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Computer and Media Integration in Japanese Engineering Education*

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Computer- and video-based instruction can provide an effective method for teaching engineering. In Japan there is an ongoing development of computer- and video-based instruction which deserves more attention. This report summarizes the impressions and results of a survey on Japanese computer- and video-based engineering education during a 15-day NSF-sponsored study trip to Tokyo, Osaka and Kyoto. This trip involved visits to the Ministry of Education, seven universities, a CAI software company and the staff of a computer manufacturer. The trip and survey revealed several developments of interest to engineering educators. These include: development of campus-wide centers for education using computer and video instruction; installation of video projection systems in engineering lecture and classrooms; and introduction of a compact video camera, lighting table for the classroom. The development of precollege computer-aided instruction at the high-school level is discussed along with the developments of a software interface between differing U.S. and Japanese computer standards.

INTRODUCTION

OVER the past decade the introduction of computers for class assignments and instruction has led to profound changes in engineering education. In contrast to engineering education literature on U.S. and European developments, there is limited reporting on Japan. The author became aware of this during his 1986–87 appointment as a Professor at the University of Tokyo [1]. In order for the author to assess the Japanese use of computers and media (video projection equipment, etc.) the National Science Foundation sponsored a 15-day study trip [2]. This trip included Tokyo, Osaka and Kyoto. During the study trip the Ministry of Education, seven universities, a computer aided instruction (CAI) software company and the staff of two computer manufacturers were visited (16–31 May 1990). This study trip revealed several developments of interest to engineering educators. These developments follow the use of computers and video in Japanese education. They include:

1. Introduction of classrooms/lecture halls with large numbers of PC computers/terminals. These systems are supported with centralized operating systems and student instruction software.
2. Introduction of video equipment in classrooms to show video tapes and project notes, book pages and computer keyboard/screens.

The Japanese Ministry of Education now requires the introduction of computers in high-school level instruction so future engineering classes will be computer literate. This requirement is creating a market for computer-aided education (CAI) packages at the high-school level and ultimately college and university level. In response to this development a number of Japanese companies displayed CAI systems and special computer, video and compact disk educational equipment at the 'CAI and New Media show '87' (23–26 April 1987) in Tokyo.

At present the Japanese PC development has not resulted in U.S. IBM PC or Apple compatibility because of the graphics and architecture needed for Japanese language display. Until this interface is resolved a visitor to a Japanese university will have a problem in transferring software. This was addressed as part of the trip.

BACKGROUND

There is a strong commitment in Japan to education starting from the early period of 1860 to the present [3]. Throughout its history, the development of engineering education in Japan has reflected changes in its historical and economic development [3–8]. The present development in Japanese computer and video introduction comes at a period marked by the following three changes.

1. Changes caused by the introduction of PC computers and databases in thesis, research, process simulation and engineering design. In some cases block grants of PC computers were made to universities to develop CAI.
2. Changes caused by the reorganization of the Japanese economy from heavy industry to a

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high-tech and service/information industry. These changes require a new engineering curriculum with advanced and emerging technology lectures.
3. Changes caused by promotion of younger, computer-using professors to decision-making positions and retirement of older teaching staff.

In contrast to the prescribed textbooks and lesson plans used in Japanese primary and secondary education, the university curriculum is relatively flexible. This flexibility is reflected in ongoing Japanese engineering education developments:

- Donations of PC/terminals by different Japanese computer manufacturers to develop computer-aided engineering education.
- Implementation of individual approaches at each university to use computers and video instruction without following a U.S.-ABET style engineering accreditation structure.

The rationale for the study trip is discussed in the following section.

STUDY TRIP GOALS AND SCHEDULE

To document the Japanese use of computers and advanced media (video, etc.) in engineering education, a study trip and survey covering the four points in Table 1 was proposed to the Division of International Programs, National Science Foundation (NSF) [2]. After review and approval, a trip schedule was organized for 16–31 May 1990. This schedule proved ideal since it came at the U.S. semester's end while in Japan the Summer semester (April–September) had just begun [6].

The observations from this short visit and survey represent 'snapshots' of Japanese engineering education development and thus provide only limited generalizations. The real merit of such trips are the up-to-date information they provide. This information is especially useful to two groups of engineering educators. The primary group is the educators interested in effective use of computers and video in the engineering classroom. The second group are faculty planning joint U.S.–Japan engineering education/research projects. This is a growing activity due to increased government and industry support [9, 10]. One issue addressed during the trip was software exchange between conventional U.S. PC machines such as IBM or Apple and Japanese PCs.

Table 1. Purpose of NSF-sponsored study trip to Japan

1. Visit to Ministry of Education to discuss development and implementation of computers in Japanese education.
2. Visit to a computer and a CAI software company to discuss development and introduction of computer-aided instruction machines and software.
3. Visit to universities in Tokyo, Osaka and Kyoto to discuss with faculty the use of computers and videos in education and their facilities.
4. Conduct a limited survey (5–8 professors) to define plans for utilization of computers and video by Japanese engineering education

PRECOLLEGE USE OF COMPUTER- AND MEDIA-BASED INSTRUCTION

At the 'CAI and New Media Show '87' (23–26 April 1987) held in Tokyo, over forty Japanese companies displayed CAI systems as well as special computer, video and compact disk educational materials. This show heralded the introduction of CAI in elementary, junior high school and high school. In my visit with the president of an Osaka-based CAI software company, PAL, Inc., Mr Morita demonstrated his company's CAI software developed for the newly revised elementary and high school curriculum. The Japanese Ministry of Education updates the elementary, junior-high school and high school curriculum at 3-year intervals [11]. This updating involves the introduction of new textbooks, course plans and equipment such as computers. For 1982 about 200 software companies marketed materials suitable for precollege CAI. In the following cycle (1985) the number of companies grew to 250. By 1987, however, the number of companies had dropped to 100 for the 1988 cycle.

Mr Morita indicated that PAL employs 20 software developers along with 20 part-time consultants who are teachers. They check out the CAI software before marketing. To give some impressions of the number of future users, Mr Morita indicated that under the Ministry of Education program, 12,500 junior high schools would each have a classroom equipped with 20–40 computers. Typically PAL software contains 20 hours of lessons corresponding to 200–300 hours of program development, checking and revision. CAI software in mathematics, physics and science have been successfully introduced. Additional lessons include languages such as English, French and social sciences such as geography (Fig. 1). This software is configured to run on more than ten Japanese PCs including the PC-88 MR, MH and PC-98 VM systems. Mr Morita indicated that a number of overseas Japanese families have used the PAL software to help their children prepare for the entrance examinations.

COMPUTER INTERFACE

The development of the Japanese PC required a provision to display the Japanese *KANJI* language. This resulted in a Japanese-language mode graphics of 640×400 pixels (one screen) corresponding to 16×16 pixels, 40 characters $\times$ 25 lines. This requirement differs from the IBM PC-based graphics, so there is a mismatch when U.S. IBM PC/Apple software is run on a Japanese

Fig. 1. Demonstration of high school level CAI software by the president of PAL, Inc., Mr Morita.

PC. One consequence is that joint U.S.–Japanese research-teaching activities must be developed to minimize this and other PC interface problems.

Among the present generation of Japanese PCs, Toshiba's J-3100 Laptop series ($3700–9500) and the Dynabook series ($1500–3700) were introduced with IBM PC and Japanese MS-DOS compatibility.

The J-3100 Laptops are configured to accept full-length IBM PC AT expansion cards and half-length PC XT cards. The 3.5 in. floppy drive supports three formats—1.44 and 1.2 Mbyte and 286 kbyte—to enable compatibility with both Japanese and overseas software [12].

The NSF office staff at the American Embassy have also followed the progress of the ongoing development of the TRON (The Real Time Operating System Nucleus) project [13]. This project is a multi-company project aimed at developing a new system of computer architecture standards to make intercompatibility of computers from different manufacturers a reality and to realize a greater capability in processing Japanese, non-European and European languages. These standards are being used to design a 32-bit microprocessor unit (MPU) which will have a processing speed of 6 mips (millions of instructions per second). It will be twice as fast as Intel's 80386 MPU and slightly faster than Motorola's 68030 MPU. TRON chip development by Mitsubishi, Matsushita and Hitachi/Fijitsu has been reported, so it is anticipated that the TRON standard will become a computer standard for the next generation of 32- and 64-bit PCs.

SURVEY ON COMPUTERS AND MEDIA INTEGRATION

During the site visits, a five-page survey was distributed to over 15 Japanese mechanical engineering professors. Eleven responses were received as detailed in Table 2.

The Tokyo University engineering program has been previously described [1, 6] and a comparison of engineering programs at the University of Tokyo, Tokyo Institute of Technology, and Osaka University has also been reported [5]. These engineering programs are 'usually trendsetters for others to follow' [5].

The larger class size at Kyoto and Osaka Universities have resulted in the building of education centers that have large classrooms furnished with PC/terminal and video monitors. In all the universities visited, lecture halls and classrooms are fitted with PC/terminals and video monitors. The initial use of these facilities was to teach computer use and CAD-CAM training. Other computer-based courses are now being introduced in the engineering curriculum. The results of this survey provide an impression of the present development of CAI and video-based instruction in Japanese engineering education. The survey replies on faculty perceptions on CAI and video use in Japanese engineering education are summarized in Table 3. While 77% of professors surveyed use the computer in the classroom, only 36% have used CAI and only 45% have used video in their classes (questions 1–3). It is evident from the replies to question 4 on the merits of CAI that the majority of the respondents indicated that CAI can improve student understanding (average rating = 4.18) and

Table 2. Responses to survey

No. of responses	Institution	No. of undergraduate engineering students
3	University of Tokyo	1865
1	Kyoto University	4349
2	Osaka University	4869
1	Tokyo Institute of Technology	3081
1	Kyoto Institute of Technology	3000
2	Kansa University	4705
1	Waseda University	1750

Table 3. Survey results of faculty perception on CAI and video use in Japanese engineering education: 11 responses (5/90)

Question		Response					Notes
		Not yet		Using			
1.	Computer use in class	3		8			72% users
2.	CAI instruction	7		4			36% users
3.	Video use in class	6		5			45% users
		Ranking (scale 1–5; 1 = low, 5 = high)					Av. rating
4.	Merit of CAI						
(a)	Patient instruction	1	1	2	5	2	3.54
(b)	User friendly	0	3	3	3	2	3.36
(c)	Instruction matched to student level	1	1	2	4	3	3.64
(d)	Flexibility to cover large/small class	0	4	1	4	3	3.82
(e)	Reduction of teaching staff	0	1	4	3	3	3.72
(f)	Improve student understanding	0	0	3	3	5	4.18
(g)	Improve student problem solving	0	4	0	5	2	3.45
(h)	Improve student test taking	0	3	3	1	4	3.54
(i)	Ease in introducing new material	0	1	5	3	2	3.54
(j)	Economical means of instruction	3	1	2	4	1	2.90
5.	Computer role in engineering education						
(a)	Tutor after class	2	1	5	3	0	2.80
(b)	Tutor during class	2	2	5	0	2	2.80
(c)	Demonstration during class	1	1	1	5	3	3.70
(d)	Computer aided instruction (CAI)	2	0	5	3	1	3.10
(e)	Report writing	0	1	2	5	3	4.20
(f)	Laboratory work	0	0	1	0	10	4.80
(g)	Graduate thesis work	0	1	0	1	9	4.50
6.	Instructional software needs						
(a)	Shell style	1	2	0	4	5	4.10
(b)	Exercise	0	0	5	3	3	4.20
(c)	Examination	0	2	5	1	3	3.80
(d)	AI controlled instruction	1	2	2	5	3	3.45
(e)	Simple style software	0	0	3	5	3	4.00
(f)	Advanced software	1	0	5	3	2	3.80

that CAI is not an economical means of instruction due to the required computer and software budget.

The respondents' view of the computer's role in engineering education (question 5) indicated a strong bias to research activities, report writing, laboratory work and graduate thesis work (4.2–4.8). At this stage, computer demonstration during class (3.70) is ranked higher than CAI instruction (3.10) and tutoring activities (2.80). This reflects the limited development of Japanese software suitable for engineering instruction. This situation was indicated during the site visits and accounts for the high ratings for the instructional software needs (question 6 in Table 3).

The area of CAD-CAM education in Japan has created quite a discussion. The traditional role of the university has been to provide students with basic education, engineering fundamentals and expose them to research throughout supervised thesis activities. In turn, the students entering a Japanese company undergo an intensive training and orientation that occupies the first years of their employment. With the introduction of CAD-CAM in the engineering curriculum a number of discussions arose as to what degree of practical training would be appropriate. Obviously, comprehensive training would overlap the company's traditional training activities. During the CAD planning for the replacement of manual drafting with computers, it became evident that this replacement involved a major shift in budget, faculty specialization and the interpretation of the goals of CAD training. It is clear from the responses in Table 4 that CAD-CAM received a low rating as an area of engineering education and university research. This reflects to some extent the view that CAD-CAM education has become an industry training activity and the realization that CAD-CAM research has been eclipsed by other subjects. The survey responses indicate that other subjects in Tables 5 and 6 are perceived as more appropriate for engineering education and research work.

The responses in Table 5 indicate the general trends towards developing computer-based courses in finite element methods, computational fluid/thermal mechanics as well as metratronics and robotics. These all follow a perceived need by industry (item E, ratings of 4.54, 4.36 and 4.18). The high ranking as project subject requires some explanation. The Japanese engineering curriculum

Table 4. Survey results on faculty perception of CAD-CAM in Japanese engineering curriculum: 11 responses (5/90)

Area of CAD-CAM		Ranking (1 = low, 5 = high) 1	2	3	4	5	Av. rating
1.	Computer graphics	2	0	2	4	3	3.54
2.	Computer design training	2	2	0	6	1	3.18
3.	Computing design skill	4	1	0	5	1	2.81
4.	Design innovation	3	3	4	0	1	2.36
5.	Computer-aided manufacturing	3	2	2	2	2	2.80
6.	Manufacturing technique development	2	1	1	5	2	3.36
7.	CAD as research area	3	1	1	4	2	3.10
8.	CAM as research area	3	1	2	3	2	3.00
9.	CAD-CAM as research area	3	2	2	2	2	2.82

Table 5. Survey results on faculty perception of computer use in Japanese engineering education curriculum. Part I—Courses: 11 responses (5/90)

Area		Ranking (1 = low, 5 = high) 1	2	3	4	5	Av. rating
1.	Finite element method						
(a)	Course subject	0	0	9	1	1	3.27
(b)	Project subject	1	1	3	5	1	3.36
(c)	Graduation thesis subject	0	3	1	6	1	3.45
(d)	MS or Ph.D. thesis subject	0	4	3	3	1	3.09
(e)	Need by industry	0	0	0	5	6	4.54
2.	Computational fluid/thermal mechanics						
(a)	Course subject	0	0	6	3	2	3.64
(b)	Project subject	1	1	4	5	0	3.18
(c)	Graduation thesis subject	0	0	4	4	3	3.91
(d)	MS or Ph.D. thesis subject	0	0	4	3	4	4.00
(e)	Need by industry	0	0	2	3	6	4.36
3.	Mechatronics and robotics						
(a)	Course subject	1	0	2	5	3	3.82
(b)	Project subject	1	0	2	5	3	3.82
(c)	Graduation thesis subject	1	0	1	5	4	4.00
(d)	MS or Ph.D. thesis subject	1	0	1	5	4	4.00
(e)	Need by industry	1	0	0	5	5	4.18

has relatively few electives. The students are required to enrol in project courses (i.e. exercises in mechanical engineering) where they perform calculations, or experiments, in areas such as finite element analysis, computational fluid/thermal mechanics and/or robotics/metatronics.

Table 6 shows the responses to several design/manufacturing-related subjects that have been developed in the past decade. Because these subjects are used in the design process, it has been difficult to introduce them as individual courses and to include them in the subjects covered in design class or a thesis project. This viewpoint is evident by high graduation thesis work rating (3.87–4.10) versus the course subject rating (3.00–3.20).

COMPUTER AND VIDEO CLASSROOMS

Considering the large market share of Japanese electronics, it is not surprising that Japanese engineering educators are utilizing computers and video projection systems to enhance their classroom effectiveness. During the visits three features of interest were observed:

1. At Kyoto University and Osaka University, specially built educational centers have been operating with PC/terminals interconnected by local area networks with a large mainframe computer (Fig. 2).
2. In the classroom/lecture rooms, overhead video enables students to follow the lecture's direction regarding software or programming (Fig. 3).
3. A compact video projection system consisting of a center video camera with two overhead

Table 6. Survey results on faculty perception of computer use in Japanese engineering education curriculum. Part II—Subjects: 11 responses (5/90)

Area		Ranking (1 = low, 5 = high)					Av. rating
		1	2	3	4	5	
1.	Statistical analysis of design/ production data						
(a)	Course subject	1	1	6	1	2	3.20
(b)	Project subject	1	0	5	3	2	3.45
(c)	Graduation thesis subject	0	1	2	6	2	3.82
(d)	MS or Ph.D. thesis subject	0	2	2	5	2	3.63
(e)	Need by industry	1	0	1	5	4	4.00
2.	Optimization in design						
(a)	Course subject	1	2	4	2	2	3.20
(b)	Project subject	1	2	5	1	2	3.10
(c)	Graduation thesis subject	0	0	3	4	4	4.10
(d)	MS or Ph.D. thesis subject	0	2	2	2	5	3.90
(e)	Need by industry	0	1	2	3	5	4.10
3.	Expert (knowledge-based systems)						
(a)	Course subject	1	2	5	2	1	3.00
(b)	Project subject	1	2	4	2	2	3.20
(c)	Graduation thesis subject	0	2	0	7	2	3.82
(d)	MS or Ph.D. thesis subject	0	2	2	4	3	3.72
(e)	Need by industry	0	1	1	4	5	4.20

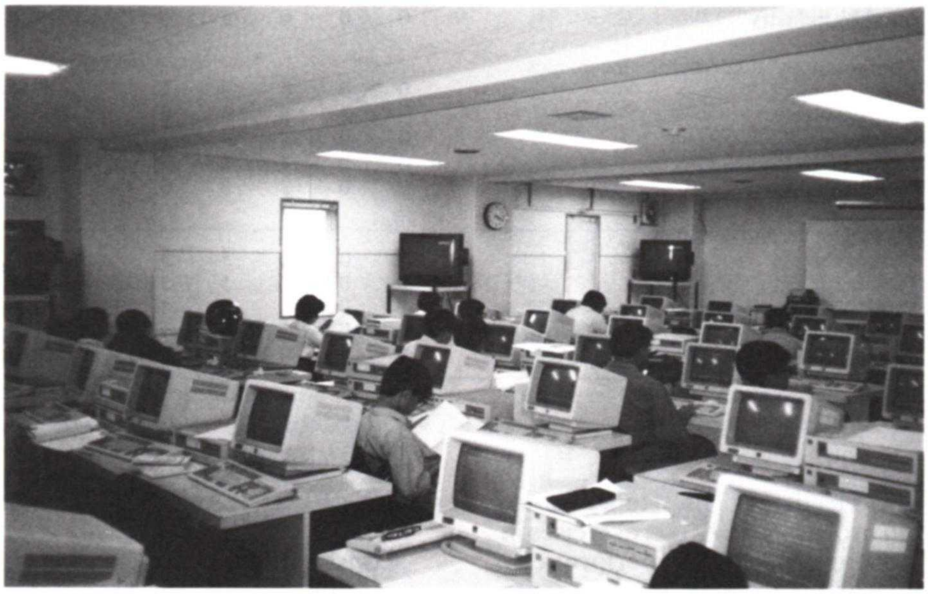

Fig. 2. Classroom in Education Center for Information Processing, Suitz Campus Center, University of Osaka.

lights (Fig. 4) is commonplace. This system allows the lecturer to present material directly from books, photographhbs or notes.

To understand the role of the educational center, it is useful to discuss the University Center for Information Processing at Kyoto University which was established in 1978. The principal roles of the center are:

- To operate a computer system and make it available for educational use.
- To promote research on educational methods in information processing.
- To give elementary courses on computer science and information-processing technology.

The center's central processing unit is a Hitachi M-680H which supports 130 Hitachi 2020 terminals in the center building and 170 satellite terminals located in other buildings and interconnected by a local area network (LAN). It is interesting to follow the center's educational activities during the period of 1984–89, which are summarized in

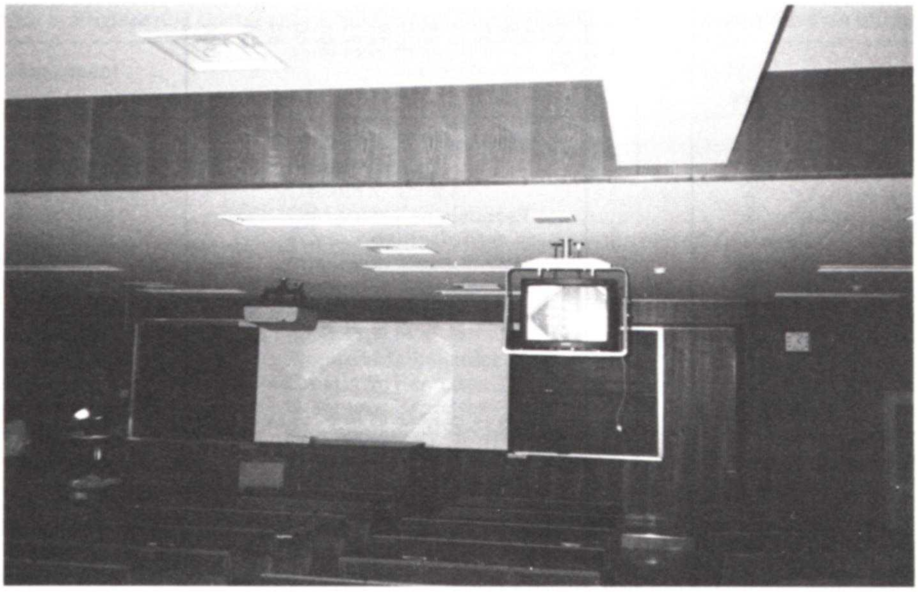

Fig. 3. Engineering lecture hall with overhead video monitor and projection system, Osaka University.

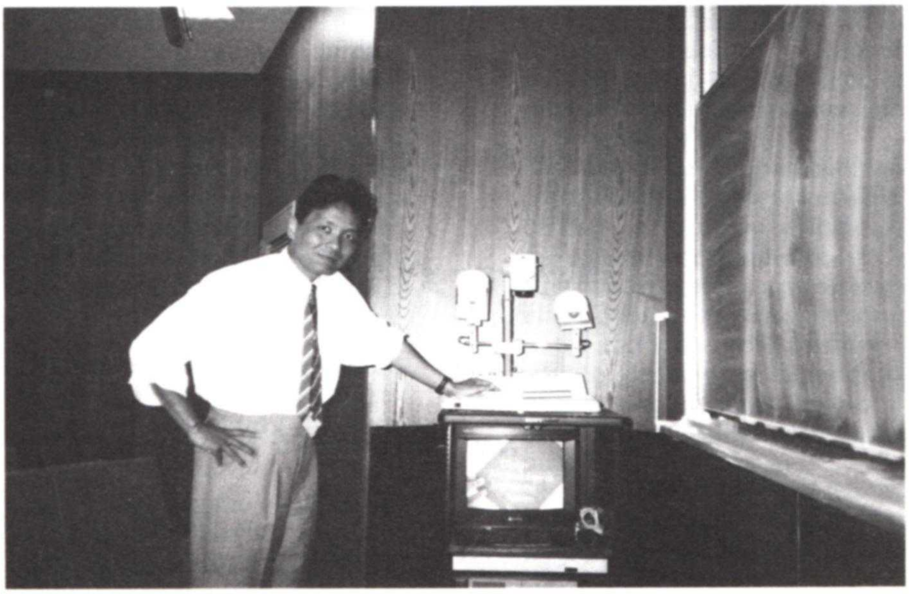

Fig. 4. Professor Asada, Osaka University, demonstrating the video projection system installed in the engineering lecture hall, Osaka University.

Tables 7 and 8. It is evident from these tables that engineering is the largest user with 30% of the classes and 35% of the students in 1989 [14]. The Education Center for Information Processing of Osaka University, established in 1981, is divided into two buildings on separate campuses. The IBM 3090-200 computer is located in the Toyonaka campus center with 168 IBM 5540/5550 terminals and 65 IBM 5540/5550 outside terminals. The Sulta campus center has 65 IBM 5540/5550 terminals with 30 IBM 5540/5550 terminals in the engineering building. These are all interconnected using a LAN to provide the user with access to a large software library and mainframe capability at each terminal [15]. These centers provide an effective use of campus resources for supporting computer-based educational activities.

DISCUSSIONS AND CONCLUSIONS

This paper has reviewed a number of developments in the use of computer and video in Japanese engineering education. Computers and

Table 7. Profile of use at Kyoto University Education Center for Information Processing [15]

Faculty	1984		1985		1986		1987		1988		1989	
	Class	Student	Class	Student	Class	Student	Class	Student	Class	Student	Class	Student
Engineering	27	1695	25	1529	25	1365	28	1560	31	1648	36	2113
Letters	0	0	0	0	0	0	0	0	0	0	0	0
Education	3	75	1	24	1	19	1	22	2	45	1	6
Law	1	81	1	68	0	0	1	75	1	41	2	72
Economics	2	152	2	526	2	650	6	904	10	764	6	737
Science	11	869	13	793	18	784	20	1074	17	494	22	845
Medicine	4	262	4	256	4	248	10	413	6	385	5	389
Pharm. Sci.	1	77	1	82	1	80	3	267	5	402	5	327
Agriculture	4	167	5	186	11	248	11	276	12	260	12	273
Liberal Arts	4	452	6	430	3	358	12	608	17	746	18	844
RI Math. Sci.	5	220	3	95	5	181	6	254	8	203	7	240
Med. Tech.	0	0	2	30	2	36	2	42	2	74	2	54
Educ. Center	1	82	1	64	1	105	1	91	1	44	3	184
Total	63	4132	64	4083	73	4074	101	5586	112	5106	119	6084

Table 8. Engineering classes at Kyoto University Education Center for Information Processing

	Department	Course	Level year	Students
1.	Sanitation	Sanitation Engineering	2	49
2.	Chemical Eng.	Process Design	4	40
3.	Chemical Eng.	Use of Computer	2	43
4.	Mech. Eng.	Computer Calculations I	3	155
5.	Mech. Eng.	Practice in Mech. Eng.	3	37
6.	Mech. Eng.	Practice in Mech. Eng. I	3	14
7.	Metallurgical Eng.	Computer Analysis in Mech. Eng.	3	85
8.	Architectural Eng.	Use of Computer	2	105
9.	Nuclear Eng.	Analysis	3	23
10.	Aeronautical	Applied Mathematics	4	27
11.	Industrial	Computer Exercises	2	64
12.	Civil Eng.	Computer Exercises	2	137
13.	Mech. Eng.	Programming Exercises	3	61
14.	Mech. Eng.	Modeling of Production Process	4	8
15.	Mathematical	Experiments in Analysis	3	49
16.	Eng. Physics	Molecular Analysis No. 2	4	46
17.	Petroleum	Physical Chemistry Exercises	2	71
18.	Electrical	Electronics 3B	4	17
19.	Electrical	Electronics 3A	4	15
20.	Electrical	Electronics 3A	4	1
21.	Electrical	Electronics Exercises	4	32

video have gained acceptance, and their use in educational activities is now beginning to increase. The first stage—involving the selection and installation of PC terminals and video in the engineering classrooms—has more or less been completed in the universities visited. The second stage of introducing computer/video instruction has been an ongoing activity. Interviews and survey responses indicated the feeling that video is a powerful educational tool. One respondent summed it up in his response:

> Video is useful in lectures, but I don't think computers have a great role in class lectures. CAI is used for students who study by themselves.

There is an ongoing change in the engineering curriculum to reflect the availability of advanced technology and video. I found the attitude summed up by, 'We need it and I do it', and 'We have to change curriculum for the change of technology every year.' In most cases a loose plan is being adopted; this reflects the limitation of experienced people, budget and, in some cases, space.

The survey and site visits involved a cross-section of Japanese engineering educators. The general impressions, interviews and survey responses provide the bases of the following conclusions:

1. There is a large ongoing effort in Japan to have students use computers in junior high school, high school and university education.
2. The limitation in student numbers in Japanese university admissions provides a basis for determining the number of computers/terminals to purchase. The use of video monitors enables relatively large classrooms with 35–50 PC units to benefit from CAI.
3. The use of LANs has been widely adopted in Japanese universities to enable CAI and the use of large subroutine/software libraries beyond the capacity of stand-alone PCs.
4. The majority of the professors interviewed have made classroom demonstrations using the computer and video with positive results. Development of courseware depends a great deal on the engineering subject. Table 8 illustrates the engineering courses presently using the computer.
5. The combined use of video and computer in a classroom is commonplace. The Japanese have a very effective video projection system which could easily be adopted in U.S. classrooms.

These developments are ongoing and will ultimately lead to a new style of engineering education. For those outside Japan, it is useful to follow these developments in order to achieve a more effective engineering education in the coming decades.

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