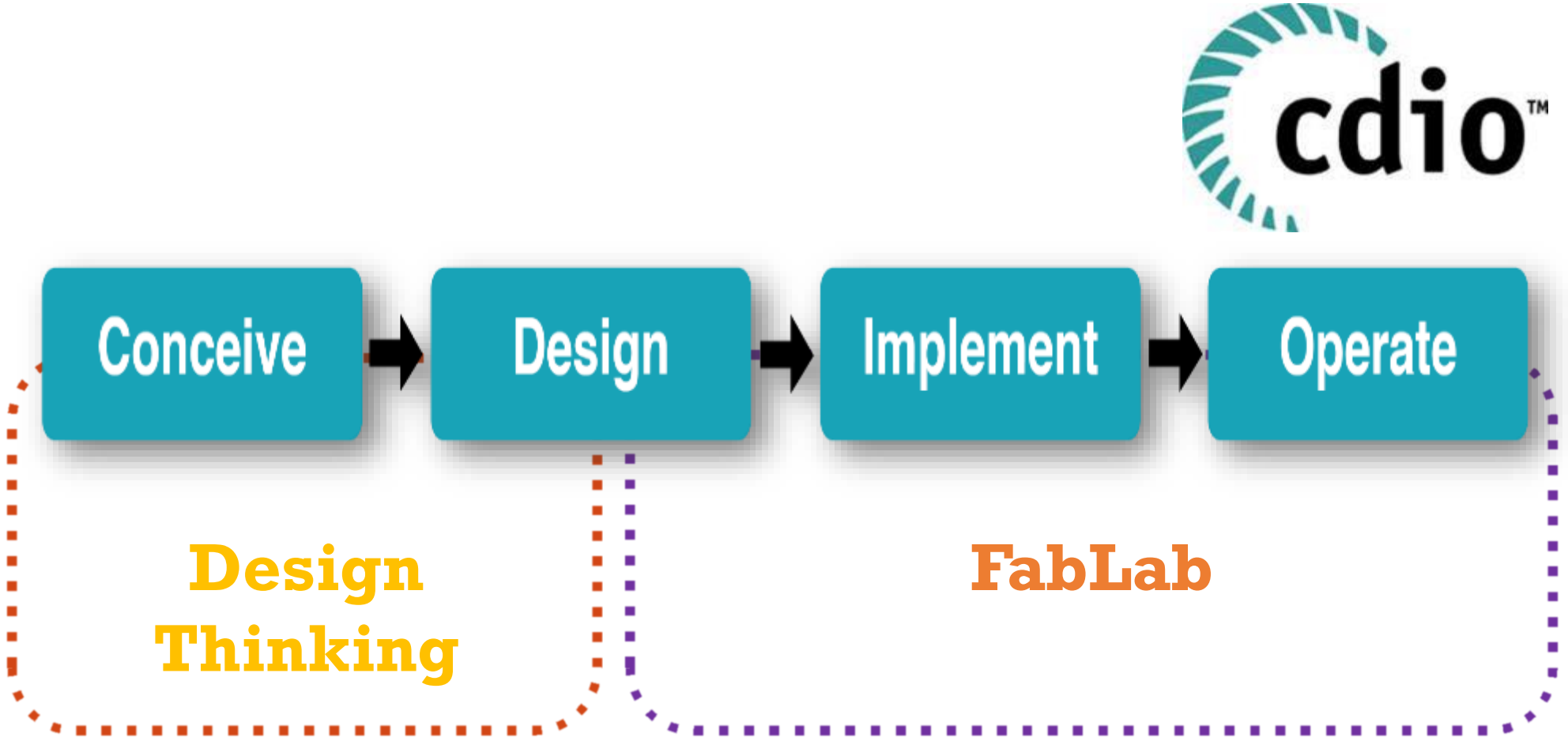
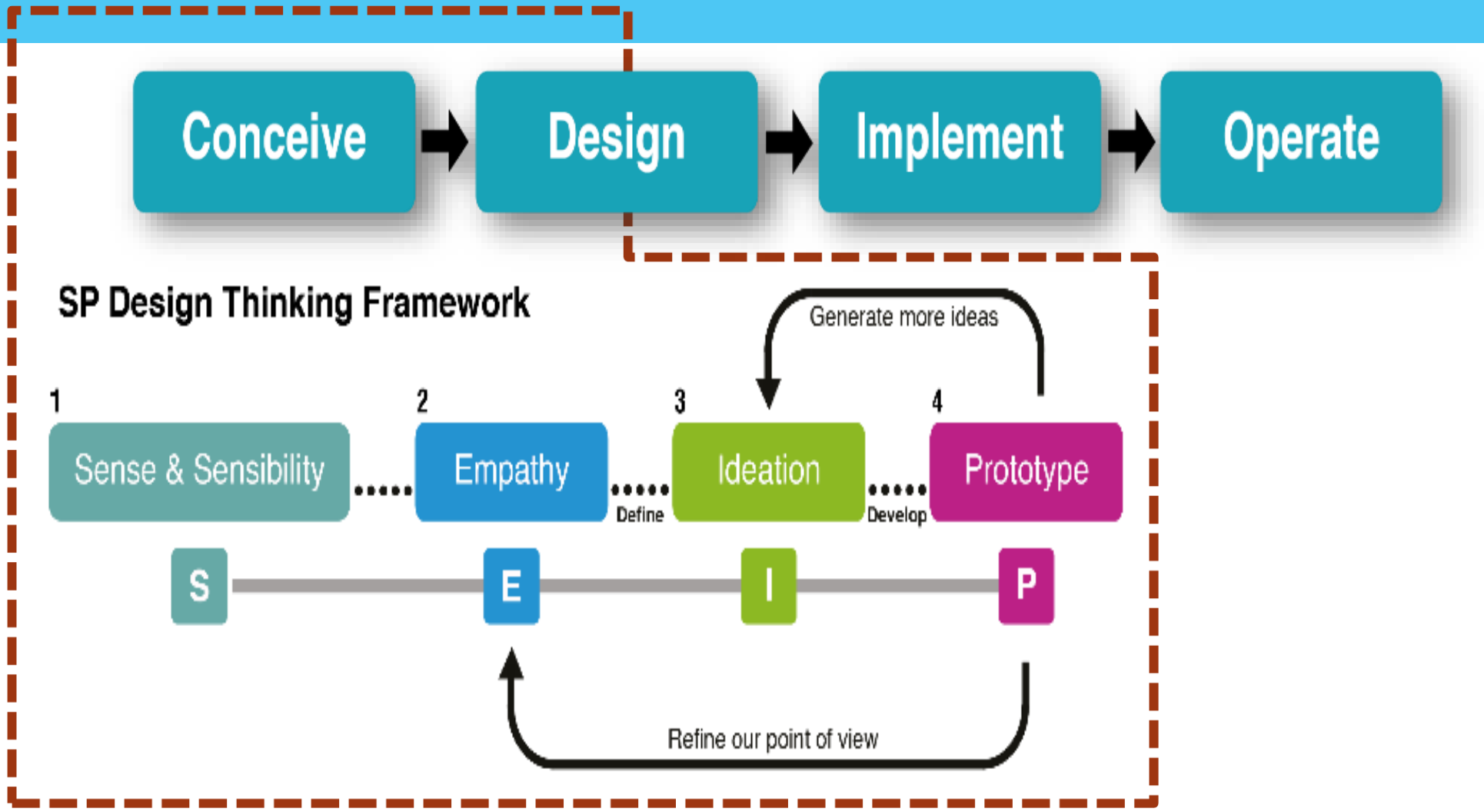
Singapore Polytechnic Engineering Training



Singapore Polytechnic Design Thinking



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Singapore Polytechnic **Fablab**

Conceive → Design → Implement → Operate

FabLab
SINGAPORE POLYTECHNIC

Fab LABS

Fab SKILLS

Fab INNOVATION

Fab COMMUNITY

FABFOUNDATION

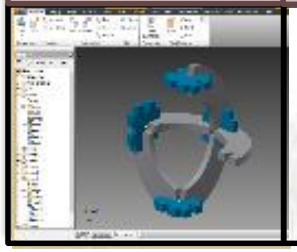
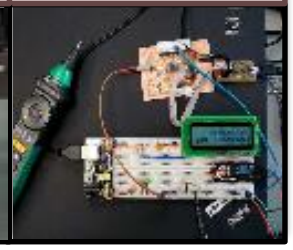
- Created in 2009 from MIT's Centre of Bits & Atoms Fab Lab program
- Mission:
  * Access to tools and knowledge
  * Educate, innovate and invent using digital fabrication
  * Allow anyone to make (almost) anything
  * Create opportunities to improve lives around the world
- Approximately 1000 FabLabs, including **FabLab Singapore Polytechnic**

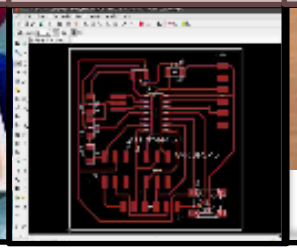
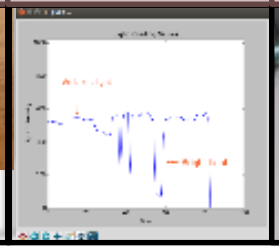
SINGAPORE POLYTECHNIC

Singapore Polytechnic **Staff** Development

FABACADEMY

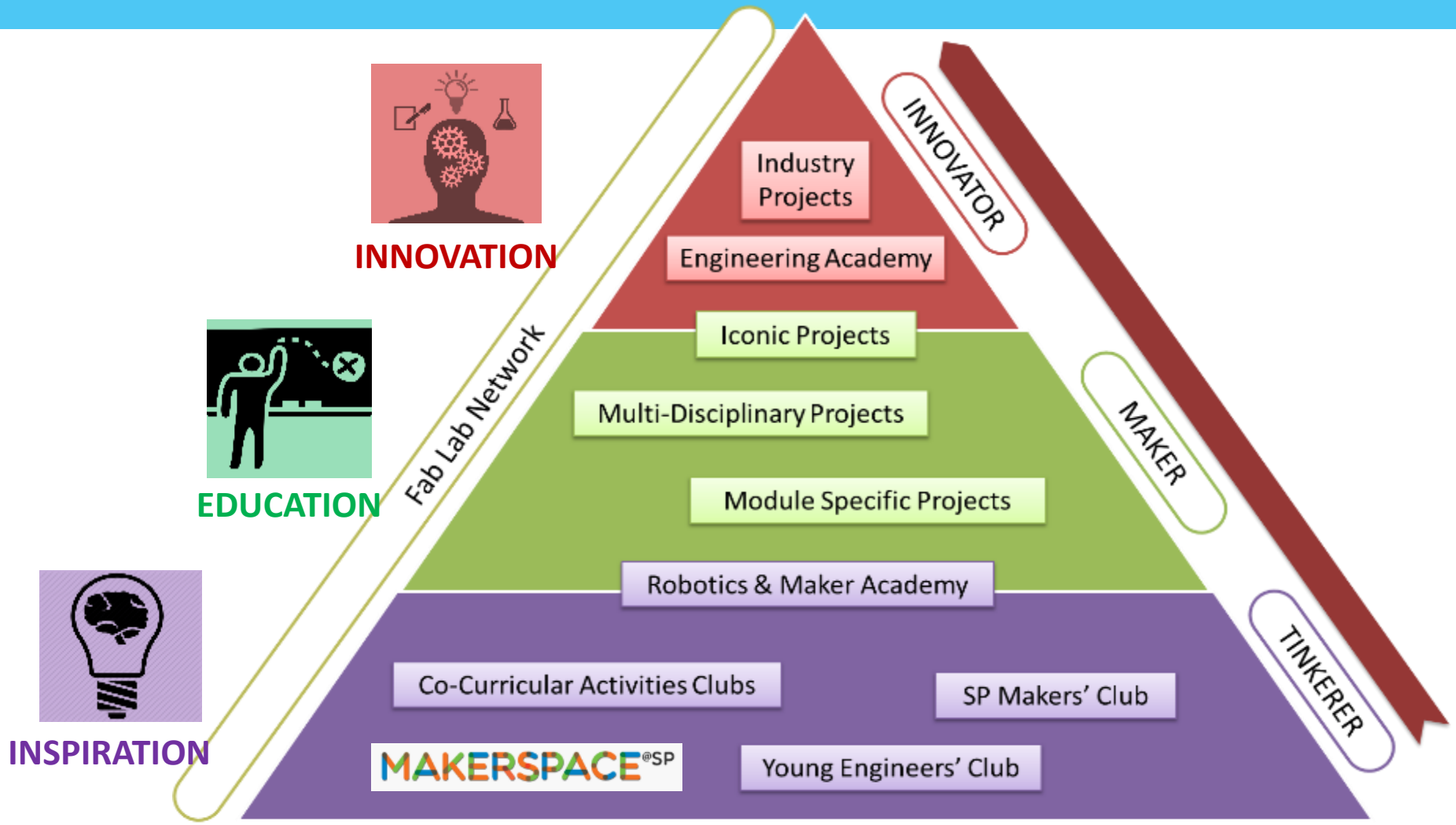
Roy Ang • Walter Chan • Rodney Dorville
Edward Tay • Chan KC • Steven Chew
Hendra • Mark Ng • Keith Tan
Teo SJ • Tham HL • Yue SC

2D/3D Printing	Place & Fit	3D Design	Electronics Fab	Composites	Moulding	3D Fabrication	Networking
							

Milling	Electronic CAD	Embedded Dsg	App Program	Input/output	Machine Bldg	Microcontroller	Final Projects
							

SINGAPORE POLYTECHNIC

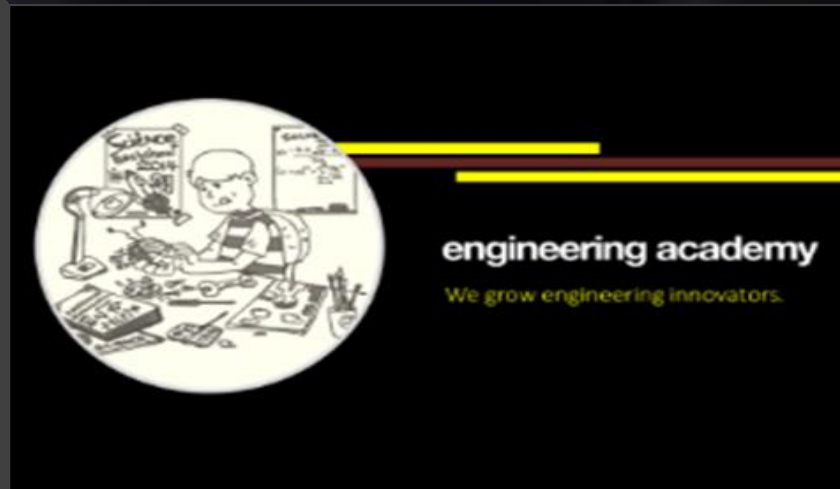
Singapore Polytechnic **Student** Skill Development Framework



Innovating

Making

Tinkering



Singapore Polytechnic **Fablab**

Dare to DREAM

CHARACTER

Curious
Collaborative
Agile
Persistent

Being

CONNECTEDNESS

Empathizing with others
Appreciating real world concerns
Understanding own motivations
Building an active community

Feeling

Dare to DO

COMPETENCE

Analyzing
Associating
Evaluating
Questioning

Thinking

CONFIDENCE

Creating
Digitally Fabricating
Rapidly Prototyping
Experimenting

Doing

SkillsFuture

SINGAPORE POLYTECHNIC

Recent Student Activities & Projects

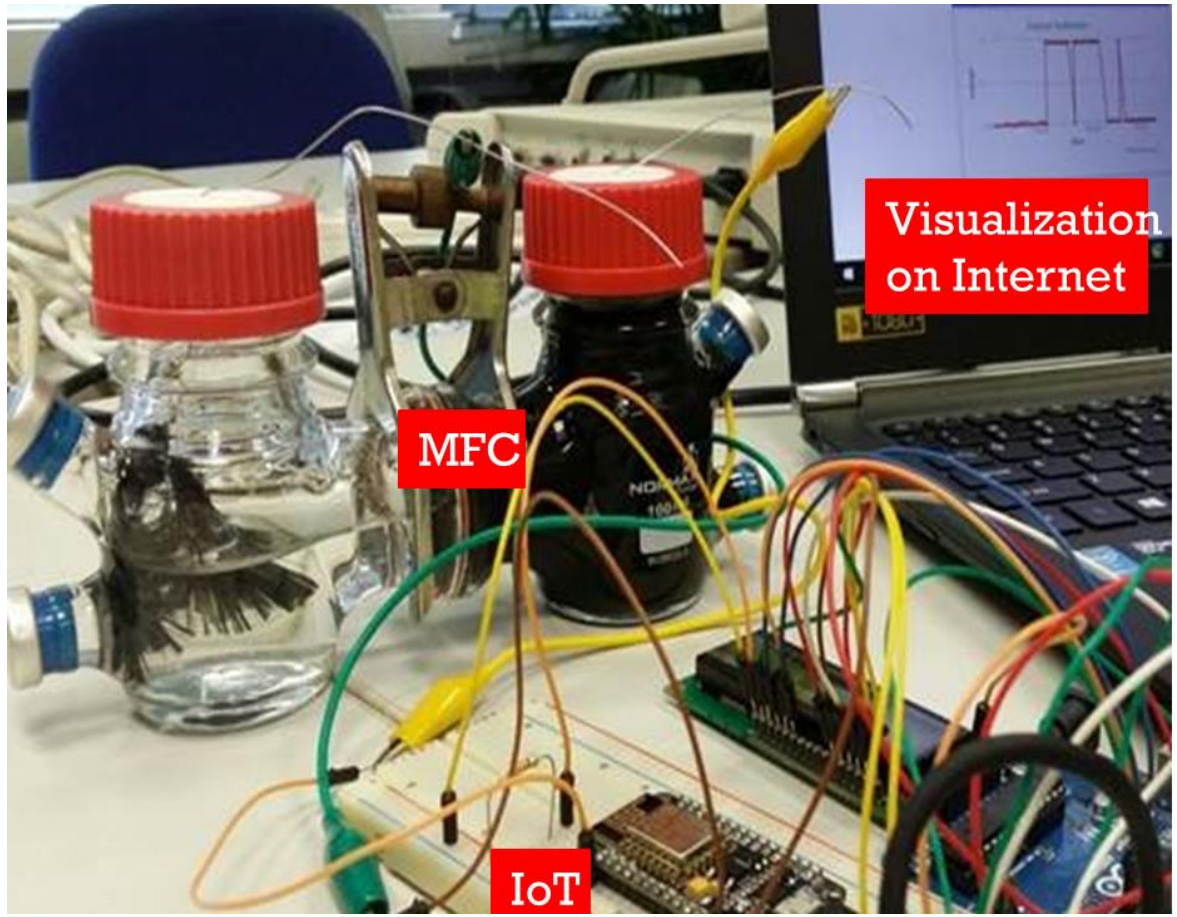
GovTech

- Singapore Polytechnic student Julian Kang demonstrating his invention to Minister for Communications and Information, Dr Yaacob Ibrahim.
- The inventive Julian has even developed a prototype gizmo that promises to connect any device to the Internet.

Recent Student Activities & Projects

MFC enabled by IoT

- Student research on Microbial Fuel Cell (MFC): bacteria and waste water to generate electricity
- Problem statement: voltage generated by MFC is logged by hand
- Come to FabLab@SP to discuss with staff & students on realizing an idea
- Conceive & Design: automating data logging for research findings
- Implement & Operate: IoT enabled data acquisition jig for MFC



Recent Student Activities & Projects

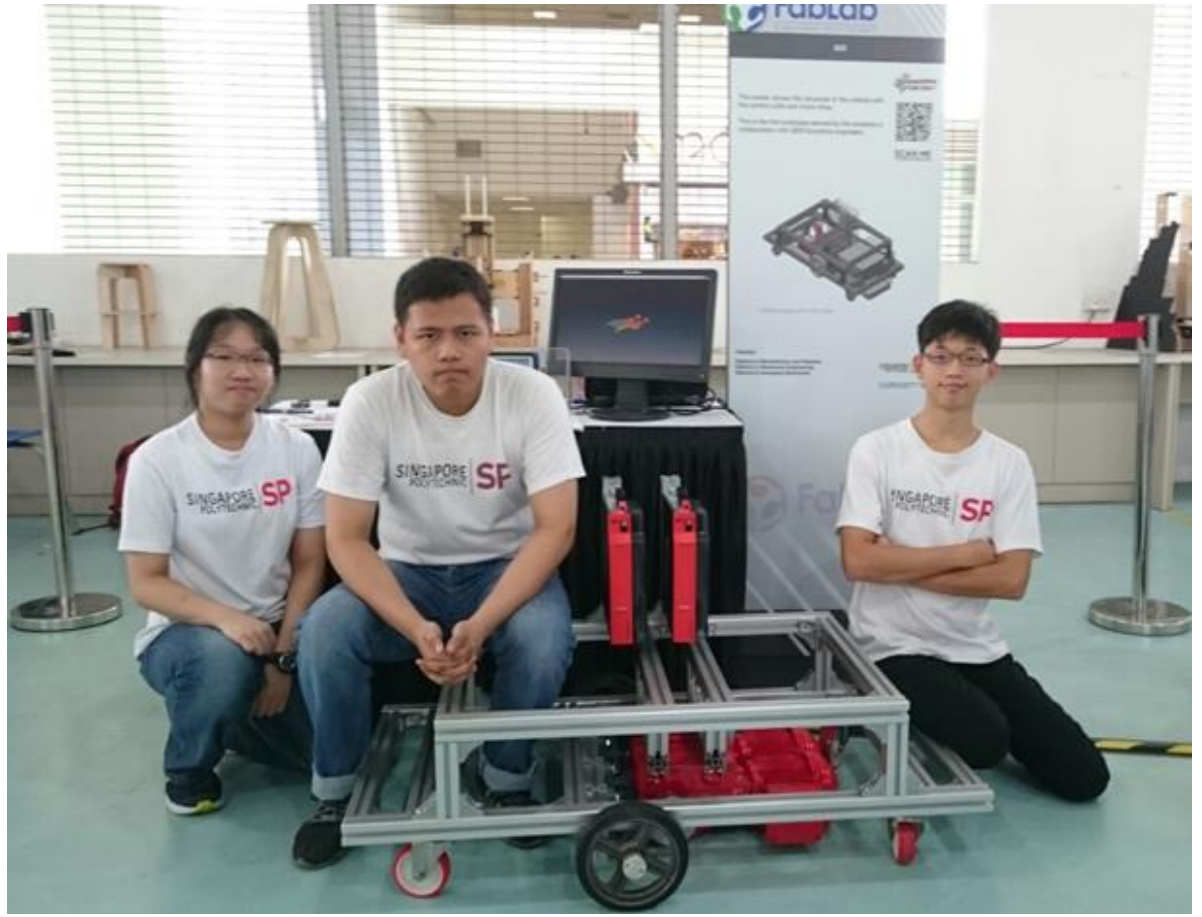
Remotely Operated Vehicle (ROV)

- Used in offshore engineering application
- Unoccupied underwater robot
- Allows remote navigation of the vehicle
- Performs underwater hazardous tasks

Recent Student Activities & Projects

Autonomous Guided Vehicle (AGV) with industry

- For a production line, using a wireless charging system provided by industry sponsor SEW EURODRIVE
- Intelligent, autonomous mobile platform delivers materials to designated workplaces
- Allows remote control, mobile data acquisition, wide area monitoring and Industry 4.0 interoperability through Cyber-physical connectivity



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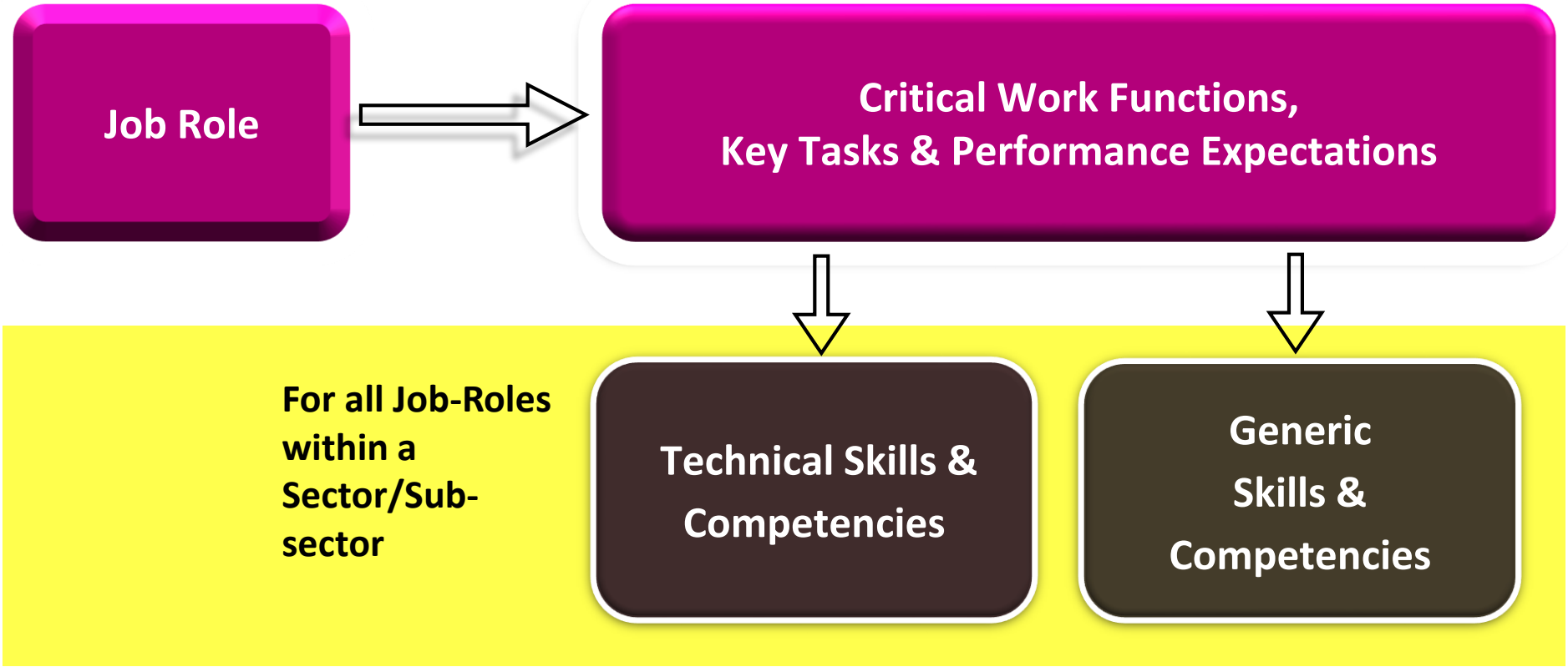
Singapore **Skills Framework**

It is an integral part of Singapore's national Industry Manpower Plan to support the growth of an economy based on productivity and innovation.



Mapping of Generic Skills & Competencies

Common Modules

- Transdisciplinary Thinking
- Computational Thinking
- Resource Management
- Communication
- Creative Thinking
- Decision Making
- Digital Literacy
- Interpersonal Skills
- Problem Solving
- Sense Making
- Teamwork
- Lifelong Learning

Institutional Modules

- Global Mindset
- Managing Diversity
- Virtual Collaboration

Generic Skills & Competencies	Basic	Intermediate	Advanced
1 Communication		Proj(CDIO)	CM/Crit
2 Computational Thinking	CM	SimPract/Proj(CDIO)	
3 Creative Thinking		Proj(CDIO)	Crit
4 Decision Making		Proj(CDIO)	CM/Crit
5 Developing People	Proj(CDIO)		
6 Digital Literacy	Proj(CDIO)		Creation
7 Global Mindset	Proj(CDIO)		
8 Interpersonal Skills		Proj(CDIO)	
9 Leadership	Proj(CDIO)		
10 Lifelong Learning	Proj(CDIO)	Crit	
11 Managing Diversity	Proj(CDIO)		
12 Problem Solving		Proj(CDIO)	
13 Resource Management	Proj(CDIO)	SimPract	
14 Sense Making		Proj(CDIO)	CM / Proj(CDIO) / SimPract
15 Service Orientation	Proj(CDIO)		
16 Teamwork	Proj(CDIO)	Proj(CDIO)/CM/(Crit/SimPract)	
17 Transdisciplinary Thinking		CM/Proj(CDIO)/Crit	
18 Virtual Collaboration	Proj(CDIO)		

Course-Specific Modules

- Service Orientation
- Leadership
- Developing People

Institutional Modules	General Education | Social Innovation Project | Communication | Education & Career Guidance | SP Graduate Attributes
Common Modules	Introduction to Statistical Literacy | Basic Mathematics | Engineering Mathematics | IT & Data Analysis for Business | P4P

Mapping to Diploma in Mechanical Engineering

S/N	Skills	DME	Status
1	Apply geometric dimensioning and tolerancing	Computer-aided drafting Design & build Advanced machining & metrology*	Mapped
2	Performing engineering simulation for design verification	Finite element methods^ Project/Internship	Waiting MOE's reply#
3	Apply materials characterisation	Engineering materials 1 & 2 Advanced machining & metrology*	Mapped
4	Apply mechanical fixtures design	Design & build Tooling engineering*	Mapped
5	Apply precision machining	Computer-aided machining Advanced machining & metrology*	Mapped
6	Implement engineering activities and processes	Industrial engineering Organisational management	Mapped
7	Apply measurement metrology in quality assurance	Introduction to engineering Quality engineering & management Advanced machining & metrology*	Mapped

*Precision Engineering Option only
^Advanced Module

Mapping to Diploma in Mechanical Engineering

S/N	Skills	DME	Status
8	Apply workplace safety and health policy	Introduction to engineering Design & build Project/Internship Workplace safety & health management	Mapped
9	Manage continuous improvement	Industrial engineering Organisational management Quality engineering & management Project/Internship	Mapped
10	Implement continuous improvement processes	Industrial engineering Organisational management Quality engineering & management Project/Internship	Mapped
11	Lead workplace communication and engagement	Various CASS modules Organisational management Project/Internship	Mapped

Conclusion: 10/11= 91% mapped

Mapping of CDIO Skills to Skills Framework to Generic Skills & Competencies

CDIO Skills Map		1 Communication	2 Computational	3 Creative Thinking	4 Decision Making	5 Developing People	6 Digital Literacy	7 Global Mindset	8 Interpersonal Skills	9 Leadership	10 Lifelong Learning	11 Managing Diversity	12 Problem Solving	13 Resource Management	14 Sense Making	15 Service Orientation	16 Teamwork	17 Transdisciplinary Thinking	18 Virtual Collaboration
2	**PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES**																		
2.1	ANALYTIC REASONING AND PROBLEM SOLVING				√								√		√				
2.2	EXPERIMENTATION, INVESTIGATION AND KNOWLEDGE DISCOVERY																		
2.3	SYSTEM THINKING																	√	
2.4	ATTITUDES, THOUGHT AND LEARNING		√	√							√		√	√				√	
2.5	ETHICS, EQUITY AND OTHER RESPONSIBILITIES					√											√		
3	**INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION**																		
3.1	TEAMWORK											√					√		
3.2	COMMUNICATIONS	√							√										√
4	**CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING**																		
4.1	EXTERNAL SOCIETAL CONTEXT AND ENVIRONMENTAL CONTEXT							√											
4.2	ENTERPRISE AND BUSINESS CONTEXT																		
4.3	CONCEIVING, SYSTEM ENGINEERING AND MANAGEMENT		√																
4.4	DESIGNING			√															
4.5	IMPLEMENTING																		
4.6	OPERATING																		

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SINGAPORE POLYTECHNIC

Enhancing Industry Relevance of Courses

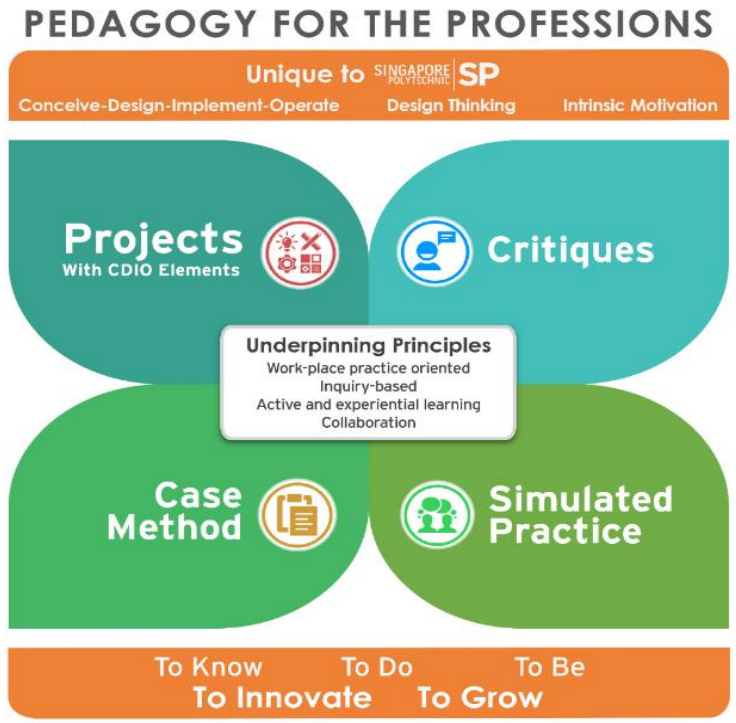
Singapore Skills Framework

WHAT
Professionals learn?

+

CDIO

HOW
Professionals learn



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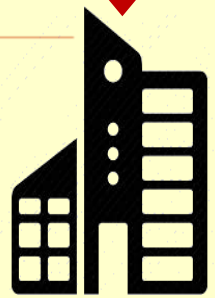
Industry Relevant Course Offerings

Industry Partnership

Learners bring **LEARNING** from polytechnic to apply in the workplace

Internships
Mini-projects
Industry Projects
Industry Tours/Talks
Simulated workplace Environments

Polytechnic



Workplace

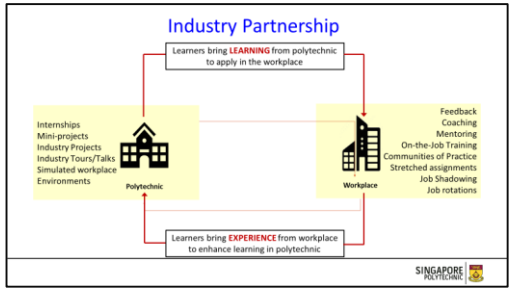
Feedback
Coaching
Mentoring
On-the-Job Training
Communities of Practice
Stretched assignments
Job Shadowing
Job rotations

Learners bring **EXPERIENCE** from workplace to enhance learning in polytechnic

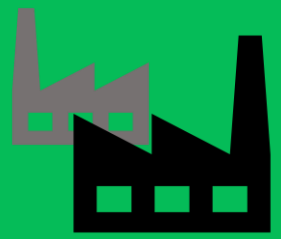
Value Exchange

Enterprise Solutions

Students



Industry



Internship

Industry Value Exchange In Action

Summary: Enhancing CDIO in Singapore Polytechnic

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Moving Forward

Back to 2004…in Mojave Desert

18 months later 2005…

2009
GOOGLE

Moving Forward

What are the implications for the future of engineering education ?

2004

2014

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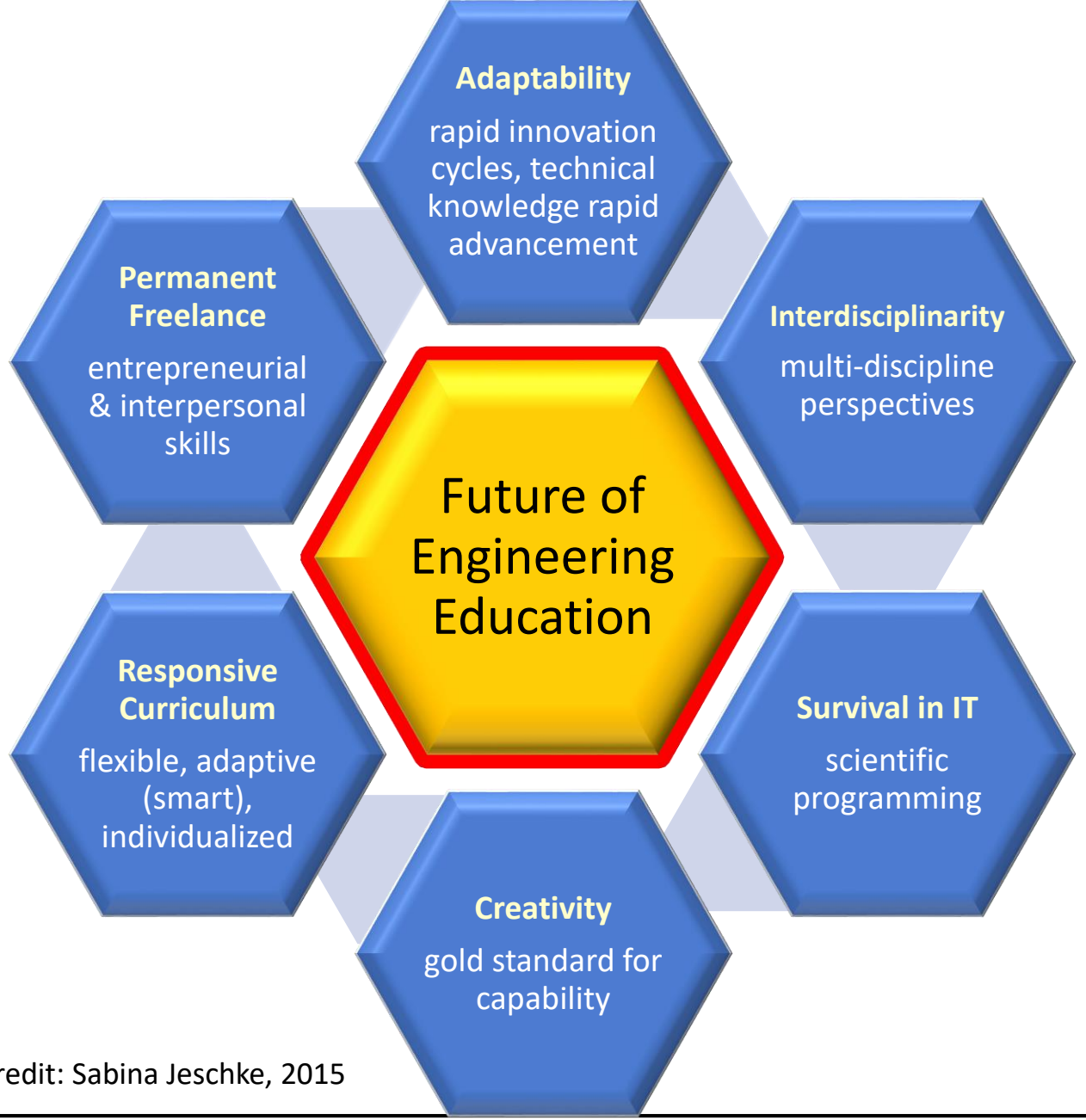

Credit: Sabina Jeschke, 2015

Thank You!