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The Integrated e-Learning System and its Practice

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Abstract This paper presents a web-based distance education system that contains synchronous (live) video lectures, asynchronous learning materials with video-on-demand (VOD) archive data, and question & answer functions through digital reporting between a lecturer and students. It is intended to provide a collaborative workplace to encourage interactions among a lecturer/learners. As such, this environment enables learners to exchange their knowledge and their way of thinking, furthermore, to refine/build the knowledge acquired via lectures. One of the main purposes in our research is to build a flexible e-Learning environment by embedding self/collaborative support functions for the digitized live lectures in order to reinforce much more meaningful knowledge and skills. Moreover, we propose an innovative educational method of a cooperative link between a university and an industry for the higher education.

The Industry and University cooperation program is a project of the Japanese Ministry of Education (Mombusho). The target objective of this program is the harmonization of university level educational research, society practice and practical business. The University of Electro- Communications has been appointed by Mombusho to fulfill some specific parts of this program. In this paper we report about our experiences with the introducing of this program, about the framework, settings, actual implementation and first results. We analyze these results and the problems we encountered, as well as offer constructive solutions.

Keyword e-Learning, Learning Technology, Learning Management System, Industry and University cooperation program.

1. Introduction

The Industry and University cooperation program is a project of the Japanese Ministry of Education (Mombusho[2]). The objective of this program is not only the completion of an environment where upstanding members of the society with business, industry or university background can learn, but also to the connection and harmonization of university educational research and society practice and practical business. Specifically, the program aims at offering the university student access to the practical, business point of view and practical knowledge on one hand, and the industry and company employee an opportunity to improve oneself and an access to higher knowledge and education[4]. In this way, we are promoting an educational collaboration program that binds university and industry[8].

The goal of the educational program we present is not the building of a large-scale novel curriculum, but the expanding and enrichment of the preexisting curriculum at the graduate school level, by adding company employees' and professional knowledge, and with the specific target of enabling practical, efficient re-training and re-education.

The Japanese Ministry of Education appointed the University of Electro-Communications (UEC) with the enacting of this cooperation program between Industry and University. The target learners are industry students as well as regular students of the university graduate courses, who wish to learn about the new Information Technology (IT) issues. The emphasis lies especially on advanced IT topics. The actual putting into practice involves the extension of the existing curriculum towards more flexibility, in contents as well as in form, in order to allow learning conditions for industry persons as well[5,6]. The implementation method is via long-distance Internet courses, which allow business and industry people to take courses from far sites, without leaving their working places. Moreover, the Internet method allows for flexible hours. Other three universities were appointed to start parallel projects in complementary

fields.

In this paper we report about our experiences with the introducing of this program, about the framework, settings, actual implementation and first results. We analyze these results and the problems we encountered, as well as offer constructive solutions.

2. The Program

The subject of career development involving acquiring of high experience and knowledge in the field of information communication technology is an important subject for the future information communication society. The starting courses of the program involve this discipline. The lectures were focused on high information technology, large-scale information system planning and application, and network technology.

For the first year period, the courses involved the following topics:

Multimedia Communication Technology
Information Security

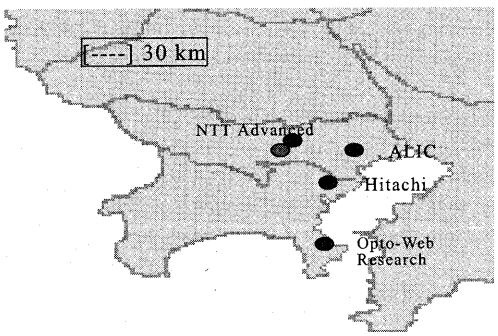

Figure 1. Distribution of distant company sites

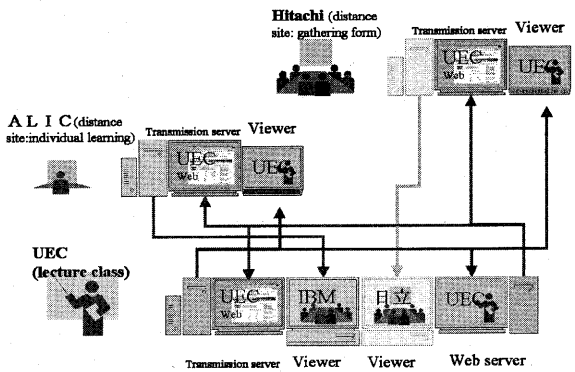

Figure 2. Distance learning system configuration

Moreover, the appointed lecturers for the industry and university cooperation program are not only researchers and professors from our graduate school, but also company researchers and implementers as well. This is due to the fact that it is important for students to acquire knowledge about not only the theoretical side related to information systems, but also about the practical side.

The lectures are held as collaborative lectures of the type called "omnibus" (each lecturer presents only one lecture). Although this new curriculum is of a flexible nature, with many evening hours (to ensure easy participation from far sites) and a relatively concentrated information contents given over a short time period (again, to ensure that company workers loose not too many hours with this program), the UEC graduate school has established a regular credit system for certification purposes. The level of certification is Master level.

3. Experimental situation

Here we report an example situation of a lecture entitled "multimedia communication science/ technology and application". The syllabus of this lecture includes: multimedia and distributed cooperation, CSCL (collaborative system collaborative learning) and collaborative memory, multimedia communication technology, ATM networks, new Internet technology, media representation form and application, data mining, multimedia and distributed cooperation learning support systems, knowledge management, standardization and new business models. The total number of learners attending the lecture was 63, among who only 13 were curriculum students. This time, the distance company sites that cooperated were located near Tokyo, in Kanagawa prefecture. The distance companies were linked via Internet and ISDN circuit, therefore establishing a real time bi-directional information transmitting & receiving environment (details in the next section). Figure 1 displays the geographical distribution of the distance company sites.

From the distance company sites to the University of Electro-Communications, the needed round trip time of the closest site is of 2 hours by public transportation, and for the furthermost the round trip is of about 6 hours. Therefore, considering the hours of time saved and the convenience of the distance education method, the system presents evident merit for both learners from far company sites as well as company managers.

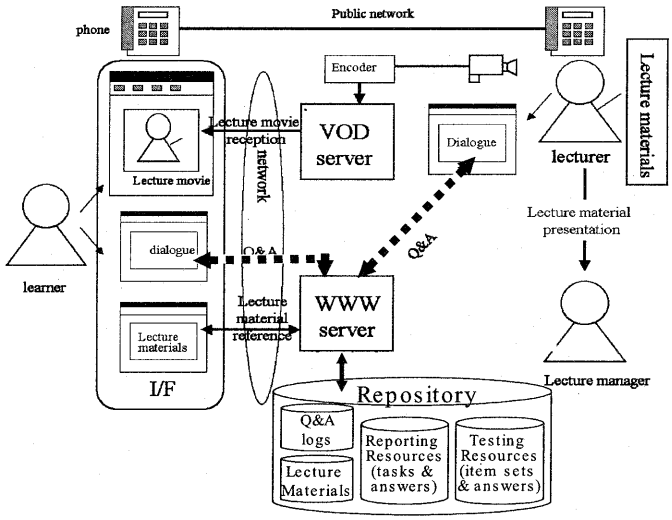

Figure 3. Hybrid e-Learning environment system

4. Distance education system configuration

It is necessary to provide a lecture environment that guarantees both the lecture movie, sound and lecture materials presentation distribution for attending students, as well as a dialogue function supporting the communication between lecturer and students. We have implemented these functions by using a VOD (Video On Demand)[3,7] server and a WWW (World Wide Web) server. Figure 2 shows the system configuration of the distance learning system.

Each site has to configure the transmission server and the viewer.

Each distance lecture site establishes two dedicated channels: one for receiving only and one for sending only. By connecting respectively the lecture classroom transmission with the distance site reception and the distance site transmission with the lecture classroom reception, bi-directional communication is implemented. Below, each function is outlined.

1) Transmission function of lecture's movie and sound : the movie and sound of the lecture is distributed to the attending sites with the help of the VOD server real time transmission function[10]. Moreover, in the case of some companies, their Internet access and therefore, the transmission/ reception of lecture movie and sound is not free. To cope with such a network environment, we had to ensure a dedicated Proxy server that relays the distribution of lecture movie and sound between Internet sites, to ensure the data reception. Students at far sites attend lectures by viewing the lecture movie and sound data distributed by the VOD server.

2) Lecture material presentation function : the lecture materials are formatted as HTML (Hyper Text Markup Language) sources and offered to students via the WWW server. Students use the WWW browser to access the lecture materials and to follow the lecture progress by referring the appropriate page.

3) Dialogue (chat) function : the communication tool between lecturer and student: Is ensured by a CGI (Common Gateway Interface) program written in Perl (Practical Extraction and Report Language). Lecturer and students access the CGI program via the WWW browser

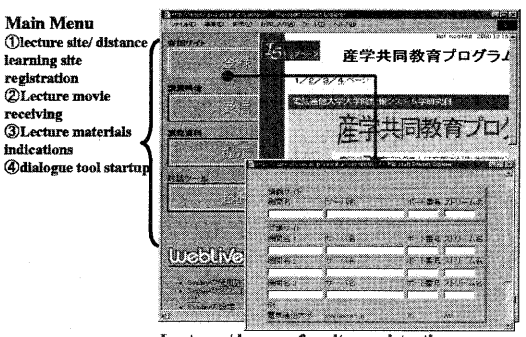

Figure 4. Lecture / distance learner site registration

and perform a questions and answers session via the chat terminal screen.

One problem appearing is that the lecture movie and sound data sending and reception conditions depend on the network traffic conditions. Namely, if the reception data has a delay, far site students have difficulty in viewing the lecture, therefore failing to understand the lecture contents. Therefore we have setup a bi-directional communication channel between lecture site and far sites. In this way the communication channel between lecturer and students is guaranteed, independent of the Internet network conditions. Figure 3 shows the distance lecture environment structure (lecture site -> far sites) as well as the interface of both lecturer and students. As can be seen in the figure, the lecture manager transforms the lecture materials into HTML form and performs the registration into the lecture materials database.

Figure 4 displays the main menu lecture site and attending sites registration window. Concretely, data recorded are machine name (organization name), VOD server IP address and port number and VOD contents stream identifier. Students attend lectures (Figure 4) via our distance lecture environment interface. Firstly, they select the lecture movie "reception" button from the main menu. The system than enquires for the movie to display.

4.1. The Environment for distributed e-Learning Contents

We have developed Web-based learning materials "Multimedia Communication Technology" by HTML, PERL, CGI, Java and VOD materials by Stream Authorware tool. The VOD materials consist of the archive data of movies / sounds from the live lectures in remote areas. According to the stream of movies, PowerPoint manuscript for each lecture is inserted with a synchronous signal in an appropriate position. This environment has three pull-down menus (i.e., a learning objective, a learning mode, and a contents-catalog) to enable learners to select and retrieve whatever they need. This distributing function has been implemented in our original Learning Management System (LMS) named RAPSODY [9].

4.2. The Collaborative Workplace for Question & Answer

We built a collaborative workplace to encourage interactions among a lecturer/learners. In such a case, learners can exchange their knowledge and their way of thinking, furthermore they can refine/build the knowledge acquired via lectures. By a collaborative workplace, we mean a kind of BBS, nevertheless, in addition to Chat function, this workplace enables data/information sharing transmitted from different sites. Figure 5 shows the configuration of relationships between the personal workplace and collaborative one.

4.3. The Assessment Module for Learners

After lecture/web-learning, a test or reporting for learners as a summative evaluation is needed. In this environment, we have provided the repository of a set of test items and reporting tasks according to subjects (course-unit) matched with each learning objective. Students can pick up certain amount of test items or reporting tasks designated by a lecturer, and then reply/send back their answers to the digital pigeon box. As such, a lecturer can score and evaluate their achievements online. The simultaneous test is carried out in order to avoid a student's copying behavior from others. Moreover, the text analyzer was implemented to check the similarity of the reporting contents from the students automatically. This analyzer was built on the statistical natural language processing method, performing the following functions:

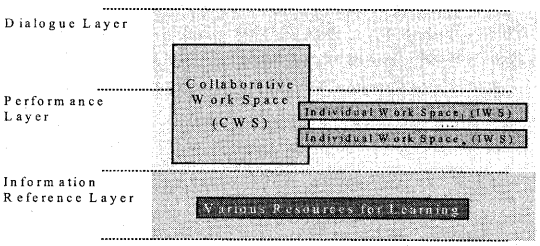

Figure 5. Configuration of relationships between the personal workplace and collaborative place

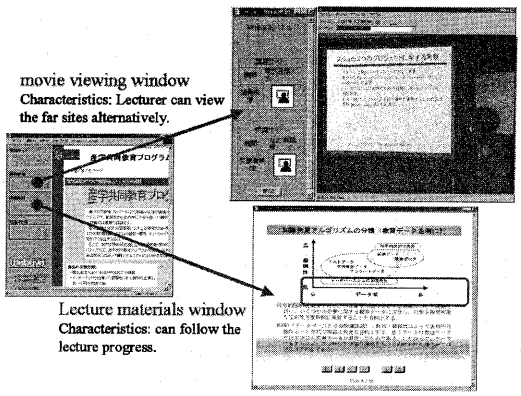

Figure 6. Movie playback/lecture material indication

picking up important keywords, its occurrence frequency, and co-occurrence of the related word for a certain word.

After pressing the button "lecture site ->lecture movie", the system pops up the "lecture movie playback" window and starts the playback (figure 6). Moreover, when clicking the main menu's "lecture materials presentation" button, the system presents the lecture materials, too. Students can browse the lecture material via the buttons "advance" and "return". To enable the questions and answers session, the lecturer has to select from the main menu the dialogue tool "startup", action that will generate a "chat" window.

Lecturers attend lectures via a similar procedure to the students. Firstly, they select the lecture movie "reception" button from the main menu (figure 4). If the students' far sites are equipped with VOD server, video camera, microphone and movie encoder, it is possible for lecturers to receive the image (and sound) of the students attending the lectures. Similarly to the students, the lecturer can view the movie and sound and use the playback function. Moreover, in the case of multiple far sites, the lecturer can switch between them. Questions and answers sessions are possible as full movie and sound exchange, as chat (in text format) or via the regular telephone line.

5. Evaluation of the Industry and University Education Cooperation Program

The evaluation of the program focuses on how many of the objectives stated in the introduction were actually achieved, and was performed from the 3 points of view enumerated below:

1) Science and technology aspect: Here we analyze the operations, functions and the lecture movie and sound data transmission and reception.
2) Educational aspect: Here we examine the meaning and significance of the distance education lecture in the frame of the industry and university collaboration project, via questionnaires filled in by the students.
3) Application and organizational aspect: Here we collect information from administrators participating in the same program; the focus is on possible improvements of the distance education system, and the data collection is done via work sheets analysis and interviews.

The analysis of the lectures from the above-mentioned points of view is a continuous process. In this section we report the results of points (1) and (2) above.

(1a) Science and technology aspects; evaluation 1: movie and sound data transmission and reception aspect

We have measured the delays, time-lapses and evolution of the lecture movie and sound data transmission. For this purpose, we have analyzed a situation with 3 sites exchanging VOD data. Each site was respectively connected to the Internet via either a high speed -, low speed dedicated circuit (maximum rate 128 kbps), or via a business provider dial up IP link. For the analysis of the transmission, we have collected data from each site on the movie bit rate (figure 6), movie frame rate (figure 7) and sound bit rate (figure 8). As can be seen in the figures, the maximum real transmission values are, respectively, 48 kbps for the maximum real movie bit rate, 10 fps for the greatest real movie frame rate and 13.2 kbps for the highest real sound bit rate.

We will firstly discuss the movie transmission. For movie bit rates of 40 kbps and above, the lecture transmission is stable, with little interruptions, and the frame transmission is of about 5 frames per second. However, we have experienced that for the dial up connections, reception at the students' far sites is of about 1 frame per 10 to 20 seconds. At this rate, the lecture movie playback window often freezes into a still image for several seconds. Students attending lectures from such sites complained therefore that movie and sound reception is often asynchronous. Compared with the movie data reception, the sound reception was relatively stable for all participating sites. The above experimental result shows clearly that for such distance lectures the limitation is given by the movie reception, and that it is recommended to implement distance lecture environments on network circuits allowing maximum transmission capacity of 128 kbps or above. If a provider IP connection cannot be avoided, the distance lecture environment can be improved with a number of adjustments, as follows.

The first adjustment is related to the lecturer's actions. The VOD system used in our distance lecture environment complies with the H.261 standard, which bases the movie distribution on information compression via a frame prediction mechanism. Namely, the transmitted/ received information weight changes according to the movie data, movie complexity and details, movement intensity, etc. If the lecturer's actions are various, the transmission data weight grows. However, if the lecturer's actions during the lecture are moderate, the movie changes are reduced and therefore the lecture movie distribution can become a

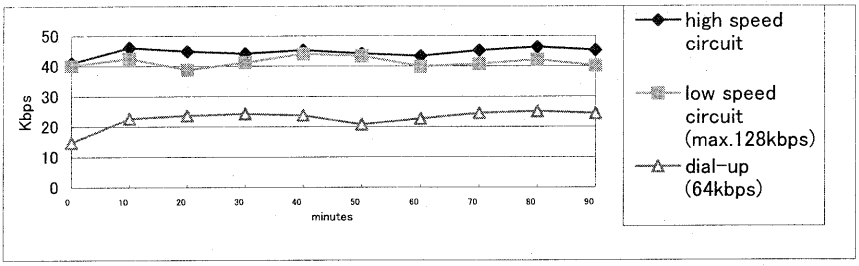

Figure 6. Movie bit rate time series

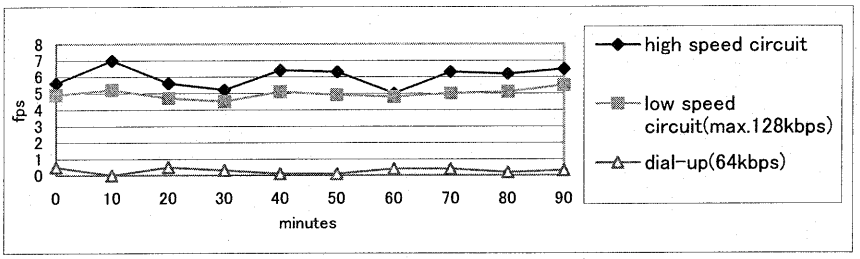

Figure 7. Movie frame rate time series

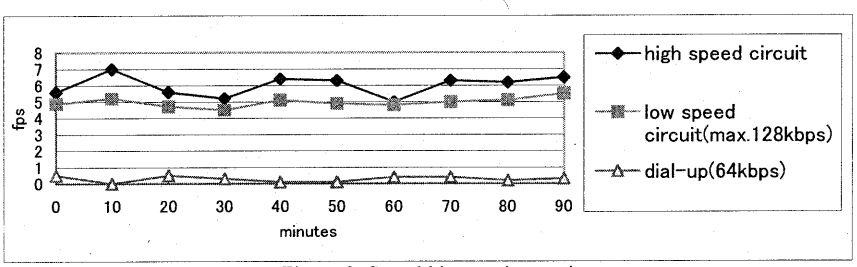

Figure 8. Sound bit rate time series

little more stable.

As another adjustment, the creation of a dedicated low speed circuit for the VOD server is necessary.

If these adjustments are made, all sites can reach similar bit rate, and the distribution occurs according to the different frame rates. I.e., according to the network bandwidth of the access points, the distribution to high speed circuit students' far sites should be high rate, whereas the low speed circuit far sites should receive low rate movie and sound data.

(1b) Science and technology aspects; evaluation 2: distance education system operatively and functions

We have identified a few possible improvement points concerning lecturing via a distance education system, with focus on application result, operatively and function. Table 1 shows the recommended improvements for the distance lecture environment. Some items in the table point to proposed solutions, others to counter- measures, and again others just present situational examinations.

(2) Educational aspects evaluation: questionnaire survey

After each industry and university cooperation program lecture we have asked the learners to fill in a questionnaire. The questionnaire contains 21 questions that are a combination of both free description form questions and questions with a 5 steps assessment scale. For the latter, the students should choose the most appropriate of the 5 steps (5: I strongly think so, 4:I incline to think so, 3: Neither Nor, 2: I incline not to think so, 1: I definitely don't think so).

As the industry and university cooperation program lectures cycle is not yet finished, we couldn't aggregate all the questionnaire results yet, and therefore cannot

Table 1: Problems and solutions of the distance learning environment implementation

Encountered problems	Solutions/ Results
Web lecture materials are not synchronous with the lecturer indications. If the lecturer is browsing quickly through the material (as often in the second half of the lecture), the distance learners cannot keep up with the current page.	By using applications with share function, the synchronous display in both lecture room and far sites is possible. One drawback is that the lecturer's personal browsing through the material is not possible anymore.
The circuit speeds of the distance lecture sites differ. Reception is therefore difficult for some sites.	Multiple preparations are necessary for correct movie & sound transmission. The server setup should follow the various requirements of the distance sites.
During the Q&A session, the communication y is reduced by the existent delay between lecture room and far sites.	There is no fundamental replacement scheme at present. New infrastructure and communication hardware is necessary. Rehearsal prior to the actual Q&A session is useful (or guidance of session by a chair person).
The phone line Q&A sound problems: 1) Noise, hauling; 2) Speaker volume & receiver volume differ.	1) Noise, hauling are caused by the using of a large combination of equipment 2) The volume difference can be cancelled by the circuit resistance value.

establish conclusive results yet. However, as at present we have finished the first round of lectures, it is possible to derive some suggestions and hints. Figure 9 shows the average answers of the first lecture. Questionnaires were anonymous and 38 questionnaires were returned from the 63 distributed. As the questionnaire (table 2) average is in general around 3-4, the result can be called satisfactory. Especially, questions Q4-6 (about students interest in the subject, the motivating effect of the lecture and about the knowledge they acquired) showed a high score.

Students had an average of 2.8 preliminary knowledge on the subject (Question Q1). This result possibly points to the fact that learners with no prior knowledge, up to learners with some prior specialty knowledge all were interested in the lecture. As the acquisition of high-level specialty knowledge is the main object of the industry and university cooperation program, this is an extremely important pointer. A low result was noticeable especially for questions Q10 and Q11 (regarding the far site transmission situation). Therefore, an important sub-goal and improvement point for the next lectures is the harmonization of the transmission with the far sites. As these were the results of the first lesson in the series, such problems were perhaps unavoidable, and the management and synchronization of lecturer, lecture manager, technical supporters, and teaching assistants was difficult to establish. Some of these problems have already been solved in the following lectures of the same cycle, but as the results were not yet analyzed, we present here our first experiences only, to be of use and serve to guide other educators worldwide.

6. Conclusion

In this paper we have presented our experience with the introducing of the industry and university education cooperation project at our graduate school to promote the

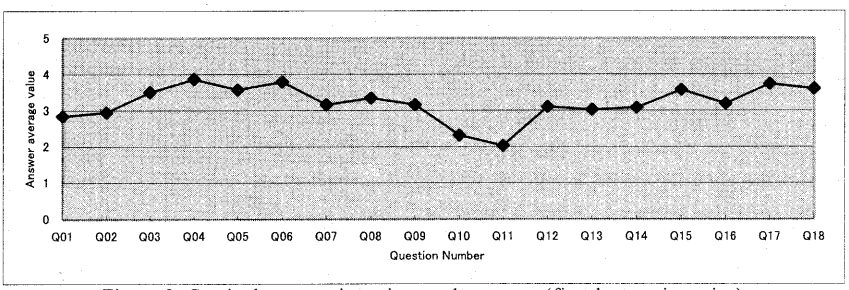

Figure 9. Curriculum questionnaire result average (first lecture in series)

Table 2: Industry-University Collaboration Program Questionnaire

Q1. Did you have previous knowledge on the contents of this lecture?
Q2. Is there an important connection between today's lecture and your research/ study field?
Q3. Do you think you will be able to use today's lecture contents in your future research/ job?
Q4. Are you interested in the topics presented by today's lecture?
Q5. Do you feel that today's lecture has opened new perspectives?
Q6. Did today's lecture deepen your knowledge?
Q7. Was today's lecture according to your expectations?
Q8. Was today's lecture level appropriate?
Q9. Was today's presented subject of expertise of importance?
Q10. Was the cooperation with the far sites smooth?
Q11. Could you consider the far sites part integrated in the lecture environment?
Q12. Did the lecture materials offered with the lecture help you in understanding the lecture?
Q13. Did lecturing and lecture material presentation run smoothly?
Q14. Was question asking made easy by the offered environment?
Q15. Were today's sound and movie transmission clear?
Q16. Was today's lecture complete and sufficient for you, although designed as a distance education lecture?
Q17. Was the time distribution appropriate for today's lecture?
Q18. Was the time distribution appropriate for far sites, with regard to the Q&A session?

future high level information communication society based on life-long education. Especially, we have highlighted the following points.

1) The implementation method as well as possible problems of the distance lecture environment offering synchronous study possibility at the lecture site as well as far sites, based on bi-directional communication. In this sense we have concretely presented the lecture form, the representation and presentation technique, as well as the implementation of the questions and answers session.

2) The issue of curriculum integration and certification/ recognition of both on-site and far-site learners. Students in the graduate school as well as far site learners achieve credits according to the Master course credit system. Credits can be obtained course-based or program-based. We have also pointed to the merits of continuous learning and self-improvement for company employees, within our program.

3) Moreover, we have discussed and presented our efforts in the direction of building the infra-structure necessary to support the lecturing within the industry and university education cooperation program. Specifically, we referred to the prior collecting of information, which is to be sent together with the lecture movie and sound transmission. This service packet contains advice and assistance information concerning the lecture contents, the collection and classification of lecture materials, text forwarding, etc.

In this way we hope to support and respond to the forecasted growing future learning demand, especially on advanced IT topics, and to create the chance and environment for a wide area high-level education.

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