Improvement of Pressure Control Skill with Knife Device for Paper-Cutting

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SUMMARY In this paper, we propose an interactive system for controlling the pressure while cutting paper with a knife. The purpose is to improve the cutting skill of novices learning the art of paper-cutting. Our system supports skill improvement for novices by measuring and evaluating their cutting pressure in real-time. In this study, we use a knife with a blade attached to a stylus with a pressure sensor, which can measure the pressure, coordinates, and cutting time. We have developed a similar support system using a stylus and a tablet device. This system allows the user to experience the pressure of experts through tracing. Paper-cutting is created by cutting paper with a knife. The practice system in this paper provides practice in an environment more akin to the production of paper cutting. In the first experiment, we observed differences in cutting ability by comparing cutting pressures between novices and experts. As a result, we confirmed that novices cut paper at a higher pressure than experts. We developed a practice system that guides the novices on controlling the pressure by providing information on the cutting pressure values of experts. This system shows the difference in pressure between novices and experts using a synchronous display of color and sound. Using these functions, novices learn to adjust their cutting pressure according to that of experts. Determining the right cutting pressure is a critical skill in the art of paper-cutting, and we aim to improve the same with our system. In the second experiment, we tested the effect of the practice system on the knife device. We compared the changes in cutting pressure with and without our system, the practice methods used in the workshop, and the previously developed stylus-based support system. As a result, we confirmed that practicing with the knife device had a better effect on the novice’s skill in controlling cutting pressure than other practice methods.

key words: cutting, knife interface, stylus, drawing display, supporting practice

1. Introduction

The creation of craft art is appealing to all generations because it helps with concentration and has a relaxing effect. However, as many crafting activities cannot be undone, it is necessary to develop various skills, such as hand dexterity, through repeated practice. In this study, we focus on the skill of paper-cutting, which involves creating art by cutting paper with a knife (Fig. 1 A).

Anyone can learn to craft art designs from books and the internet. However, it is difficult for novices to adapt motifs created by other artists, because of the skill gaps between them. Novices find it difficult to cut smoothly while learning paper-cutting. They tend to cut the paper with excessive pressure. Therefore, some paper-cutting instructors teach novice students to practice tracing the paper with a pencil. When a novice traces the paper with excessive pressure, the pencil tip wears down or breaks. The purpose of this instruction is to encourage the novices to learn how to maintain the appropriate pressure for paper-cutting through practice. However, cutting and tracing are different; therefore, novices must constantly practice to improve their cutting skills.

The paper-cutting techniques are difficult to learn, and some people practice for several months to years in the paper-cutting course for novices. Novices tend to cut the paper with too much pressure, and hence, they cannot cut the paper smoothly. Some paper-cutting instructors instruct novice students to practice tracing the paper with a sharp pencil. When the novice traces the paper with too much pressure, the pencil tip is lacking. The purpose of such training is for novices to practice to maintain the appropriate pressure for paper cutting. We have developed a practice system for improving pressure control skill that uses a tracing motion [1] (Fig. 1 B). In [1], the user uses a stylus (Apple Pencil, Apple) to tracing on a tablet device (iPad Pro 12 inch, Apple). The system evaluates the tracing pressure. Users practice drawing based on the evaluation from the system, similar to the pencil practice method in the workshop. Beside, we have built a system that measures the cutting motion using a blade attached to the tip of a stylus [2], [3]. This system can measure the pressure and coordinates when the user cuts the paper. It supports the improvement of the cutting operation by measuring the pressure when the user cuts paper. We used the same system as in [1] for this pressure evaluation function. In this paper, we compare the skill improvement between tracing training [1] and cutting training [2], [3].

![Fig. 1](image-url)
We aim to improve the cutting skills used to create paper-cutting art. In this study, we focus on the cutting pressure that many instructors teach novices in workshops. We developed a device to measure cutting pressure and a system to support pressure control for novices by measuring the pressure control of experts (Fig. 1C). Pressure control is intangible information; therefore, it can only be learned through repeated training. We introduced a supporting system to improve the cutting skills needed to create cut pictures.

In Sect. 3, we describe the developed support system and its effect on the ability of novices to control cutting pressure. In Sect. 4, we experiment to determine the differences between the cutting pressure values of novices and those of experts. Based on the results of this experiment, we implement the correct range of pressure and create a display that is described in Sect. 5. In Sect. 6, we compare the cutting pressures of novices who have practiced using different pressure control patterns. We verify the effect of the system from the results to confirm that it improves the skill of the novices to control cutting pressure. We present the discussion and the conclusion in Sects. 7 and 8.

2. Related Work

The observation and imitation of an expert is one method to improve the creative skills of novices[4]. The use of technology, as a means of assisting users to draw, has been explored in modeling applications. Studies [5]–[7] assist users in drawing faces and eyes. These studies rely on a face and a set of sketch recognition algorithms to generate domain-specific instructions and textual or on-canvas feedback. Studies [8], [9] present an image-guided pen-based suggestive interface for sketching 3-dimensional (3D) wireframe models. Studies [10], [11] support 2D/3D drawing practices and promote correction and improvement by comparing the user’s imitation of a picture with the original.

In a study to improve the novice’s movement, actions performed by the experts are measured and the novices are instructed according to the differences observed. Many studies visualize the measurement and expression of movement and promote the practice and support of creativity through various imitations[12]. The system provides appropriate instructions to the user by measuring the coordinates and pressure of the stylus in real time. Some researchers support art creativity by controlling the pressure on tools used in sketching [13] and calligraphy [14]. These studies are evaluated based on input pressure. Studies [15] and [16] use an intuitive ghost metaphor and a first-person viewpoint for effective motion training. The result is an image of the subject performing gestures with the accuracy of an expert [17], [18]. Using a camera, study [19] compares the movement of the user’s arm with that of an expert during pottery modeling. It then uses a projector to provide instructions to the user about arm movements. These studies compare the behavior of the users with that of the experts. The systems in these studies instruct the user in real time on appropriate ways to improve motion. Similarly, our system improves the users’ cutting pressure control by comparing the cutting pressure values of users with those of experts in real time.

Various support systems provide guidance via a projector, monitor, and tablet device. Study [20] uses a method that involves cutting along a line projected on paper to support paper-cutting performance. Projector-Guided Painting [21], [22] decomposes the target painting into coarse-to-fine layers. Users paint over the projection of each layer, following the guidance to orient individual brush strokes or paint all the strokes of a given color. Similarly, study [23] allows users to trace over a 3D scene projected on paper. Study [24] supports sculpting work using a projection of 3D objects. Moreover, study [24] improves tracing accuracy by displaying instructions on a head-mounted display. Study [25] corrects tracings by comparing the drawings with those in a database on a tablet device. Study [26] allows expert users of sketching software to generate tutorials for novice users. This system offers on-canvas guidance and feedback such that users can replicate the strokes of experts along each step of the tutorial. These systems allow novices to imitate the behavior of experts. Our system aims to allow users to cut paper with the same amount of pressure used by experts. This is achieved by displaying the difference between the pressure applied by the users and that applied by experts.

3. Cutting Device

In this section, we discuss the design of our system, which consists of a drawing display and an attached stylus. A blade is attached to the tip of the stylus. The purpose of our system is to measure the pressure with which the user cuts the paper as well as the cutting time.

3.1 Stylus with Blade

This device is designed to measure cutting pressure. We modified the stylus to collect data by attaching a blade (NT BDC-200P) to the tip of the touch pen (Wacom PenPro2) (Fig. 2A). We glued the tip of the knife to the stylus with ultraviolet resin. A pressure sensor is in the stylus.
3.2 Display Unit

The drawing display unit (Wacom Cintiq Pro16, 3840 × 2160 pixels, 275 dpi) shows pictures, as shown in Fig. 3. The display acquires the coordinates of the knife every 1 pixel (0.2 mm). The system only responds when the stylus is in contact with the screen. Although the tip of the stylus and the surface of the screen are not in contact, the display unit can recognize the coordinates of the stylus. It can obtain the location and angle data for the stylus via electromagnetic induction. Paper is affixed to the screen, which is protected with tempered glass. The user cuts the paper with the device, and our system measures pressure, coordinates, and cutting time.

3.3 Cutting Patterns

The system provides four patterns for practicing paper-cutting (Fig. 4). These are plotted in a square measuring 100 mm × 100 mm. Some experts use these patterns during paper-cutting workshops to instruct users on how to practice cutting. Figures 4 A and 4 B show simple patterns. In addition, the participants divide these patterns into three parts. Figure 4 C shows a pattern in which the margins gradually decrease in size. The participants start from the wide left margin of the pattern and only cut vertically. The pattern in Fig. 4 D comprises circles that gradually become smaller, and it is cut from the outside of the circle with the smallest curvature.

4. Experiment 1: Differences in Cutting Pressures between Novices and Experts

4.1 Objective

In this section, we present our experiment for measuring the pressure applied by novices and experts. The purpose is to compare the pressure applied by novices with that of experts and determine the pressure range of experts. We measure the pressure, time, and coordinates when novices, as well as experts, cut paper using our knife device.

4.2 Experiment Configuration

Twenty participants were asked to use our knife to cut paper on the drawing display. There were 10 novice participants (seven males and three females with an average age of 27.4 years) who had never performed paper-cutting, and 10 expert participants (six males and four females with the average age of 32.5 years), who were artists and instructors. The participants were asked to cut the borders between the white and black portions for all four patterns, as shown in Fig. 4. They were instructed to repeat this process 10 times.

4.3 Result

We compared the average pressure and the variance for all four patterns together, as well as the average pressure and cutting trace for each individual pattern.

4.3.1 Average Pressure and Variation

Table 1 shows the average pressure when each participant cut all the patterns. As a result, Novices performed the cutting with 1.4 times more pressure and expended 1.3 times more time than the experts expended. The experts quickly cut the lines with an average pressure of approximately 300.0 g.

Figure 5 shows the variability based on all pressure data when each participant cut each pixel (0.2 mm). In this box-and-whisker plot, the left and right line segments show the minimum and maximum pressure values, respectively, and the centerline of the box shows the median pressure. The results showed that the pressure of novices was from 324.4 to 480.1 g. On the other hand, the experts cut in a pressure range of 248.9 to 354.2 g.
Table 1  Average pressure and moving time in for the pattern in Fig. 4.  

|               | Novices | Experts |
|---------------|---------|---------|
| Pressure (gram) | 437.7   | 303.3   |
| Time (second)  | 58.9    | 44.8    |

|               | Average | SD |
|---------------|---------|----|
|               | 23.9    | 14.8|
|               | 6.6     | 3.9 |

Note: Rounded to one decimal place

4.3.2 Cutting Trace of Pressure in the Patterns

We plotted the average coordinates and the pressure when the participants cut each of the four patterns (Fig. 6)). As shown in Fig. 6 A, the novices cut the entire straight line with higher pressure than that applied by the experts. Figure 6 B shows that the novices cut the curved pattern with higher pressure than that applied for the straight line. Conversely, experts cut paper with similar pressures regardless of the pattern. As can be seen in Fig. 6 C, the novices cut the boundaries with higher pressure as the margins narrowed. They also cut the pattern in Fig. 6 D with higher pressure as the curvatures grew larger.

The cutting trace performed by the novices is very different from that of the experts, particularly with regard to the smallest circle in Fig. 4 D (10 mm diameter). Figure 7 shows the difference between the cutting performed by one representative participant from each group. One of the novices cut an irregular circle by applying a pressure that was too high (Fig. 7 A). However, one of the experts smoothly cut a circle by appropriately adjusting the applied pressure (Fig. 7 B).

4.4 Experiment 1 Conclusions

During Experiment 1, we measured the average pressure and pressure variation when novices and experts cut the same pattern. It was observed that the novices cut with higher pressure compared to the experts. Furthermore, the cutting time and the pressure of novices were higher for thin lines and small circles. When we interviewed the participants after the experiment, we observed that the experts attempted to maintain uniform cutting pressure on all the lines. Cutting the paper with excessive pressure makes it difficult to operate the knife. Therefore, the experts cut with pressure ranging between 250 and 350 g. Conversely, novices cut the more difficult patterns with higher pressure. They cut carefully and have been unaware of maintaining the pressure. We found that the novices cut with higher pressure as the difficulty of the patterns increased. From the above results, we confirmed that there is a difference in cutting pressure between novices and experts.

5. Drawing Display

One of the purposes is to improve the skill to control the pressure of novices. We interviewed five experts (two males and three females with an average age of 32.5 years) about the presentation method to experience pressure control for novices. They were artists and instructors. As a result, they answered the method of telling the user to see and hear. At the workshop, the instructor teaches the participants with gestures and voices. The instructor and the participants avoid teaching with active touching. The reason is that they have the risk of injury with a knife. Therefore, our system notifies the evaluation of the user’s pressure with color and sound.

Our drawing display has a function called Displaying Applied Pressure. This function synchronizes with the pressure of the knife and produces corresponding colors on the drawing display along with sound alerts. It is confirmed from Experiment 1 that the experts cut paper with a pressure ranging from 250 to 350 g. Therefore, we designed the color and alert thresholds according to the pressure difference between the users and experts. The evaluation is provided based on a comparison of the pressure applied by
the users and that of experts (Fig. 8). The user cuts the paper fixed on the drawing display with a knife that measures the pressure. Our system measures the cutting pressure of the user and displays how it differs from that of the expert, thereby supporting the acquisition of his/her cutting skills.

When the pressure applied by the user is 250 g or less, the display is white. When the applied pressure is in the range 250 to 330 g, the display color gradually changes to dark green. In the range of 330 to 350 g, the display changes to yellow to alert the user about excessive pressure. At pressures greater than 350 g, the display color turns red. When the color changes from green to yellow or red, the system produces an alert through the speaker. The user can control his/her applied pressure based on the display and alerts. This alert is a notification sound installed in macOS.

6. Experiment 2: Comparing Changes in Pressure Control

6.1 Experiment Configuration

In this experiment, we present an experiment on the effectiveness of the Displaying Applied Pressure function with knife device [3] and stylus [2]. The purpose of this experiment is to compare the effectiveness of our system with that of conventional practice methods. We measure the pressure, time, and coordinates, when the participants cut in the pattern shown in Fig. 9 A twice. This picture is drawn on a 100 mm square and published in a textbook as a design for novices [27]. The wavy line in the picture is especially complex and involves several changes in the cutting angle, as shown in Fig. 9 B. We compare the changes in cutting behavior when the participants cut these complicated patterns.

6.2 Experiment Procedure

In this experiment, 40 novices, who have never performed paper-cutting, execute the following tasks.

- Step 1. Cut the picture (Fig. 9 A) with our pressure measuring knife.
- Step 2. Practice cutting on the patterns (Fig. 4) using various methods.
- Step 3. Repeat Step 1.

Because all the participants cut the same pattern in Step 1, we divide the participants into three groups of 10 based on the average pressure applied in Step 1. Next, the participants practice using different methods, as mentioned in Step 2. During Step 3, they repeat Step 1.

During Step 2, the participants, who are divided into Gr 1, Gr 2, Gr 3, and Gr 4, perform the following tasks using the picture shown in Fig. 4.

- Gr 1: Practice with the knife device and the ‘Displaying Applied Pressure’ function.
- Gr 2: Practice with the knife device without pressure presentation.
- Gr 3: Trace the patterns using a pencil.
- Gr 4: Practice with the stylus and tablet device as previous research [1]

The participants of Gr 1 use a knife device and a drawing display with a pressure presentation function. Gr 2 uses a knife device but hides the function. Gr 3 trace the pencil exercises used in the workshop, taught by the instructor. They traced the cutting line with No. 2 pencils (uni, Mitsubishi). Gr 4 traces with the stylus (Apple Pencil, Apple) on a tablet device (iPad Pro 12inch, Apple) using the system of [1]. The tablet device has the ‘Displaying Applied Pressure’ feature described in Chapter 5. The ‘Tracing system’ is based on the pressure of the stylus, while the tablet system evaluates the user’s strength. This environment is the same as [1]. Gr 1 uses a knife device, and Gr 4 uses a stylus. Besides, they make use of the same ‘Displaying Applied Pressure’ feature.

We compared their pressure values with those of the participants who cut the pattern in Fig. 9 twice. We verified the difference between the effectiveness of the system and that of the existing practice method by comparing the pressure of each group in Step 1 and 3.

6.3 Results

We compared the average pressure applied by each group
and the variation between Steps 1 and 3 in Experiment 2. Moreover, we compared complex wave-line cut marks (Fig. 9 B).

### 6.3.1 Average Pressure

Figure 10 shows the average pressure when each group was cut in Step 1 and Step 3, as in Experiment 1. The error bars are variations based on the average pressure of each participant in each group. In Step 1, the average pressure applied by all the groups exceeded 400.0 g. In Step 3, Gr 1 had the highest reduction ratio of 27.0%. However, the reduction of Gr 2 was 9.8%, and the average pressure of Gr 3 decreased to 12.6%. In Experiment 1, the reduction of Gr 4 was 14.7%. Moreover, we tested the normality of the average pressure between Step 1 and 3 of each group. As a result, we could not conclude that the pressure follows a normal distribution; hence, we evaluated our results using a Mann-Whitney U test, which is a nonparametric test method. The results of the U test show that the pressure of Gr 1 was significantly reduced at $p < 0.01$. However, the pressures of Gr 2 and Gr 3 were not significantly different. The pressure of Gr 4 was significantly lowered at $p < 0.05$, similar to the results of [1]. Similarly, we evaluated the cutting pressure in Step 3 of each group using the Steel-Dwass test. The Steel-Dwass test is a multiple comparison method based on a nonparametric test method. As a result, we showed that Gr 1 was significantly lower at $p < 0.05$ than the cutting pressure of other groups.

### 6.3.2 Pressure Variation

Figure 11 shows the variation based on all the pressure data when each participant cut at each pixel, as in Experiment 1. In Step 1, all groups cut paper using a wide range of pressures from 300.0 to 500.0 g. As a result, in Step 3, the pressure range of Gr 1 was the most reduced than the other groups at 56%. On the other hand, Gr 2 showed a decrease in pressure but not in the pressure range. Similarly, the pressure range of Gr 3 was only reduced by 25%. Finally, the pressure range of Gr 4 was reduced by 36%; however, not as much as the decrease for Gr 1. We tested the normality of the pressure range between Step 1 and Step 3. The results showed that the pressure range did not follow a normal distribution. Therefore, we evaluated it by Mann-Whitney’s U test. The results showed a significant change in the range of Gr 1 at $p < 0.01$. On the other hand, the Gr 2 and Gr 3 ranges did not change significantly. Moreover, Gr 4 showed a significant difference at $p < 0.05$. These results showed a similar change in the average pressure between Step 1 and Step 3.

### 6.3.3 Cutting Trace with Wavy Line

Figure 12 shows the cut traces in Step 3 of one participant from each group, where the red line is the original (Fig. 9 B). The Gr 1 participant cut along the original line. However, the cut line of the Gr 2 participant protruded from the red line for each curve. In the lines of the Gr 3 participant, the low curvature (base of the curve) part follows the original image; however, the high curvature (tip of the curve) part protrudes at an acute angle. The cutting of Gr 4 was in line with the original as compared with Gr 2 and Gr 3; however, it progressively bulged outward after the changing curvature.

Figure 13 shows the average coordinates and pressures when the participants cut the pattern in Fig. 9 B. As a result, Gr 1 maintained pressure in the yellow area. However, the pressure of Gr 2 was red or dark red. Moreover, Gr 3 cut with pressure in the red and yellow areas. Conversely, Gr 4 was orange at high curvature and yellow at low curvature.
6.4 Conclusion of Experiment 2

In Experiment 2, we examined the effect of a knife device and the ‘Displaying Applied Pressure.’ We compared the changes in mean pressure and variance between Step 1 and Step 3 for the participants who practiced the various methods. From the results of Gr 1 and Gr 2, we confirmed the effect of the function to improve pressure control. Besides, Gr 1 and Gr 3 show that our system reduces participant pressure more than the workshop practice method. Finally, from Gr 1 and Gr 4, practicing the pressure presentation function in cutting was more effective than when practiced in tracing.

The pressure applied by Gr 1 reduced significantly after learning how to control force adjustment, which based on knowledge of the users’ pressure values compared with the pressure range of experts (250.0 to 350.0 g) in Step 2. Owing to this effect, the range of pressure variation also significantly decreased. Therefore, by stabilizing the pressure at the time of the first cutting, Gr 1 could cut smoothly. Conversely, Gr 2, without support from the system, did not change significantly. Beside, the change in pressure range showed the smallest results. Therefore, Gr 2 did not improve their cutting skill using high pressure; hence, it was impossible to manipulate the knife along the high curvature even with a wavy line. Gr 3 practiced tracing with a pencil, and although the value of cutting pressure decreased, the change was not significant. As Gr 4 practiced with the stylus and pressure assessment function, the average pressure and the range reduced. However, this result did not decrease as much as the pressure in Gr 1. Besides, we compared the pressure between Gr 1 and Gr 4 in Step 3. The result showed a significant difference in their pressure. Therefore, we confirmed that the practice of cutting with the knife device improved the skill of controlling pressure more effectively than the method of tracing with the stylus.

After the task, we interviewed the participants that they felt the cutting pressure for production. All participants did not know the proper pressure to make the paper-cutting in Step 1. Therefore, they decided to control their power based on whether they could cut the paper with a knife. Gr 1 felt that it was possible to easily reproduce the cutting pressure in Step 3 by experiencing the adjustment of the force like an expert in Step 2. Gr 2 was only concerned about whether or not the paper was cut as in the previous task, and made his/her pressure without knowing the proper control in Step 3. Gr 3 used a pencil to experience rough pressure and his adjustment. However, because they could only feel the vague limits on pressure, they thought it was challenging to cut with a knife while continuing control. Gr 4 practiced with the stylus and Displaying Applied Pressure function in Step 2. In Step 3, because their tools changed from the pencil to the knife, they were unable to reproduce the sensation of pencil work. They felt that the higher the curvature, the harder it was to cut, at the curve that is characteristic of paper-cutting production.

7. Discussion

One of the purposes of this research is to improve the skill of adjusting cutting pressure to create paper-cutting. One of the cutting skills for creating paper-cutting is controlling the pressure. Therefore, we developed a cutting practice system comprising a drawing display and a blade on the tip of a stylus. In Experiment 1, we built a device for measuring cutting pressure. Moreover, we compared pressure values between novices and artists. Results show that the novices cut papers using 1.4 times more pressure than the experts do. We interviewed novices and experts after the experiment. The novices were overly cautious about cutting along the line, cut with too high a pressure, and were unable to adjust the power. Conversely, the experts attempted to maintain a uniform cutting pressure in all the lines. Therefore, curves with high curvature cut by novices show more irregularity than those cut by experts. In Experiment 2, we developed a system that shows the difference in user pressure based on the average pressure of experts. We compared the skill improvement to control cutting pressure. The cutting pressures of novices decreased by 27.0% by using our system. Moreover, we compared these results with those of the practice method using pencil, which is one of the practices for novices. The group using our new system improved more than the group that used the previous system (decreased 14.7%).

In this paper, we compared the effect of the practice system that we have developed so far [1]. In [1], we have developed a support system that controls pen pressure through the practice of tracing. In some workshops, the instructor allows participants to practice controlling pressure through the training using a pencil. The system evaluates the user’s tracing pressure based on what the instructor teaches at the workshop. As a result, the users improved the skill of controlling the cutting pressure in the production of the paper-cutting. In Gr 4 of Experiment 2, we reproduce the same situation as using the system in [1]. The difference between the group using the knife device (Gr 1 in Experiment 2) and the group with the stylus (Gr 4) is the device, and they used the same threshold of Displaying Applied Pressure. As a result, the Gr 1 reduced the cutting pressure and the variation when making paper-cutting than Gr 4. Moreover, Gr 4 was...
unable to maintain pressure control in difficulty parts such as lines with high curvature when making paper-cutting. On the other hand, Gr 1 works in the same environment at the practice stage (Step 2 in Experiment 2) and the production stage (Step 3). Therefore, we consider that the proper pressure control Gr 1 experienced in Step 2 was also highly reproducible and adaptable in Step 3.

The purpose of this research is to improve the cutting skill to create paper-cutting. However, the cutting skill has many elements other than pressure, e.g., finger positions during cutting. In this study, we focused on the pressure, which is the element that the instructor teaches in the workshop. In the future, we aim to improve cutting skills more effectively by developing systems that correspond to various factors.

8. Conclusion

We developed a cutting practice system comprising a drawing display and a blade on the tip of a stylus. Our knife measures the pressure applied by the user, and the drawing display has a function that utilizes color and sound to present the difference between the knife pressure of experts and that of the users. The purpose of this research is to improve the paper-cutting skills of novices. Using the proper pressure to cut paper is an important skill for artistic and craft artistic expression. First, we measured the cutting pressures of novices and experts. Next, based on the results, we compared changes in the pressure of groups practicing pressure control with the system, groups practicing without the system, and groups practicing with the existing pencil method. The group using our system improved more than the group that used the existing practice method. The average pressure used and pressure variation both decreased because of using our system. Our system has the benefit of enabling the cutting pressure of novices to be within an acceptable pressure range.

Our current research supported improving the cutting skill of novices from this paper. Moreover, we are studying how to measure the cutting skill levels and difficulty levels associated with cutting patterns [28]. The aim of [28] is to adjust the difficulty level of the optimal task to promote user skill level improvement. By combining these studies, we bring great fulfillment and happiness by matching their skills and tasks for novices and making users in a flow state.

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