# Assessment of Student Learning in Engineering Programs in Japan, Korea and the Unites State of America

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***Abstract*** *¾ This paper describes student learning in engineering education at Chiba Institute of Technology (CIT) in Japan, Korea University of Technology and Education (KUT) in Korea and Loyola Marymount University (LMU) in the United States. The purpose of this paper is to discuss the innovative approaches of engineering and project management education at CIT, KUT and LMU. Assessment of the student learning in these institutions will also be described. Finally, it demonstrates how our strengths and weakness are measured and shared with other institutions.*

*Index Terms ¾ project management, new manufacturing system, factory of the future, creation of idea*

## INTRODUCTION

Engineering programs in all countries of the world are undergoing tremendous changes to meet the challenges of the 21st century. One of the key factors of that change is student learning. It is a challenge for educators in any country to assess the effectiveness of student learning as it relates to the program outcomes and assessment.

The objective of this paper is to investigate student learning in engineering education at Chiba Institute of Technology (CIT) in Japan, Korea University of Technology and Education (KUT) in Korea and Loyola Marymount University (LMU) in the United States. In an effort to meet the educational needs of the students, CIT, Japan has pioneered a progressive and innovative project management program that uses innovative methods of teaching and learning to prepare students better for rapidly changing and highly competitive marketplace. Key features of the program include issues relating to research and development, social systems, campus education, etc. Korea University of Technology and Education in Cheonan, South Korea, has developed an innovative university-industry partnership for the effective learning of engineering education. This paper describes the program and the assessment of its undergraduate engineering education. Loyola Marymount University`s (LMU`s) Mechanical Engineering (ME) Department has also developed an innovative option in manufacturing. Principles and applications of modern manufacturing are taught using a hands-on approach. The department has also developed an assessment process and improvement methods that involve our constituents. The process is very time-intensive and requires a direct involvement of the faculty. The student learning of engineering education has been assessed using Engineering Criteria 2000 (EC 2000). The purpose of this paper is to discuss the innovative approaches of engineering and project management education at CIT, KUT and LMU. Assessment of the student learning in these institutions will also be described. Finally, we will demonstrate how our strengths and weakness can be measured and shared with other institutions.

## CHANGE IN SOCIAL ENVIRONMENT IN JAPAN AND ENGINEERING EDUCATION AT THE CIT

After World War II, Japan became a large economic power in the second world by producing a large amount of high-quality, low-price products and exporting them. However, the social state was not accepted by the consumer even if it is a high-quality, high performance, low-priced and excellent commodities, has been generated. The reason seems to be the change of production structure in Japan, the change of man's sense of value, the rise of personnel expenses, the production base to foreign countries and the import of large amount of low-priced commodity. It is very important to introduce a new strategy for the development of products and offer of services, such as the commodity with value added, an environmentally-friendly commodity, a healthy maintenance commodities and a safety-guaranteed commodities. This means business transfer from a good products to useful, safe, and healthy products for human beings.

It is necessary to introduce a new educational curriculum even in the Institute of Technology in-line with the changing of social state, business and production system, instead of the traditional educational curriculum The new educational systems composed of three faculties, such as faculty of technology, information science and social system science, were introduced to the Chiba Institute of Technology (CIT), Japan in 2001. The faculty of technology will be changed from 2003 into five departments, such as mechanical science,

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electric/electronics information, life environment science, architecture/civil, environment and design. Otherwise, the faculty of information science has two departments of information technology and information network. Also the faculty of social science has two departments of management information and project management (hereafter called PM). Japanese university is classified into national, public and private university.

The CIT is one of the private colleges in Japan, but the education system was changed from the college to the technological university including three faculties corresponding to the request of age. In this research, the new educational contents of the department of project management (hereafter called DPM) in the faculty of social science, in which one of authors belongs, is introduced. In the DPM, there are three types of courses: software development management, the social project and the business creation course [1].

## Education for Business Creation

The educational subject of business creation which is one of the courses of the DPM is introduced here. Business creation is a course, where a new business is created by using PM. When China becomes a factory in the world, a man of talent from whom "making-structure" which exceeds "making-product" is requested to the industry of Japan. It is important to develop the strong technology, but "making-personel" is more important in the course. The outline of the course is that the student can learn how to integrate between design, confidence, knowledge, and finance, and how to make the value added using the integration results.

It becomes a necessary condition for students to learn the complex nature of business. PM will be defined simply as a methodology for the realization of "dream and idea". It is also defined as the integrated structure among the scenario of conception, planning and making-structure. Figure 1 shows an educational program of the business creation course .

In the context of global economy, the cooperation between government, industry and university, and business base developments are taken up as a research education theme. In a future development of businesses, R&D for products and business, e-manufacturing, and supply chain management will be treated. In the mutual agreement of the community formation, communications, organizational study, and gaming simulation will be treated. In the program management, management strategy, business model, and project management will be treated.

These new curriculums are proposals for the education, that is the change of education mind from "making-products" to “making structure” corresponding to the change of social environments in Japan. These educational programs were not included in the past Japanese technological education program.


FIGURE.1
EDUCATION IN BUSINESS CREATION COURSE

## Case Study of Future Development Business Education

The future development business education in CIT is classified into the product development (R&D) and the social system development.

In this research, the e-finishing, as a case study of R&D project, is introduced. Figure 2 shows the concept of e-finishing, whch is proposed by a student project.

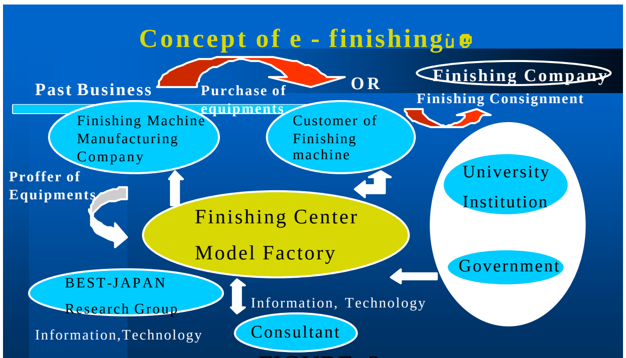


FIGURE. 2
CONCEPT OF E- FINISHING

The finishing business is one large market in which machine manufacturing companies, finishing machine customers, finishing/deburring consignment enterprises, an individual consultant, and research laboratories all work together. The burr removal operation and the surface finishing of mechanical machine parts have been carried out using various types of finishing machines.

The customers have to invest in finishing plant and/or some other equipment. However, when the amount of capital investment in manufacturing companies decreases, the ratio of finishing/deburring consignment to outside companies is increased. The e-finishing which can promote the finishing business, corresponding to the change of the social environment, is proposed by a student project. In e-finishing, a deburring center is located in the center of business, and the finishing business can be developed. The model factory for various finishing in the deburring center of the network manufacturing is provided, and finishings/deburring of high-quality parts corresponding to user needs will be possible by the closed cooperation of research laboratories. The construction of core competence and introduction of supply chain management will be necessary condition for the strategy of finishing companies as shown in Figure 3.

### Evaluation of PM Education

As mentioned in the previous section, PM will be defined simply as a methodology for the realization of "dream and idea". It is proposed as an educational scenario of conception, planning and making-structure. To practice these themes, it is necessary to train the student's abilities such as the planning, conception power, originality, communication, problem solving, business skills, and presentation skill. These abilities will increase the strength of students through each case study in the DPM of CIT.

The new educational program has to be evaluated based on many criteria like a number of entrance applicants, educational satisfaction rate of the school life, and the finding employment situation to the enterprise. Table 1 is an evaluation data of the number of entrance applicants, the employment rate, and the student satisfaction rate. The PM education subjects were top grade among 13 departments of CIT, and a new curriculum corresponding to an educational content, especially the change in the social environment was evaluated of high school students, school life, and the enterprises.

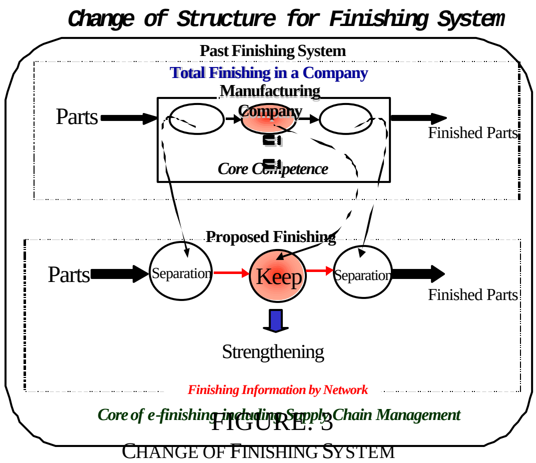


FIGURE. 3
CHANGE OF FINISHING SYSTEM



TABLE. 1
EVALUATION OF NEW EDUCATION AT DPM IN CIT

**Entry (high School student) for Entrance Examination**

Competition ratio : 4.5 times (2001)
3 times (2000)
Ranking in the CIT : 8 / 13 departments (2001)
12 / 13 departments (2000)
before campus

**Decision of Examination for Employment**

Ranking in the CIT : 1 /13 departments, (from April to December, 2000)
1 / 13 departments, (from April to December,2001)
after campus

**Survey Results of Students Campus-Life Satisfaction**

Satisfaction Ratio : 52 % (Average of other department : 32%, 2001 )
Ranking in the CIT : 1 / 13 departments (2001)
in campus

## UNIVERSITY OF TECHNOLOGY AND EDUCATION

Korea University of Technology and Education in Cheonan, South Korea, has developed an innovative university-industry partnership for the effective learning of engineering education. This section of the paper describes the program and the assessment of its undergraduate engineering education.

Competition of semiconductor controls a fever worldwide and technology development is accelerated, in semi-conductor production, making equipment is becoming pivotal point in all of investment and manufacturing technique. Especially, Korea has the best manufacturing technology in memory production, but considerable portion is depending on foreign equipment. To keep and develop the highest level of manufacturing technique we must manufacture equipment of high efficiency directly by our-selves and introduce equipment with superior performance and price competitive power rapidly.

In an effort to meet the needs of the semicondictor industries, the Korea University of Technology and Education has developed a Semiconductor Equipment Technology Education Center (SETEC) which works closely with other engineering departments of the university.

### Purpose of This Study

This study is to find the problems relating to curriculum, teaching materials, and other various things the most engineering colleges are currently facing at the actual fields and it is to suggest the innovative directions for more efficient engineering educations based on the study. The detailed study is as follows:

(1) The viewpoints from the engineering undergraduates and graduates are to be investigated to find the real

problems in the engineering education.

(2) The viewpoints from the engineering professors are to be investigated to find the real problems in the engineering education.

(3) The viewpoints from the industry are to be investigated to find the ability and the virtue, which are required in the industry, of the engineering graduates.

(4) By adopting the cooperative educational system between the engineering college and the industry, we try to suggest the efficient engineering educational directions for the knowledge based society.

### Current Status of Engineering Education

The employment rate of engineering graduates at the matched area with their majors is believed to be around 50%. According to "Yearly Report of Statistics in Education" published by Ministry of Education in 1996, the employment rate of four-year engineering college graduates including science majors at the manufacturing companies were 32.9% and the employment rate including construction companies were estimated to be around 50%. More emphasis has been placed on teaching the "theories', rather than the hands-on approach that might have produced industry-ready engineers. Except in a few departments, there has been no university-industry partnership.

### Survey Methods

The tool of this study is the question and answer sheet which has been developed following the research output by "Designing and Conducting Survey Research [1]. The questions which are both appropriate and being related with the study are developed, and the survey groups are reviewed by engineering education expert group. The selected survey groups are (1)Professors who are really teaching engineering students, (2)Administrative staff members who may sum up the statistics of their engineering college, (3)Undergraduate students who are presently taking engineering courses, (4)Engineering graduates who are presently being employed in the industry, and (5)Personnel managers who may also provide their viewpoints and the statistics on their engineers. The survey has been carried out for 95 professors at 21 different colleges, 54 administrators of the different universities, 350 students at 6 different universities, 192 engineers at 15 different companies, and 14 personnel managers at different companies. The companies participated in the survey consist of large size company(51%), medium size company(24%), and small size company(25%) and 80% of them are in manufacturing fields. The data surveyed have been analyzed for the percentage of the different questions.

### Survey Results

Engineering Undergraduate Students

(1) Degree of Satisfaction with College Life
It is evaluated that the degree of satisfaction with the whole college life is not high.

(2) Degree of Satisfaction with Lecture
The degree of understanding the whole contents of lecture is very low. It needs to examine separately whether it is because that the basic learning ability of students is low or whether it depends on teaching methodology. 70.9% of students are positive on the major theoretical courses. The expectation on practical laboratory works is not satisfactory and 69% of students are negative on their textbooks of major engineering courses.

(3) Communication and Computer Skills
Students feel that the more computer and communication skills are needed. This implies that there are more rooms to modify the curriculum or else.

(4) Jobs after Graduation
70.5% of students have not decided their future jobs or professional career.

(5) Areas to Be Emphasized in Engineering Education
42.5% of students need to emphasize the laboratory works and 32.2% need to emphasize the field experience in the industry.

Engineering Graduates Employed at Companies

(1) Relationship between Present Job and Study in College
85.3% of graduates are presently working for their major areas. 94.9% of graduates feel that they are doing their jobs well.

(2) Degree of Satisfaction with Lecture
81.4% of graduates are positive on the contribution of theoretical courses to their field works. The contribution of laboratory works is found to be less than that of theoretical courses.

(3) Weak Areas to Do Their Jobs
24.3% of graduates feel that the knowledge of new technology is the weak area for them to do their jobs. 23.2% indicate the area of foreign language and 19.8% feel the shortage of references and information. 10.3% feel the weakness of basic science including physics, mathematics, and chemistry, and 7.8% point out the weakness of computer related knowledge.

(4) Recommendations to Engineering Students
40.5% recommend the hard work in learning foreign language and 19.1% suggest to participate in major courses and laboratory works actively. 17.5% emphasize the computer related technology and 14.2% are with the basic science such as physics, mathematics, and chemistry.

Engineering Faculty

(1) Areas to Be Innovated in Engineering Education
48.7% indicate the educational environment and 23.7% point out the level up of adaptability of curriculum to the work fields. 11.8% suggest the modifications of teaching and learning methodology and 3.9% request the change of viewpoints of society and industry.

(2) Future Direction of Engineering Colleges
52.2% need the more practical engineering education and 21.7% suggest the more specialized education. 15.9% emphasize the more research oriented university and 5.8% point out the importance of university services to local communities. 2.9% favor the excellent job search activities and the only 1.4% emphasize the international cooperative programs.

(3) Level of Students and Facilities
The understanding of lecture by students is very good and the competitiveness in entrance examinations of engineering colleges becomes lower. The laboratory facility and equipment are very poor.

Personnel Managers at Industry

(1) Preference for Hiring New Engineering College Graduates
52.3% prefer the basic technology in their majors and 20.5% ask for better human relations. 15.9% like creative engineers although it may be possible for them to hit upon failures. 11.4% want new engineers who are always doing their jobs without complaints.

(2) Attitudes of Engineers
70% feel that engineers are excellent and 27.5% think “so so”. 75% evaluate that their human relationship is excellent and 20% feel “so so”. 35% believe that engineers have excellent creativity and 65% are negative on creativity of engineers. 50% think that at least one year is needed for new graduates to be more trained before they are assigned to their duties. 25% feel two years to be more trained.

(3) Engineering Colleges
57% agree with the big gap between college education and requirements by industry. 22% feel the shortage of expertise and 8% think the weakness in basic sciences. 36% suggest the more field related curriculum and 20% recommend to upgrade the educational environment. 42% desire the specialized engineering schools and 30% want the practical engineering schools for future engineering colleges. 70% think that the years of studying may be flexible depending upon the majors. 22.5% agree with the current academic system and 7.5% recommend one or two years of extension.

Administrative Staff at University

(1) Industry Cooperative Experience of Faculty
47.2% are less than 3 years' industrial experience and 38.9% have 3-5 years' experience in industry. 11.1% have 5-10 years' field experience. 38.9% are the colleges where 50-75% of faculty are doing the projects sponsored by industry. 25% think that their engineering colleges have 25-50% of faculty who get funding from industry. 16.7% agree with less than 25% faculty who are doing projects with industry.

(2) Number of Students Advised by a Professor
75% have more than 30 students per advisor and 19.5% are for 20-30 students. 5.6% have 10-20 students.

(3) Employment Rates
48.5% report that 50-75% of graduates are employed in the manufacturing companies and 39.4% for less than 50% employment in manufacturing areas during the past three years. 51.5% are the colleges whose engineering graduates' 50-75% are employed at their major areas and 27.2% are for less than 50% graduates hired at same areas as their majors in colleges.

## ENGINEERING EDUCATION IN THE UNITED STATES OF AMERICA

Loyola Marymount University's (LMU's) Mechanical Engineering (ME) Department has developed an innovative option in manufacturing. Principles and applications of modern manufacturing are taught using hands-on approach. The department has also developed an assessment process and improvement methods that involve our constituents. The process is very time-intensive and requires a direct involvement of the faculty. The student learning of engineering education has been assessed using Engineering Criteria 2000 (EC 2000).

### Assessment Process

Our process was based upon the needs of our constituents and was driven by our Advisory Board. Our process was used as a roadmap to plan and implement the activities that were required for assessment. A simplified model of our process was published by the author in ICEE'01[3]. It is compatible with the "2-loop" assessment process that has been suggested by ABET [4] and Jakubowski and Calder [5]. The numbers on top of the boxes correlate with the model of Aldridge and Benefield [6]. The feedback paths to our Advisory Board and program outcomes are indicated for the improvement cycle, but the details for improvement are purposely not shown.

After listening to the "voice of our constituents"[7], the ME Department established its mission, vision and goals. The mission and vision were formed using a SWOT (i.e., S = strengths, W = weaknesses, O = opportunities, and T = threats) analysis for strategic planning. Our mission was leveraged on our strengths and opportunities in conjunction with our available resources (i.e., budget and manpower). Our mission was to "provide the best practice-oriented, design-focused curriculum that prepares students for leadership roles in industry and graduate studies." Three global goals were established that impacted our educational objectives and program outcomes:

- Provide an excellent learning environment and a transition into the workplace and graduate studies.
- Solve real-world design and research problems.
- Instill engineering fundamentals for a changing environment and for life-long learning.

The assessment process starts with our Advisory Board and the needs of our constituents. Based on theses needs, the mission of the ME Department and LMU, our educational objectives were formulated. Then these objectives were combined with ABET's Criterion 3 [8] and linked to our program outcomes. The program outcomes were linked to the curriculum; and the curriculum was linked to learning objectives; and the learning objectives were linked to the course topics. This linking process was charted using the methods of quality functional deployment (QFD), which were previously discussed [9].

**Improvement Process**

In the search for continuous improvement of our ME program, a process was developed for implementing changes (Fig. 4). From our assessment methods, the data are collected and compared with our achievement expectations, which generated a performance gap. A positive gap (when the data exceed the expectations) indicated a strength. A negative gap (when the data fell below the expectations) indicated a weakness. The negative gaps were reviewed by our ME Advisory Board and/or the President's Council to confirm its validity. If the gap is consistently negative for several of the assessment tools, then corrective actions are recommended, and changes are implemented. These changes are documented and reviewed each year.

Our program outcomes are assessed using the assessment tools, and the results are reported on summary sheets. These sheets consist of assessment tools vs. strengths and weaknesses under each program outcome. If the weakness was consistent (i.e., occurring in at least two assessment tools), then it is recommended for corrective action at the bottom of the sheet. When the corrective actions are actually implemented, the date and faculty member who implemented them are recorded on the sheet.

The improvement process will be described using examples. As an example, Table 2 illustrates this process for Program Outcome (g): ability to communicate effectively using all of the assessment tools. In this case, the weakness in oral communication (via the EBI Survey) is not consistent. Hence, no corrective actions were taken. To our knowledge, this process creates a systematic record of documenting our improvements to the ME program. In the future, we expect to improve our measurement methods, assessment tools and further refine our processes.

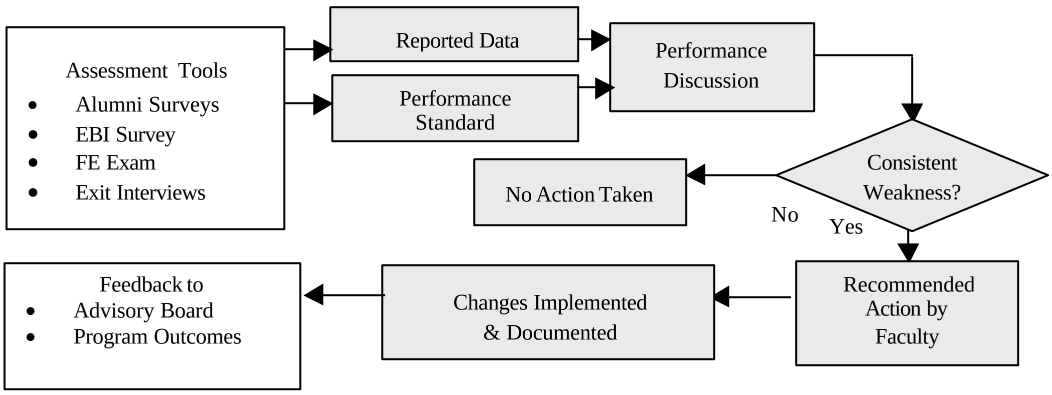


FIGURE.4
IMPROVEMENT PROCESS

TABLE 2
ASSESSMENT OF PROGRAM OUTCOME (g): ABILITY TO COMMUNICATE EFFECTIVELY

| Assessment Tool | Strength | Weakness | Consistent Weakness |
|---|---|---|---|
| Course Evaluations | NA* | NA* | None |
| Senior Survey | Communicating orally, in prepared talks, and in writing | None indicated | None |
| Exit Interviews | NA* | NA* | None |
| FE Exam | NA* | NA* | None |
| Alumni Surveys | Technical report writing | None indicated | None |
| EBI Survey | Communicating in written reports | Communicating in oral reports | Weakness is not consistent. |
| Corrective Actions: None are recommended at this time. | | | |
| * NA = Not applicable for assessing Program Outcome (g) | | | |

## CONCLUSIONS

Three engineering programs in three advanced manufacturing countries of the world have been studied here. All three programs recognize the need for changes to be incorporated into their respective engineering programs to improve student learning. Following the needs of each constituents, the educational objectives of each program are established. All programs need to develop assessment process and methods to improve the engineering education.
Each program needs to be assessed by various assessment tools to find out the strengths and weaknesses of the programs. Corrective actions are to be taken to address the weaknesses for continuous improvement of the program. EC 2000 is an effective tool to assess and improve the engineering education of the world.

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