Visit to Prof H. Inoue, University of Tokyo, June 5, 1991:
New Departmental Alignment in Mechanical Engineering

Background

Prof Inoue is in the Mechanical Engineering Department and is currently head of the new Mechano-Informatics Department. How this new department came into being is the subject of this report.

The University of Tokyo (Todai) is Japan's most prestigious. Its graduates go into the best government and university positions, including most of the new hires into Todai's own faculty. The buildings are quite old, solid reinforced concrete, and hard to modernize. Budgets are tight. Almost all the students are self-supporting, including graduate students. Tuition is high but apparently not nearly as high as at private US universities.

The typical course of study is 4 years for Bachelor's degree, 2 more for Master's, and 3 more for PhD. The undergraduate curriculum is almost all classroom courses while graduate study is mostly lab work and thesis with only a few classes. This is important to understand in view of the subject of this report, which depends heavily on curriculum reform.

New Departments

Mechanical engineering used to be split into three subdepartments called Mechanical Engineering, Mechanical Enineering for Production, and Marine Engineering. The latter came into being about 20 to 30 years ago as Japan became a prime shipbuilding country. Since Japan no longer leads in shipbuilding, this department has been totally eliminated in the new structure. When it existed, it dealt primarily with engines and other ship machinery, not with ship structure or other traditional naval architecture. Elsewhere in Todai there is now a Department of Shipbuilding and Naval Architecture.

Three years ago the ME department decided that it was losing students or would soon, with the defectors going into more modern technologies based on computers and information sciences. (Inoue said this twice during our talk.) The response was to "restructure" and modernize the curriculum. The attached summary from Inoue gives the rationale and lists the "chairs" in each of the new departments. Inoue is the chair of Information Systems Engineering in Mechano-Informatics as well as the Department Head this year.

The pressure to restructure came not only from trends visible in student registrations but also in general from the rush of technological change in society and industry. Japan identified information-intensive products as strategically important as early as 1970 with the launching of the PIPS (Pattern Information Processing Systems) 5 year national project, and has pursued this area intensely since. Obviously mechatronic products will proliferate and engineers will be needed to design them. Industry is quite interested in this new restructuring.

Inoue noted that the restructuring began three years ago and the Ministry of Education took until this January to give final approval. Todai is a national university subject to the Ministry's governance. I do not know if there is an equivalent of ABET other than the Ministry, but I doubt it. He also notes that all the debate, curriculum creation, and course design occurred during this time, so the big fights are over and the new structure is fully in effect.

Department and Curricular Structure

The new department structure recognizes "traditional deep" ME, broad ME, and mechano-informatics (new ME). Broad ME includes Industrial Engineering and Production Engineering. Both design and computing appear in all three subdivisions. Students majoring in any one of these three take courses from the various chairs, with 50% recommended from the home department and 25% each from the other two. There are no required subjects. The requirements for what we call "humanities" subjects, basic science,and math are satisfied in the first 1.5 years when the students attend a different campus. This way of setting up the curriculum may have been adopted in order to reduce conflict between the advocates of the new curriculum and those of the old who usually ask in such debates what mechanical engineering really is. The new structure actually moots this question in a very realistic way, acknowledging the fact that the old curricular and discipline boundaries have long since been destroyed by external events and it is necessary to build new ones.

On subsequent visits I hope to delve deeper into such questions as the relation between university training and company training and whether the university thinks any one student can really learn all the things that are offered. What should a competent design engineer know in a world of mechatronics? Since there are no required subjects, only "strongly recommended" ones, the department has not taken a rigid stand on these points. [This topic is addressed in the report on Hitachi Construction Machinery.]

I raised the question of the place of algorithms in this curriculum. It may seem odd to relate algorithms to mechanical design but Inoue agreed immediately that this is an essential ingredient. Many complex products are algorithm-driven by their embedded microprocessors. Many have complex user interfaces and multiple internal states, both mechanical and electronic. Thus a sense of algorithms is essential for a comprehensive design approach.

A related question is why algorithm-aware students don't go into computer science. The simple answer is that there is no CS department in Todai's engineering school! There is a CS department in the School of Science, however. I did not learn much about what it teaches. The EE department in Engineering deals mostly with power and information systems, including signal processing and vision. Most US universities have CS departments or CS divisions of EE departments. At Todai such competition does not exist, leaving a clear path to ME for such students who also have a mechanical bent.

Discussion

Many universities in the US have trouble changing their curricula radically, in spite of obvious reasons to do so. At MIT I saw leading professors introduce new material at the graduate level and prove it out before trickling it down to the undergraduate curriculum. This can take many years and lacks a department-wide strategic approach. It also lacks a methodology for removing outdated material, leading to crowding in the undergraduate syllabus. At Todai the graduate curriculum has so few classes that this method may not be available.

The methodology at Todai is not totally clear to me, except that the pressure came from within the department, apparently, and not from the dean. The methodology for selecting elements of the new curriculum is also not clear, except that the chairs focus on areas that are related to their research. This creates expertise but does not guarantee that generic material will be taught or that the students will obtain a balanced education.

What is clear is that the change was quite radical and has defined "mechanical engineering" in a way that would be almost unrecognizable at many schools in the US.

Postscript

This report was distributed in draft form to many US educators and drew an interesting response from Prof Masayoshi Tomizuka, Vice Department Chairman of Mechanical Engineering at UC Berkeley. Tomizuka did his PhD research with me at MIT in the early 1970's after getting his SB and SM from Keio University in Tokyo.

Tomizuka said (and Dr Kozo Ono of Hitachi Construction Machinery Company and a Todai graduate confirmed) that Japanese undergraduate engineering education is broad and shallow. One is exposed to many fields but learns almost no deep knowledge. Tomizuka said he was surprised by the depth of the MIT doctoral qualifying exams and had to study very hard to learn the material to pass them.

Tomizuka also said that curricular reforms like those described above actually happen fairly frequently in Japan and do not represent the revolution that is implied by my report.

The comments of Tomizuka and Ono raise a difficult question: if Japanese university education in engineering is so shallow, how come Japanese product engineering is so good? The answer apparently lies in the additional education the young engineers get on the job, plus such factors as lifetime employment, extensive use of past design data on new designs, and the length of time an engineer keeps the same job responsibilities.

An advantage of this kind of education is that it sets the pattern for "universal experience," meaning that an engineer more easily learns and practices many fields during his/her career. "Mechanical" engineering graduates do not feel a professional committment to mechanical engineering but rather to their employeer, who may alter their professional concentration as a result of assignments and training. These alterations apparently do not cause much discomfort. Cross-trained engineers perhaps can understand each others' design problems, making concurrent engineering easier to implement.

US engineering students, on the other hand, devote a lot of their education to becoming "mechanical engineers" for example and might feel their school time was wasted if their employeer tried retraining them as EEs. Similarly, US companies expect new hires to function productively soon after being hired,just because of the focussed character of their education, and would not think of retraining them to a different field. Engineers thus rapidly become specialized and less able to communicate with engineers in other fields.

Therefore, education, career paths, and company training (or lack of it) are symbiotic in both countries.