Tokyo Tech Graduate Program Allied with Thailand

TAIST (Thailand Advance Institute of Science and Technology) - Tokyo Tech

Akinori Nishihara
The Center for Research and Development of Educational Technology
Tokyo Institute of Technology
Tokyo Japan
aki@cradle.titech.ac.jp

Abstract—**Tokyo Institute of Technology has been active in academic collaboration with Asian countries, and we opened our overseas offices in Bangkok, Manila, and Beijing, in 2002, 2005, and 2006, respectively. International distance education has also been conducted since 2002. Backed up with those experiences, in 2007 we started a new graduate program allied with National Science and Technology Development Agency (NSTDA) and Thai universities. The program is called Thailand Advance Institute of Science and Technology (TAIST) - Tokyo Tech. TAIST will serve as a virtual institution and focal point. NSTDA provides researchers to act as adjunct professors, research projects and scholarships for graduate students. Thai universities provide an academic framework, academic staff to oversee and guide students and degrees for the successful candidates. Currently two master programs are running; Automotive Engineering (AE) and Information and Communication Technology for Embedded Systems (ICTES). Tokyo Tech is responsible for most of its coursework. To get rid of long travel between Tokyo and Bangkok (separated by 4,600km), distance education is effectively utilized. In the ICTES program, 7 lecture courses out of 18 are entirely taught from Tokyo, and some others combine distance education. All the course materials are uploaded on the e-learning site, where lecture videos are also available for some courses. TAIST-Tokyo Tech is expected to initiate the start of a positive spiral of human resource development system in Asian region. TAIST-Tokyo Tech aims to harmonize advanced technology with the environment and to realize research and human resource development for global sustainable development. Operations of this graduate program and distance education activities are introduced.**

Keywords- Allied graduate school; distance education; international collaboration

I. INTRODUCTION

Information and communication technology can suitably be used to overcome not only physical distance but also mental distance between learners and teachers as well as among learners. Tokyo Institute of Technology (Tokyo Tech) installed Academic Network for Distance Education by Satellite (ANDES) system in 1996, and utilized it for various kinds of distance education programs; university - high school collaboration, lecture exchange with Hitotsubashi University, lecture distribution to workplace engineers, and international distance education. In some parts on the globe, internet is not yet developed well, and satellite communication is important. On the other hand, in many other places (especially in big cities) broad-band internet connection is well established and even high-definition video communication is possible. Internet environment is considered to gradually develop and distance education will become easier to conduct from the viewpoint of communication channel.

II. TOKYO INSTITUTE OF TECHNOLOGY

Tokyo Tech is ranked No. 55 in the Times Higher Education-QS World University Rankings 2009 (No. 19 in engineering and information technology).

Among about 10,000 graduate and undergraduate students, there are 1,100 foreign students. This ratio of foreign students is one of the highest in Japanese universities.

Tokyo Tech started International Graduate Program in 1993, in which students can take entrance examinations and lectures in English. Students are enrolled in October, unlike regular enrollment in April. Currently, a choice of seven curricular programs in which students can obtain a master's or doctoral degrees in English is provided in the International Graduate Program. More than 100 courses are currently taught in English. The program now makes it possible for qualified students with little or no knowledge of Japanese language to pursue a full degree-course of advanced study in this country. The provision of such a program not only eliminates the previous language requirement but also, thereby, significantly shortens the period of study. It can thus be said that the program provides qualified overseas students with another option for admission to graduate schools. Since lectures and seminars are given in English, it is no longer essential to master the Japanese language. However, since Japanese is the language of daily life, students in the program are encouraged to attend a few Japanese classes per week on a regular basis for further enrichment.

Tokyo Tech Open Course Ware (Tokyo Tech OCW) [1] is a platform maintained by Tokyo Tech for providing free access to course materials for users around the world aiming at releasing the Tokyo Tech's high-level educational resources on science and technology as the world's public property. Tokyo Tech OCW is one of the core material of the web- based electronic knowledge system. Starting in May 2005, Tokyo Tech OCW covers all of 1,910 undergraduate and 1,581 graduate courses, for which course outlines are shown. Lecture materials are shown for more than 551 courses at this moment, and we will cover almost all the courses in the future. This number of 551 courses is more than half of the total lecture

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materials released by Japanese OCW Consortium consisting of major Japanese universities in cooperation with Massachusetts Institute of Technology. Tokyo Tech OCW pages get more than 6,000 hits per day, which is about 20% of the whole accesses to Tokyo Tech web pages.

III. DISTANCE EDUCATION AT TOKYO TECH

The Center for Research and Development of Educational Technology (CRADLE), established in 1973, set up the ANDES system in 1996, for the use in lecture deliveries via commercial communication satellite. The ANDES system has been used for lecture exchange with Hitotsubashi University, famous national university in social science, open lecture delivery to workplace engineers, and high-School university collaboration in which undergraduate lecture courses are transmitted to high-school students all over in Japan who are interested in science and technology. Since 2002 some of the courses taught in English in the International Graduate Program are transmitted to Thailand using ANDES system [2]. We use 3Mbps or 6Mbps MPEG2-DVB for video transmission. The lectures were received by NSTDA, Asian Institute of Technology (AIT), and King Mongkut's Institute of Technology Ladkrabang (KMITL). The courses to be transmitted are chosen by the request from the Thai side and willingness of lecturers. All the courses had been taught in English and not much load is added to the lecturers. Lecturers are requested to put their lecture notes on the Tokyo Tech OCW (or send them to the students) in advance of the lecture. Since 2006 we use a Japan-Thailand link of Japan Gigabit Network 2 (JGN2, and it is JGN2plus since 2008), an open testbed network environment for research and development, which is operated by National Institute of Information and Communications Technology (NICT) [3]. JGN2 is an ultra-high-speed testbed networks for research and development collaboration among industry, academia, and the government with the aim of promoting a broad spectrum of research and development projects, ranging from fundamental core research and development to advanced experimental testing, in areas including the advancement of network-related technologies for the next generation and diverse range of network application technologies. We mainly use H.323 audio-visual communication sessions with about 500 kbps, but we are testing the use of high-definition (1920x1080) video transmission [4].

To manage the international distance education and research collaboration, Tokyo Tech Office (Thailand) was established in 2002 in the NSTDA building in the Thailand Science Park (TSP). In 2005 Tokyo Tech Office (Philippines) opened at De La Salle University, Manila, and Tokyo Tech Office (China) opened at Tsinghua University in Beijing in 2006. Those offices act as communication hubs for people in those areas. Through these offices remote students are taken care of. The Offices also handle research partnerships and information about studying at Tokyo Tech, and offer guidance for academic-industrial collaboration.

IV. TAIST TOKYO TECH

Based on those experiences and MOU with NSTDA, we established a new graduate program named TAIST. TAIST is based on the idea of collaboration among Tokyo Tech, NSTDA and partner universities to develop the human resources. TAIST will serve as a virtual institution and focal point. NSTDA provides researchers to act as adjunct professors, research projects and scholarships for graduate students. Tokyo Tech provides world class background, expertise and experience, academic instruction and research advice. Thai universities provide academic framework, academic staff to oversee and guide students, and degrees for the successful candidates. The viability of the idea is nicely demonstrated by the creation of TAIST Tokyo Tech.

The main objective of TAIST Tokyo Tech is to establish an institution for human resource development to foster and support world-class researchers and high-level engineers through a combination of advising from Tokyo Tech professors, excellent facilities and research staff in NSTDA, and established resources of Thai universities. The participating Thai universities are KMITL, Sirindhorn International Institute of Technology (SIIT), Kasetsart University (KU), and King Mongkut's University of Technology Thonburi (KMUTT).

NSTDA is an agency under the Ministry of Science and Technology and supports research in science and technology and their application in Thai economy. It promotes innovation and research activities in Thailand. Its mission is research and development to strengthen Thailand's sustainable competitiveness, complemented by technology transfer and the development of human resources and science and technology infrastructure, with outcomes that have positive impacts on society and the economy. It is affiliated by 4 research centers;

- National Center for Genetic Engineering and Biotechnology (BIOTEC)
- National Metal and Materials Technology Center (MTEC)
- National Nanotechnology Center (NANOTEC)
- National Electronics and Computer Technology Center (NECTEC)

NSTDA and those 4 research centers are located in the TSP about 40km north of central Bangkok. The TSP is the country's leading integrated R&D hub which came into operation in 2002. The TSP is also located close to three of Thailand's leading universities; AIT, SIIT, and Thammasat University. Tokyo Tech Office (Thailand) is a tenant of TSP.

NSTDA prepares TAIST classrooms in the TSP with distance education equipment and internet infrastructure. It also lends a notebook PC to each of TAIST students.

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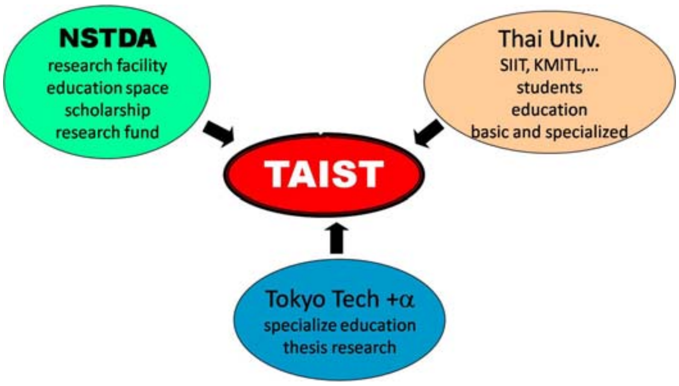

Figure 1. Concept of TAIST Tokyo Tech

The TAIST Tokyo Tech project aim to attain world top level performance by mobilization of whole institutional resources based on long history of education and research of participating institutions. Tokyo Tech and TAIST Tokyo Tech share the same philosophy of education and research - "human resource development by promoting cutting-edge research activities".

It is expected that TAIST Tokyo Tech will initiate the start of a positive spiral of human resource development system in Asian region. TAIST Tokyo Tech aims to harmonize advanced technology with the environment and to realize research and human resource development for global sustainable development. Looking back at the history of modernization through industrial development, factors such as global warming, unusual weather and the pollution of air, water and soil indicate that there is a real risk of serious destruction of nature and life in the near future. It is urgent for us to recognize this paradigm shift in science and technology and concentrate our effort and intelligence on technologies which are in harmony with the environment. In Thailand, development and industrialization have been so drastic, compared with developed countries, that problems derived from these factors are much more serious as they become obvious. In light of such a situation, expanding research and education to harmonize advanced technology with the environment effectively and efficiently will be quite necessary and the outcome of such effort will be valuable for Thailand, as well as other countries of the world.

All first year students receive full scholarships for tuitions and fees. In the second year, researches for dissertations will be carried out mainly in NSTDA various laboratories with NSTDA researchers acting as supervisors or co- supervisors. The second year students are expected to receive scholarships for tuitions and fees from research projects of their supervisors. Professors from Tokyo Tech will actively participate in the educational process of the students throughout each program. After a successful completion of both course work and thesis, the students receive degrees from the host universities and certificates from Tokyo Tech. These programs are:

1. Master's Degree Program in Automotive Engineering. The program started accepting the first group of students in the Academic Year 2007. The host universities are KMITL and KMUTT, and the host institute at NSTDA is MTEC.

2. Master's Degree Program in Information and Communication Technology for Embedded Systems (ICTES). The program started accepting students in the Academic Year 2008. The host universities are SIIT and KU, and the host institute at NSTDA is NECTEC.

3. Master's Degree Program in Environmental Engineering. The program is expected to start in the Academic Year 2010.

4. Master's Degree Program in Biotechnology is now under discussion for its start.

Each program accepts 30 students every year. TAIST students are not restricted to Thais. In fact there are students from neighboring countries in AE program, and we hope more students will come to TAIST programs from various countries.

V. TAIST ICTES PROGRAM

The goal of the TAIST program in ICTES is to prepare students with comprehensive understanding of the hardware and software technologies in ICTES, with in-depth knowledge of embedded systems in VLSI designs and embedded software development, as well as broad knowledge of their applications in communications, networking, signal processing, human interface, artificial intelligence, etc. Students also experience actual development of embedded systems using the state-of-the-art Computer Aided Design (CAD) tools for both hardware VLSI (Very Large Scale Integration) and software in "Embedded Systems Design Exercise Class". Here, students work in teams to also learn about project management, product planning and marketing aspects of the embedded systems development. Master of Engineering. program in ICTES welcomes full-time students as well as part-time students from the industry, both of which will greatly benefit from the unique learning environment which this program is designed to provide. Furthermore, the graduates of this program can further pursue a doctoral study at Thai universities or at Tokyo Tech. ICT (Information and Communication Technology) is the fastest growing sector in the economy with a 70% increase in growth rate projected between 2002 and 2012. However, there is an enormous shortage of ICTES engineers, especially in the area of embedded systems, and this trend will continue to grow with the coming of the "ubiquitous society" in a global scale. The Master of Engineering program in Information and Communication Technology, therefore, has been established to offer an outstanding and state-of-the-art education in both theoretical and practical areas in ICTES with a strong focus on embedded systems. It is expected that all Thai graduates of the Master of Engineering Program in ICTES acquire the necessary skills to be the leaders in Thailand's electronics industry, and also to be highly competitive in the fast-growing global embedded systems market.

TAIST ICTES program has the courses shown in Tables 1 and 2.

TABLE I. REQUIRED COURSES

Computational Mathematics Set theory; Relations; Formal proof methods; Finite automata; Regular expressions; Context-free grammar; Pushdown automata; First order logic; Theories related to counting, graphs and networks; Interplay between continuous models and their solution via discrete processes; Vector spaces, basis, dimension, eigenvalue problems, diagonalization, inner products, unitary matrices; Introduction to applied statistics and its application to intelligent systems; Introduction to supervised statistical learning including discrimination methods
Software for Embedded Systems Software programming; Embedded operating systems and middle-wares; Verification and testing for Embedded Systems; Software issues in the design of embedded systems; Microcontroller architectures and peripherals; Compilers and debuggers; Timer and interrupt systems; Interfacing of devices; Software issues in communications and networking.
Hardware for Embedded Systems Basic digital system design; Processor architecture design; Very Large Scale Integration (VLSI) design methodologies; Hardware concepts on microcontroller architectures and peripherals; Device interface; Hardware for communications and networking
Software Design Exercise for Embedded Systems Hardware and software development tools; software project management techniques and tools; Embedded operating systems; Software development project: requirement analysis, software detailed and test case design, software coding and testing, software documentation; Project planning; System specification design; Software coding; Software implementation and verification on Field-Programmable Gate Array (FPGA) prototype board.
Hardware Design Exercise for Embedded Systems Hardware development tools; Hardware Description Language (HDL); Field-Programmable Gate Array (FPGA) design flow: input and output pin assignment, synchronous and asynchronous logic design, logic simulation and optimization, verification of design constraints; Custom hardware development project; Software and Hardware implementation and verification on FPGA prototype board; Practical issues on microcontroller and FPGA.
Research Methods in Information and Communication Technology for Embedded Systems Research principles and methods in information and Communication Technology for embedded systems problem analysis for research topic identification, data collecting for research planning, identification of samples and techniques, research analysis, result explanation and discussion, report writing, presentation and preparation for journal publication.
Seminar in Information and Communication Technology for Embedded Systems Presentation and discussion on current interesting topics in information and Communication Technology for embedded systems at the master degree level.

TABLE II. ELECTIVE COURSES

Communication Information theory; Signal processing; Communication systems; Data and digital communication concepts; Theory and techniques in data communications: transmission, encoding, decoding, error detection, error correction, link control, networking, and standards; Communication hardware and software; Synchronization subsystems; Time-division multiple-access systems; Code-division multiple-access systems.
Signal Processing Digital signal processing theory; Video and audio processing; Discrete-time signals and systems; Linear time-invariant systems; Sampling of continuous-time signals and convolution; Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) filter designs; Discrete Fourier transform; Fast Fourier transform algorithms; Relations between Fourier Transform (FT), Discrete-frequency Fourier Transform (DFFT), Fourier series Discrete-time Fourier Transform (DTFT), and Discrete Fourier Transform (DFT); Speech analysis; Speech recognition; Speech sysnthesis; Vector quantization (VQ) techniques; Hidden Markov model (HMM); Speech and audio coding; Noise reduction; Morphological analysis; Formal language; Parsing; Spoken language human interface; Image transformation and filtering, image segmentation, image object detection, High-efficiency video coding fundamentals, video coding standards, processing requirements, architecture for the DCT, hardware for motion compensation, nonstandard coding techniques, perspective on the "ke-tai"(mobile phone) service, network human interface
Intelligence Processing Human interface; Human information processing; Artificial intelligence; Concept and design of human-machine interface; Trends of human interface design; Graphic user interface, interactive software design; Hardware technology for human interface; Foundations of human visual and auditory systems; Information processing of the perceptual systems; Color vision, Space perception; Auditory and visual scene analysis; Current research and application of artificial intelligence; Artificial intelligence languages; Search techniques; Knowledge representation, reasoning and inference; Machine learning; Expert systems.
Environment and Control Systems Control system theory; Laplace transform; Control system description and block diagrams; Dynamics of typical controlled systems; Development and simplification of transfer functions; Analytic tools for predicting system response and performance; Geographic Information Systems(GIS) for environment control; spatio-temporal database, fusion of embedded systems and distributed intelligent systems, remote-sensing techniques for environment control; Disaster Control Systems; Spatio-temporal GIS for disaster prevention, map-embedded information processing systems for local government,

mitigation of earthquake disaster, tsunami disaster, Car navigation systems; data structure for car-navigation, map-data utilities; Environment control systems, Power management systems and methods
Selected Topics in Information and Communication Technology for Embedded Systems Selected topics in information and Communication Technology for embedded systems at the master degree level. Topics are subject to change each semester.

In addition to taking courses, all the students are required to perform research and write their master theses.

Thesis

- Each student is assigned to a laboratory in NASDA in the second semester.
- In the thesis project (2nd year) the students perform research under the supervision of Thai University staff (*advisors*), NSTDA staff (*co- advisors*) and Tokyo Tech staff (*co- advisors*). Advisors and co-advisors compose a thesis committee.
- The students receive credits for the thesis project.
- The project is conducted at NSTDA laboratories.
- In order to prepare for the thesis project and get an overview of ongoing research, students attend the master seminar and a course on selected topics in embedded systems. After choosing a topic for a thesis project, but before actually starting the research, a student writes a thesis proposal containing a problem statement for the proposed research, positioning of the research with respect to other research, an overview of the literature in the field, and a planning for the project. The proposal should be accepted by the thesis committee before the project can start.

Figure 2. Distance Education Control Room

- The students perform the research according to the plan in the thesis proposal and write theses about the result.
- The project is finished with a defense of the thesis in front of the thesis committee.

V. DISTANCE EDUCATION FOR TAIST ICTES PROGRAM

TAIST ICTES lecture courses are taught by a team of Tokyo Tech professor as a main lecturer and a Thai faculty member as a co-lecturer. Co-lecturers supplement the course taught by main lecturers and undertake exercises. In 2008 among 18 courses 7 were 1-week intensive face-to-face lectures given by Tokyo Tech professors who traveled to Bangkok, 7 courses were completely delivered from Ookayama campus in Tokyo or Suzukakedai campus in Yokohama of Tokyo Tech, and the rest were combination of face-to-face and distance education.

We use H.323 video conference system with about 500kbps. Fig. 2 shows a control room attached to a distance education classroom. There are 4 video cameras and 2 video projectors in this classroom. A lecturer can give a lecture by showing a computer screen or by writing on a blackboard. He can see students in the remote site behind local students (if any) sitting in front of him.

Since most of Tokyo Tech professors are not accustomed in conducting distance education, CRADLE distributed a one-page instruction entitled “Notes on Distance Education”, which had been used in conducting distance education. In addition, we had a training session entitled “How to Conduct TAIST ICTES Distance Education”, which includes operation of communication equipment, usage of tools, and educational methods. A Teaching Assistant (TA) is assigned to each lecture course, and he/ she helps the lecturer by assisting the preparation of lecture materials, connection with the remote site, and controlling the cameras. Lecture materials and other information for students are put on a special TAIST ICTES site named ELITE (E-Learning for Information Technology Education) operated using a hosting service of Tokyo Tech TSUBAME super computer.

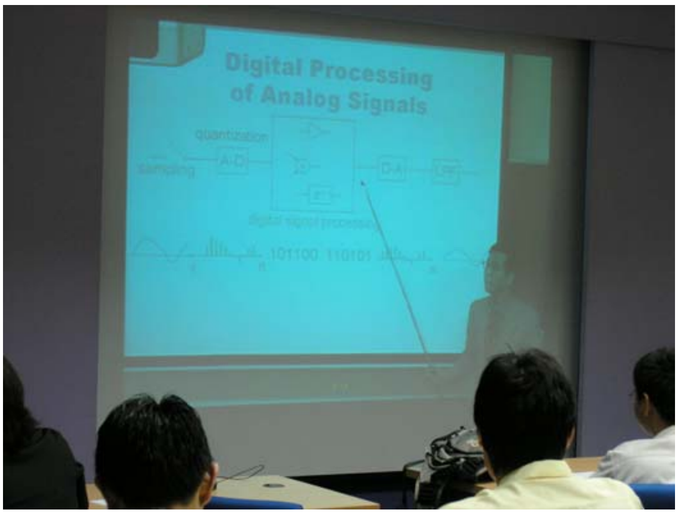

Figure 3. Lecture Transmitted from Tokyo

Figure 4. TAIST ICTES Classroom

For some TAIST ICTES courses, lectures are recorded and the videos are put on the ELITE site together with the lecture materials as shown in Fig. 5, so that students can review the courses afterward.

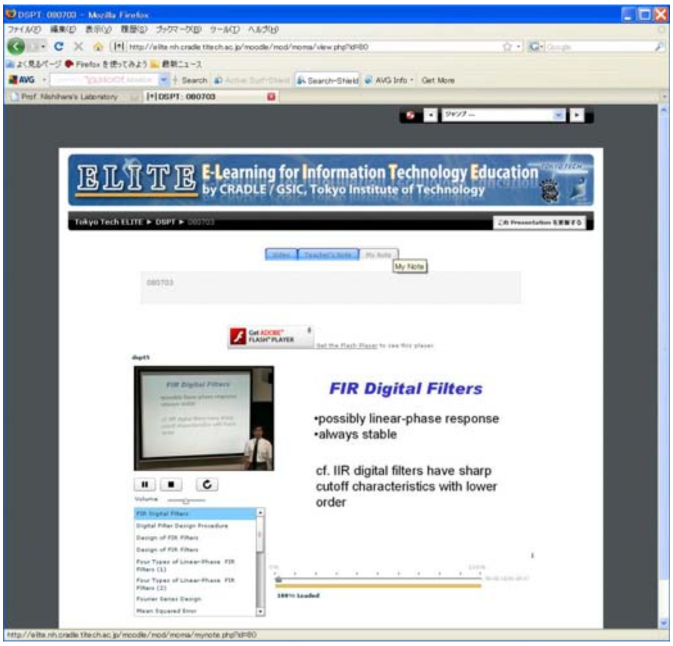

Figure 5. ELITE Site

In the thesis projects, second year students have to make presentations for thesis proposal, progress report, and final defense. We use video conference systems for such occasions.

After finishing the first academic year, we compared the grades of the 26 first-batch students. Except for some students who did not take some elective courses, we compared grades of 7 distance education and 7 face-to-face courses for each of 21 students, and we found no significant differences. This is probably because the number of courses in each style and the total number of courses per student are too small. So we compared the grades of all the students in the lump. The results are shown in Fig. 6, where face-to-face courses have higher grades with 99% significance. As seen in the figure, the course "4.1 Digital Signal Processing Theory" has the lowest score among all the courses, and the course "5.2 Human Information Processing" has the second lowest score. The courses 4.1 and 5.2 are difficult subjects from the lecturer point of view, and the lecturer of 4.1 is probably too strict in grading. If we exclude the course 4.1, there is no significant difference between distance education and face-to-face courses.

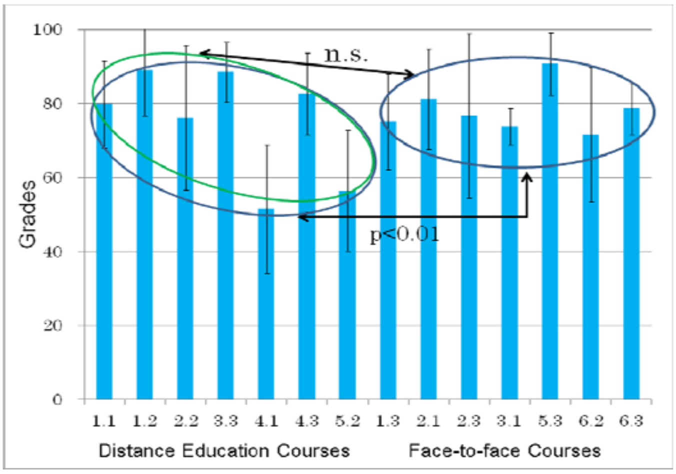

Figure 6. Comparison of Grades

The grades have 99% significant correlations between the following 4 pairs;

- "1.1 Algorithm and Software Design" and "2.2 Processor Architecture Design",
- "1.1 Algorithm and Software Design" and "2.3 VLSI Design Methodology",
- "1.2 Embedded Software Design Techniques" and "2.1 Basic Digital System Design", and
- "1.2 Embedded Software Design Techniques" and "2.3 VLSI Design Methodology".

Those courses cover fundamentals of hardware and software, and so it is considered to be natural that there are correlations among those courses. Other pairs of courses that have correlations with marginal significance are as follows;

- "1.1 Algorithm and Software Design" and "5.2 Human Information Processing",
- "1.1 Algorithm and Software Design" and "2.1 Basic Digital System Design",
- "1.2 Embedded Software Design Techniques" and "2.2 Processor Architecture Design",
- "2.2 Processor Architecture Design" and "1.3 Real Time System Design",
- "2.2 Processor Architecture Design" and "2.1 Basic Digital System Design",
- "2.1 Basic Digital System Design" and "2.3 VLSI Design Methodology", and
- "2.3 VLSI Design Methodology" and "6.2 Environment Control System".

The following one pair;

· "2.2 Processor Architecture Design" (distance education) and "3.1 Information and Coding Theory" (face-to-face education)

has negative correlation coefficient of -0.965 with 95% significance. They are, of course, rather different, but there may be other reasons. Investigation will be continued for the following years.

ELITE site is also used as a student evaluation system using 4 Lickert scale questionnaires. Some of the results are shown in Fig.7. Sense of achievement for distance education is higher than that of face-to-face education with marginal significance. This is probably because students felt more sense of achievement after overcoming the unusual situations of distance education. Other items of questionnaires have no significant differences between distance and face-to-face education. We believe that those facts justify the use of distance education. It is to be noted, however, that those result from much effort of lecturers and co-lecturers.

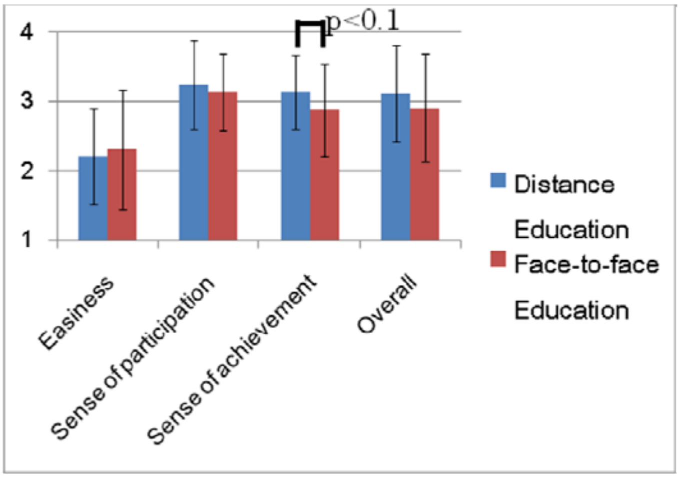

Figure 7. Comparison of Questionnaire Results

For the course "4.1 Digital Signal Processing Theory", questionnaire results are summarized in Table 3. The results are generally favorable, but improvement is necessary for picture quality, sense of participation, and sense of achievement. The score is not so good for the question to compare the course with face-to-face lecture. It is 2.5, just a median of 1 and 4. So we believe we are doing well.

To improve the picture quality, we are seeking for the use of high-definition video in which lecturer's facial expressions are easily seen [5], and lecturer can much more clearly see the students. The key for that is whether we can secure enough bandwidth, which is still a big problem because internet is usually a best-effort network.

TABLE III. QUESTIONNAIRE RESULTS

Question	1	Average	4
Interest u	ninteresting	3.5	interesting
Easiness di	fficult	1.9	easy
Lecturer's face	Unseen	3.5	seen
Moving picture	Bad	2.9	good
Lecturer's voice	unclear	3.7	clear
TA's help	useless	3.8	useful
Exercise format	Bad	3.5	good
Sense of participation	not felt	3.2	felt
Sense of achievement	not felt	3.2	felt
Compared to f2f	Bad	2.5	good
Overall Bad		3.0	Good

VI. CONCLUSIONS

New joint graduate program operated by Tokyo Tech, NSTDA, and Thai universities is introduced, where distance education is well utilized. The roles of co-lecturers are very important to have good educational effects, if not comparable to face-to-face courses. The program has just started, and continuous improvement is necessary in educational systems, technical supports, and collaboration framework. Joint degree system will be much more attractive for many students, and we are studying its feasibility.

ACKNOWLEDGMENT

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