Some Approaches for Enhancing Engineering Education in Tokyo Tech

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Tokyo Tech Constitution

• Undergraduate Schools (3 Schools)
  enrollment: 1,068/year
  (90% students go on to graduate school)
• Graduate Schools (6 graduate schools)
  enrollment: master course: 1,327/year
  Ph.D. course: 543/year
• Foreign Students: 1,103 (77 countries)
• Total Students: 10,086

Overview of engineering education for undergraduates in Tokyo Tech

- Overview of engineering education for undergraduates in Tokyo Tech
- Introduction to engineering education for freshmen
  - Ex. Mechanical engineering literacy
- Effective and systematic professional curriculum
  - Ex. Lecture-laboratory integrated classes
- Education for creativity
  - Various engineering design competitions

Undergraduate Schools

Departments for undergraduates are categorized into 7 groups. Freshmen belong to each group.

• Group.1: Depts. of Basic Sciences (School of Science)
• Group.2: Depts. of Material Science and Engineering
• Group.3: Depts. of Applied Chem. & Chem. Engineering
• Group.4: Depts. of Mechanical Engineering
• Group.5: Depts. of Electrical and Electronic Engineering
• Group.6: Depts. of Architecture, Civil Engineering, and Social Engineering (School of Engineering)
• Group.7: Depts. of Bioscience and Bioengineering (School of Bioscience and Bioengineering)

Each sophomore student will belong to a department of his/her choice among 23 departments according to his/her scholastic record in freshman.

Objectives of engineering education for undergraduates in Tokyo Tech

- Engineering knowledge
- Intellect and culture
- Global vision
- Deep thought
- Leadership
- Creativity

Wedge-shaped Curriculum

Master thesis research
Bachelor thesis research
Professional education
Healthy university
Liberal arts education
Effective and systematic classes
Experiments and practice
Freshmen seminar
Engineering design competition
Research experience
Introduction to engineering
Introduction to engineering education for freshmen

Ex. Mechanical engineering literacy by Group 4 (ME departments)

Contents of the class

- Recognition of 3D solid and usage of paper, pencil and scissors
- Projection drawings from solid model
- Paper crafts from development drawings
- How to transfer design information
- Various solutions based on engineering design
- Mechanical parts design with 3D-CAD/CAE software
- Design competition and rapid prototyping
- How to design shape of objects

Keypoints

- Not only to experience crafts but also to understand objectives of engineering to learn in near future
- Basis of education for creativity
- Competition for original design

6 courses and 1 lecture

- How to transfer design information (Mechanical drawing)
- How to design shape of objects (3D-CAD/CAM/CAE)
- How to process objects (Machining and measurement)
- How to drive objects (Fluid dynamics and heat transfer)
- How to control objects (Mechatronics and control)
- How to discuss and present (Management of group)
- Lecture on engineering ethics

Cooperation of many faculties and staffs

- 240 students, 3 faculties, 5 TA's
- 4 weeks (9 hrs)/course, 4 credits/year

Background and objectives

From high school to university:

Science education in high school
- Basis of engineering
- Methods to solve known problems
- ‘Only analytical solution’ ‘Thought on a desk’
- Ideal conditions

Engineering education in university
- Fundamentals to applications
- Creative solution for unknown problems
- ‘Various design solutions’ ‘Experiments/practice’
- ‘Want to develop robots as soon as possible’ ‘Tired to learn more mathematics and physics’

It is important to establish a new attractive class for freshmen so as to support smooth connection to engineering and to keep motivation on engineering study.

Freshmen’s voice:

From high school:
- Requirement for art and craft practices
  - ‘Want to develop robots as soon as possible’
- Requirement to learn engineering application
  - ‘Tired to learn more mathematics and physics’

From university:
- Requirement for art and crafts practices
  - ‘Want to develop robots as soon as possible’
- Requirement to learn engineering application
  - ‘Tired to learn more mathematics and physics’
How to control objects
Assembly of a gyro-stabilize electronic circuit for control
Experience of engineering dynamics and mechatronics
Group discussion and presentation using business games
Experience of group management

Background and objectives
Effective and systematic curriculum is strongly required to make students understand professional subjects.
- Lack of faculties’ cooperation
  “The same contents in different classes”
- Weak relation between lectures and laboratories
  “Experiment by a small group before lecture”
- Incomprehensible objective for students
  “What’s the objective of each class?”

A new curriculum for professional education:
- Integration of lecture, laboratory(experiment) and exercise
- Integration of academic fields
- One class per day
- Cooperation of faculties, staffs and TA’s in a class
“Lecture-laboratory integrated classes”

Effect of the class
- Students satisfy the attractive class (Few drop out students).
- Innovation of classes on mechanical design and processing after 2nd year
- Engineering education awards:
  Awards from Japanese Society for Engineering Education

Effective and systematic professional curriculum
Ex. Lecture-laboratory integrated classes by dept. of mechanical and intelligent systems engineering

Lecture-laboratory integrated classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Contents (Reason for integration)</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics of Deformation and Vibration I, II</td>
<td>Dynamics of Machinery, Strength of Materials (Common fundamental equation)</td>
<td>2nd Year Spring, Autumn</td>
<td>3-1-1</td>
</tr>
<tr>
<td>Fluid Mechanics, Thermal Engineering</td>
<td>Concept on material transportation</td>
<td>2nd Year Spring, Autumn</td>
<td>3-1-1</td>
</tr>
<tr>
<td>Energy and Fluid Flow I, II</td>
<td>Material Science, Design Engineering, Production Engineering (Design from material to processing)</td>
<td>2nd Year Autumn, 3rd Year Spring</td>
<td>3-1-1</td>
</tr>
<tr>
<td>Design and Manufacturing I, II</td>
<td>Control Engineering, Electronics, Transmission Engineering (Design of mechatronics system)</td>
<td>3rd Year Spring</td>
<td>3-1-1</td>
</tr>
</tbody>
</table>

Advanced classes & Creative project classes
Advanced classes without laboratory and creative project classes are offered after 3rd year.
Experiments in the integrated classes

- Mechanics of deformation and vibration
- Design and manufacturing
- Energy and fluid flow
- Mechatronics

Education for creativity

Various engineering design competitions by many departments

Preparation for the class

- Portable experimental apparatuses should be developed.
  - Compact, high accurate and revealing apparatus
  - Simple rigid pendulum
  - Linear slider with frictions
  - Elastic bar with rotational inertia
  - Ex. Three kinds of apparatuses to measure natural frequency

- A department has to own a laboratory classroom.
  - Many experimental tables, PC-assisted classroom

Effect of the classes

- Few students are absent from the class.
- Students can deeply understand mechanical engineering through lecture and laboratory.
- Good communication between faculties and students
- Engineering education awards:
  - Award from Japan Society for Mechanical Engineers

Categories of creativity education classes

1. Start-up  
   - 1st year
   - Experience of engineering design

2. Spiral-up  
   - 2nd year and 3rd year
   - Competition and group work
   - 4th year
   - Experience of research (graduation thesis)

3. Originality  
   - Graduate students
   - Students set up targets by themselves
     (master/Ph.D. thesis)

Origin and progress

- The origin of Robot Contest started in Tokyo Tech 40 years ago.
- Many departments have various classes creativity in various semesters.
Example of course on creative education:
Introduction to creative design in Control Eng.

Students joining to design remote controlled robot in 2nd year.

Final competition by students from various universities in International Design Contest.

Tokyo Tech continues to innovate engineering education

Thank you!

Other Examples

- Electrical and Electronic Eng.
- Human power generation competition
- Ceramic radio
- Mechanical intelligent robot
- Inorganic Materials Eng.
- Intelligent System Creation
- Ceramic radio

Effect of the classes

- Those classes stimulate students’ creative mind.
- Attractive crafts make students keep motivations to learn engineering.
- Students will understand engineering background in ‘Monotsukuri’.