Materials Science Education at KEIO University: Adopting U.S. Instruction Practices in Japan

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1. Number of universities and entering students in Japan
2. Introductory Materials Science course for 1st year students
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Number of universities and population of age 18 in Japan

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Trend in Science and Engineering

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Keio University

Founder: Yukichi Fukuzawa
Established in 1858 (oldest priv. university)
Letters, Economics, Law, Medicine,
Science&Technology, Business&Commerce
Policy Management, Human Relation, etc.

1,500 Full-time faculty members
28,000 Full-time undergraduate students

Currently 6 (out of 22) Ministers of Japan
are Keio graduates

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Science and Engineering at Keio
http://www.st.keio.ac.jp/index-e.htm

250 Full-time faculty members
4500 Full-time undergraduate students
1750 Full-time graduate students (MS&PhD)

11 Departments
Administration Engineering
Applied Chemistry (MSE related)
Applied Physics (MSE related)
Biosciences and Informatics
Chemistry (MSE related)
Electronics and Electrical Eng. (MSE related)
Information and Computer Science
Mathematics
Mechanical Eng. (MSE related)
Physics (MSE related)
System Design Engineering

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1st year at Keio Sci. & Technology

Course 1: Physics related
1. Physics
2. Applied Physics
4. Mechanical Engineering

Course 2: Math related
1. Mathematics
2. Administration Engineering
3. Information and Computer Science

Course 3: Chemistry related
1. Chemistry
2. Applied Chemistry
3. Applied Physics
4. Bioscience and Informatics

Course 4: Mechanics related
1. Mechanical Engineering
2. System Design Engineering
3. Administration Engineering
4. Applied Chemistry

Course 5: Information Related
1. Information and Computer Science
2. Electronics and Electrical Eng.
3. System Design Engineering
4. Bioscience and Informatics

Each student belongs to one department from the 2nd year

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Introduction to Materials Science

Freshmen in Course 1-5, 150 enrollments

Chapter 1: Crystal Structures & Defects
Chapter 2: Thermodynamics and Kinetics
Chapter 3: Materials Science of Japanese Katana (sword)
Chapter 4: Ceramics
Chapter 5: Electronic Materials
Chapter 6: Magnetic Materials

Promote students’ interest in Materials Science!
Introduction to Materials Science
Introduction to Materials Science
Introduction to Materials Science
Materials Science Program at
Dept. Applied Physics and Physico-Informatics

Double major in Electrical Engineering and Physics (120/class)

2nd year: Electricity and Magnetism, Engineering Math, Electronic Circuits, Programming, Logic Circuits, Quantum Physics, Thermal Physics, Labs


4th year: Senior Research

Requirements in Red

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Challenges

Japanese University Traditions

- Strict control of the Ministry of Education
- Once a week lecture for every course
- No teaching evaluation by students
- Very little homework, same exams
- Strong seniority system
- No office hours
- Little support for teaching assistants (TA)
Solid-State Physics for 3rd year

**US teaching style**

- Requirement – Every student must take it
- Once a week lecture plus a discussion session by TA for 13 weeks
- Homework every week for 10 weeks
- Take home mid term exams
- Final exams
- Office hours, teaching evaluation
- Mechanical grading (30% HW, 20% ME, 50% FE)
Evaluation by students (after UC Berkeley)

**GENERAL RATINGS**
Please rank from one (1) to seven (7)

1. Considering both the limitations and possibilities of the subject matter and course, how would you rate the **overall teaching effectiveness** of this instructor?

2. Focusing now on the course content, how **worthwhile was this course** in comparison to others you have taken in this department?

**CLASSROOM PRESENTATION**
Please rank from one (1) to five (5)

1. Gives lectures that are well organized.
2. Is enthusiastic about the subject matter.
3. Identifies what he/she considers important.
4. Has an interesting style of presentation.
5. Uses visual aids and blackboards effectively.

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**INTERACTION WITH STUDENTS**
Please rank from one (1) to five (5)

1. Encourages questions from students.
2. Is careful and precise in answering questions.
3. Relates to students as individuals.
4. Is accessible to students outside of class.
5. Is friendly and helpful to students during office hours.

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**ASSIGNMENTS AND EXAMS**
Please rank from one (1) to five (5)

1. Gives interesting and stimulating assignments.
2. Gives exams that permit students to show their understanding.
3. Uses a grading system that is clearly defined and equitable.

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**COURSE**
Please rank from one (1) to five (5)

1. Required course material is sufficiently covered in lecture.
2. Pace of the course is too fast.
3. The required text/notes are beneficial.
4. Workload is heavier than for courses of comparable credit.
1/2 love it, 1/4 think OK, 1/4 hate it.

Students who like it
- have learned a lot (regardless of final grades)
- have found Materials Science very interesting
- have started graduate studies in the US

Students who think OK
- have found the work overwhelming
- have stronger interests in other fields (subjects)

Students who hate it
- have not been prepared for so much work
- have found it unfair
3rd Year Labs

Once a week, 5 hours, for 24 weeks
- Power Amplifier
- Statistical data processing
- Brownian motion
- Hall effect
- Liquid crystal
- Light emitting diodes
- Logic circuits
- Analog computing
- Simulation and modeling
- Dielectrics and Phase transition
- Optical fibers, etc. etc.

Example: Light emitting diodes (LED)
- Measure I-V and C-V of Green, Blue, Orange, and Red LEDs

\[ E_g = h\nu \]

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<td>~1.9 eV</td>
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<tr>
<td>Orange</td>
<td>~2.1 eV</td>
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<tr>
<td>Green</td>
<td>~2.5 eV</td>
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<tr>
<td>Blue</td>
<td>~2.8 eV</td>
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3rd Year LED Experiment

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I-V curve

C-V curve

1/C^3 for linearly-graded junction

1/C^2 for step junctions
4rd Year Senior Research

- Every student chooses an advisor and performs research
- Students take less than 3 courses in their 4th year
  - Each research group establishes study group
- Unique opportunity to experience what is like to be scientists and engineers
- Experience research proposals, thesis writing, presentation, and possibly publishing journal papers.
- Opportunity for faculty members to evaluate students’ ability to perform research
Superconductivity in Ba₈²⁸Si₄₆ and Ba₈³⁰Si₄₆

Vibrational spectroscopy by Raman
Senior Research Topics at Itoh Group

Molecular Beam Epitaxial (MBE) growth of isotopically engineered low-dimensional silicon structures

99.2% $^{28}$Si single crystal

96% $^{29}$Si single crystal

99.3% $^{30}$Si single crystal
Summary

- Interest in Engineering is going up but in Materials Science is going down in Japan
- 1st year general Materials Science course is important
- US teaching style has been well received
- Strong emphasis on undergraduate lab courses
- Senior research has been successful

- English-based graduate programs on Nanoscience is starting on Fall 2003.
  http://www.st.keio.ac.jp/index-e.htm