Higher Education, Innovation and Entrepreneurship

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Changing Roles of Higher Education in a Globalized World
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There are various factors which we need consider for educating innovative entrepreneurs.
(1) Why do we need Innovations?

In the process of realizing sustainability, we must solve various problems which we have never experienced in the past. As progresses along continuous path do not solve them, we must take a step toward unknown space. It is innovation.
Sustainable Development

Sustainable Development by G.H. Brundtland (1987)

= (Sustain the earth) ^ (Develop Less-developed Regions)
Making a Shift toward Sustainability

“Industrial Transformation by Innovations”

Traditional development:
development at the expense of environment

Traditional environmental preservation:
preservation by suppressing growth

Sustainable development:
concurrent realization of development and preservation by industrial transformation

Development

Environment
Move of Centre of Gravity of Industries (Japan)

Preliminary Metrics by AIST

- Emission of CO2 (tons)
  - Raw-material Industry
  - Manufacturing Industry
  - Service Industry

- Value added (million yen)
  - Expansion of Size
  - Diminution of Size

Direction of Improvement

1990-1995-2000
From Observation to Action

We have successfully observed changes of global environment by science and technology. Now, we should make more scientific and technological efforts toward actions to prevent the growth of and to protect us from the deterioration of sustainability.

We shall discuss manufacturing industry here, that is based upon science and technology and the most useful to develop less developed regions and, on the other hand, the most crucial to influence the global environment,

and try to find a way for society to realize sustainable development by industry.
**Actions in Society**

*Information Cycle for Sustainable Evolution*

**Useful knowledge for sustainability**
( Utilization Knowledge, Factual knowledge)

**Actors**

**Society**

**Engineering Scientists**

**Science Community**

**Observing Scientists**

**Social State Values Environment**

**Actions for sustainability**

*Actors in Society are:*

- statesmen,
- policymakers,
- business humans,
- administrators,
- engineers,
- educators,
- writers,
- artists,
- journalists,
- etc...

who move society.

*We must design evolulional loops in society for sustainability.*
Elaboration of **Actions** in Manufacturing

- **Production planning/management**, **Production Facilities**, **Processing**
  - Revised design of products
  - **Manufacturing**
    - Products
    - **Distribution**, **Selection**, **Utilization**, **Pause**, **Maintenance**, **Termination**
  - **Inverse Use**
    - **Use**
      - **Inverse Manufacturing**
        - **Used products**, **Record of use**
        - **Extraction of data of use**, **Waste management (reuse/recycle)**, **Waste-processing facilities**, **Processing**
  - **Judge of products**
    - **Analysis of use**, **Design of products**, **Preparation of manufacturing**, **Material selection/processing/supply**

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(2) Innovation Process

Innovation is not realized within a single discipline. Whenever an action is innovative, it is based upon the integration of diversified disciplines. Normally, it takes years to integrate them.
Dr. Muhammad Yunus of Grameen Bank has successfully developed a bank which encourages women and ameliorated the poverty in Bangladesh. The bank is innovative. It is interesting to investigate the process of development after conception.
Dreams, Nightmares and Reality

General pattern of science-technology based innovation process

People’s interest

Social support

Time for research and development →

Dream (scientific discovery, epoch-making invention)

Nightmare

Reality

1985 J.Hatvany, H.Yoshikawa
Integration of Disciplines is Necessary

Thought process within their own disciplines

Thought process in “intersection” of many disciplines

Dream Research

Nightmare Research
Conceptual picture of full research in life science for health

**Universities**

Basic researches in physics, chemistry, material science, computer science, etc

**Basic Research in Life Science**

- **Type-1 Basic Research**
- **Type-2 Basic Research**

Collaboration among disciplines

Synthetic researches in mechanical, electrical, environmental, computational, sociological, economical, etc

**Enterprises**

- Hospital
- Pharmacy
- Medical Instrument
- Agriculture
- Food
- Housing
- Gymnastics
- Environmental Remedy
- etc

**Independent Agencies (AIST etc)**

Product Realization Research

Production
University-Industry Cooperation through **Full Research**

*A Method to Implement the Network of Excellence*

* P.P.R : Product Realization Research
In order to realize sustainability scientifically, we need new engineering knowledge based on new disciplines in science. Universities and research institutes must pioneer for them and professors of different disciplines should make collaboration.
Knowledge Integration for Sustainable Science

- Integrated Knowledge in Real World (indigenous knowledge)
- Separate Knowledge in Abstract World (Science)
- Integrated Knowledge in Abstract World (Integrated Science)

(1) Modern masters
(2) Collaboration of different scientists
(3) Theoretical study on disciplinary integration

Fact + Use + Meaning

Abstraction

Integrated Science

Fact
Use
Meaning

Integration

New Disciplines?
(4) Synthesis-oriented Education in Engineering

Two cases of education for innovation at University and Research Institute will be shown. The case of University of Tokyo is based on general design theory, which is extracting the commonality from disciplines of diversified conventional engineering departments. The case of AIST is education for post doctoral fellows, which offers opportunity of type-2 research.
(4) Synthesis-oriented Education in Engineering

Traditional **Departmental Curricula**

*which educate disciplinary specialists*

- Manufacturing Practice
- Design Practice
- Optimization technique
- Theory
- Laws
- Mathematics

( Methods for synthesis )

<table>
<thead>
<tr>
<th>Engineering knowledge</th>
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<tbody>
<tr>
<td>Mechanical Eng.</td>
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<tr>
<td>Electrical Eng.</td>
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<td>Metallurgy</td>
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<tr>
<td>Chemical Eng.</td>
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<td>Biological Eng.</td>
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( Factual knowledge )

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An Inverted Curriculum

*education for sustainable development (ESD of UNESCO)*

- Manufacturing Practice
- Design Practice
- Optimization
- Theory
- Laws
- Mathematics

**General theory of synthesis**

**Systematic factual laws**

**Engineering knowledge**

- Mechanical Eng.
- Electrical Eng.
- Metallurgy
- Chemical Eng.
- Biological Eng.
A curriculum named “Flames”
炎のカリキュラム

(Factual Laws and Methods of Synthesis)

Actually practiced at the Precision Engineering Department, University of Tokyo for 1975 -1994.
(5) Entrepreneurship

In Japan, social and economical condition for young people to challenge for entrepreneur is not good. We are now developing it in the system of education and university-industry cooperation.
Development of Types of University-Industry Cooperation

Two dimensional cooperation

University

Company

Three dimensional cooperation

University

Company

Type-A Univ. in Company

Type-B Company in Univ.

Researchers from university and company live and work together within a laboratory.
Architects in 3-dimensional Interface between University and Industry

Architects as connector

Supplier of Knowledge (University and Research Institute)

User of Knowledge (Industry)

Innovation Architect
Industrial architect
Information architect
Robotics architect

Architects know both research frontiers and user’s demands (like building architects). Architects are either employed by or independent of research institutes. Architects who are matured may run their own companies. Architects are educated in the 3-dimensional interface.
Education for Innovators in AIST

AIST SCHOOL of INNOVATION
Professors are Heads of Unit of AIST

Post Doctoral Researchers in University

University Doctoral Course

Post Doctoral Researchers in AIST

Project employment

Post Doctoral Researchers in AIST

Institute employment

Education for Innovators

Researchers in Companies

Innovators in Companies

High-tech Start-ups

Permanent Researchers in AIST
Schools for Innovative Entrepreneurs

Entrepreneurs from schools (Innovation Architects) will make:

Innovations
Science-technology based, Economical, Social, Cultural, in Society and Industry, and for Sustainability

etc
end