

Title	Effect of Rearrangement and Annotation in Digitized Note on Remembrance
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Citation	IEICE TRANSACTIONS on Information and Systems, E90-D(10): 1630-1636
Issue Date	2007-10-01
Type	Journal Article
Text version	publisher
URL	http://hdl.handle.net/10119/7847
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Description	

Effect of Rearrangement and Annotation in Digitized Note on Remembrance

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SUMMARY Note taking is a fundamental activity for learning, and many software tools which enable students to take digitized notes have been proposed. Digitized notes are advantageous because they can be easily edited, rearranged, and shared. Although many note-taking tools have been proposed, there has been little research to examine the effect of note annotation and rearrangement with a digitized tool in terms of knowledge acquisition. Therefore, we have investigated the effect of note annotation and rearrangement on how well lecture content is remembered by learners. By annotation, we mean adding both handwritten and typed text, and rearrangement includes moving and deleting handwritten notes. We developed a simple note-taking application specialized for explanation, and evaluated it through a laboratory experiment with eight participants. The results show that note annotation and rearrangement significantly improved how well the participants remembered lecture content. Thus, the effect of annotation and rearrangement on remembrance was confirmed with respect to digitized notes.

key words: knowledge acquisition, handwritten note, tablet PC

1. Introduction

A lecture is the most commonly used format for transferring information and knowledge from a teacher to students in educational organizations. During classroom lectures, note taking is the most popular way for students to remember the main points of the lecture content. Students can easily review a lecture if they have well-organized notes, but students often find it difficult to take good notes during the actual lecture because the content of the lesson is unfamiliar and the students are apt to be absorbed in understanding each part of the content during the lesson.

To improve the organization of their notes and to master the lecture material, students are expected to later rearrange and review their notes. This rearrangement means improving the notes for future reference by annotating and better organizing the contents. The revised notes may help a student remember much information, even within a short time, since the revised notes include the lecture points organized from the student's perspective. Furthermore, the act of note rearranging itself will help the student comprehend and remember lessons.

In this paper, we investigate the effect of note rear-

rangement on the acquisition of knowledge from a lecture. We center on the note-taking of students. To examine this effect, we have carried out a laboratory experiment. The objective of this research is to confirm whether the note rearrangement tasks on digitized note improve knowledge acquisition. When it is confirmed, the possibility of digitized note will be augmented. The rest of this paper is organized as follows. We describe related work in Sect. 2, present the design and results of our experiment in Sect. 3, and conclude with our directions for future work in 4.

2. Related Work

In this section, we describe previous work, which ranges from large-scale surveys regarding note-taking practices to the technical challenges of applying computers to improve a person's ability to take notes.

Khan collected comments about note taking from various types of participant through interviews, where the questions asked about the characteristics, strategies, motivation, and so on for conventional paper-based note-taking during business meetings [1]. Based on this survey, Khan presented some general findings regarding note-taking and considered their implication for system support. Fox investigated actual note-taking habits and usage, including those in a digital environment, of many students by online survey and selective follow-up interviews [2]. While both of these studies provided useful survey results, neither was based on a laboratory experiment done in a controlled environment.

Ward et al. developed the NoteTaker application and observed the use of this application during classes [3]. After analyzing the lecture notes taken by students and through careful design of its keyboard shortcuts, they implemented NoteTaker so that it allowed users to fully utilize both pen and keyboard input methods. This study was intended to provide a practical note-taking application. We have also adopted a hybrid means of input similar to that of NoteTaker, but our study emphasized the effect of rearrangement and annotation on lecture-content remembrance.

There have been several attempts to utilize multimedia to improve note-taking; the Classroom 2000 project [4], Dynamite [5], and Audio Notebook [6] aim at augmenting notes by capturing audio and video data and relating this to the user's notes. Reference to this multimedia data can reinforce the user's remembrance of a lecture. These approaches help enrich the user experience through technology. In contrast, our aim has been to reveal the effects of fundamental

Manuscript received January 24, 2007.

Manuscript revised April 27, 2007.

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DOI: 10.1093/ietisy/e90-d.10.1630

note rearrangement activities. Kim et al. investigated the effect of note-taking activity in terms of digital devices [7]. They compared three devices—paper, a PDA, and a Tablet PC—to determine what differences arose from the device being used. Gwizdka compared the effect of note-taking and post-labeling interfaces for note capturing and structuring during engineering design meetings, and found that the separation of input areas by category led to problems and that attaching pre-defined labels to free-form notes after the note-taking could cover more key points [8]. Though the process of our experiment was similar to this study, we focused on the rearrangement of lecture notes rather than engineering notes.

3. Experiment

In this section, we describe our experiment to investigate the influence of note rearranging on knowledge acquisition. We also evaluated the usability of our Pen Memo system. We hypothesize that the rearrangement and annotation improve remembrance of lecture contents. In the experiment, participants took notes while watching a video rather than during an actual lecture. The video is later described in detail.

Even though paper is a popular medium for note-taking, digital devices offer several advantages such as the ease of reviewing, revising, relating, and sharing [9], [10]. We used a digitized note-taking environment for the experiment since we wanted to focus on these advantages. In addition, we intended to isolate and compare only the effects of note rearranging, not the effects of note digitizing.

3.1 Pen Memo Note-Taking Application

We developed a simple note-taking application called Pen Memo for our experiment. Figure 1 shows a Pen Memo screenshot. The basic function of Pen Memo is similar to that of Windows Journal, but we reduced the number of functions for our experiment. We designed Pen Memo to accept text input by keyboard as well as by tablet because we think keyboard input can complement handwritten notes and the input augments the representation of notes. We have

emphasized the function of both moving and deleting content rather than the refinement of the appearance of notes.

Here, we explain the functions of Pen Memo. The user can use a stylus to make handwritten notes by writing text or drawing figures. The user can also select a particular drawing by dragging with the modifier key (a button on the stylus) to specify a region. The selected drawing region can be moved by simple dragging, and can be removed by tapping a button on the bezel of the Tablet PC or the backspace key on a non-Tablet PC. When the user presses the enter key, a text input field appears, and the system enters “text input mode.” The text input to the field is placed at the position of the mouse cursor when the mode is changed. The user can also freely move the text by dragging. In addition, the user can modify text by double-clicking, and can remove text by pressing the backspace key after selecting the text by single clicking.

For experimental control, the function to move content, which is useful for rearranging, could be disabled from the “Arrangement” menu. While the function was locked, the user could not move either drawings or typed text.

(1) Design

To evaluate the influence of note rearranging on knowledge acquisition as well as the usability of Pen Memo, we referred to the ISO9241-11 document issued by the International Organization for Standardization. According to ISO9241-11, usability is a measure of the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. The effectiveness, efficiency, and satisfaction are described as “Accuracy and completeness with which users achieve specified goals,” “Resources expended in relation to the accuracy and completeness with which users achieve goals,” and “Freedom from discomfort, and positive attitudes towards the use of the product” respectively [11]. To apply ISO9241-11 to our objective, we considered that the specified goal is to remember the contents of lecture, and the specified context of use is to review by browsing and annotating to note. Also we respectively adopted a remembrance test score as accuracy, time spent on note rearranging as resources consumed, and questionnaire survey as positive attitude towards the achievement of goals. We decided these items correspond to the effectiveness, efficiency, and satisfaction in our experiment.

(2) Lecture Video

We used a lecture video authorized by NTT CSL [12] for this experiment. The video (DVD) describes various types of research done in the lab and introduces technologies for implementing human activities (such as watching, hearing, talking, and thinking) in computers. We separated the video into three parts: (1) introduction, (2) the topic of watching and hearing, and (3) the topic of talking and thinking. We used (2) and (3) as a lecture video set for the experimental sessions and (1) for a dry-run session. Each lecture video lasted 10 minutes, and the narrator and the narrative format

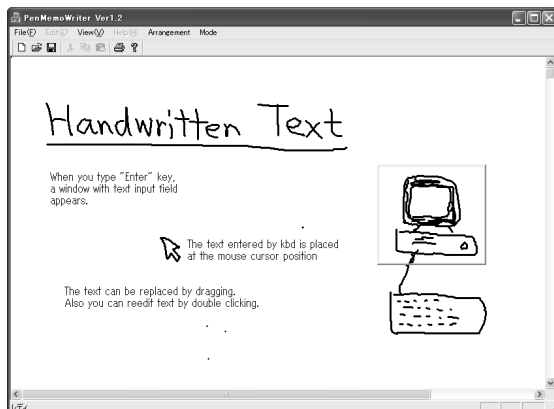


Fig. 1 Pen Memo snapshot.

was the same. We assumed an equal level of comprehension difficulty for each video.

(3) Participants

The participants in the experiment were eight graduate students of our institute. Since the participants were used to take lecture, we considered them as specified users in ISO9241-11. All participants habitually used computers to work. Thus they were accustomed to typing text with a keyboard. None of the participants had experience using a Tablet PC.

3.2 Procedures

The experiment was done over two days. We separated the participants into four groups and asked them to perform tasks. To avoid the effect of personal performance, we chose a within-subject design. In addition, the order effects were counterbalanced. The procedure details are given in Table 1.

(4) Day 1

After providing initial guidance with a dry run, we asked the participants to watch the lecture videos. During the lecture, participants took notes with Pen Memo on a Tablet PC. At that time, the participants were permitted to take only handwritten notes. Participants were not allowed to pause or rewind the video. After the lecture, participants reviewed

the lecture by browsing notes within 10 minutes. Participants could rearrange notes by adding text and moving notes when such arrangement (Arr) was allowed. When arrangement was not allowed (indicated as – in the review rows of Table 1), participants only browsed their handwritten note. After the review session, we had the participants work out a simple sum for one minute to reset their short-term memory. Participants then took a test to evaluate their remembrance. The participants could not refer to notes during the test. The test consisted of 10 questions, and each question required the participant to write an answer including two keywords. When two keywords were included in the written answer, the participant gained two points. If the answer included only one keyword, the participant gained one point. Thus, a perfect score for each test was 20. Following the test, participants were asked to answer a questionnaire. After a rest period, this entire procedure was repeated.

(5) Day 2

In the second day of the experiment, held two days after day 1, we asked the participants to review their notes for 5 minutes. During the review session, the participants were allowed to rearrange the notes from how they were previously arranged. The participants then worked out a simple sum as on day 1 before taking a test and completing a questionnaire. On day 2, we used the same test as on day 1. Following the questionnaire for the first review, the participants rested and then the procedure was repeated. Note that we reversed the order in which videos (2) and (3) were used on Day 2.

Table 1 Experimental procedure for each group. (2) and (3) indicate the video/test experiment set.

		Group			
Step		A	B	C	D
<i>Day 1</i>		<i>Exp. Set of Video/Test</i>			
1	Watch Video & Take Notes	(2)	(3)	(2)	(3)
2	Review	Arr	–	–	Arr
3	(Calculation)				
4	Test	(2)	(3)	(2)	(3)
5	Questionnaire				
6	(Rest)				
7	Watch Video & Take Notes	(3)	(2)	(3)	(2)
8	Review	–	Arr	Arr	–
9	(Calculation)				
10	Test	(3)	(2)	(3)	(2)
11	Questionnaire				
<i>Day 2 (Two days after Day 1)</i>		<i>(exchanged one member from each group: A \rightleftharpoons B, C \rightleftharpoons D)</i>			
12	Open Notes and Review	(3)	(2)	(3)	(2)
13	(Calculation)	–	Arr	Arr	–
14	Test	(3)	(2)	(3)	(2)
15	Questionnaire				
16	(Rest)				
17	Open Notes and Review	(2)	(3)	(2)	(3)
18	(Calculation)	Arr	–	–	Arr
19	Test	(2)	(3)	(2)	(3)
20	Questionnaire				

3.3 Installation

Each participant used three computers: a Pen Memo Tablet PC, one to play the lecture video, and one for answering the test questions. The Tablet PC had a keyboard, but the keyboard was disabled by keeping it folded while the participant watched the video and took notes (see Fig. 2). In the review session where note arrangement was permitted, the Tablet PC was unfolded and the participants could use the keyboard. The Japanese IME learning function was dis-



Fig. 2 Experimental setting.

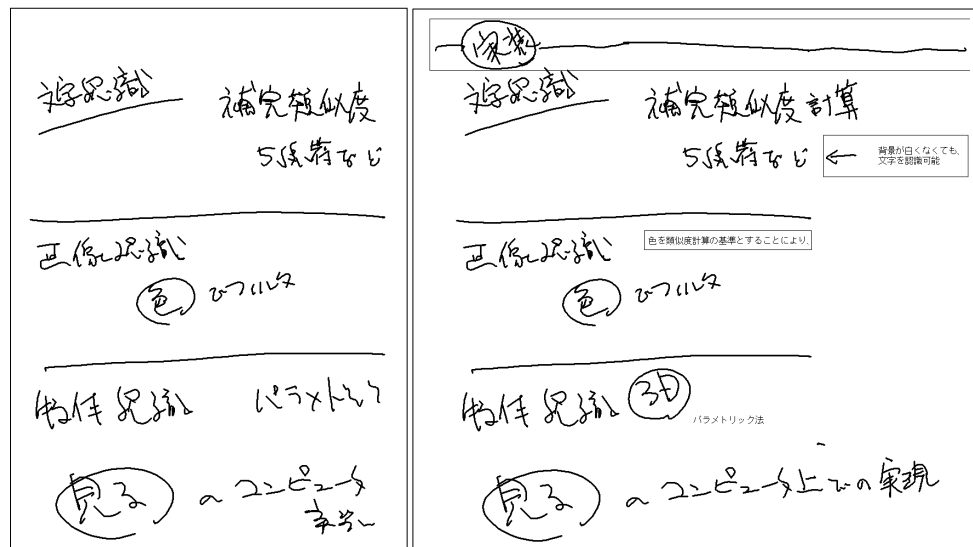


Fig. 3 Excerpt from participant P08's notes for Video (2) (left: before rearrangement, right: after rearrangement). Rectangles highlight added parts.

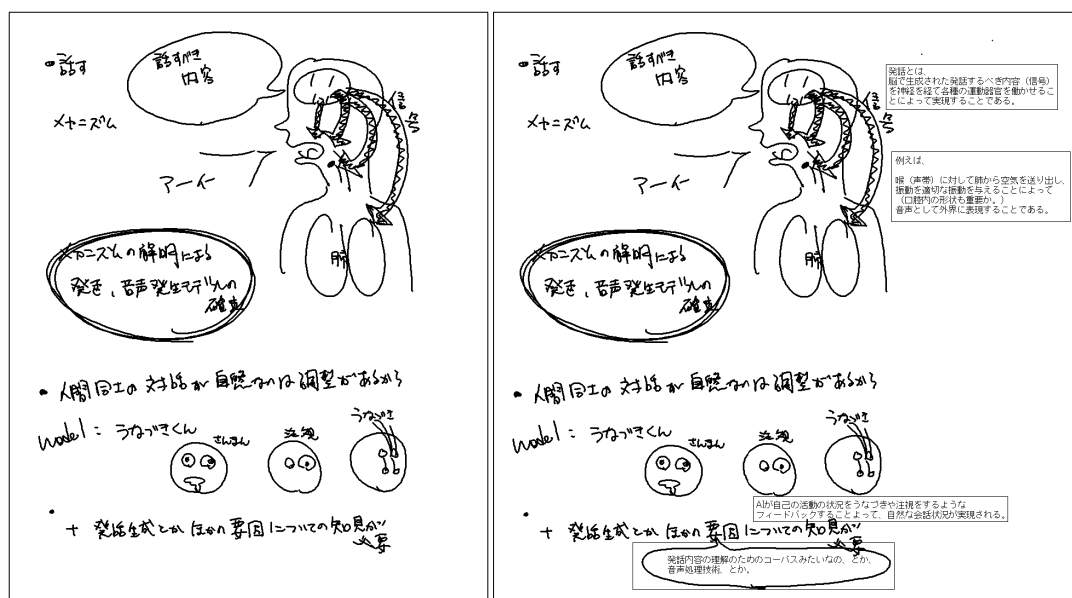


Fig. 4 Excerpt from participant P06's notes for Video (3).

abled. Before the experiment, participants were allowed to change their chair height, move the computers, and control the video volume. However, the resolution, window size, and font size of the applications were fixed for all participants.

3.4 Results

(6) From Observation

First, we describe the characteristics of the notes taken by participants with Pen Memo. The participants used only a tablet pen to handwrite notes on Day 1. Thus, the format of the notes before arrangement was similar to that of notes

written on paper, and the notes included figures and drawings. The notes were written from top to bottom and left to right in chronological order. The main difference in the notes written using Pen Memo from typical notes written on paper was the size of the handwritten characters. This was due to the thicker line of the Pen Memo stylus and the different feeling of writing on the tablet. Figure 3 and Fig. 4 show excerpts from participants' notes.

We observed from the note rearrangement during the review sessions on Day 1 that most of the participants enhanced their notes by adding text messages and extra drawings. In most cases, the text inputted from a keyboard was added near the handwritten characters to improve the legi-

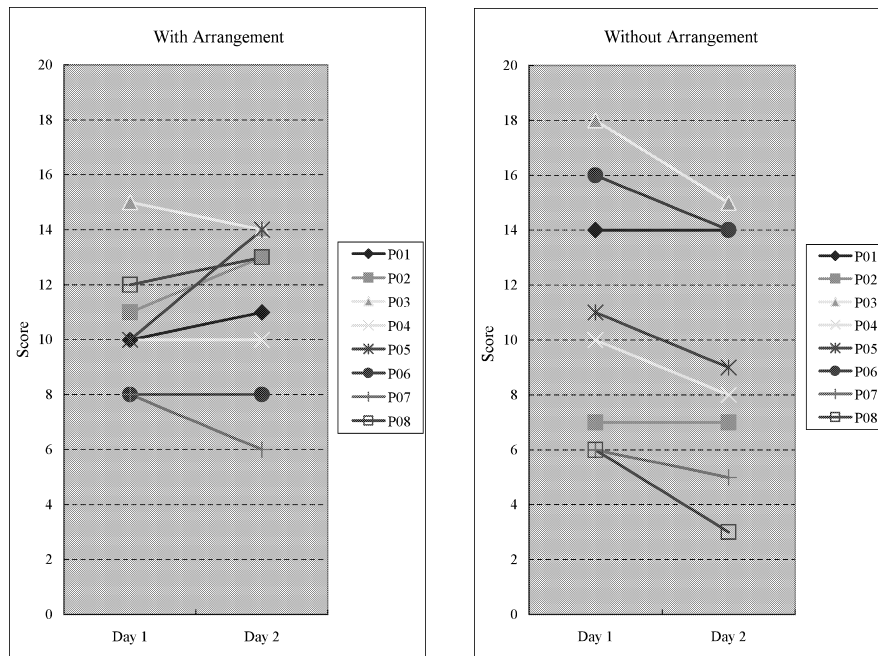


Fig. 5 Test scores: with arrangement (left) and without arrangement (right).

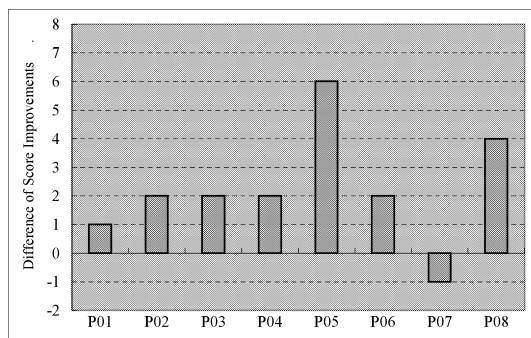


Fig. 6 Differences in score improvements. (P01–P08 indicate participants).

bility of notes. Participants also added lines as separators and arrows or balloons to relate text with notes. Some participants replaced their handwritten characters with text.

Next, we describe the results pertaining to the effectiveness, efficiency and satisfaction, in that order.

(7) Effectiveness

Figure 5 shows the test scores with arrangement (left) and without arrangement (right). A Day 2 score close to the Day 1 score indicated that the participant remembered much of the lecture content through note reference. With the arranging function, the average score of Day 2 increased by 0.625; whereas without arranging, the average score of Day 2 decreased by 1.625. Figure 6 shows the difference in the score improvements D , calculated as

$$D = (A_{day2} - A_{day1}) - (N_{day2} - N_{day1})$$

where A is the score with arrangement and N is the score

Table 2 Time Spent on Review (unit: sec).

	Mean	Std. Dev.
Day 1: With Arr	545.9	76.3
Day 1: Without Arr	168.8	165.4
Day 2: With Arr	166.5	86.2
Day 2: Without Arr	178.0	101.3

without arrangement. Positive values indicate the note arrangement improved remembrance. A paired-sample t test showed that the means of $(A_{day2} - A_{day1})$ and $(N_{day2} - N_{day1})$ significantly differed: $t(7) = 3.100, p < .05$ ($p = .017$). Thus, we ascertained that the note arrangement significantly enhanced remembrance.

(8) Efficiency

To evaluate the efficiency of Pen Memo, we compared the review time with and without arranging. Table 2 shows the means and standard deviation of the time. Note that the standard deviation of [Day 1 Without Arr] was larger than that of [With Arr]. The reason was that some participants quit reviewing process earlier than the given 10 minutes, because they only allowed to browse note. A paired t test indicated that review with arranging took significantly longer than that with no arranging on Day 1: $t(7) = 6.168, p < .01$. This was because the arranging task required additional text input and the moving of notes. On Day 2, however, although the amount of notes was increased by the arranging task, there was no significant difference in the review time: $t(7) = 0.468, p > .1$ ($p = .654$). We observed that few participants added text or notes during the second review on Day 2. This means most of participants did not need to add extra annotation and rearrangements on Day 2. We also found that much of the time needed to review notes without

Table 3 Questionnaire results regarding notes (* indicates significance with 5% probability) (rated by 7-point scale) (7–1).

	With Arr.		Without Arr.		<i>t</i> (7)	<i>p</i>
	Mean	Std.Dev.	Mean	Std.Dev.		
<i>Day 1:</i>						
Were you satisfied with your answer?	3.88	1.81	3.88	1.73	.00	1.00
*Were you satisfied with your notes?	4.63	1.41	3.25	1.28	2.58	.036
Did you have enough time for review?	5.50	1.69	5.75	2.19	–.370	.722
<i>Day 2:</i>						
Were you satisfied with your answers?	4.00	1.20	3.13	1.13	1.70	.133
Were your notes legible?	4.88	1.73	3.63	0.74	1.49	.180
Could you remember the lecture content?	4.37	0.74	3.75	1.67	1.49	.180
Could you remember the meaning of your notes?	5.38	1.19	4.88	0.83	1.08	.316

Table 4 Questionnaire results (use of Pen Memo to rearrange notes) (rated by 7-point scale) (7–1).

	Mean	Std.Dev.
Did you feel comfortable writing with the pen?	3.25	1.91
Was it easy to move note?	4.88	1.13
Was it easy to type text?	5.00	1.41
Was it easy to move text?	4.88	1.64
Was it easy to rearrange your note?	5.38	1.60

arranging was due to the difficulty of reading handwritten notes. During the lecture, participants had to take notes as rapidly as possible. Consequently, the rough writing later prevented quick recognition. The additional text inputted by keyboard enhanced the rough writing of note and accelerated the participant's recognition. Thus we can say that our PenMemo system has advantage on efficiency for reviewing if the user added proper annotations.

(9) Satisfaction

We had each participant complete a questionnaire after each test. Participants rated each item on a 7-point scale (1 = extremely no, 7 = extremely yes). Table 3 shows the questionnaire results concerning the notes taken by participants. According to the results for Day 1, participants were fairly satisfied with their notes when arrangement was permitted. The result concerning the adequacy of time for review and arranging showed that although the mean satisfaction was slightly lower when arranging was allowed, this difference was not significant. We consider the simpler function of Pen Memo, which was specialized for arrangement, to have worked effectively. The Day 2 results revealed a difference in how satisfied the participant's were with their answers compared to Day 1. These outcomes were due to the improved legibility of notes when arrangement was allowed.

The questionnaire results concerning the use of Pen Memo (Table 4) show that the participants did not find it comfortable writing with the stylus. This was mainly because of the unfamiliar surface of the Tablet PC and the latency of note updating. Results concerning the functions for arranging and reorganizing showed above-average satisfaction.

4. Conclusion

We have evaluated the effects of rearranging lecture notes on

remembrance using a simple note-taking application called Pen Memo. Our experimental results indicate that note rearrangement significantly improved remembrance. We believe that note rearrangement, such as adding and moving drawings and annotating by inputting text, has three effects: (1) it makes lecture notes more legible, (2) it forces the student to think about the lecture content, and (3) it strengthens the impression of the lecture and the activity itself. Even though the initial rearrangement takes a considerable time, we found there was no significant difference in the second review time thanks to the reinforcement. Therefore, students can make better notes which are legible, well-organized, and easy to review if they spend time rearranging their original notes.

Regarding the Pen Memo system, the rectangular region for selection should be improved to enable a flexible selection and moving function. More flexible and effective selection and grouping functions, similar to those of ScanScribe [13], should make arrangement tasks easier.

In this experiment, the content of the video lecture was well organized so there was little need for the participants to drastically rearrange their notes. Moreover, the scrolling metaphor adopted for Pen Memo might reduce the need for rearrangement, compared to that when using a fixed page format like that of an actual paper notebook, because the participants could take notes on a continuous page. We believe this arrangement will be especially effective for taking notes during class discussions and meetings which do not follow prepared scenarios. In our future work, we will investigate the effect of note rearrangement for such activities. Also, we will continue to investigate relationships between amount of rearrangement and level of understanding.

Acknowledgment

Our research was partly supported by a fund from the Ministry of Education, Culture, Sports, Science and Technology, Japan, under the title "Cluster for Promotion of Science and Technology in Regional Areas," and Grant-in-Aid for Scientific Research No. 17011028 from the Japan Society for the Promotion of Science.

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