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Application of Distance Learning Support System SEGODON to Exercise-type Classes

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We have developed a distance learning support system called SEGODON for exercise-type classes, and applied this system to "Applied Mathematics Exercise" classes four times, continuously. The system consists of 40 personal computers, a workstation and inexpensive input equipment. A teacher can conduct an exercise-type class with students via a network. We developed a report submission system to conduct exercise-type classes. A student can submit a report to a teacher during class, and the teacher can mark the report and return it to the student. We have solved problems of applications to exercise-type classes and have developed the necessary functions for the "Applied Mathematics Exercise". We found the following results from these applications. (1) The distance learning class (exercise) using SEGODON was as effective for the students as the normal class (exercise). (2) We found that the treatment of reports was important in an exercise-type class. We found that the maximum number of submitted reports that could be checked by a teacher and a TA was approximately 70. (3) We found that special functions for the exercise, i.e., the expression input support palettes, were required.

1. Introduction

Networks have come into wide use recently and high performance personal computers (PCs) have appeared. We have applied this computer technology to the field of education and developed a distance learning system. Distance learning support systems have been much studied and developed[1)~7)]. Although there have been a number of reports on this type of system, there are almost no examples of distance learning support systems which use PCs full-time for lectures. One of our goals has been to build an effective distance learning support system. Thus, we have created a relatively inexpensive system called SEGODON that can use up to 40 PCs for 40 students.

With this system, a teacher can conduct exercise-type classes with students from a remote site via a network. The PC at the teacher's site continually displays a view of the classroom using a remote control camera. The PCs at the students' site (the classroom) display the teacher from the waist up. During Q&A sessions, the teacher and one student can communicate using audio and video equipment. The students' PCs also display teaching materials as they are presented and controlled by the teacher. Compared with the former system for lecture-type classes[8)], we have added the use of a new file server (WS) for exercise-type classes, and then a report submission system and other special functions for the exercise-type classes were developed.

In this paper, we applied this system continuously to exercise-type classes (a class of Applied Mathematics Exercise). Although there are examples of continuous applications[3)], there are almost no examples of a distance learning support system such as ours in which students use PCs continuously during exercise-type classes. Our system is placed as a distance learning support system, which uses PCs effectively in a classroom situation.

Section 2 deals with the construction method and outline of this system. Section 3 shows the outline of the applications to exercise-type classes. Section 4 shows the added and improved functions based on the results. Section 5 shows the evaluations and comments on the system based on the applied results. Section 6 is the conclusion of this paper.

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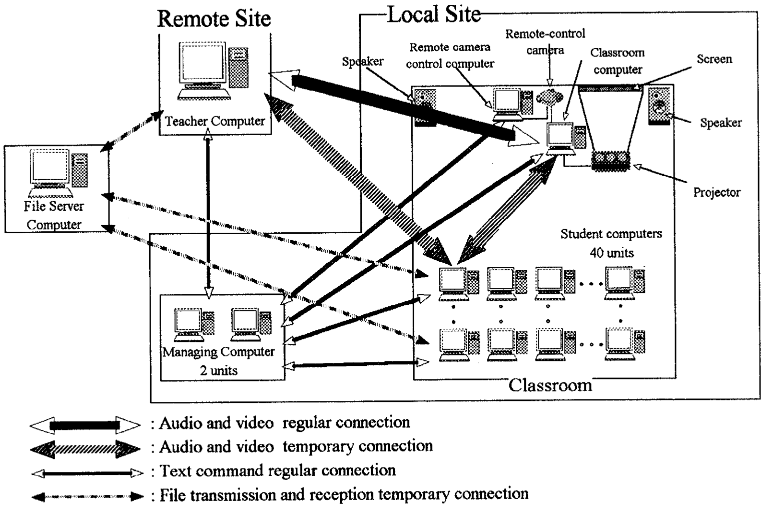

Fig. 1 System Configuration.

2. Distance Learning Support System

2.1 Design Policy

Before developing SEGODON, the following items were requested. The following item is an especially required policy for an exercise-type class.

- A report storing and sending system. This is because the system is required for exercise-type classes.

The following items are fundamental policies required for distance education.

- The capacity for 40 students per class. This is because 40 students are a standard class size in most Japanese universities.
- Distance learning classes communicated via a network. This is because teachers in outlying areas frequently take business trips. They wish to teach from wherever they happen to be staying.
- Q&A sessions between a teacher and one student. Students seldom ask a teacher questions during class time in Japanese universities. We should develop functions for Q&A to increase the number of questions.
- The ability of the teacher to observe the situation of the classroom from a distant location. Teachers will find it difficult to teach efficiently, if they can't see the students' reactions.
- The contents on the teacher's monitor are displayed on each student's monitor, as well as two shared cursors. This is because WYSIWIS is necessary for distance learning.
- The card type screen for teacher (the blackboard system) and student (the note system). This is because the card system is familiar to the Japanese.

Based on the above specifications and requests, we had developed the system.

2.2 Hardware Configuration

The multimedia environment of our classroom consists of the following:

- 40 computers, 15-inch monitors, CCD cameras and microphones.
- a projector, a screen and two speakers.
- each computer is connected to the Ethernet in the classroom, and the network of the classroom is connected to the Internet.

An overall view of the distance learning support system is indicated in **Fig. 1**. This system uses the teacher's computer (PC), 40 students' computers (PC), 2 managing computers (PC), a file server computer (WS), a remote camera control computer (PC), and a projection computer (PC). Additional equipment is a remote control camera, a projector and two speakers.

The hardware equipment for the students consists of the Power Macintosh 8100/100AV (Apple Computer) with a 15-inch monitor, a CCD camera, and a microphone. For the teacher's computer, any kind of Power Macintosh will do. In addition, a CCD camera and a microphone are required. The file server computer (S-4/20, Fujitsu) is mainly used to store students' reports. The reason for using a WS as a file server is for storing reports submitted not only in class time, but also outside of class time. Furthermore, in comparison with a PC,

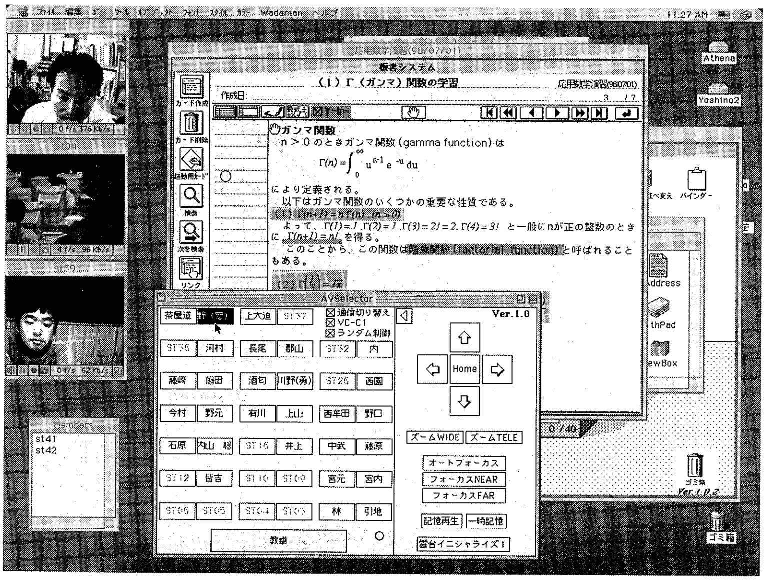

Fig. 2 An example of a teacher's screen.

a WS is generally more stable. The managing computer is a so-called reflector, which implements synchronous operations on both the teacher and student sides. The students' computer, the teacher's computer and the managing computer are of the same specifications as the former system [8].

2.3 Software Configuration

The software for this system consists of the blackboard system, note system, audio and video switching system, HyperQTC and NetGear [9]. The blackboard and note systems, based on our card-type database software called Wadaman [9], have been developed and enhanced with additional functions. HyperQTC and NetGear are our original intercomputer multimedia communications software.

The blackboard system is displayed on the monitors of the teacher and all the students, and allows the teacher to show the materials to the students. The teacher can control the system. The blackboard system corresponds to the conventional blackboard on which a teacher writes the contents of his lesson. The note system is a subsystem for students to use as in note taking. Its interface is almost the same as the blackboard system. Students cannot control the blackboard system, but they can freely use the note system. The note system uses exactly the same materials as the blackboard system. Students can submit reports using this note system during exercise-type classes. The teacher's computer displays an audio and video switching window, which is indicated in the bottom middle window of **Fig. 2**. The left part of the window is the arrangement of the students' computers. The right part of the window is the remote-camera controller.

The audio and video switching system, NetGear and HyperQTC are the same as the former system, as are the blackboard system and note system except for the functions for an exercise-type class; the details of the features are given in Ref. 8).

Table 1 indicates all the supporting functions of the system. In the "New" item of Table 1, the unmarked functions were developed the previous year, the "○" mark shows the functions developed for SEGODON. We describe the function related to exercise-type classes among the newly added functions. The report submission system supports report submissions from students to a teacher during class time. We developed this function to conduct exercise-type classes. We discovered that many students found drawing expressions with a mouse to be a troublesome task. Thus, we developed the expression input support palettes for applied mathematics exercises. The palettes support easy input of the expressions used in "Applied Mathematics Exercises". The one-touch title creation function automatically creates a report title with one-touch. This was developed because a teacher was troubled by untitled reports submitted by students at the time of marking and return.

Table 1 A list of supported functions.

Supporting functions	Explanations	New
1. Audio and video switching button	The names of students that are input upon registering to the class are shown. The name list can also be used as a seating list.	
2. Remote-control camera operating pointer	It enables a teacher to view specific spots in the classroom using a mouse pointer. It controls panning, angle of elevation and zooming.	
3. Remote-control camera random operating function	It randomly focuses on a student every 10 seconds and shows them on the monitor.	
4. Teacher's shared cursor	The teacher's cursor is shown on the students' monitor as it is moved.	
5. Students' shared cursor	The student's cursor is displayed on the monitors of both the teacher and the student during Q&A sessions.	
6. Interlocking card turning function	The teacher's and students' card number corresponds automatically.	
7. Question button	When a student pushes the question button, the audio and video-switching button of his or her name is highlighted.	
8. Card material transmission system	It enables the transmission of the teacher's material in card form to all students. Adding and correcting of the material can also be done. Furthermore, it enables students' questions and comments to be transmitted to all participants using the blackboard system during a Q&A session.	
9. Interlocking card creation function/ Interlocking card deletion function	As a teacher creates/deletes a card in the blackboard system, a card is created/deleted in the blackboard system on the students' side.	
10. Interlocking marker function	A teacher can write a color marking to a teaching material using this function.	
11. Question and answer system	The function supports questions and answers between a teacher and students using the Wadaman card.	○
12. Report submission system	The function supports report submission from students to a teacher.	○
13. Mail system	The function supports an exchange of mail in this system using the Wadaman card.	○
14. Concealment function of a file operation system	The function does not make "Finder" start. Finder is a file operation software equipped by MacOS.	○
15. Automatic distance learning system starting function	The function starts a distance learning support system automatically. Students just put in a log-in name.	○
16. The expression input support palettes for applied mathematics exercise	The function makes easy inputs of the expressions used in the "Applied Mathematics Exercise."	○
17. Automatic installation function	This function automatically distributes teaching materials to each student's PC before a class.	○
18. The operation support palette for applied mathematics exercise	The palette collects the functions frequently used by students in the "Applied Mathematics Exercise".	○
19. Automatic input of a student's name	This function can automatically input the student's name using a log-in name.	○
20. Report title one-touch creation function	This function creates automatically a report title (a submission time, a real name, a login name and an exercise name) by one-touch.	○

2.4 Interface

The image on the teacher's computer monitor during distance learning classes is indicated in Fig. 2: the upper part of the teacher's body, the view of the classroom by the remote-control camera, the blackboard system, and the audio and video switching window. During Q&A sessions with a student, his or her image window is displayed as well. The image on the student's monitor during distance learning classes is indicated in **Fig. 3**: the upper part of the student's body, the blackboard system, and the note system. The students' blackboard system has a "question button" (Table 1: item number 7). When a student pushes the "expression button" in the note system, expression input support palettes and an operation support palette appear (Table 1: item numbers 16, 18). During Q&A sessions with the teacher, the teacher's image window is displayed as well. The screen in the classroom displays the blackboard system, the image of the classroom and the image of the teacher.

3. Application to Exercise-type Classes

The former system [8] was developed in 1997, and was applied to lectures. Distance learning classes applied were 1 or 2 applications to each lecture. As our goal for a distance learning support system, we wish to carry out all lectures from remote locations. Then, as a first step, we applied our system to the same classes continuously. In particular, we applied the system to exercise-type classes, which require the submission, marking and return of reports between a teacher and a student during lectures.

Distance learning classes using SEGODON were conducted continuously 4 times between buildings in Kagoshima University. A teacher was in the teachers' room on the 6th floor of the department of electrical and electronics engi-

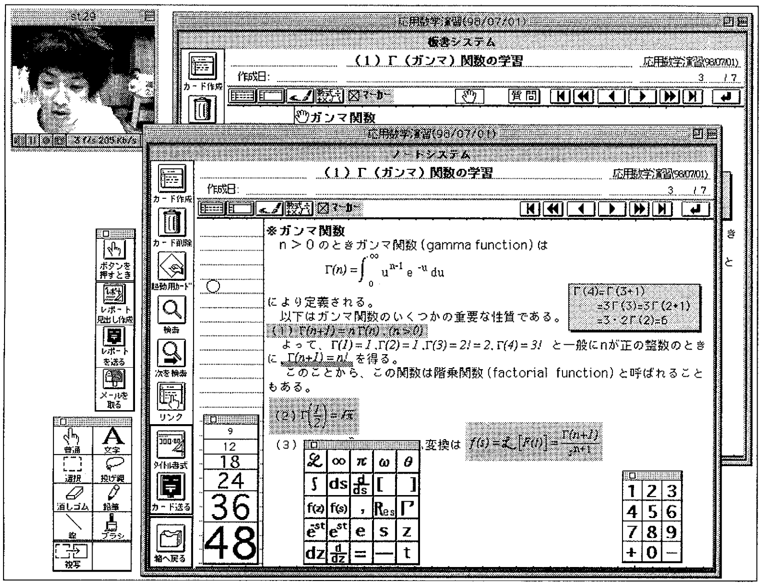

Fig. 3 An example of a student's screen.

Table 2 Attending students in every class.

Date	6/3/98	6/17/98	6/24/98	6/30/98
The number of attending students	32	28	31	30

neering. Students gathered in the computer exercise room on the 2nd floor of the department of information and computer science. **Table 2** shows the number of students who attended the distance learning classes. A questionnaire was carried out each time. From the results, we extracted the problems and improved the system. The students were sophomores of the department of bioengineering, and 29–32 students participated. The class was "Applied Mathematics Exercise" and the contents of the classes were about the Laplace transforms. The class time was 90 minutes, and they were conducted by the following procedure.

(1) The teacher lectured on the solution method of the exercise problems using the blackboard system.

(2) Each student solved a problem and submitted an answer report using the report submission function.

(3) The teacher checked the submitted reports and returned the results to the students during the lecture. (This was carried out from the 2nd application.)

We applied our system to this distance learning classes 4 times following 6 normal classes. Moreover, in order to evaluate the application effect of the system, after the normal classes we examined the contents of the exercises. We did the same after the distance learning classes as well.

4. Application of Classes and Improvement of SEGODON

In order to apply this system to the "Applied Mathematics Exercise", we carried out the development of functions in advance. Moreover, we developed additional functions after every distance learning class. In fact, we developed the additional functions after the 1st and 2nd applications. The new functions of Table 1 ("○" mark) are added functions after the above improvement. **Table 3** shows a list of improved time and added functions. The following paragraph describes the reasons for the development of each function.

4.1 Development and Improvement in Advance

We developed the following functions before these applications.

(1) Question and answer system, Report submission system, and Mail system
These systems were developed to be used for the exercise-type class. The systems use the Wadaman card [10] for exchanging media. The question and answer system and mail system were equipped with our other system DEMPO II [10]. Those sys-

Table 3 A list of improved time and added functions.

Improved time	Added functions
Improvements before application	(1) Question and answer system, Report submission system, Mail system (2) One-touch system starting function (3) Concealment function of a file operation system
Improvements after the 1st application	(1) Automatic distance learning system starting function (2) The expression input support palettes for applied mathematics exercise
Improvements after the 2nd application	(1) Automatic installation function (2) The operation support palette for applied mathematics exercise (3) Automatic input of a student's name (4) Report title one-touch creation function (5) Adoption of teaching assistant (This is not a function.)

tems were incorporated into SEGODON with slight modifications. The report submission system was developed as a new function using the mail system as the base. A student submits a report, which only the teacher receives.

(2) One-touch system starting function
The "distance learning starting button" is displayed at the starting time of the PCs. When a student pushes the button, the system starts.

(3) Concealment function of the file operation system
This function does not make "Finder" start. Finder is a file operation software equipped by MacOS. This is an improvement intended to reduce the amount of unnecessary operation during lectures.

4.2 Improvement after 1st Application

(1) Automatic distance learning system starting function
After the students logged in to the PCs, we wanted to use the "one-touch system starting functions". However, some students touched the system shutdown button, and their PCs happened to restart. We made the system so that it could start completely automatically; the students need to do nothing after logging in to the PCs.

(2) The expression input support palettes for the applied mathematics exercise
To the question, "What did you feel was difficult to use?" 8 out of 17 students asked replied, "I felt difficulty in writing characters with a mouse". **Figure 4** shows a report that was drawn by a student with a mouse. Then, we developed the expression input support palettes into which expressions can easily be inputted in the "Applied Mathematics Exercise". **Figure 5** shows these palettes. **Figure 6** shows a report that was drawn by the expression input support palettes.

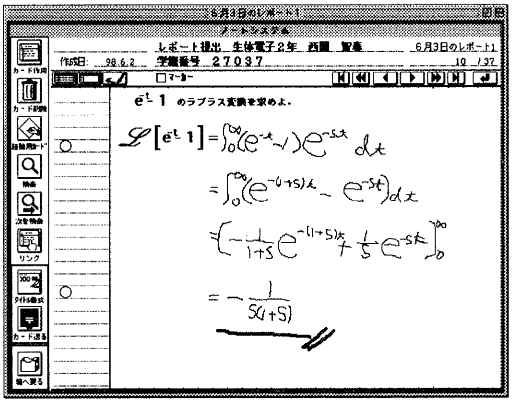

Fig. 4 A report before using the expression input supports palettes.

4.3 Improvement after 2nd Application

On and after the 2nd application, we checked and returned the submitted reports during the lecture.

(1) Automatic installation function
This function automatically distributes teaching materials to students' PCs before a class. We developed this function in order to save the installation time at each lecture.

(2) The operation support palette for the applied mathematics exercise
The palette collects the functions frequently used by students in the "Applied Mathematics Exercise". This function was developed so the attending students could operated the system simply.

(3) Automatic input of a student's name
This function automatically inputs the student's name using a log-in name. Most students are poor at inputting their name using the keyboard. Therefore, this function was developed in order to reduce the students' difficulty.

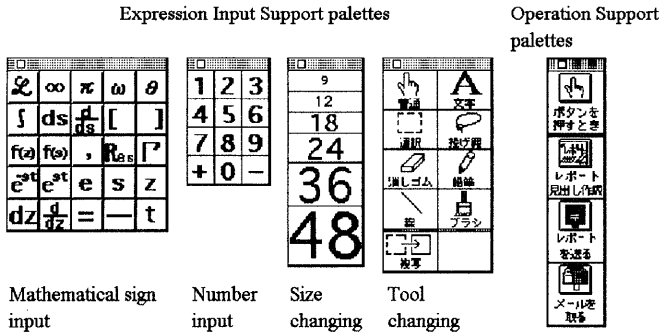

Fig. 5 Expression input support palettes and an operation support palette. (The left four windows are expression input support palettes. The right window is an operation support palette.)

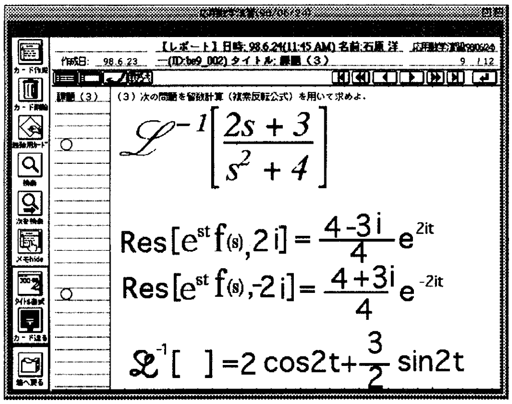

Fig. 6 A report after using expression input support palettes.

(4) Report title one-touch creation function
The teacher explained to the students in advance that their name and log-in name are required for the title of their report. However, 20% of the students submitted reports that had no name and log-in name. Because of this, we prepared a function in which pushing a button automatically creates the title (submission date and time, a name, a log-in name, and a report name) of a report.

(5) Adoption of teaching assistant (TA)
This is not a function. 160 reports were submitted during the 2nd lecture. However, only about one third of those reports could returned to the students during the lecture. **Table 4** shows the number of report checks. As a solution to this, TA was adopted in order to check reports during lectures.

Table 4 Number of report checks.

	06/17/98	06/24/98		07/01/98	
	T	T	TA	T	TA
Total of submitted reports	160	112		69*	
Number of report checks	55	20	51	22	49
Number of submission reports	6	5		2	

T: Teacher, TA: Teaching assistant
※ The total number of submitted reports on 07/01/98 was smaller than the sum of the number of report checks. This was because a teacher and a teaching assistant checked the same reports.

5. Evaluation and Discussion

5.1 Evaluation by Questionnaire

After each lecture, a questionnaire was given to the students. We evaluated the students' degree of satisfaction and students' evaluation of our system in the questionnaire. **Table 5** shows the items of the questionnaire. Each number in Table 5 expresses a questionnaire order for students. The letter after each number expresses an evaluation field ((a) understanding the content of the class, (b) impressions on the class, (c) delays in communication and processing, (d) questions to a teacher in class, (e) the function for an exercise, (f) other). We had a 5 point scale (with answers “1: very bad”, “2: bad”, “3: neutral”, “4: good” and “5: very good”) for students to evaluate each item on the questionnaire. The questionnaire results are shown in **Fig. 7**.

We mention some items of interest about the results of the questionnaire. The students were

Table 5 Items of questionnaire.

1	(a)	Have you understood the contents of the lecture?
2	(a)	Have you understood the contents of the lecture by the teacher's face and the expression on the screen?
3	(a)	Have you understood the contents of the lecture by the teacher's voice from the speaker?
4	(a)	Have you understood the contents of the lecture by the card screen of a monitor?
5	(a)	Have you understood the contents of the lecture by the teacher's shared cursor?
6	(b)	Did you feel nervous during the lecture? (1: relaxed, 5: nervous)
7	(b)	Were you satisfied with the lecture?
8	(b)	Is a distance learning class more desirable than a normal class?
9	(b)	Do you want to participate in a distance learning class again?
10	(b)	Was it easy to operate the system?
11	(b)	Was the lecture interesting?
12	(c)	Was your computer in running order?
13	(c)	Did you mind the delay of communication?
14	(c)	Did you mind a change of card data?
15	(c)	Did you mind the delay of a shared cursor?
16	(b)	Did you feel like taking a lecture?
17	(d)	Was it easy to carry out a question?
18	(d)	Did you think that you could communication at the time of a question?
19	(f)	Did you mind your own video?
20	(e)	Did you use the note system?
21	(f)	Did you mind the remote-control camera?
22	(c)	Did you mind the gap between the video and the voice?
23	(c)	Did you mind the gap between the voice and the shared cursor?
24	(b)	How was the progress of the lecture? (1: slow, 3: moderate, 5: fast)
25	(b)	Were the contents displayed legibly in the monitor?
26	(b)	Did you want to make a handwritten memorandum?
27	(f)	Did you think that a teacher's video was required?
28	(f)	Did your eyes get tired?
29	(f)	Did your hands get tired?
30	(d)	Did you feel that it was easy to carry out a question?
31	(b)	How was the feeling of distance with the teacher? (1: out of university, 3: same building, 5: same class)
32	(c)	Did you feel that the teacher's video was uncomfortable?
33	(c)	Did you feel that the teacher's voice through the speaker was uncomfortable?
34	(c)	Did you mind the delay of the teacher's voice?
35	(f)	How was the brightness of the teacher's video?
36	(f)	How was the size of the teacher's video?
37	(e)	Were the input support palettes useful?
38	(b)	Did you participate in the lecture eagerly?

※ Each number in the table expresses a questionnaire order for students. The letter after each number expresses an evaluation field ((a) understanding the content of the class, (b) impressions on the class, (c) delays in communication and processing, (d) questions to a teacher in class, (e) the function for an exercise, (f) other).

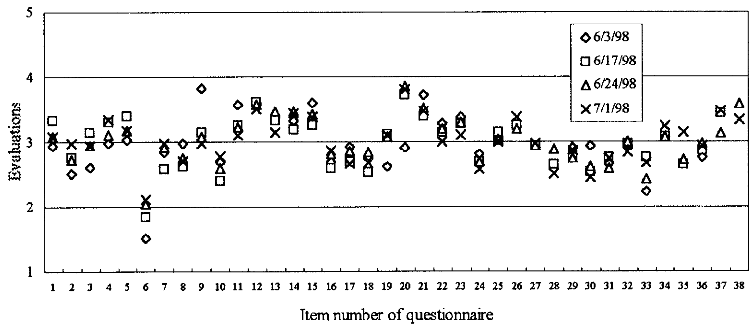

Fig. 7 The results of questionnaires.

relaxed during the lecture (Table 5: item number 6). This result is almost the same as that of the former lecture-type classes[8]. It was also found that the students participated eagerly (Table 5: item number 38). We also discovered that the 1st lecture had a high evaluation compared with the subsequent lectures (Table 5: item number 9). Evaluation of the 1st application was high, as with former lecture-type classes. The students had several questions during the performance of the four exercises in these applications. It seems that the students think that it is a little hard to ask a question to a teacher (Table 5: item numbers 17, 18 and 30). The students thought that the pace of the classes was somewhat quick (Table 5: item number 24). This reason was that a teacher displayed his prepared teaching materials during class in our system. It was found that students had a desire to take handwritten notes (Table 5: item number 26). Regarding the ease of hearing of the teacher's voice, when howling occurred, the evaluation of students fell immediately (Table 5: item number 33). The students used the expression input support palettes from 2nd application. The 2nd and 4th evaluations are high. At the 3rd application, there were inputs of letters in exercises. Since the input of letters was not included in the expression palette, the evaluation fell. As an overall tendency, evaluations were critical compared with the former lecture-type classes. We think this is because a student has to operate the system actively in an exercise-type class. A description item in the questionnaire, "How many times out of 15 would you want to take the lecture by distance learning?", showed that although after the 1st lecture the average was 5.8 times, it fell after the 2nd lecture. Moreover, after the 3rd and 4th lectures the average increased.

5.2 The Attending Students' Scores

We examined a small test on the lecture range after 6 normal classes. Moreover, we examined a small test on the lecture range after 4 distance learning exercises. No difference was seen in the average or distribution by the results of the examinations (normal exercises: average of 50.5 points, distance learning exercises: average of 51.3 points). However, there is also the factor of the difference in the level of difficulty experienced by the subjects, etc. More investigation is required. We think that the results of the test are good since they are not bad compared with the results of the test in normal exercises. Moreover this system has the merit that a teacher in a remote place can conduct an exercise-type class.

6. Conclusion

We have developed a distance learning support system called SEGODON, which consists of 40 personal computers, a workstation and inexpensive input equipment. We applied this system to the classes of "Applied Mathematics Exercise" four times, continuously. We found the following results from these applications.

(1) The distance learning class (exercise) using SEGODON was as effective for the students as a normal class (exercise).

(2) We found that the treatment of reports was important in an exercise-type class. We found that the maximum number of submitted reports that could be checked by a teacher and a TA was approximately 70.

(3) We found that a special function for the exercise, i.e., the expression input support palettes, was required.

We are planning to further evaluate the cases in which the same students continue to take distance learning classes.

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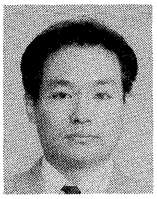

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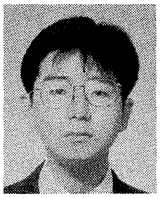

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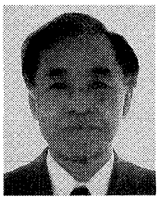

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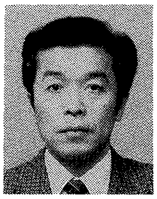

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