

# 工程教育：挑战与对策

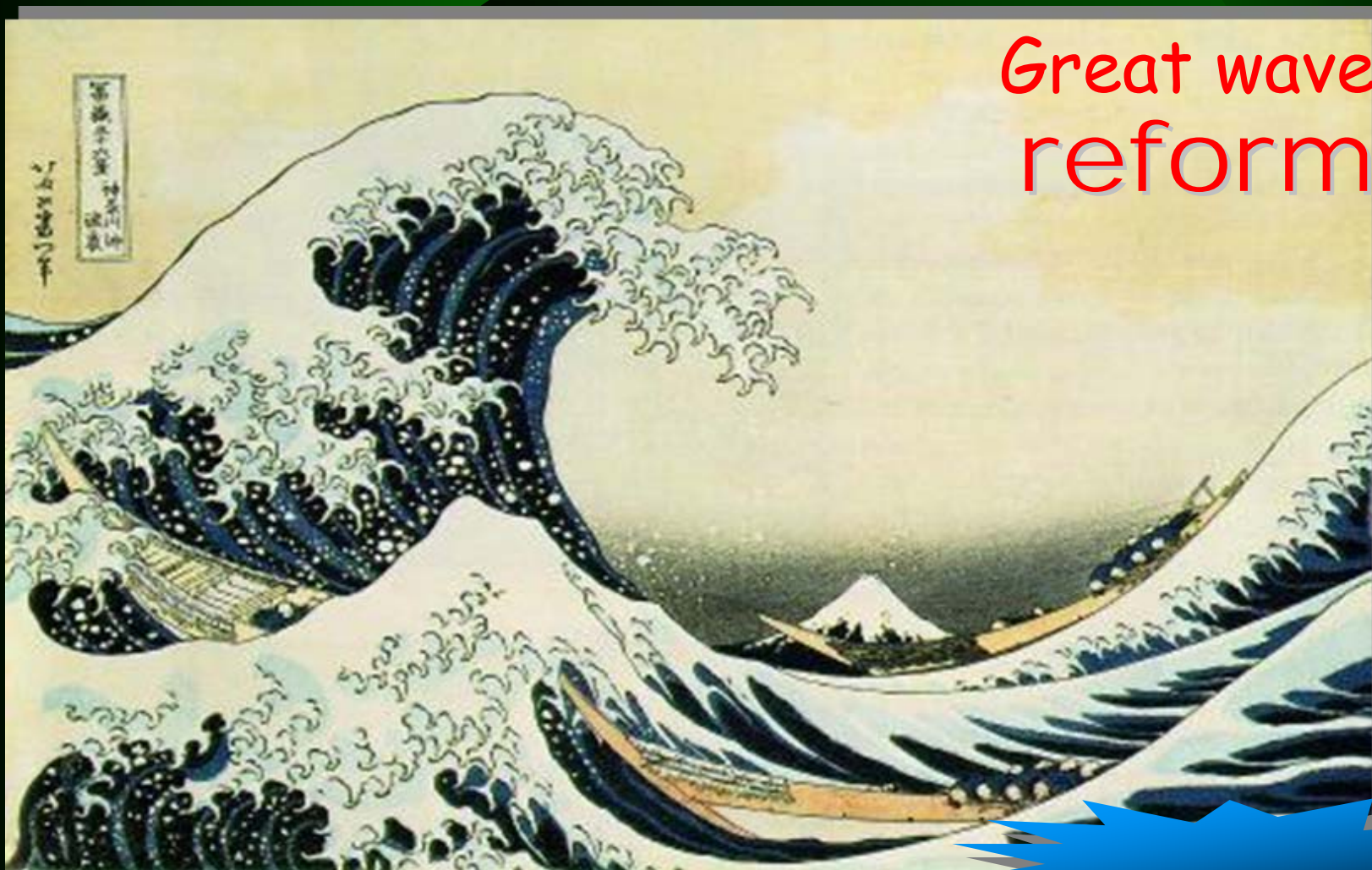
Engineering Education: Challenges and Strategies



*Research Center for Science, Technology & Education Policy  
Zhejiang University, China*

# E<sub>ngineering</sub> E<sub>ducation</sub>

Great wave  
reform



# E<sub>n</sub>gineering E<sub>d</sub>ucation

The new wave  
innovation



Great wave  
reform



**problems**

**challenges**

**strategies**

# Problem\_1

- The goal of Engineering Education in China is for making scientists but not engineers.

科学家探究已有的世界，  
工程师开创全无的天地。

Scientists study the world as it is, engineers create the world that never has been.

—— *Theodore von Karman* (1881.5.11-1963.5.6)

[http://en.wikiquote.org/wiki/Theodore\\_von\\_Karman](http://en.wikiquote.org/wiki/Theodore_von_Karman)

# Problem\_2

- Engineering Education in China is lack of practices, which is the soul of engineering.

## Engineering practice models of engineering education

**Engineering is the art** of applying scientific and mathematical principles, experience, judgment, and common sense to make things that benefit people. Engineering is the process of producing a technical product or system to meet a specific need. — ASEE

# Problem\_3

- Narrowly technical engineering education and technically narrow engineering education both exist in China.

Call for integration of  
GIRs, Engineering, HASS

GIRs (math, physics, chem, etc.)

Thompson, J.:

*New BEng and MEng courses*

Proc. 4<sup>th</sup> International Conference on the Education and Training of Engineering Designers

London, 1985

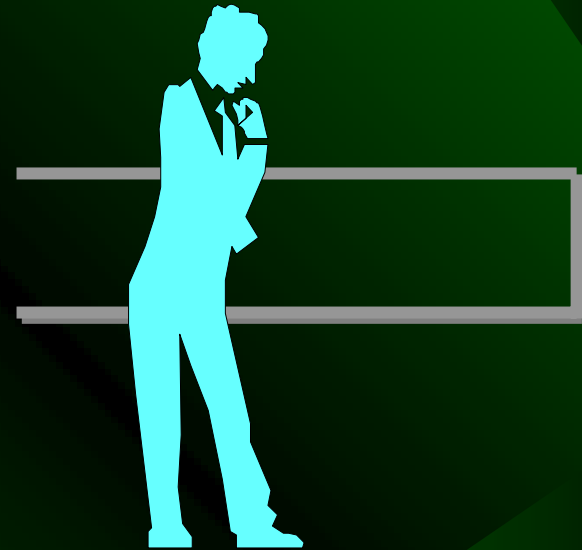
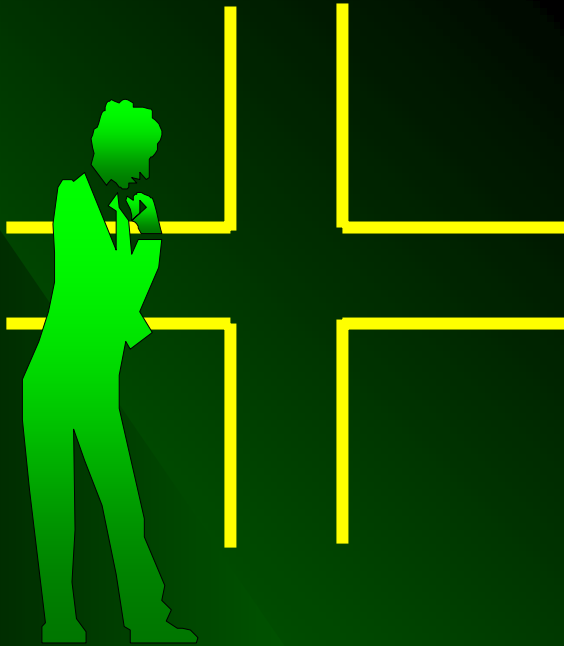
# Problem\_4

- Engineer qualification system is not established in China.





# Engineering education: At the crossroads or in the impasses ?



**It is a mass !**

**problems**

**challenges**

**strategies**

# Challenge\_1

High-tech and new technology are booming day by day. It shortens the period of commercialization.

高、新技术不断涌现  
商品化周期日益缩短

纳米科学和技术 Nanoscience & Nanotechnology  
生命科学和技术 Life Science & Engineering  
材料科学和技术 Material Science & Engineering  
电子与信息系统 CIT & Information System  
制造工程和系统 Manufacturing Engineering & System



# Challenge\_2

Research work (knowledge production) is playing an important role more than ever before.

各种

学问研究（知识生产）的作用愈益重要

## 两大类知识

explicit knowledge vs tacit knowledge

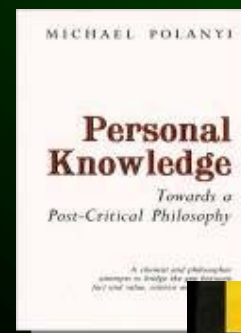
## 两类知识生产领域：

arts & science vs professions

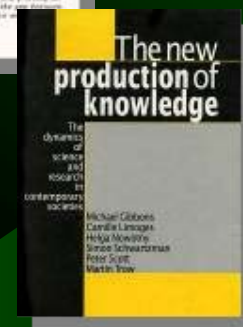
## 两类研究模式和评价准则：

Mode I: traditional "academic science" research

Mode II: trans-disciplinary problem-oriented research



1958



1994

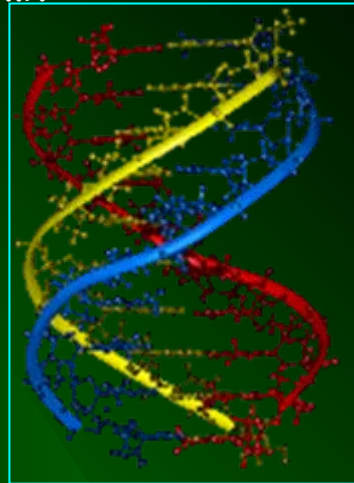
# Challenge\_3

University, industry and government become the coupling and interact with each other.

大学、产业、政府加强耦合，积极互动

academic alliance  
with industry

Triple Helix



Global Engineering Excellence

# Challenge\_4

Disciplines infiltrate into each other and are obviously influenced by the development of technology.

各学科与技术领域深入交叉、不断渗透

CSBi  
NBIC



学科会聚与科技平台  
高新技术高峰论坛  
2005. 10. 20 - 22



浙江大学科教发展战略研究中心 (rcstep)  
<http://www.rcstep.zju.edu.cn>

# Challenge\_5

How to Train engineering talents is becoming a highlight in the world.

工程科技人才培养已成全球关注焦点

International Forum on  
Engineering Higher Education  
for the 21st Century



INTERNATIONAL ENGINEERING EDUCATION  
- a conference organised by INAE, CAETS and IITM  
March 1<sup>st</sup> and 2<sup>nd</sup> 2007, at Indian Institute of Technology Madras, Chennai, India

2007 International Mechanical Engineering Education Conference



At the Massachusetts Institute of Technology it was discovered that there were **two root causes** for this continued lack of convergence between engineering education and practice, *i.e.*,

*an absence of rationale, and  
an absence of detail .*

## 一不懂事情的道理， 二不会正确地做事

不懂“何处来、何处去”，不懂“当前处何环境”，不懂自己的使命和愿景。  
不会选择正确的目标；不会设计实现目标的途径，不会采取正确的行动。

a mountain of problems 成堆的问题  
challenges from far and near 全方位的挑战  
the rare opportunities 前所未有的机遇





**problems**

**challenges**

**strategies**

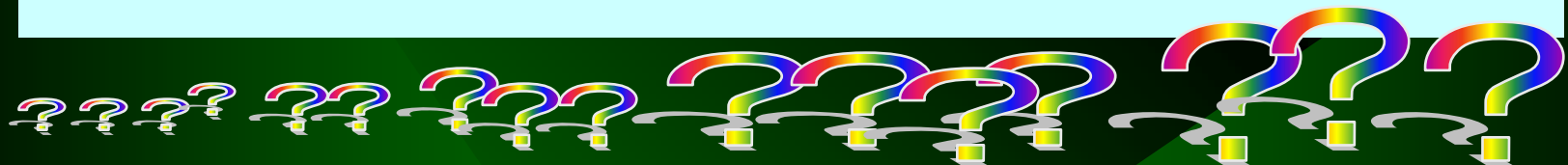
# Vision & Action

*Project 1:*

*The Reform of Engineering Education in  
the Innovative China*

*sponsored by Ministry of Education (MOE)*

教育部科学技术委员会重大专项研究  
面向创新型国家建设的工程教育改革研究

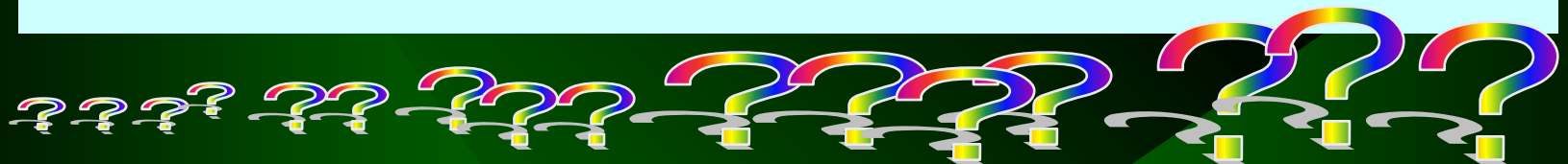


# Vision & Action

*Project 2 (undergoing):*

*Making Innovative Talents of Engineering  
sponsored by Chinese Academy of Engineering (CAE)*

中国工程院教育委员会重大专项研究  
创新型工程科技人才培养的研究

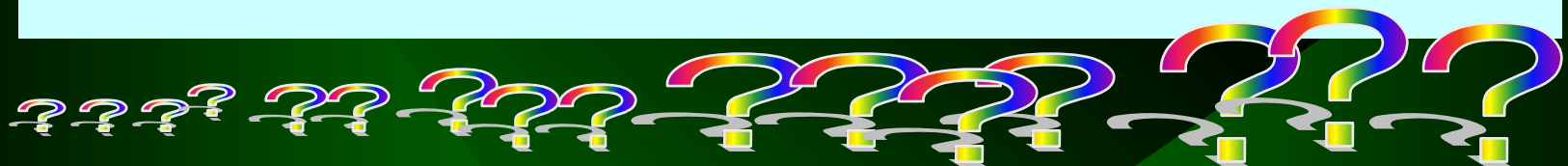


# Vision & Action

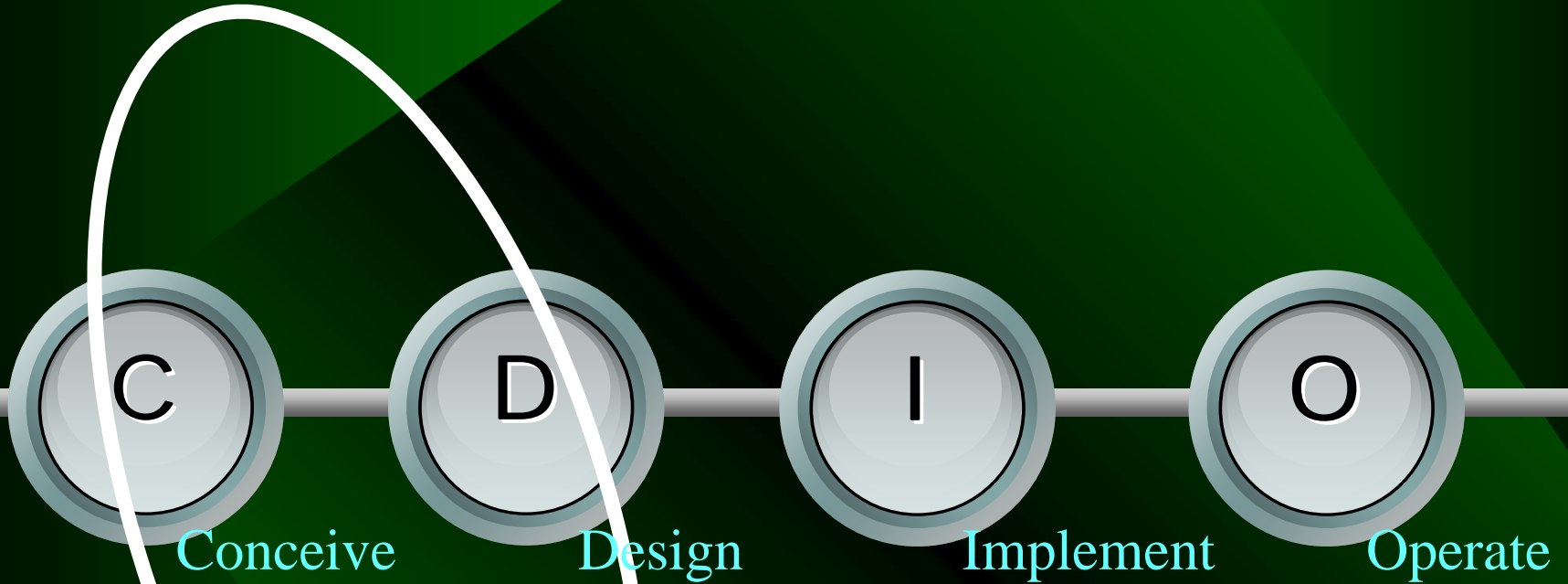
*Project 3 (undergoing):*

*The Research Program of the Innovation  
of Science and Engineering Education  
sponsored by Chinese Academy of Science (CAS)*

中国科学院技术科学部专项咨询研究  
科学和工程教育创新研究

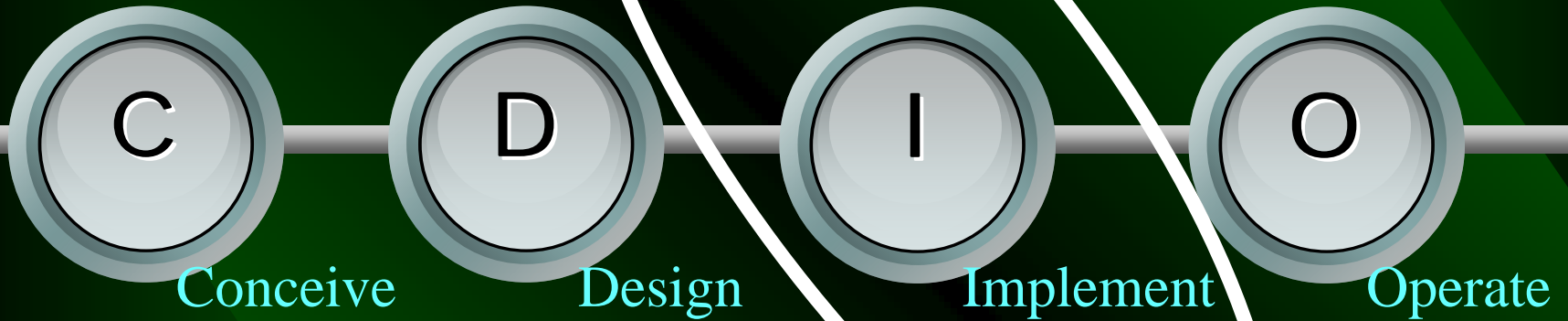


# Methodology



Learning by thinking

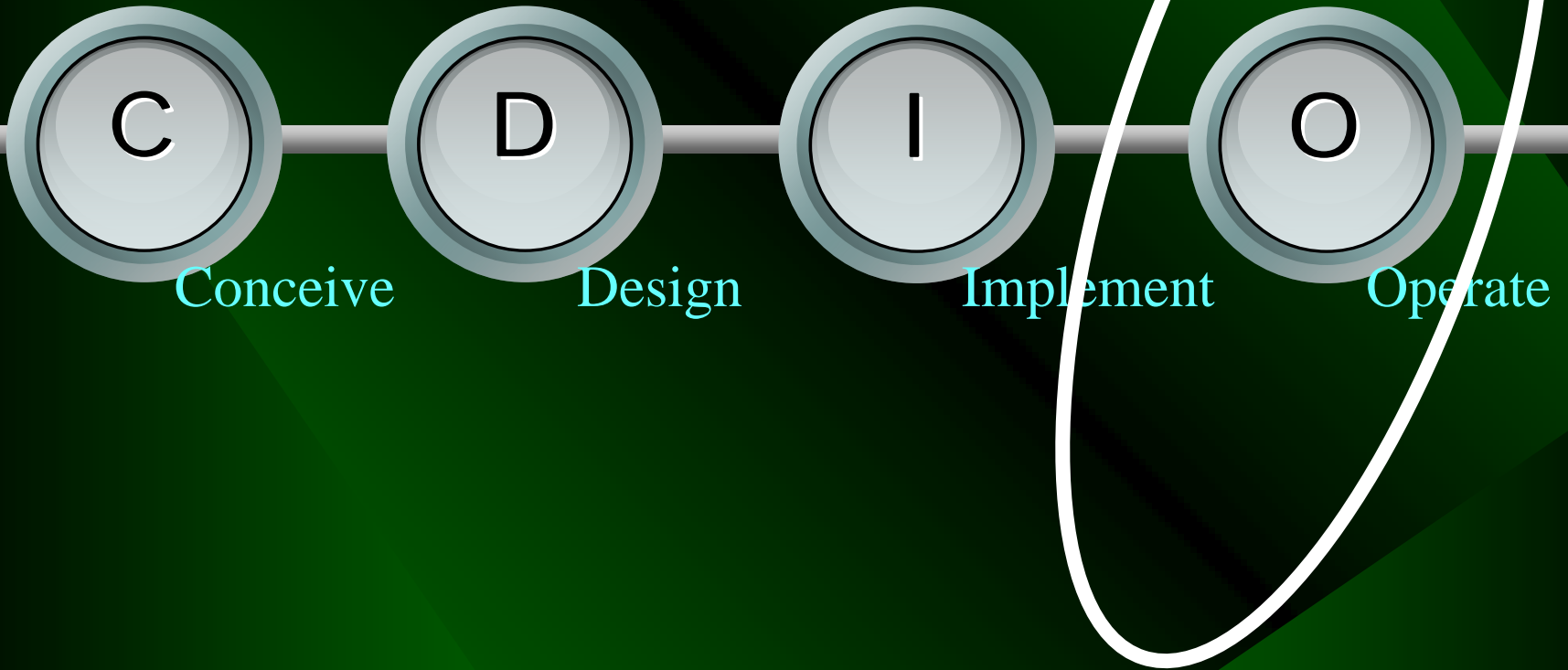
# Methodology



Learning by doing

# Methodology

Learning by use



# Triple Key\_1



解放思想  
更新观念  
面向实践  
系统解决

Concept Innovation

概念创新

vision

慧件: Wetware/Humanware



# Triple Key\_2

问题导向 知识整合  
最佳实践 学习借鉴

课程创新  
**Curriculum Innovation**

action



硬件: Hardware

# Triple Key\_3

交叉集成  
学科汇聚  
组织再造  
创建平台

模式创新

Pattern Innovation



软件: Software

# Top Design 顶层设计

Return to engineering practice !

Face real problems in the real world !

Break barriers between disciplines !

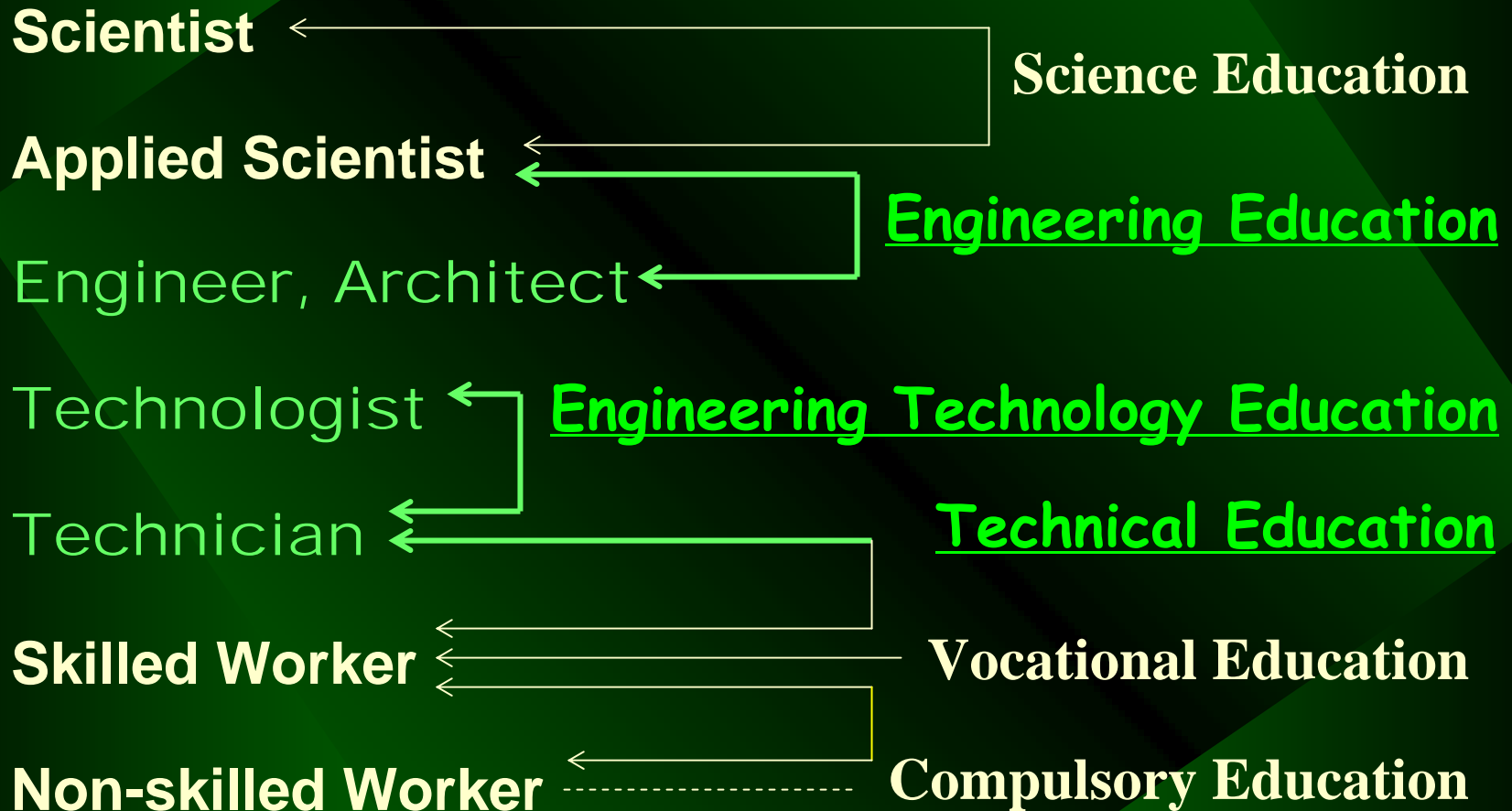
Call for systematic change of engineering education !

Innovation through integration !



# Preparation for 目标定位

“科学—技术—生产”范畴的工程职业



# Engineering Functions 功能定位

Research, Development, Testing...

研究 开发 试验 设计 制造 建造 生产 运行 维  
修.....

工程设计与制造

**Core: Design and Manufacturing/Build**

...Production, Operation, Maintenance

工艺、材料；装备、管理

Technique, Material  
Equipment, Management

Engineering with a big "E"

工程文化：第三种文化

Engineering culture: Third  
Culture

Engineering Our World

<http://web.mit.edu/engineering/enews/>

Engineering Your Future

[http://www.tc.cornell.edu/Services/Education/Gateways/Math\\_and\\_Science/engineering.htm](http://www.tc.cornell.edu/Services/Education/Gateways/Math_and_Science/engineering.htm)

# Strategies

To establish new engineering discipline

加强科学预见，创建新的工程学科

To restructure engineering discipline

借助需求工程，重组工程教育内容

To explore new methods of teaching and learning

勇于探索，引进工科教学新模式

To layout new approach of engineering education

系统设计，规划工程教育新途径

To broaden boundary of engineering education

集成整合，开拓工程教育新疆界

To bring up talents for nation competitiveness

弘扬实学，造就国家有用工程之才

To build engineering education research capabilities

夯实学科，打造工程教育研究平台

# Strategy\_1

加强科学预见，创建新的工程学科

## To establish new engineering discipline

### Molecular Engineering

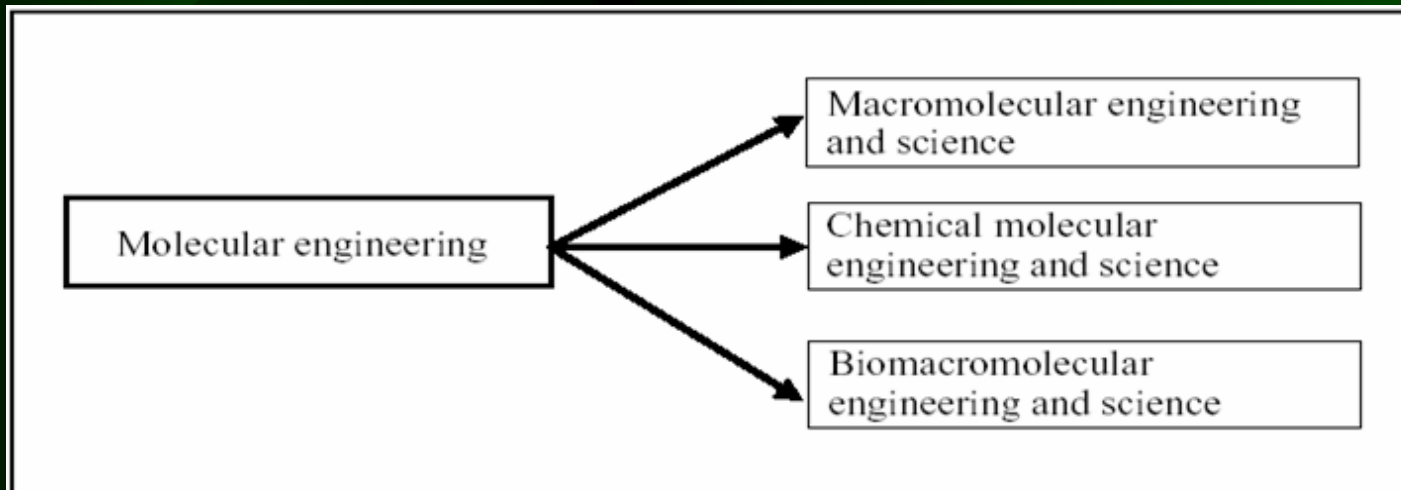


FIGURE 2 The new engsci discipline of molecular engineering, which breaks up in the junior year into three separate engsci disciplines.

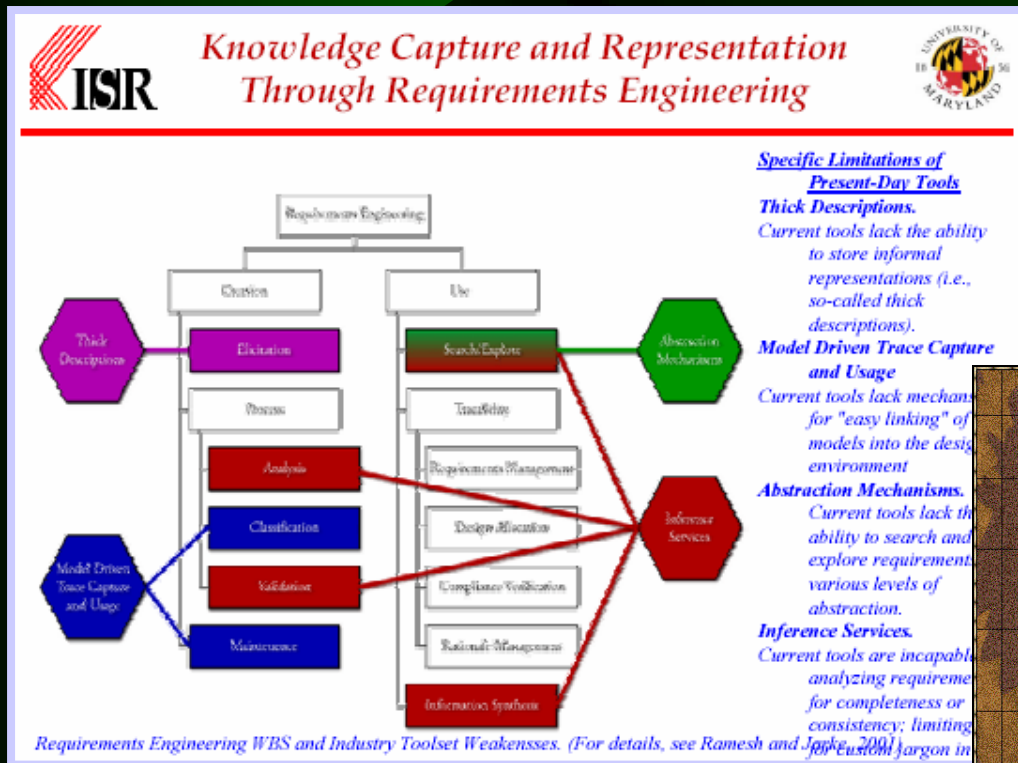
### 分子工程结合纳米技术 美国制成纳米鼻和纳米舌

德国《明镜》周刊9月17日报道，美国宾夕法尼亚大学和莫内尔化学中心的科学家研制出嗅觉和味觉非常敏锐的纳米鼻和纳米舌。它们实际上是一种传感器，是由壁上涂上一层专门培养出来的脱氧核糖核酸（DNA）的、尺寸为纳米量级的小碳管构成的。纳米鼻和纳米舌有如下四个优点。第一，它的灵敏度很高。第二，由于负责感应的脱氧核糖核酸涂层是“专门订做”，因此它们能应用于检测各种气味和味道。第三，这些脱氧核糖核酸涂层可以连续使用50多次以上。第四，它们的尺寸很小，可以发现分子量级的目标，而且可以在任何地点和场所投入使用。（北京晚报 青水）

# Strategy\_2

借助需求工程，重组工程教育内容

## To restructure engineering discipline



## Requirements Engineering

### Engineering Discipline Structure

- ✦ Discipline focus provides essential bedrock - this is both desirable and necessary.
- ✦ Advances the body of systematic knowledge.
- ✦ Provides a foundation for the interdisciplines.
- ✦ Disciplines couples engineering education to the engineering and basic sciences.
- ✦ Disciplines are necessary, but no longer sufficient.
- ✦ Preserve the discipline structure, but overlay with key interdisciplines !

波比特课程设计模式  
(Bobbitt, 1918)



# Strategy\_3

勇于探索，引进工科教学新模式

To explore new methods of teaching and learning

## Inductive Methods

探究式学习 (INQUIRY LEARNING)

基于问题的学习 (PROBLEM-BASED LEARNING)

基于项目的学习 (PROJECT-BASED LEARNING)

案例教学 (CASE-BASED TEACHING)

发现式学习 (DISCOVERY LEARNING)

适时教学 (JUST-IN-TIME TEACHING)

Inductive Teaching and Learning Methods: Definitions,  
Comparisons, and Research Bases

MICHAEL J. PRINCE & RICHARD M. FELDER, JEE (2006) 2

# Strategy\_4

系统设计，规划工程教育新途径

## To layout new approaches of engineering education

University of Southern California

### SoSE Compared to Traditional SE Activities

<ul style="list-style-type: none"> <li>- Traditional SE Activities (EIA/ANSI 632)             <ul style="list-style-type: none"> <li>- Acquisition and supply                 <ul style="list-style-type: none"> <li>▪ Product Supply</li> <li>▪ Product Acquisition</li> <li>▪ Supplier Performance</li> </ul> </li> <li>- Technical management                 <ul style="list-style-type: none"> <li>▪ Process Implementation Strategy</li> <li>▪ Technical Effort Definition</li> <li>▪ Schedule and Organization</li> <li>▪ Technical Plans</li> <li>▪ Work Directives</li> <li>▪ Progress Against Plans and Schedules</li> <li>▪ Progress Against Requirements</li> <li>▪ Technical Reviews</li> <li>▪ Outcomes Management</li> <li>▪ Information Dissemination</li> </ul> </li> <li>- System design                 <ul style="list-style-type: none"> <li>▪ Acquirer Requirements</li> <li>▪ Other Stakeholder Requirements</li> <li>▪ System Technical Requirements</li> <li>▪ Logical Solution Representations</li> <li>▪ Physical Solution Representations</li> <li>▪ Specified Requirements</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- Traditional SE Activities (continued)             <ul style="list-style-type: none"> <li>- Product realization                 <ul style="list-style-type: none"> <li>▪ Implementation</li> <li>▪ Transition to Use</li> </ul> </li> <li>- Technical evaluation                 <ul style="list-style-type: none"> <li>▪ Effectiveness Analysis</li> <li>▪ Tradeoff Analysis</li> <li>▪ Risk Analysis</li> <li>▪ Requirements Statements Validation</li> <li>▪ Acquirer Requirements Validation</li> <li>▪ Other Stakeholder Requirements Validation</li> <li>▪ System Technical Requirements Validation</li> <li>▪ Logical Solution Representations Validation</li> <li>▪ Design Solution Verification</li> <li>▪ End Product Verification</li> <li>▪ Enabling Product Readiness</li> <li>▪ End Products Validation</li> </ul> </li> </ul> </li> </ul>
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Center for Systems and Software Engineering 11

University of Southern California

### Sample Dynamic SoS: Metropolitan Area Crisis Management System

Center for Systems and Software Engineering

University of Southern California

### Sample "Steady-State" SoS: Enterprise Wide Integration of Core Business Applications

Center for Systems and Software Engineering 16

- System of System Engineering
- Macro - Engineering

# Strategy\_5

集成整合，开拓工程教育新疆界

## To expand boundaries of engineering education

### *Integrated Engineering Program*



*Integrated Engineering with Biomaterials*  
*Integrated Engineering with Computer Science*  
*Integrated Engineering with Medical Biophysics*  
*Integrated Engineering with Business*

<http://www4.registrar.uwo.ca/Calendars/index.cfm>

... ..

# Strategy\_6

弘扬实学，造就国家有用工程之才 竞争力

## To bring up talents for nation competitiveness



居今日而图治，以培养人才为第一义，  
居今日而育才，以讲求实学为第一义。  
—— 林启（浙江大学创建者）

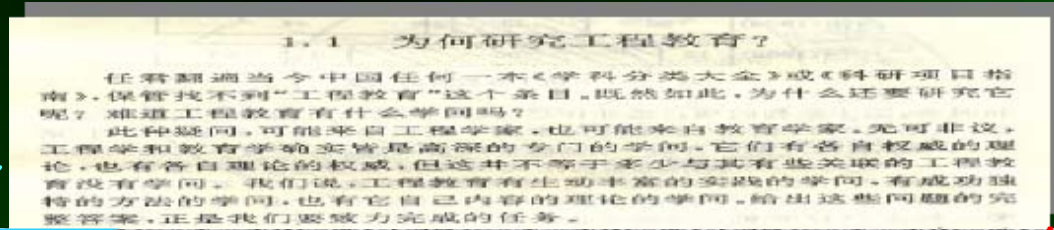
# Strategy\_7

夯实学科，打造工程教育研究平台

## To build engineering education research capabilities

Engineering Education Sustainable Development

Essentials of Engineering Education



1994



**Conducting Rigorous Research in Engineering Education**

*The Community of Practice*

Engineering Educators

Learning Scientists

Faculty Developers

NSF

UNIVERSITY OF MINNESOTA

SCHOOL OF ARCHITECTURE 1874 COLORADO

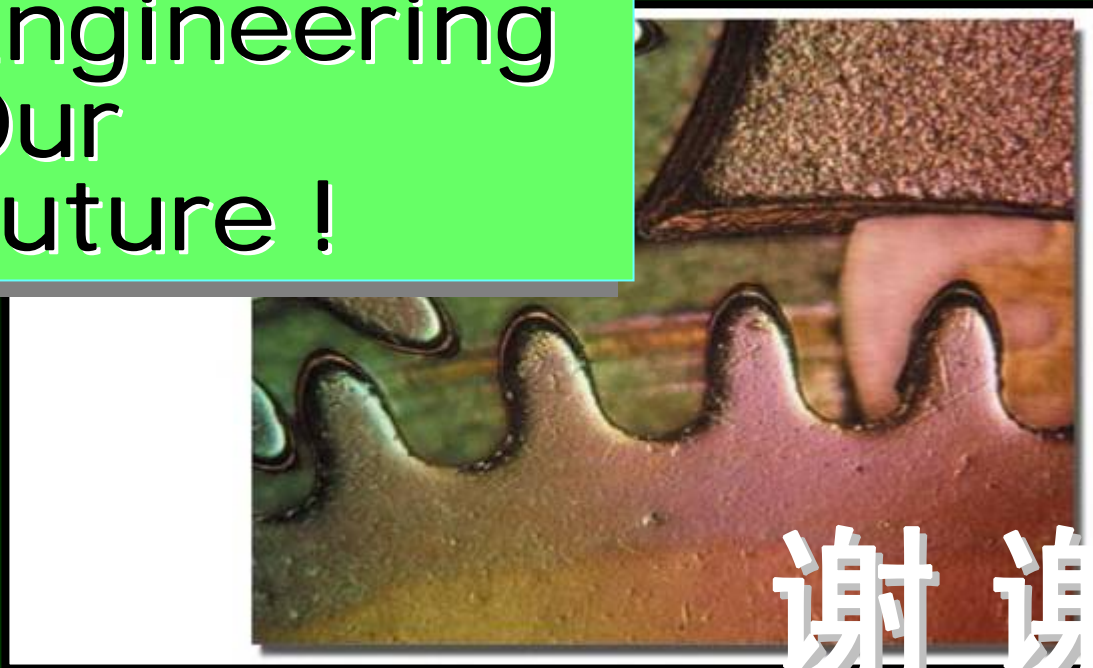
## Wishes to all

没有行动的愿望，只能是一个梦想；  
缺少思路的行动，白白地浪费时光；  
付诸行动的理想，定能把世界开创！

Vision without action is merely a dream,  
Action without vision just passes the time,  
Vision with action can change the world.

-- Joel Barker

Engineering  
Our  
Future !



谢谢

Thank you  
for your attention

310027

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# Re-engineering Engineering Education in China

— 中国工程教育再造计划

1. Undergraduate Engineering Training Program
  2. Enhancing Faculty Engineering Ability Program
  3. Six-years Engineering Master Program
  4. University-Industry Strategy Alliance Program
  5. Engineering Education Research Platform Program
  6. Engineering Elite Scholarship Program
  7. Engineering Dean Leadership Program
1. 大学生工程训练计划
  2. 教师工程能力提升计划
  3. 工程本硕贯通计划
  4. 产学合作战略伙伴计划
  5. 工程教育研究平台计划
  6. 工程精英奖学金计划
  7. 工学院院长领导力训练计划