Developing world-class engineering sector in Chinese research universities

Zhang, Jie
Shanghai Jiao Tong University

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A  Engineering Education in China’s Context
B  Brief introduction of SJTU
C  Industry-University-Research Cooperation at SJTU
Engineering science and Modern Society

“The scientist seeks to understand what is;
the engineer seeks to create what never was”

Science – chasing frontiers of new knowledge

Engineering – innovation, concerning practical needs in industry

Engineering science is the origin of future industries
  e.g. Chemical industry in Germany in 19th century
  Electrical industry in Japan in mid-1950s
  Information technology industry in the US in 1990s

Engineering science is the strategic partner for business development
  e.g. Relationship between Engineering-oriented universities and high-tech communities in the US after World War II
China in transitional period

- Since 1980, China’s economy has grown at an average rate of about 10 percent a year, and has recently become the No. 2 economy in the world.

  - **cheap labor**
  - **high resource consumption**

- Labor supply - shortage of skilled workers; rapidly aging population.

- Natural resources – With 22 percent of the world's population, China has only 7 percent of the planet's fresh water and cropland, 3 percent of its forests, and 2 percent of its oil.

**Great Challenges as well as great opportunities**
China is currently in the transitional period from factor-driven economy to efficiency-driven economy, in which the key influential factors are higher education and training, technological readiness, and even innovation to prepare for the next stage.
Opportunities for Chinese Engineering Science

- A new wave of technological revolution is ready to start
- To Build an innovation-oriented country is China’s strategic option for future development
- Immediate needs to change economic growth patterns
- Emerging pressure on enterprise's independent innovation capability
Challenges facing the Engineering Education in Chinese Universities

Bottle-neck problem in Chinese industry (remains in low-end manufacture):

- lacking of independent research and development (R&D) capability

Engineering education in Chinese research universities should take dual responsibility in the transitional period:

- solving practical problems for domestic enterprises in project construction and technology development.

- conducting applied research in advanced technology and future industry at a world-class level
Engineering Education in China’s Context

Brief introduction of SJTU

Industry-University-Research Cooperation at SJTU
Shanghai Jiao Tong University (SJTU): One of the oldest universities in China

Founded in 1896, as Nan Yang Public School

Mission: to develop China through education and industry
Disciplines: Specialized programs started in 1900;
  Railway, navigation, ME, EE in 1907;
  Management in 1918; MSc. in 1943

With a first-class curriculum in the 1930s
SJTU was regarded in China as the
“MIT in the East”
SJTU: Cradle of Engineers in China

Engineering Education in SJTU traced back to a century ago, and was crowned as the 'Cradle of Engineers' in China. SJTU pioneered in setting up the disciplines of Engineering in China, and has so far fostered a great number of distinguished engineers, scientists, educators, statesmen and entrepreneurs.

Electrical engineering in SJTU started in 1908. Students were doing experiments in class (photo above). SJTU's first-year undergraduates in ME were striking iron for practice (1910s). Students gained practical experience at SJTU's factory in 1930s.

Students gained practical experience at SJTU’s factory in 1930s.
SJTU’s Outstanding Alumni

Jiang Zemin, EE 1947
Former Chinese President

Wang Daochan, Former President of ARATS

Lu Dingyi, Former Chief of the Central Propaganda Department

Cai Yuanpei, Educationist

Huang Yanpei, Former Vice-Premier of China

Cai E, Revolutionary leader

Shao Lizi, Educationist, Politician
SJTU’s Outstanding Alumni

Tsien Hsue-shen, ME 1934
“Father of Chinese spaceflight”

Mao Yisheng, Expert on bridge construction

Zhang Guangdou, Specialist in hydraulic engineering

Lin Tongyan, Structural engineer

Wu Wenjun, Mathematician

Xu Guangxian, Chemist

Yao Ming, Basketball athlete
SJTU contributed many “Firsts” to China

- Chinese Typewriter
- 10,000 Ton Ship
- Gasoline Engine
- Space Rocket
- Nuclear Submarine
- Hovercraft
- Mach 2 Fighter
- Deep-sea Rescue Vehicle
- Heart Transplantation

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### SJTU: One of the Top Universities in China

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Time</th>
<th>Number</th>
<th>Ranking in China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academicians</td>
<td>At present</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td>Thousand Talent Project</td>
<td>At present</td>
<td>49</td>
<td>1</td>
</tr>
<tr>
<td>‘973’ Chief Scientists</td>
<td>At present</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>NSFC grants</td>
<td>2011</td>
<td>753</td>
<td>1</td>
</tr>
<tr>
<td>NSFC Funding</td>
<td>2011</td>
<td>421 Million RMB</td>
<td>1</td>
</tr>
<tr>
<td>Research Funding</td>
<td>2010</td>
<td>2.34 Billion RMB</td>
<td>3</td>
</tr>
<tr>
<td>SCIE Papers</td>
<td>2010</td>
<td>3140</td>
<td>2</td>
</tr>
<tr>
<td>SSCI Papers</td>
<td>2010</td>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>ESI Top1% Disciplines</td>
<td>At present</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Quality of students at Entrance</td>
<td>2006-2010</td>
<td>Admission standards for science</td>
<td>3</td>
</tr>
<tr>
<td>National distinctive Ph.D dissertations</td>
<td>2010</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>AAA-rated Affiliated Hospitals</td>
<td>At present</td>
<td>12</td>
<td>1</td>
</tr>
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</table>
SJTU Data: Rapid Rise in the Past Decade

- SCI papers grew by **27.8 times**
- Patents grew by **69.4 times**
- NSFC grants & funding: top 1 in China

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### SCI Papers

- 1998: 113
- 2001: 389
- 2003: 744
- 2008: 2736
- 2010: 3140

### Patents

- 1998: 13
- 2001: 38
- 2003: 208
- 2008: 615
- 2010: 902

### NSFC Grants & Funding (Million)

- 2006: 94.7
- 2007: 109.8
- 2008: 144.4
- 2010: 223
- 2011: 421
SJTU: One of the Most Internationalized Universities in China

- UM–SJTU College – joint institute with University of Michigan established in 2005
- In 2009, SJTU and other 6 leading technical universities, including Imperial College London, CalTech, ETH Zürich, etc. founded a global technical university alliance, Global Tech
- High-end energy training in cooperation with MIT
- Cooperation in aeronautics with Cambridge, Oxford, and Southampton
- Cooperation in energy, food safety and genetic engineering with UC Berkeley, Cornell
- CREATE (Campus for Research Excellence and Technology Enterprise) project with National University of Singapore
SJTU: Strong Engineering Disciplines

Three of SJTU’s disciplines are ranked 1st nationally

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Ranking in China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Naval &amp; Ocean Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Clinical Medicine</td>
<td>1</td>
</tr>
</tbody>
</table>

Three of SJTU’s disciplines are ranked top 20 globally

(According to ESI publication statistics)

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Ranking Globally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Science</td>
<td>12</td>
</tr>
<tr>
<td>Engineering</td>
<td>12</td>
</tr>
<tr>
<td>Computer Science</td>
<td>18</td>
</tr>
</tbody>
</table>
Engineering Education in China’s Context

Brief introduction of SJTU

Industry-University-Research Cooperation at SJTU
Engineering Research at SJTU: Industry-University-Research Cooperation

IUR’s Contribution to Research Funding Growth

Industry-SJTU-Research Cooperation’s Contribution to research funding growth at SJTU (2006-2010), in Million RMB

- Annual Research Funding
- IUR Cooperation Research Funding
- Proportion of IUR Cooperation Funding to total

![Graph showing research funding growth from 2006 to 2010 with percentage contributions for each year.]
Engineering Research at SJTU: Industry-University-Research Cooperation

Approaches

1. Constructing multi-dimensional structure of IRU cooperation
2. Exploring diversified modes of cooperation
3. Reforming assessment mechanism to allow for more creativity
4. Responding to emerging industries with multi-disciplinary effort
1. Constructing Multi-dimensional Structure for IRU Cooperation

- SJTU Research Management Office, International Office
  IUR Cooperation Administration

- Technology Transfer Centre
  Promotion & Transfer of technology

- Advanced Industry Technology Research Centre
  Early incubation for key technology breakthrough

- University Industrial Park
  Technology transfer and incubation of new spin-offs

- Intellectual Property Office
  Support & Guarantee

- University-owned Group
  Market operation
## 2. Exploring Diversified Modes of Cooperation

### Comparison of Four types of Cooperation

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Character</th>
<th>Length</th>
<th>Partner</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic Alliance</td>
<td>Cooperation by contract</td>
<td>Focus on collaborator’s technology area</td>
<td>Mid to Long</td>
<td>Key enterprises</td>
<td>Joint Committee</td>
</tr>
<tr>
<td>Joint Research Platform</td>
<td>Joint research centres</td>
<td>Specialized generic technology</td>
<td>Mid to Long</td>
<td>Enterprises, regional</td>
<td>University</td>
</tr>
<tr>
<td>Large Project Cooperation</td>
<td>Projects</td>
<td>Special technology</td>
<td>Short</td>
<td>All kinds</td>
<td>N/A</td>
</tr>
<tr>
<td>Industry Technology &amp; Regional Research Centre</td>
<td>Independent legal entities</td>
<td>Comprehensive</td>
<td>Long</td>
<td>within 2 ~ 3 hour’s drive; in developed regions</td>
<td>With a complete structure of organization</td>
</tr>
</tbody>
</table>
2. Exploring Diversified Modes of Cooperation

Strategic Alliance

Cooperation Approach: establish strategic cooperative system with key enterprises, take it as a base and start to collaborate comprehensively on multiple levels, by which joint research platforms and collaborative projects will take shape

Partners: more than 20 state-owned large enterprises including BaoSteel, CNOOC, CGNPC, China Shipping, ACAE
2. Exploring Diversified Modes of Cooperation

- **Joint Research Platform**

  - **Cooperation Mode:** partner enterprise raises research question and provides funding; R&D platform and research team set up in collaboration with the university

- **Typical Cooperative Platforms** *(more than 40 in total)*

  - SJTU – Gan Shang Group High Temperature Superconductivity Technology Joint R&D Centre
  - BaoSteel – SJTU Automobile Steel Sheet Technology Joint Lab
  - General Motor – SJTU Automobile Manufacture Technology Joint Lab

  .......
2. Exploring Diversified Modes of Cooperation

Large Project Cooperation

Cooperation Mode: university, enterprise, and regional government jointly set up large projects aiming for specific scientific breakthroughs or pressing market demands.

Typical Cooperation Projects (More than 10 Projects):

- Perfluorinated Ionic Membrane Materials Cooperation Project
- ADTB-T (Advanced Digital Television Broadcasting System-Terrestrial) Cooperation Project
- Modern Container Logistics and Equipment Management Technology Cooperation Project

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2. Exploring Diversified Modes of Cooperation

- **Industrial Technology Research Institute**

**Status:** independent corporate legal person

**Function:** guide emerging industries with state of the art research

**Aim:** build a public service platform integrating innovative elements including knowledge, technology, sufficient funds and talents
2. Exploring Diversified Modes of Cooperation

Regional comprehensive research institutes: designed to serve as a technology innovation engine for the community within 2 ~ 3-hour’s drive and developed areas
3. Reforming Evaluation System to stimulate more active creativity

To concentrate on 4 indicators

- Market application results/benefits
  - A key indicator of scientific level
- Economic, market, and development prospects
  - A key indicator to evaluate research findings
- Level of market transfer of the research findings
  - A key indicator for faculty academic position assessment
- Nurturing top talents in innovative engineering and technology
  - A key indicator for performance evaluation of engineering faculty
4. Encourage multi-disciplinary engagement

- Optimize the structure of fundamental and applied disciplines, and enable the subject clusters to cope with industries.

- Live up to the integration trend across disciplines and establish new research centers such as Shanghai Center for Systems Biomedicine, MED-X and the Energy Research Institute covering multiple disciplines.

- Discipline development respond to national strategic demands, and the trend in industry-university-research-application cooperation.
# Engineering Education: Practical Experiences

"For Excellent Engineers"

| Joint centers/practice bases with industry | 6 Engineering Education practice centers  
55 Enterprises participated University-Industry league  
181 practice bases with industry |
<table>
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<tr>
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<tbody>
<tr>
<td>Joint courses with industry</td>
<td>More than 10 courses are based on basic theory taught by academic staff, combined with latest technology, engineering case study, and practical solution taught by more than 80 lecturers or researchers in industry.</td>
</tr>
</tbody>
</table>
| Practices in industry         | 8 third-year undergraduates doing internship at General Motor  
370 students gained practical experience in more than 20 enterprises for 6 – 10 days  
Cultivation of 80 postgraduates jointly with BaoSteel |
Engineering Education: “for Excellent Engineers”

Goal: future leading talent in industry & designing master in engineering science

Towards future society
Towards sustainable economic growth
Towards global knowledge economy
Towards technology frontier
Towards engineering science

Excellent engineering talents

Aiming at serving for Economic growth & Industry development

solid foundation of scientific basic theory

capability to discover problems
capability to solve problems
capability to apply knowledge
International competitiveness
sense of professionalism
teamwork
leadership
International Evaluation of Schools

Mid/Long Term International Evaluation: Based on the university strategic development plan, taking discipline development level as evaluation target, setting the world first class university as evaluation standard, utilizing both written and onsite evaluation (Based on quantitative analysis) from peers/subject matter experts as measures to promote the development of disciplines from all perspectives.

- **Looking for Differences**
  - Comprehensively evaluate the current development status of schools/departments
  - Learn the main difference between international first class universities

- **Conducting Diagnoses**
  - Provide advice to the future development of schools/departments
  - Provide reference to afterwards resource allocation and strategy of the university

- **Promoting Development**
  - Increase the international visibility of schools/departments
  - Establish solid foundation for talent import & cooperation with enterprises
International Evaluation of Departments

- Peer review model based on objective statistics
- Evaluation Content: Full Aspects Investigation => Core Value Evaluation of Scientific Research Capacity
- Evaluation Index: Rigidity Measure => Soft Judgment with reference to statistics
- Evaluation Period: Annual Evaluation => Long Term Evaluation on a 5-year basis
- Evaluation experts mainly consist of overseas internationally renowned scholars specialized in relevant disciplines. Evaluation will be implemented into two stages: written communication and onsite evaluation
  - Communication Evaluation: Review the core findings and academic influence of research teams
  - Onsite Evaluation: Review the full aspects of development of schools/departments from Strategic Development Positioning, Organizational Management, Students Cultivation, International Schooling etc. and provide improvement plan.
International Evaluation Criteria

Towards world-class Engineering Science

- Talent cultivation
  - towards innovation
    - undergraduate
    - PhD education
  - postgraduate
    - cultivation system
- Scientific research
  - towards international technology frontier
    - basic research capacity
    - publishing papers
  - International reputation
- Serving for society
  - towards industrial modernization
    - aiming for future industry
    - meeting the industrial needs
  - national key project
  - knowledge transfer
Conclusion

- China is currently in the transitional period from cheap labor-driven economy to knowledge-driven economy.
- The transitional period provides Chinese research universities great challenges as well as great opportunities, dual responsibilities.
- Chinese research universities should meet the engineering technological requirements, participate in industry’s R&D process in the transitional period. This will provide extra-acceleration for the universities.
- Chinese research universities should also focus on the cutting-edge research on engineering sciences. This will define the future global position of Chinese universities.
- The leadership should pay special attention on the adjustment of weight-factor between the two roles upon the stage of the industrial development.