A proposal of Arc Palette for a hand writing application used on a tablet device

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Abstract: As tablet devices became widely used, many useful hand writing applications have appeared. However, it seems that an instructive hand writing application for educational uses in the classroom does not exist. We consider this is because most of the existing hand writing applications for educational uses have an immature user interface. This paper focuses on a hand writing application for tablet devices that will be used in schools. We propose a new palette design named "Arc Palette", that helps students efficiently take notes. Arc Palette is an arc shaped design that is shown near a manipulating finger, so that items can be easily chosen. It will enable students to take notes smoothly. We designed several types of Arc Palette and, compared their operation times with typical palettes that are set on the left side of a display. As a result, it was found that the operation time of one of the Arc Palette designs is faster than the operation time of other types with the palette on the left side of the display. Operationally speaking, the Arc Palette will be an efficient option for a hand writing application.

Key words: Arc Palette, design, education, tablet device, user interface

1. Introduction

Since the network infrastructure has progressed, information technology has improved, many schools start introducing tablet devices in the classroom. Now the tablet devices tend to be used as textbooks, dictionaries and some kind of media players but not for taking notes. Although students are still using a paper notebook for note taking in the classroom, we consider that using a paper notebook will be replaced using a digital tablet device very soon. Therefore we are developing usable hand writing application for tablet devices.

Hand writing functions are now built into many kinds of educational applications so that it makes students easy to use those applications. For instance, Anthony [2] et al. had introduced hand writing and its recognition function for an intelligent tutoring system.

When a hand writing application is used in a class, the application should support students in efficiently taking notes. There are many useful hand writing applications but most of them are not supposed to be used by students in the classroom, and, do not take into consideration how they can be more efficiently applied to note taking. We expect that those applications should have a suitable user interface for taking notes in the classroom.

Kim [6] et al. has researched the requirements for electronic note taking systems and found that students want to have simple and quick note taking systems rather than having many optional functions that disturb the basic way of note taking. This study shows a clear direction for developing the note taking application. From many approaches to improve the efficiency of taking notes, this time we selected to improve a manipulation speed. Because taking notes in the classroom requires rapidity.

The purpose of this study is to propose a new palette design for a hand writing application, which enables students to take notes smoothly.

When taking notes with a tablet device, every application needs to have a palette in order to change the color and line weight. Most of the existing applications set the palette on sides of the display, which causes mainly two problems. First, smooth writing will be hindered, because of the far-off palette as writing will be hindered when the color or line weight needs to be changed. Second, because of the existence of the palette, the area of the display is occupied and the writing space is thus reduced. We have developed a new palette named "Arc Palette", which is specifically designed to write contents smoothly. Arc Palette is arc shaped and is shown dynamically near a manipulating finger. We designed different types of the palette and measured the operation time for the following series of actions: finish writing, choose another item on the palette and restart writing. Then we compared the action times of the Arc Palette with the action times of applications with palette on the left side of the display.

This paper is structured as follows: Chapter 1 describes the present situation and problems of hand writing applications for educational uses. Chapter 2 introduces related works. Chapter 3 gives detailed account of the Arc Palette. Chapter 4 describes three types of experiments. Chapter 5 gives results. Chapter 6 gives the conclusions and future research.

Note that we use "palette" as a set of items, which can be chosen. In this paper, "menu" has the same meaning as "palette".

2. Related work

Most hand writing applications and drawing software have a palette on either side of, or the top or bottom end of a display. For instance, Microsoft Paint [8] sets its palette on the top end of the display. Adobe Illustrator [1] has its palette on the left side of the display. This is a typical user interface for PC software. When we think about designing a hand writing application for a tablet device, and because the tablet device has a smaller display, such types of palettes will occupy a certain space on the display. An example is shown in Figure 1.

Hopkins [5] designed a unique round shaped menu called "Pie Menu" (shown in Figure 2), which when the mouse cursor is clicked, items appear around the cursor. The mouse with very small movements can easily choose items. Callahan [3] et al. compared the pie menu with a liner menu and indicated the benefits of the pie menu. In their experiments, a pointing device was used; however, when the pie menu is used in a tablet device, some items on the menu will be behind a manipulating finger.

Xiangshi [10] et al. made "Layer-Pie-Menu", which is an enhanced pie menu. It has some layers in order to set more items than the ordinary pie menu. But in our study, an application is supposed to be used in the classroom as an educational tool. A smoothly writable condition is more important than the number of items available.

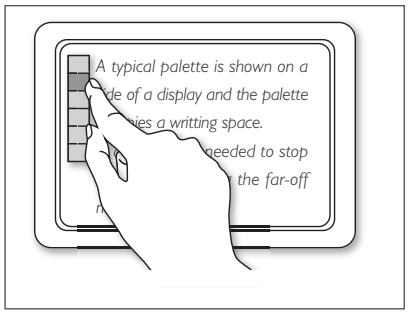

Figure.1 Typical palette

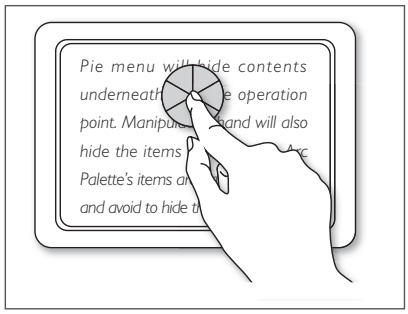

Figure.2 Pie Menu

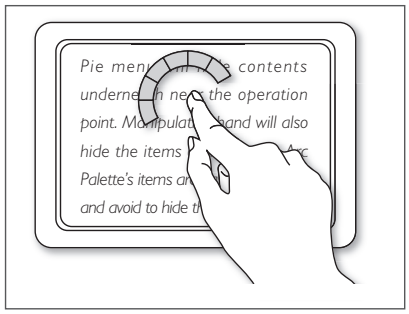

Figure.3 Arc Palette

These pie menus provide an effective way to make menu selections. But one of the problems is that the menu hides the contents underneath, and this will disrupt smooth writing.

An application named "Note Anytime [7]" has a functional palette. There is a small round shaped icon on the display, and when it is tapped, some items appear around the icon, from which items can be chosen. Although it is necessary to tap the icon again to remove surrounding items, this palette achieves minimizing the palette area within the display. That said, from the view point of achieving smooth writing for educational uses, too many processes are needed: find the icon (icon can be set anywhere on the display), tap the icon, choose an item, and tap the icon again to remove items.

Arc Palette is shown in Figure 3. The unique arc shaped design has much potential to solve such problems. The shape avoids covering the contents near the finger. It also enables items to be recognized smoothly. When contents are written, Arc Palette is not shown and the display is fully available.

3. Arc Palette

While considering a new palette design for a hand writing application for educational uses, we set the basic design concepts of the palette as follows.

- Students can take notes efficiently using the palette.
- The describing area should be as wide as possible.
- The palette should not hide writing contents.

Based on those concepts, we designed "Arc Palette", which has an arc shaped design and is shown dynamically near a manipulating finger. There are two important factors in the characteristics of the arc shaped design.

One is that the palette avoids covering the contents underneath and near the finger, and let the students take notes efficiently. Another is that the palette avoids being covered by the hand so that all items on the palette can be clearly recognized. In addition, when students are writing contents, Arc Palette will not be shown on the display, and the writing area of the display is fully available. The hand writing process with Arc Palette is shown in Figure 4.

In this study, we developed a hand writing application with JavaScript and HTML5. It runs as a web application so that most tablet devices, which are connecting to the Internet, can run the application.

4. Experiment

In order to achieve our ambitious goal, we developed several types of Arc Palette and, had three experiments. Each experiment has a purpose, which are listed below.

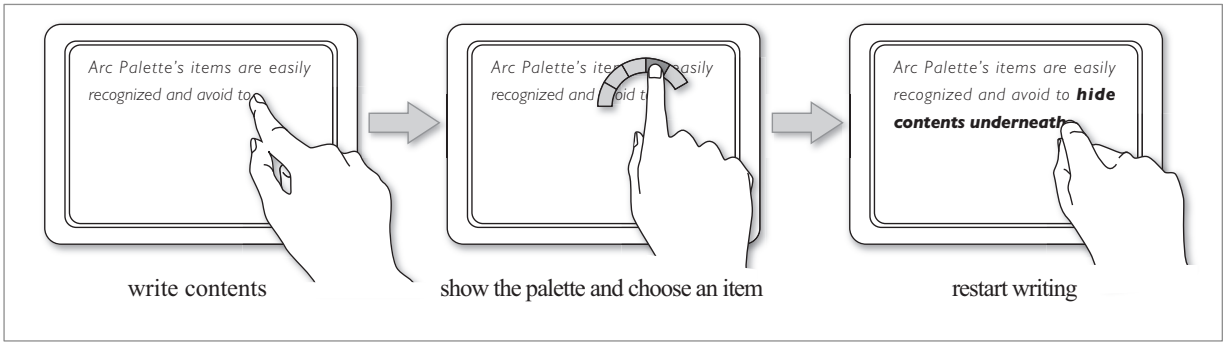

Figure.4 Writing process with Arc Palette

- Experiment 1 is to confirm reactions for our prototype of Arc Palette.
- Experiment 2 is to reflect the results of the experiment and to confirm any improvements.
- Experiment 3 is to carry out research for suitable target users, reflecting all results and considerations.

4.1 Experiment 1

4.1.1 Overview

There were four subjects in this experiment. They were three males and one female, all aged from thirty to fifty. Three subjects were right-handed and one subject was left-handed. They used an iPad as a tablet device.

We showed them a picture (drawn in Figure 5) as an object. Three types of shape: squares, circles and triangles are on the picture and each of them is colored white, red, blue and green. Each picture has arrows that subjects follow in a specific order to complete the drawing.

We asked them to draw the picture twice with two types of palettes. One is an ordinary design palette named Stayed Line Palette (SLP) (shown in Figure 6) that is set on the left side of the display. The SLP is positioned in the same location, and is shown all the time. Another is an Arc Palette, which is shown in Figure 7. Each of the palettes has two columns, and we set the same height and width for each item. When subjects want to pop up the Arc Palette, they need to double tap the display, then, the palette appears near the double tapped place. After a briefing on the experiment and its purpose, the subjects took approximately ten minutes for a practice trial in order to get used to the tablet device and the two types of palettes. We referred to “Fitts’s law [4]” to record all of the drawing processes and, observed the time taken for actions 1 to 3.

1. Finger up (after drawing a stroke)
2. Select an item
3. Finger down (to start drawing a new stroke)

4.1.2 Result

After recording all of the drawing processes, we calculated the set of actions and made average scores for each palette. Both palettes have same size of items, so the manipulation speed will only depend on the distance between the writing point and items. Arc Palette appears near the finger and the distance between the writing point and items are always same. Although SLP is positioned in the same location, its distance between the writing point and items are not constant and mostly farther th an the Arc Palette’s distance. Therefore we expected the Arc Palette to be manipulated faster than the SLP. However, all subjects produced the opposite results and the manipulating speed of SLP was faster than the speed of the Arc Palette.

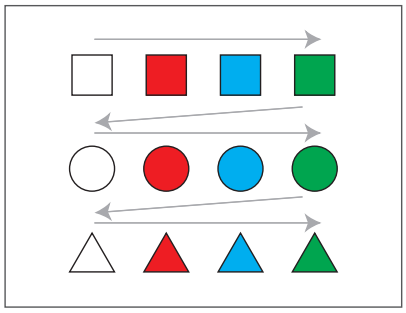

Figure.5 Picture object

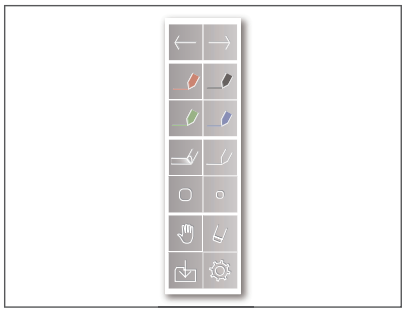

Figure.6 Stayed Line Palette

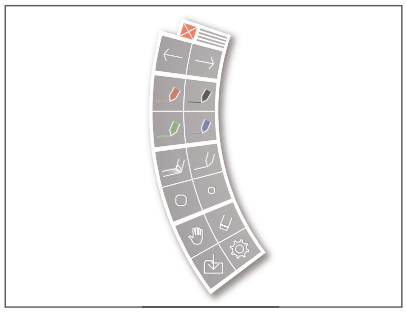

Figure.7 Arc Palette

4.1.3 Consideration

After the experiment we hold a group discussion and found causes for the delays in using the Arc Palette manipulation. One reason was that the SLP was shown all the time in the same location, so it was easier to remember where the items were. The Arc Palette was only shown after double tapping and accordingly it was more difficult to remember the items' positions. 14 items were there on each palette and, it was too many to remember all of them.

Another reason for the slowness of the Arc Palette manipulation was the lack of operability. After choosing an item, the Arc Palette would disappear after subjects tapped a white space, otherwise, without doing so, the Arc Palette would stay in the same position. The subjects commented that this was really stressful, because sometimes the Arc Palette was in the place where they wanted to start drawing and they needed to remove it. Although the Arc Palette had items to move, and remove itself, our subjects wanted to remove the palette after choosing the color or line weight, so that they can continue writing smoothly.

In addition, we found that some subjects tended to tap a specific point to show the Arc Palette, rather than tapping near the manipulating point. This was because they had not become accustomed to the Arc Palette and they had a fixed idea that a palette should be shown in the same location.

4.2 Experiment 2

We designed another prototype of an Arc Palette (shown in Figure 8). It displayed two parts of the palette separately. It seemed meaningful, as it intentionally avoided contents underneath, as well as the manipulating hand. But, when this palette was applied to the tablet device, we noticed that our hand moves much more flexibly than our expectations and the hand often covered some parts of the palette. Finally, we redesigned a simpler Arc Palette (shown in Figure 9). We had put 14 items on the previous palette however, this time we reduced the items from 14 to 8. For this decision, Miller's magical number [9] was referred to. Two columns had been too complex, and thus, all items were set in one column. When selecting items (other than the undo and redo buttons) the palette disappears so that subjects can easily restart writing regardless of new stroke location.

4.2.1 Overview

The four subjects who took the experiment constituted three males and one female aged from thirty to fifty. One of them had taken the last experiment, while the rest of them had not. Three subjects were right-handed and one subject was left-handed.

We compared three types of palette. One is the Arc Palette. The subjects can choose suitable angles for right-handed or left-handed.

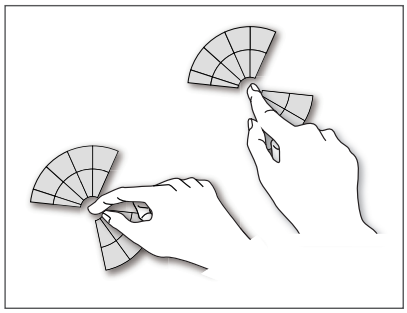

Figure.8 Prototype Arc Palette

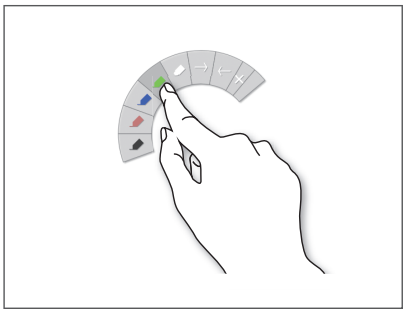

Figure.9 Simpler Arc Palette

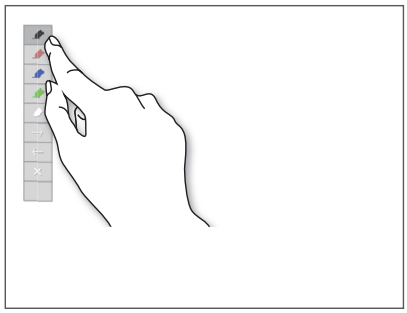

Figure.10 SLP and PLP

Another palette is named Pop-up Line Palette (PLP), which appears and disappears (as does the Arc Palette), and the remaining palette is Stayed Line Palette (SLP), which is shown on the display all the time. All palettes have the same items and same size. The PLP and SLP have the same design, which is shown in Figure 10, and they were both located on the left side of the display. Double tapping pops up the Arc Palette and PLP. An object to be written was changed to alphabetic symbols and numbers. We carefully explained how to use the palettes correctly. Other conditions were the same as the last experiment.

4.2.2 Result

There was a significant difference in the operation time for the Arc Palette (mean 2.05, s.d. 0.82) and the PLP (2.73, 1.08). Conditions; $t(95) = 3.682$, $p = 0.0002$ (< 0.05). Though the SLP (1.76, 0.72) was still faster than Arc Palette. Conditions; $t(107) = 1.925$, $p = 0.0280$ (< 0.05).

4.2.3 Consideration

When the Arc Palette and the PLP are compared, both of them have to be double tapped to show themselves. Because of this similar condition, the operation time follows “Fitts’s law” and these results are understandable.

When the Arc Palette and the SLP are compared, the SLP is visually recognizable, thus the operation time of the SLP will be faster than that of the Arc Palette. To improve on the Arc Palette, we carefully traced all processes of this experiment and found convincing indications that double tapping makes the operation time slower. In addition, we paid strict attention to eye movement. In experiment 1 and 2, we showed the picture and the alphabetic characters in front of them. The subjects had to have a quick look at the object and had to remember it. Through this process their eyes moved in many directions. From this point of view, we expect that if the object were to be set on the background of a display and subjects trace it, the operation time would be faster.

4.3 Experiment 3

4.3.1 Overview

Our main target users are students though, and in order to compare differences, young and adult subjects took this experiment. There were six subjects whose average age was 11.8, and all of them study in school. We call them subjects S (S from students). Three of subjects S were males and three of them were females. One of subjects S was left-handed. Three subjects were adult and we call the adults subjects A (A from adults). One of the subjects A was a male and the others were females. All of the subjects A were right-handed. The average age was 41.6.

We explained our purpose of this experiment to the subjects, and, how to use the three types of palette. After the experiment the subjects were sent out a questionnaire.

We prepared a Japanese character object because some of the subjects S might not understand alphabetic symbols. The object was set on a background of the display. Three types of palettes were used, the Arc Palette, the PLP and the SLP. Single tapping shows the Arc Palette and PLP. All other conditions were the same as in the previous experiments. Figure 12 shows how the experiment was held.

4.3.2 Result

Including the final experiments, we recorded all operation processes and calculated the average time for each palette. Further, we calculated average times for subjects S and A separately. The average time is shown in Figure 11.

The results of the subjects S shows that the operation time of the Arc Palette (mean 1.77, s.d. 0.51) was faster than the SLP (1.96, 0.94) and the t-test result was t (153) = 1.816, p = 0.0356 (< 0.05). As compared with the PLP (2.31, 0.89), the t-test result was t (171) = 5.562, p = 0.0001 (< 0.05). The results are shown in Table 1. The subjects A showed different results. The operation time of the Arc Palette (mean 1.85, s.d.0.50) was slower than the operation time of the SLP (1.66, 0.89), though there were no significant effects. The t-test result was t (85) = 1.344, p = 0.0911 (< 0.05). As compared with the PLP (2.22, 0.51), it gave a significant effect. The t-test result was t (109) = 3.921, p = 0.0001 (< 0.05). The results are shown in Table 2.

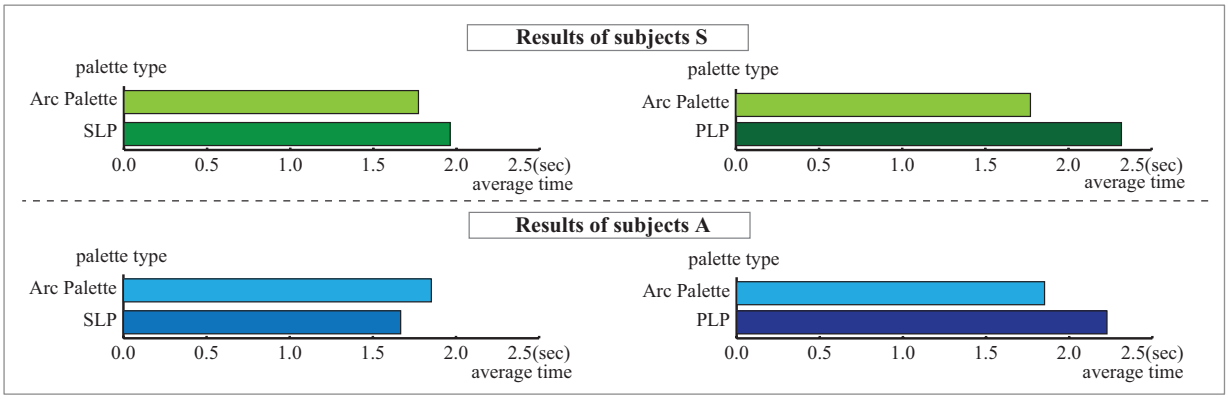

Figure. 11 The average manipulation time for the subjects S and A

Table. 1 Results of subjects S

Comparing Means [t-test assuming unequal variances (heteroscedastic)]				**Comparing Means [t-test assuming unequal variances (heteroscedastic)]**			
Descriptive Statistics				***Descriptive Statistics***			
Palette type	*Sample size*	*Mean*	*Variance*	*Palette type*	*Sample size*	*Mean*	*Variance*
Arc Palette	111	1.77117	0.26	*Arc Palette*	111	1.77117	0.26
SLP	102	1.96176	0.88	*PLP*	109	2.31835	0.80
Summary				***Summary***			
Degrees Of Freedom	153	*Test Statistics*	1.82	*Degrees Of Freedom*	171	*Test Statistics*	5.56
One-tailed distribution				***One-tailed distribution***			
p-level	0.0356	*t Critical Value(5%)*	1.65	*p-level*	0.0001	*t Critical Value(5%)*	1.65

Table. 2 Results of subjects A

Comparing Means [t-test assuming unequal variances (heteroscedastic)]				**Comparing Means [t-test assuming unequal variances (heteroscedastic)]**			
Descriptive Statistics				***Descriptive Statistics***			
Palette type	*Sample size*	*Mean*	*Variance*	*Palette type*	*Sample size*	*Mean*	*Variance*
Arc Palette	56	1.85179	0.25	*Arc Palette*	56	1.85179	0.25
SLP	55	1.66727	0.79	*PLP*	55	2.22727	0.26
Summary				***Summary***			
Degrees Of Freedom	85	*Test Statistics*	1.34	*Degrees Of Freedom*	109	*Test Statistics*	3.92
One-tailed distribution				***One-tailed distribution***			
p-level	0.0911	*t Critical Value(5%)*	1.66	*p-level*	0.0001	*t Critical Value(5%)*	1.66

Figure.12 The conditions of the experiment

4.3.3 Number of items

We asked subjects S about writing materials typically found in a pen case that they usually use. Although the average number of writing materials utilized were around 8, the subjects answered that only 4 materials are frequently used on average. The number of writing materials is shown in Table 3.

We set 8 items on each of the palettes and, it seemed too few, but according to the questionnaire answers, it was enough for taking notes while using an application for educational purposes in the classroom. The number of frequently used writing materials was 4. This indicates that the suitable number of items for a palette is 4 to 8.

Table. 3 Number of the writing Materials in pen cases

	Subject S1	Subject S2	Subject S3	Subject S4	Subject S5	Subject S6	Average
Writing materials	**6**	**14**	**6**	**5**	**11**	**6**	**8**
Frequently used materials	**4**	**6**	**3**	**2**	**4**	**5**	**4**

4.3.4 Consideration

In the case of subjects S, we found that even though the SLP was shown all the time, the operation time of the Arc Palette is faster. Setting an object on a background contributed to subjects' concentration with regard to writing. Single tapping was effective in shortening the operation time of both the Arc Palette and the PLP.

In the case of subjects A, however, the average operation time of the SLP was slightly faster than the time of the Arc Palette, but there was not a significant difference.

On the other hand, both the subjects S and A showed that the operation time of the Arc Palette is much faster than the time of the PLP.

We examined the reasons for the differing results between the subjects' operation times for the Arc Palette and the SLP. It was supposed that the subjects A had already gotten used to an ordinary palette design (like the SLP), and could not become accustom to using the Arc Palette. We recalled that, when we undertook the first experiment, some subjects tapped the same position to show the Arc Palette. Adults might have a fixed idea and cannot imagine operating a palette that shows itself near the manipulating position.

On the other hand, subjects S had become accustom to either the SLP or the Arc Palette, therefore, they easily adapted to the Arc Palette. They had no preconceived or fixed idea with regard to either palette. We asked the subjects if they had had any previous experience in using an iPad or drawing software. Some subjects had had previous experience, and some had not. This meant that their previous experiences did not affect the results so much, and we can conclude that their minimal experience in using ordinary designed palettes has not had a negative affect.

Of course, there could be other possibilities. The size of the Arc Palette might fit students' hands but not adults, though this is a mere guess that we could not figure it out.

5. Result

Through all experiments, instructive facts were discovered. The operation time of the Arc Palette was faster than the time of the PLP. If the size of the writing area was considered and adopted to the PLP, the operation time would be slower. Although the SLP occupies a writing area, the operation time was fast enough. The differences in the operation speeds between the Arc Palette and SLP depended on conditions. In experiment 2, the operation time of the Arc Palette was slower than the time of the SLP. In that case, the Arc Palette was manipulated by double tapping, with the objects being shown in front of the subjects.

In experiment 3, the student subjects' operation times with the Arc Palette was faster than the times with the SLP. The subjects A's operation times with the Arc Palette and SLP were no significantly different. This time, the Arc Palette appeared by single tapping, with the objects being shown in the background of the display.

6. Conclusion

We found that the operation time of the Arc Palette is faster than that of the PLP. Moreover, when subjects S use the Arc Palette, the operation time is faster than that of the SLP. In particular, a combination of single tapping and tracing a background object gives remarkable fluency for manipulation. These results will contribute to greater efficiency of hand writing applications for educational purposes.

Sometimes unique designs tend to have a lack of usability. The meaningful design of the Arc Palette, however, showed massive possibilities. Each item on the palette avoided being covered by the manipulation hand. The arc shaped design provides a clear recognition of the contents near, but not hidden by, the fingers.

Although we found that the manipulation time of the Arc Palette is faster than that of the SLP; this was only the case when subjects S used the Arc Palette. In the same case, subjects A showed differing results, and we did not figure out the reason for the differences between subjects S and A. We have however surmised several reasons for the curious results. Subjects A might be accustomed to the ordinary designed palette, while subjects S have not, thus allowing them to easily cope with the Arc Palette. Or, it might be because the size of the Arc Palette did not fit the hand sizes of the subjects A. We did not discover the reasons for certain, though they will be part of our further research.

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