

Graduate Education of Mechanical Engineering in China: Issues of Concern and Recommendations for Reform

Professor Zhu Jianying

Nanjing University of Aeronautics and Astronautics
Nanjing 210016, China
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Developing Tendency of Science and Technology in the 21st Century (1)

1. Transferring Tendency of Central Science and Technology

1) Information Science and Technology (IST)

IST takes its leading place from now to 30's of 21st century.

2) Biology Science and Technology (BST)

BST will take its leading place from 30's to 70's of 21st century.

3) Cognition Science and Technology (CST)

The intelligence tendency has now appeared. CST will take its leading place from 70's to the end of 21st century.

Developing Tendency of Science and Technology in the 21st Century (2)

2. Transferring Tendency of World Scientific Center

China (3rd-13th Century)→

Italy (1540—1610)→

U.K (1660—1730)→

France (1770—1830)→

Germany (1810—1920)→

U.S.A (1920—)→

May transfer to the East
(China and Japan)

Arias of High Technology and Its Industry(1)

- (1) **Information Science and Technology** (including Micro-photo-electric Science and Technology)
- (2) **Biology Science and Technology** (including Life Science and Technology)
- (3) **New Energy Science and Technology** (including Nuclear Energy Science and Technology)
- (4) **New Material Science and Technology** (including Nano Science and Technology)
- (5) **Environment Science and Technology** (including Earth Science and Technology)
- (6) **Aerospace Science and Technology** (including Military Science and Technology)

Arias of High Technology and Its Industry(2)

- (7) **Ocean Science and Technology** (including Earth Science and Technology)
- (8) **Advanced Manufacturing Science and Technology** (including Micro-electrical-mechanical system Science and Technology)
- (9) **Management Science and Technology** (including Soft Science and Technology)
- (10) **Cognition Science and Technology** (including Human Brain and Intelligent System Science and Technology)

The Science and Technology Which Will Change Human Life in the 21st Century

Science

1. Substantial Science
2. Life Science
3. Cognition Science

Technology

1. Information Technology
2. Biology Technology
3. Nan Technology
4. Energy Technology
5. Material Technology
6. Advanced Manufacturing Technology

China issues guidelines on national medium- and long-term sci-tech development program(1)

- **China plans to become a innovative nation in the next 15 years and a world power nation in science and technology field by the middle of the 21st century.**
- **By 2020, China's entire investment in research and development is expected to top 2.5 percent of the GDP, while progress of science and technology will contribute 60 percent and above to the country's development.**
- **Meanwhile, the country's reliance on foreign technology will decline to 30 percent and below.**
- **Manufacturing and information industries are expected to master a number of core technologies that have a bearing on the country's national competitiveness.**

China issues guidelines on national medium- and long-term sci-tech development program(2)

- **The development of defense technology will be able to meet the fundamental demands of modern weapons and informationization of the Army.**
- **A large number of world-class scientists and research teams will emerge in the country, who will be able to make a number of innovative achievements , especially in the fields of information, biology, materials, energy, space, and manufacturing.**
- **There will emerge a couple of world-class research institutions and universities .**
- **The realization of all goals is reliant on manufacturing technology and higher education of mechanical engineering.**

When the concept “converging technology” was first proposed ?

On December 3-4, 2001 the Technology Administration (TA),USA joined with the National Science Foundation (NSF),USA and the National Science and Technology Council’s Subcommittee on Nanoscale Science, Engineering and Technology (NSTC-NSEC),USA to sponsor a workshop on “**Converging 4 Major Technologies (Nano-, Bio-, Info-, Cogn-) for Improving Human Performance**”, in which the concept of **converging technology** was firstly proposed.

Definition of Converging Technology(1)

The **converging technology** is a synthesized cross-technology converged, coordinated and combined by **nano-technology** (including MEMS), **bio-technology** (including life science and technology, bio-pharmacy, genic engineering), **info-technology** (including advanced computers, networks and communication), **cognitive science** (including cognitive neural science) and **manufacturing technology** (including all advanced manufacturing technologies, especially, micro-nano non conventional manufacturing technology).

Definition of Converging Technology(2)

For short, the converging
Technology can be defined as
“**NBICM** technology”:
NBICM=**N**ano+**B**io+**I**nf+
Cogn+**M**anuf

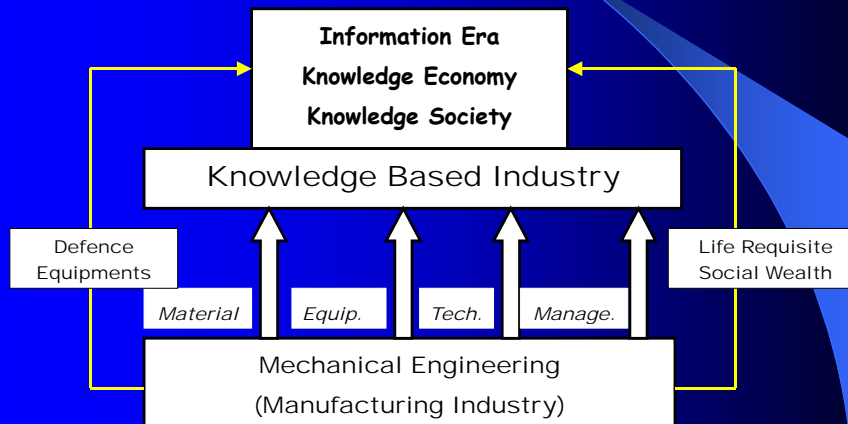
Importance of Converging Technology(1)

- **The human intelligence and potential will be mostly inspired.** Human being will, in the nano-layer of substance, know and reform the objective world and themselves.
- **The human living standard and life quality will be mostly improved.**
- A large number of smart products will produced by minimum costs, minimum resources and energy consumption , minimum production period and deliver time, maximum productivity and best product quality.

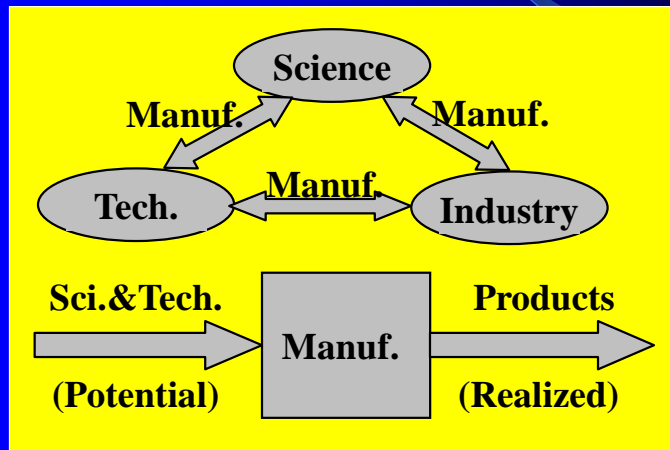
Importance of Converging Technology(2)

- Nations will possess various advanced weapons, networks and information systems which can be protected from any attack. Hence, **national safety will be greatly enforced.**
- **In general, NBICM converging technologies will certainly arouse a new industry revolution, achieve a new breakthrough** for the development of science, technology and economy and bring human society into a new creative and prosperous era.

The Significance of Mechanical Engineering(1)



The Significance of Mechanical Engineering(2)



Universities Are Facing to Serious Challenges

- A challenge of **rapid development of science and technology**
- A challenge of **globalization** of economy, science, technology and culture
- A Challenge from further extension of **university's social functions**;
- A Challenge from drastic competition for reaching to **world top-ranking universities** .

Issues in Higher Education of Mechanical Engineering

- Education is departed from economy and society.
- Full quality education is only in the slogan.
- Innovation education have not been put into effect.
- Individuality education have not seriously been regarded.
- Teacher qualities are much more worried.
- Teaching material and content are quite old.
- Education internationalization are much more backwards.
- Must attach importance to technologies.
- Must prevent from turgidity and falsity during informationization.

Attach Importance to Technologies (1)

- In essence, the science can just be discovered, not be created, only the technology can be created. Because scientific laws are objective existences, while technologies are created by human being.
- The technological revolution directly drives the industry revolution, economic development and social progress.

Attach Importance to Technologies (2)

- **The USA is a young country.** She was established just after <the Declaration of Independence> appeared in 1776 in the second continental conference. The USA only has 230 years history. However, **the USA is a most fast developed country.** She was the original place of the 2nd, 3rd and 4th industry revolution. In 2005, American GDP reached to \$12.77 trillion dollars (China: ¥18.23 trillion Yuan, equal to \$2.27 trillion dollars), account for 1/3 of world GDP and the increasing rate achieved to 3.5% (China: 9.9%).
- The highest economic development of USA is profited from that **the USA has paid much more attention to technologies and applications .**

Attach Importance to Technologies (3)

- There has been a profound thought root in looking down on technologies in China:
In China, people have been regarding technology as a skill, i.e. a kind of “**雕虫小技, the trifling skill of a scribe**”, that means those technical people are poor of prospects

Attach Importance to Technologies (4)

- Chinese enterprises now are much more **lack of advanced technicians.**
- In factories, the wages of technicians and engineers are much more low. It is hard to have the titles for a technical post, even hard to have the big “award of scientific and technological progress” for those people.

Attach Importance to Technologies (5)

- **Our academia does not attach great importance to technologies :**
- For example, the famous universities of USA : California Institute of Technology and Massachusetts Institute of Technology were translated into Chinese words as: “California Institute of **Science** and Technology ” and “Massachusetts Institute of **Science** and Technology ” .
- **Among our key universities, there is no any university named as technological university** and the non-key university is named as “technological university”.

Beware Of turgidity and falsity during informationization

- **“Information vase”(信息花瓶):** Considering informationization as “computer + network”, there is no self-designed software, computer becomes furnishing.
- **“Empty but virtual”(虚而不拟):** Many researches are only done by computer simulation, not by physical experiment.
- **“False but simulation”(仿而不真):** Computer simulation is only reliant on subjective intent, not on real facts.
- **“Bully the weak and fear the strong”(欺软怕硬):** Bully doing software design and fear doing hardware work.
- **“Mechanical research without mechanics”(无机之谈):** There is no mechanics in the research of mechanical engineering.

Educational Idea : Universalism

The words “university” and “universe” have the same etyma, “univers”.

Hence, the universalism should be the key ideology for world top- ranking universities, that means:

- 1) Teachers should come from all over the world
- 2) Students should come from all over the world
- 3) Research and teaching should be very comprehensive (universal)
- 4) University’s social functions should be very comprehensive (universal)

The world top-ranking universities must take three main tasks of education, research and service as an integer.

Educational Idea : Full Quality Education

- Full quality education is full development education of **moral, intelligence, physique, beauty and labor.**
- To place **moral education as first important** in full development education .
- Combination of knowledge education with ability education.
- Especially regarding **fundamental knowledge education and innovation ability training.**
- **Combination of engineering, science and humanity.**
- The key point is to reform current university **entrance examination system.**

Educational Idea : individuation Education(1)

1. University education is the human education, which is **on the base of individual.**
2. **Students with individuation are always promising ;**
3. The principle **“teach students in accordance of their aptitude”** has always been the basic educational principle , since 2000 years ago ;

Educational Idea : individuation Education(2)

4. How to Carry Out Individuation Education?

- 1) Implement true and perfect **credit system**;
- 2) Implement true and perfect **tutorial system**;
- 3) Implement **academic freedom**;
- 4) Implement **democracy of governing university**;
- 5) Implement the **independence of running university**.

Educational Idea : Innovative Education

- It is declared in the <National Medium- and long-term Sci-tech Development Program > (NMSDP) that **China plans to become a innovative nation in the next 15 years**.
- Guiding principles of NMSDP: **1) Self-reliant innovation**; 2) Great spanning in important arias; 3) Supporting development; 4) Leading to future.
- **Talent persons** are extremely important: **China plan to build up several would top-ranking universities**.
- The first task for universities is to train a large number of **innovative students**.
- **Innovative education is the core of university education**.

Higher Education Reform of Mechanical Engineering (1)

1. Adopt educational ideas of **universalism, full quality education, individuation education and innovative education.**
2. **Reform entrance examination system** for universities.
3. Appoint university president and teachers from **all over the world.**
4. Recruit university students from **all over the world.**

Higher Education Reform of Mechanical Engineering (2)

5. Teach lectures (50% of courses) **in English;**
6. Widen **independent power** of running university;
7. Implement **academic freedom;**
8. Implement true and perfect **credit system;**
9. Implement true and perfect **tutorial system;**

Higher Education Reform of Mechanical Engineering (3)

10. **The training goal** of higher education for mechanical engineering is **to train engineers** with modern high quality.
11. **Reform structure and contents** of mechanical engineering specialty:
 - 1) Specialties are adopted with development of sci.-tec.;
 - 2) Renovate the teaching contents;
 - 3) Set up more flexible elective courses.
12. **Reform the teaching methods:**
 - 1) Enforce the fundamental education;
 - 2) Enforce the ability training;
 - 3) Enforce the practice forging;
 - 4) Enforce the innovation activity.

Enforce Fundamental Education

1. **Science Foundation**
Mathematics (**Modern Engineering Applied Mathematics**), Physics, Chemistry, Biology
2. **Technology Foundation**
Information Science and Technology (**Engineering Software Design**)
3. **Language Science Foundation**
Chinese, English (**Applied Communicating English**)
4. **Humanity Science Foundation**
Philosophy, Art, History, Literature, Social Science

Enforce Practice Forging

1. **Teachers must have enterprise experiences (German engineering professor must have 5 years enterprise experiences);**
2. **Students must go to enterprise for practice;**
3. **Teaching and research with the combination of industries, universities and research institutes;**
4. **Undergraduate students must join in research activities;**
5. **Education Ministry must set up engineering training bases for universities;**
6. **Universities must set up industry centers inside campus.**

How to Carry Out Innovation Education

1. **The base of innovation is learning.**
2. **Needs** are headstreams of innovation.
3. **Question** is the start point of innovation.
4. **Integration** is the route of innovation.
5. **Combination** with philosophy, art, and science.
6. **Combination** with deduction and induction.
7. **Three innovation approaches:**
 - 1) **original innovation**
 - 2) **integration innovation**
 - 3) **import –absorption-re-innovation.**
8. **Exchange-collision-fusion-innovation.**

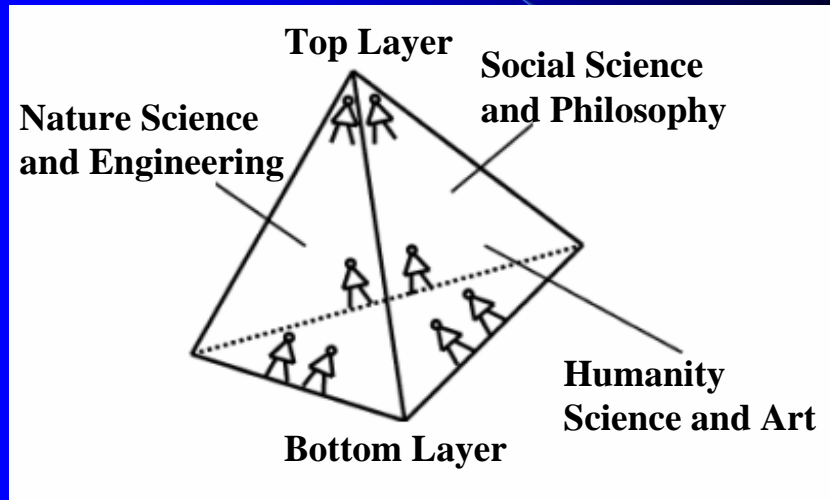
Combination with Deduction and Induction

- **The limitation of Chinese thinking method:** more induction, less deduction.
- **A lot of scientific theories are obtained from deduction**, for example, Maxwell's electromagnetic field equation.
- **By deduction**, such as analysis, decomposition, comparison, classification, estimation, reasoning etc. **one can go deep into thing's inside**, while **by induction**, such as abstract, clustering, composition, integrating, synthesis, decision-making etc. **one can seek results**.

Combination with Philosophy, Art, and Science

- **By the reveal of making music staff by musician, Mendeliev discovered element periodical table.**
- **Scientific development view of philosophy reveals innovative thinking, for example:**
 - 1) **"infinity view" reveals there are super-light velocity, super absolute zero ;**
 - 2) **"one divides into two view" reveals that electron can be divided.**
 - 3) **"Helix development view" reveals that the world center of science and technology is transferring toward west, at last it will reach to the east.**

Unification of Science on the Top Layer



Exchange-collision- Fusion-Innovation

- A famous physical scientist **Heisenberg** said: **“science takes root of exchange, comes of discussion.”**
- The basic functions of scientific team are developing academic exchange, booming academic garden, driving development of scientific disciplines, **promoting growing of talent people.**
- **Exchange-collision-fusion leads to innovation.**
- **Modern scientific results are much more reliant on team collective and innovative working.**

Knowledge

Knowledge = 6W + 2Q

6W

Why(知因)
What(知事)
How(知窍)
Who(知人)
When(知时)
Where(知地)

2Q

Quality(质量)
Quantity(数量)

Ability

- 1) **Learning** (学习能力)
- 2) **Thinking** (思维能力)
- 3) **Analyzing & Integrating** (分析与综合能力)
- 4) **Designing & Planning** (设计与计划能力)
- 5) **Decision Making** (决策能力)
- 6) **Competing** (竞争能力)
- 7) **Innovating** (创新能力)
- 8) **Practicing** (实践能力)
- 9) **Communicating** (沟通能力)
- 10) **Organizing** (组织能力)

Success

Success (成功) = 6I + 3W

6I

Inspiration(激励)
Imagination(想象)
Investigation(调研)
Innovation(创新)
Integration(集成)
Implementation(实现)

3W

Will(志愿)
Work(工作)
Wait(等待)

Thank You !