Design and Development of a Learning Support Environment for Apple Peeling using Data Gloves

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Abstract. We designed and developed a learning support environment that advises a learner about correct apple holding and correct knife handling for improving apple peeling. The learning support environment is designed from an apple peeling expert's motion data. We verified the learning effect by comparing experimental group with a control group. In the training phase of the evaluation experiment, each learner in the control group only watched a movie of the learner's own apple peeling. The experimental group not only watched such a movie, but also used our learning support environment. After the evaluation experiment, we administered a questionnaire survey. Results show that the experimental group obtained more concrete and varied awareness than the control group had.

1 INTRODUCTION

A decline in manual skills of the fingers and hands has been reported [1]. Figure 1 shows results of a questionnaire administered to junior high school students. In terms of the frequency of cooking, about half of them answered that they seldom cooked. Furthermore, only about 30% of the students answered that they were capable of peeling with a kitchen knife. Consequently, we infer that they have been caught in a vicious circle in which they have too few cooking opportunities to improve their kitchen knife skills.

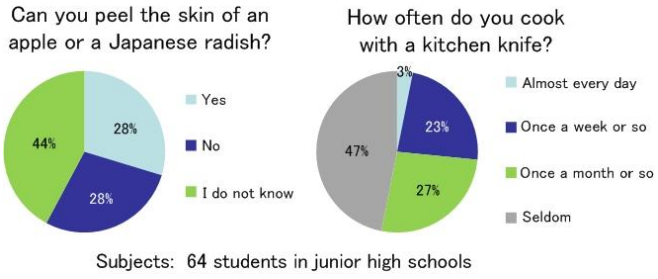

Figure 1. Results of a questionnaire administered to junior high school students

Previous studies of movements during cooking with a kitchen knife include Suzuki's studies of the effect of using a kitchen knife that has been developed specially for children on skills learning [1] and of the size of cut pieces to acquire kitchen knife skills [2]. However, they deal with a chopping motion, and They did not report any study on the peeling motion of an apple. The peeling motion is more difficult than chopping motion.

For skills learning, the early stage of skill acquisition is extremely important [3]. Once skills are wrongly ingrained in the early stage, it is difficult to correct them. The concern arises about its effect on the progress of learning, which suggests the importance of teaching the correct way to students who answered "I do not know" to the question asking about their capability of peeling.

Home economics classes, which provide opportunities to acquire kitchen knife skills, have been shortened every time the national curriculum is revised [4]. Furthermore, a teacher must teach numerous students during the class. It is difficult to say that such an environment is ideal for learning.

Based on the points presented above, we think that an environment in which students can efficiently learn the correct way rapidly is necessary to master peeling.

Regarding the current situation, this study is intended to design and develop a learning support environment in which learners can learn correct ways of holding and peeling an apple and to examine the learning effect. Subjects were those who were unable to peel at all or who peeled using an incorrect technique at that time.

2 LEARNING SUPPORT ENVIRONMENT

This section presents a description of details and how to use the developed learning support environment.

2.1 Device to be used

For this study, we used a data glove (for the right hand and the left hand, 5DT 14 Ultra series; Fifth Dimension Technologies) to measure finger motions. The fiber-optic data glove has 14 sensors. Sensors in the joint parts output the stretching state as 0 and the bending state as 1. Sensors in the crotch of the fingers output the open state as 0 and the closed state as 1. Each sensor has a designated name (Fig. 2).

2.2 System design

The learning support system (Fig. 3) is intended to support home economics teachers when giving advice to students based on objective data when teaching them apple peeling skills. The input is a learner's finger motion. The outputs are the learner's motion data and advice for the learner.

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The procedures for use are as follows. A learner wears the data gloves and calibrates them. Then, when the learner holds an apple and a kitchen knife to perform peeling, the system judges whether the apple and kitchen knife are being held correctly. Subsequently the learner peels the apple. After peeling has been completed, the system gives advice by text messages and illustrations. Motion data and results of analysis are not presented directly to subjects who used the system.

Figure 2. Name of each data glove sensor

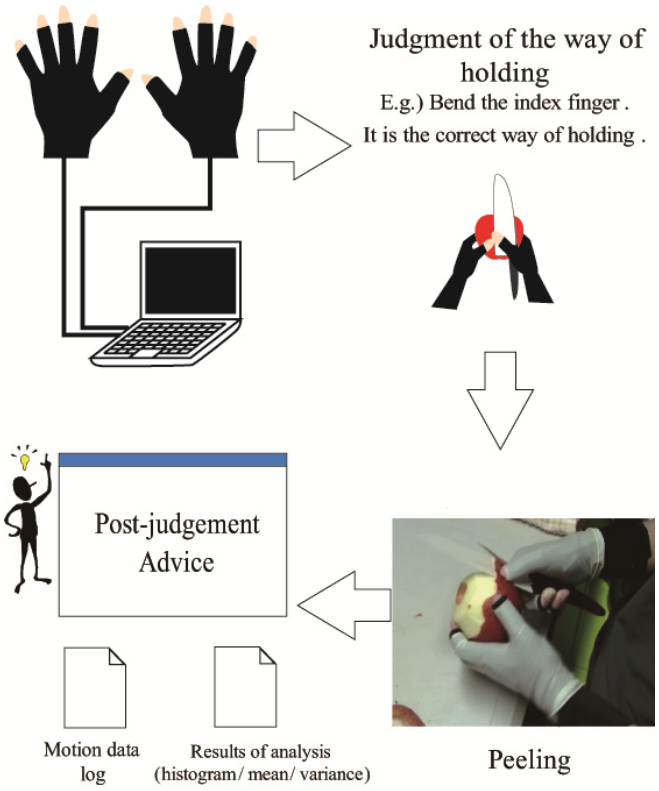

Figure 3. System overview

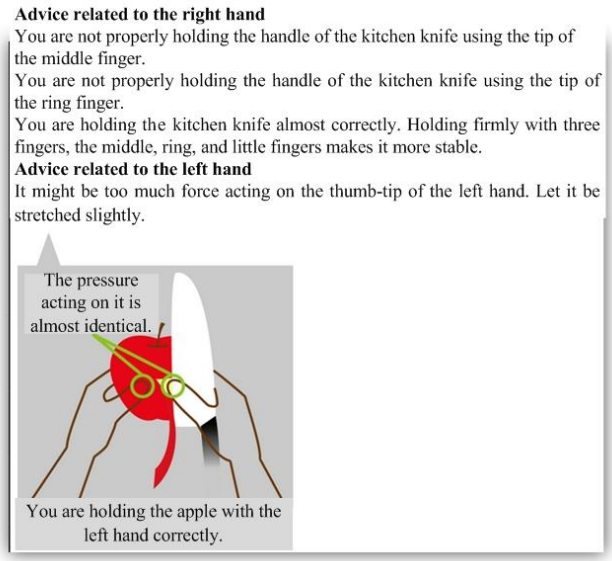

Figure 4. Example of advice

2.3 Advice examples

For learners who used the system, advice is presented after peeling, as portrayed in Fig. 4. Table 1 is an example of the threshold between sensor values for use to generate advice. The threshold is set based on the experts' data in the next subsection.

Table 1. Example of advice generation

1	Condition Message	0.3 < Thumb/Index sensor value "Hold an apple spreading the thumb."
2	Condition Message	0.2 < IndexNear sensor value "You are putting too much force on the index finger."
3	Condition Message	0.05 < MiddleNear sensor value "You are putting too much force on the middle finger."
4	Condition Message	0.06 < RingNear sensor value "You are putting too much force on the ring finger."
5	Condition Message	0.15 < LittleNear sensor value "You are putting too much force on the little finger."
Condition Message		If all formulas 1–5 are FALSE "The way of holding with the left hand is OK."

2.4 Data gathering

To determine thresholds to present advice as shown in Table 1, we gathered data from 7 experts. The condition to be an expert was to have met the qualifying standard for the *Katei ryori gino kentei* (= Certification Examination for Home Cooking)[5]. Figure 5 presents an example of a histogram showing sensor values across the experts' left-hand MiddleNear sensors as a cumulative bar chart. The relevant part of the sensor is shown in Fig. 6. The comparative frequency of the histogram is distributed around small values. According to previous studies, these are characteristics of the way

in which experts hold an apple [6]. Therefore, we set the threshold of the values for the left-hand MiddleNear sensor as 0.05. When the threshold is exceeded, advice will be presented to the subject who used the system.

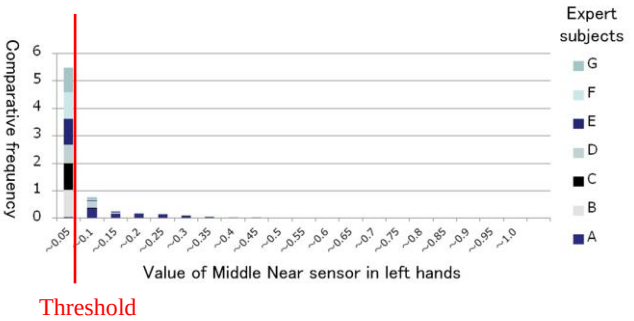

Figure 5. An example of histogram of sensor values (Example: left-hand MiddleNear sensor)

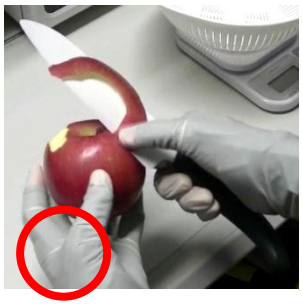

Figure 6. Relevant part in the left-hand MiddleNear sensor.

3 EVALUATION EXPERIMENT

This section explains an evaluation experiment that was conducted to verify the usefulness of the learning support environment.

3.1 Procedures of the experiment

The experiment procedures are portrayed in Fig. 7. Six subjects were divided into an experimental group and a control group. Both groups performed peeling three times.

In the pre-questionnaire shown in Table 2, we asked how often they cooked and whether they were capable of peeling. With regard to the frequency of cooking, about half answered “seldom” and half answered “once a week or so”. Although one subject answered “Yes, I can peel,” we did not regard the person as an expert but treated the person as a subject for the evaluation experiment because the person did not peel correctly.

The first trial of peeling was conducted as pre-test to check the skills at the stage.

The second trial of peeling was for training. In the trial, the experimental group used the system and received advice after watching an example video. The control group only watched the example video. Subsequently, an attitude survey was administered through a questionnaire.

The third trial of peeling was conducted as post-test to measure the level of improvement. Outcomes such as disposal rates were organized into the results of the experiment.

Table 2. Subjects’ data list

		Capability of peeling	Frequency of cooking	Dominant hand
Exp. group	Subject A	No	Once a week or so	Right-handed
	Subject B	No	Seldom	Right-handed
	Subject C	Yes	Once a week or so	Right-handed
Cont. group	Subject D	No	Seldom	Right-handed
	Subject E	No	Once a week or so	Left-handed
	Subject F	No	Seldom	Right-handed

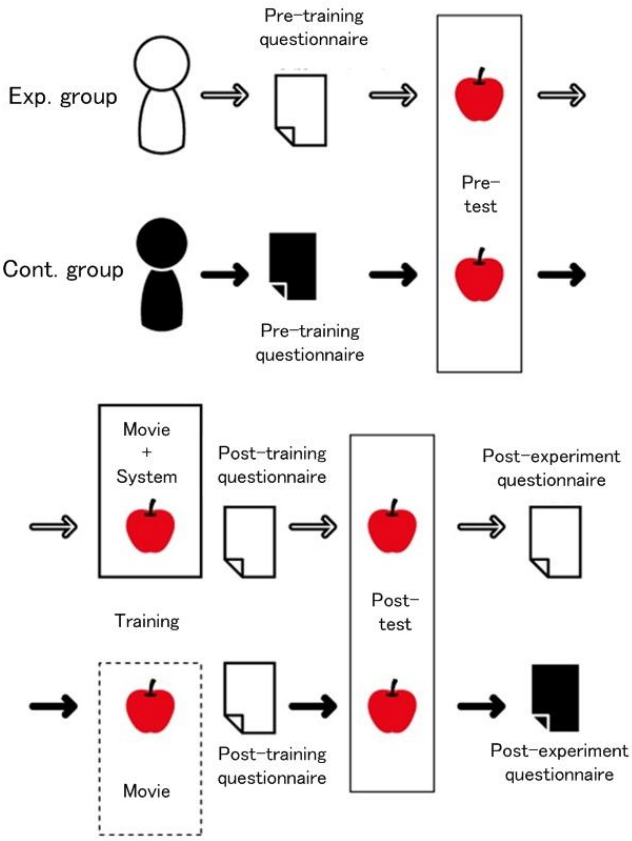

Figure 7. Procedures of the experiment

Figure 8. System utilization (in the experimental group)

3.2 Example video

The example video is a video watched by both groups (Fig. 9). We subtitled explanatory text for the video, showing a home economics teacher demonstrating peeling on the video. The explanatory text was the qualifying standard for the certification examination for home cooking and explanations that the teacher gave students.

Figure 9. Capture of the video

4 RESULTS OF THE EVALUATION EXPERIMENT

In this section, we describe the results of an evaluation experiment for learners.

4.1 Experimental results

In Table 3, we compared the results of the pre-test (= first trial) with the post-test (= third trial) of peeling by subject. The disposal rate 15% is regarded as ideal, and we regarded improvement as occurring when the difference from 15% became smaller and worsening when it became greater.

Improvement was found because the experimental group and the control group were able to shorten the time to peel. A reason why the disposal rates rose is presumed that they peeled the skin thickly to reduce the number of times the skin was being cut off.

Table 3. Results of the evaluation experiment

Experimental group	Subject A	Subject B	Subject C
Disposal rate (%)	23.9	12.5	22.9
Difference from the first trial	6.3% worsened	5.1% improved	2.4% improved
Only skin disposal rate (%)	9.2	8.4	11.6
Difference from the first trial	0.8%	-10.0	1.5%
Time (s)	121	287	150
Difference from the first trial	-66 (-36%)	-88 (-24%)	-12 (-8%)
Number of times being cut off	0	7	3
Difference from the first trial	-11	-8	1

Control group	Subject D	Subject E	Subject F
Disposal rate (%)	23.0	24.1	16.9
Difference from the first trial	6.1% worsened	1.4% improved	2.2% improved
Only skin disposal rate (%)	9.4	12	10.7
Difference from the first trial	-0.6%	1.1%	4.6%
Time (s)	190	96	191
Difference from the first trial	-80 (-30%)	-21 (-18%)	-28 (-13%)
Number of times being cut off	2	2	5
Difference from the first trial	-35	-2	-4

4.2 Results of the post-training questionnaires

We organized the results of questionnaires conducted after the second trial, which was a training session, in Table 4 and Table 5.

According to Table 4, the experimental group was better in terms of the number and the concreteness of awareness. By verbalizing, awareness was more useful for peeling the next time.

Awareness, which is regarded as engendering future improvement, is presented in red bold letters. The experimental group gained more concrete and numerous instances of awareness. In addition, many occasions of awareness led to improvement. Subject F did not gain any awareness at all in terms of the left hand.

Table 4. Post-training questionnaire 1

Hand holding an apple		
Exp. group	Subject A	"I was only conscious of the thumb on how to hold an apple. Other fingers were neglected."
	Subject B	"I held the apple too firmly. It did not work with the hand holding a kitchen knife. The fingers from the index to the ring finger were spread open. The starting position of cutting was too low. The power balance of the fingers from the middle to the little finger was not good. I should have supported an apple lining up the fingers from the index to the little finger, but I held it with them bending."
	Subject C	"I concentrated on moving the apple. It was easier to peel upward."

Cont. group	Subject D	"I moved more restlessly than the example. I feel that too many times the position to hold is changed."
	Subject E	The angle to incline.
	Subject F	Nothing in particular.

Table 5. Post-training questionnaire 2

Hand holding a kitchen knife		
Exp. group	Subject A	Hold of the kitchen knife. Hold of the handle of the kitchen knife. The way of moving the thumb is more closely and shorter in the distance than the example.
	Subject B	"I peeled like scooping. For that reason, I often returned back and started peeling again. The surface was not smooth and like a staircase. The position placing the thumb is not fixed, such as on the edge or far from the edge. At the start of peeling, the direction of the edge was not fixed and dangerous."
	Subject C	"I was conscious to position the thumb just as shown in the example."
Cont. group	Subject D	"It is slipping upward."
	Subject E	"I peeled using the upper part of the kitchen knife. The position was not stable." Motion of the thumb.
	Subject F	Placing the thumb on the position capable of peeling the skin of an apple.

4.3 Results of the post-experiment questionnaires

We next describe the results of questionnaires conducted after all three trials of peeling were completed.

To the question for the experimental group, "Did you understand the content of advice?" all answered "Yes". In response to the question "Was it easy to follow the advice?" all answered "No".

- Subject A: I cannot put it into practice even being aware of the left hand.
- Subject B: I am absorbed in peeling and forget the contents of advice.
- Subject C: It was difficult to follow the advice telling me that the fingers of the right hand holding a kitchen knife were not bent sufficiently.

The results presented above are regarded as conditions in which "it can be understood as formal knowledge but it is not acquired as body knowledge" and in which "it is beyond the limitations of short-term memory." The latter will be resolved by adding the design capable of real-time diagnosis to the system.

We received the answer "improved" in terms of peeling an apple from both groups. When asking the experimental group the reason, we obtained the following answers.

- Subject A: Because the amount of the skin being cut off decreased.
- Subject B: Because only the skin disposal rate was reduced.
- Subject C: Because I became able to peel faster.

All three of the items shown above appear as numerical results. To maintain an appetite for learning, it will be necessary to present numerical data that are both visible and easy to understand. However, the numerical data show "results", and it is predictable that it will not engender the improvement in the "process". For example, even if peeling is performed incorrectly, it is still possible to achieve a low disposal rate without the skin being cut off.

"Gained awareness" in the control group is described in Table 6. Subject F remained unable to understand how to hold the apple even after all three trials.

Table 6. Results of the post-experiment questionnaire for the control group

Subject D	Differences existed in motion of the hands. Learning how to hold a kitchen knife was particularly helpful. I tried to practice the way of holding a kitchen knife, but returned it in the middle.
Subject E	The way of holding an apple. The position of holding an apple with the left hand. How to hold a kitchen knife. How to use the thumbs of both hands.
Subject F	Pressing the part of the skin to be peeled with the thumb of the right hand. I do not understand how to hold a kitchen knife.

4.4 Discussion

We believe that this evaluation experiment demonstrated the usefulness of the system. In questionnaire 3 for the experimental group which used the system, the outstanding answer was that it was difficult to follow the advice. However, probably the experimental group which used the system was able to have higher awareness for improvement than the control group, which did not use the system.

Learners exhibited unexpected motion for which the system generated advice. We found a way of holding in which bending of the MP joints of the left hand holding an apple and a learners' particular way of peeling which was regarded as attributable to the angle of the index finger of the right hand holding a kitchen knife. They are expected to be sorted out by gathering widely various motion data from learners.

The data gloves used this time are less invasive and are suitable to detect a peeling motion. If devices were selectable according to the learner's level, then points that they became aware of this time could be addressed. The width of the apple skin can be displayed through a head mounted display. If the relative position and the angle between a kitchen knife and hands were available by positioning sensors, then more detailed advice could be given.

5 Conclusion

For this study, we designed and developed a learning support environment using motion data, which are objective data in the motion of peeling an apple.

Results demonstrated that the control group in the evaluation experiment improved somewhat through carefully watching an expert's video. However, the observation is the learners' subjective observation and if they themselves do not find new discoveries through the observation, there will be limitations to rapid

improvement. However, the experimental group was likely to widen their views because they had advice from the system when watching the video, in addition to the observation from own perspective. In fact, the experimental group found more concrete and numerous differences between the expert and themselves than the control group.

Although it remains as a future challenge, there are apparently limitations to learning using only motion data through data gloves. To peel an apple, one uses not only one's own body but also a tool, which is an extension of the body. Using the relative position and the angle between a tool and the body, advice can be broadened to a great extent.

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