Preliminary Quantitative Evaluation of Effect of Learning from Text, Illustrations, and Animations on Understanding

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Abstract. Animation is often used to aid understanding of information and to facilitate learning. However, in many studies, the benefits of animation have not been proved. There is also a problem that information contained in one sort of content might not match that of another sort of content. In this study, three experiments were conducted to investigate the effect of the sort of presentation of learning content on understanding. The animations and illustrations used in the experiments included all of the information of the text. The posttest scores from the first two experiments confirmed the benefits of the animation presentation. However, experiment 3 using a dual-task methodology to assess the cognitive load did not show benefits of animation presentation. However, using a visual stimulus in a secondary task was found to have a significant effect. This effect will be considered in the next experiment.

Keywords: Animation · Multimedia learning

1 Introduction

Animation is often used to help learners understand information and facilitate learning. Animated explanations of concepts and mechanical structures have become common in educational content thanks to the spread of e-learning. Animated explanations help to improve or speed up the learner's understanding of the concepts and structures being taught; they can even be used to illustrate abstract concepts that cannot be easily visualized. However, many studies have failed to show any benefits of animation, or sometimes have shown benefits only under certain conditions. There is also the problem that the information depicted in the different content does not match [1, 2]. It is necessary to verify the benefits of the animation under general conditions and animations must be compared with informationally equivalent illustrations and text. In this study, three experiments were conducted using carefully designed content to investigate the effect of the presentation of the learning content on understanding.

2   Experiment 1

This experiment was conducted to verify two hypotheses:

1. Presentation of animation reduces the time required to understand difficult content compared with presentation of text and illustrations.
2. Presentation of animation improves understanding of difficult content compared with presentation of text and illustrations.

2.1   Design and Materials

The participants were nine graduate students (males) from the University of Electro-Communications. Experiment 1 tested different combinations of learning content (three levels of difficulty) and presentation method (three kinds: text, text + illustration, and text + animation). The participants were assigned three combinations randomly (Latin-square design). Three pieces of learning content with different difficulties were created in text format and then three illustrations and three animations were created based on the text content. The learning content described a method for setting up an imaginary machine to prevent the effect of prior knowledge. In addition, the illustrations and animations were created to include all of the information of the text. Table 1 shows the levels of difficulty of the learning content, and Fig. 1 shows a screenshot of the animation used in Experiment 1.
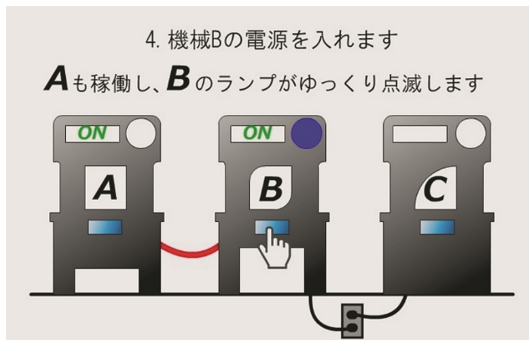

Fig. 1.   Screenshot of the animation in Experiment 1

Table 1.   Elements of learning contents in Experiment 1

Difficulty	Included content
1	3 procedures + 2 notices
2	5 procedures + 3 notices
3	7 procedures + 4 notices

2.2   Procedure

One combination of difficulty and presentation method was selected and presented to the participants. The participants were required to understand the content as quickly as possible and to report when they understood it. The text and illustration were presented on paper, and the animation was presented on an iPad. After reporting that they understood the content, the participants were required to answer posttest questions immediately. This process was performed three times per subject. The dependent variables were the time taken for understanding and posttest score.

2.3   Results and Discussion

Figure 2 shows the results of Experiment 1. The time taken for understanding and points scored in the posttest were recorded, and the three presentation methods were compared using ANOVA on these values. The results showed that there were no significant differences between the three methods. However, the time taken for understanding with the animation presentation tended to be shorter than those of the other methods for difficulty level 3. On the other hand, the posttest score was higher for all of the difficulty levels. These results show the possibility that the difficulty of the learning content was low overall, so it might be necessary to use more difficult content.
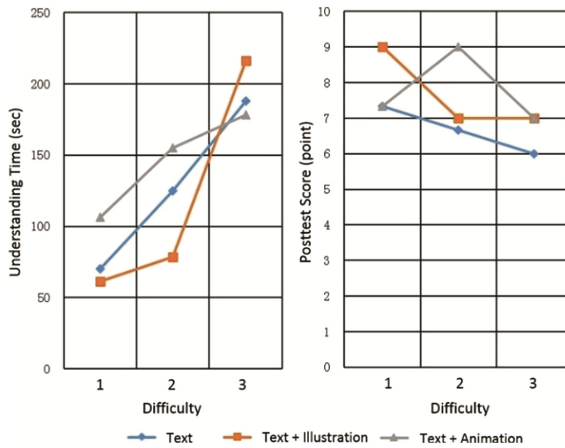

Fig. 2.   Results of Experiment 1

3   Experiment 2

3.1   Design and Materials

The participants were the same eight male graduate students who had participated in Experiment 1. The learning content from Experiment 1 was used. The illustrations and

animation were created in the same way as in Experiment 1. Table 2 shows the levels of difficulty of the learning content. The procedure was the same as that of Experiment 1.

Table 2. Elements of the learning content in Experiment 2

Difficulty	Content included
1	6 procedures + 3 notices
2	9 procedures + 5 notices
3	12 procedures + 7 notices

3.2   Results and Discussion

Figure 3 shows the results of Experiment 2. Regarding the time taken for understanding, there were no significant differences between the three presentation methods. On the other hand, the posttest score of the animation presentation method was significantly higher than those of the other presentation methods ($p < 0.05$). These results support hypothesis (1) and indicate the benefit of presenting animation to support understanding of difficult learning content.
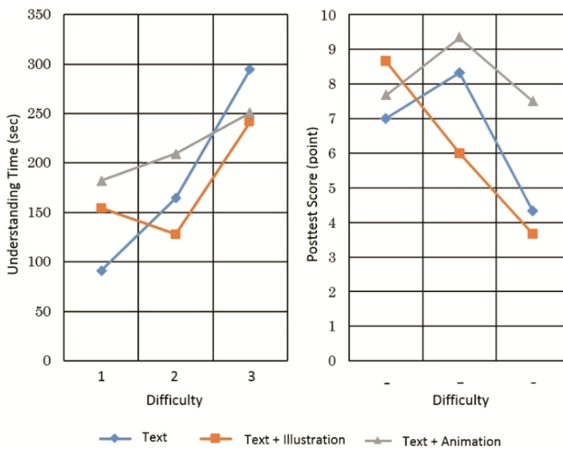

Fig. 3.   Results of Experiment 2

4   Experiment 3

Despite that there was no difference in the time needed for understanding in Experiment 2, there remained a possibility that the animation presentation method had a low cognitive load even though it did not reduce the time needed for understanding. Therefore, a new hypothesis was created.

1. Presentation of animation reduces the cognitive load of understanding difficult content more than does the presentation of text and illustrations.

In Experiment 3, a dual-task methodology was used to test this hypothesis. This methodology is promising for assessing cognitive load induced by multimedia learning systems [3]. The participants were nine male graduate students who had not participated in Experiments 1 and 2.

4.1   Procedure

As the primary task, the participants were required to perform the same task as in Experiment 2 (understanding the learning content). Additionally, they were required to press a foot switch immediately when a stimulus (a red frame) appeared on the screen to indicate the secondary task. The primary task and secondary task were performed simultaneously, except for during the posttest. The stimulation of the secondary task was presented within a random time interval. In this experiment, all of the contents were displayed on a single tablet (20 inch screen) for the secondary task. The dependent variables for the primary task were the time taken for understanding and posttest score, and the dependent variable for the secondary task was reaction time.

4.2   Results and Discussion

Figure 4 shows the results of Experiment 3. Regarding the time taken for understanding and posttest score, there were no significant differences between the three presentation methods. However, the understanding time of the animation presentation tended to be shorter than those of the other methods at difficulty level 3. It is possible that the small number of participants and small number of attempted tasks affected the results of the posttest score.
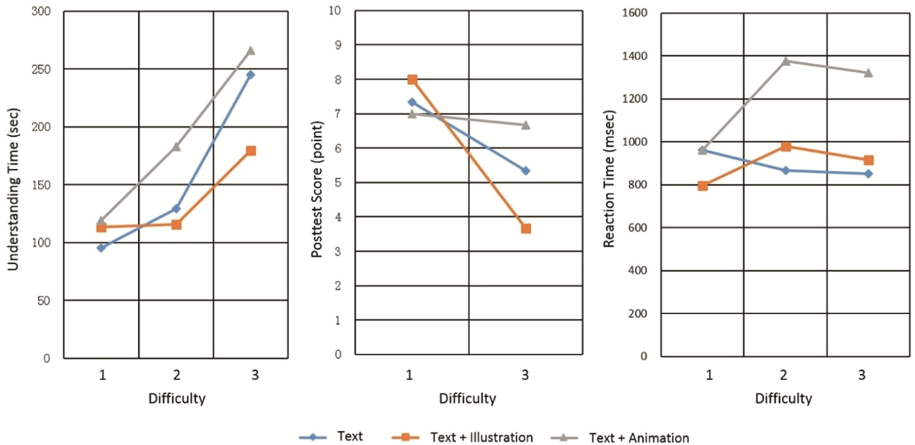

Fig. 4.   Results of Experiment 3

The reaction time results in the secondary task indicated that the animation presentation had the longest reaction times for difficulty levels 2 and 3. These results were contrary to hypothesis (3).

The behaviors of the participants during the experiment were analyzed. It was found that the gaze of the participants was concentrated on the screen when they were looking at the animation, and they were unaware of peripheral stimuli. Figure 5 shows the relationship between the reaction time of the secondary task and the content being gazed at. It was inappropriate to use a visual stimulus in the secondary task.
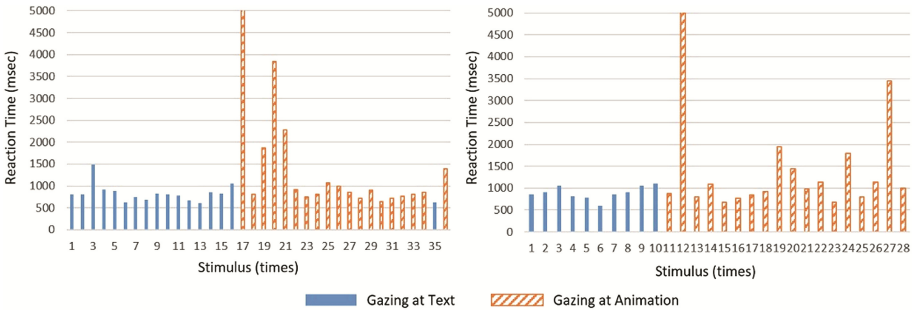

Fig. 5. Relationship between reaction time and content being gazed at

5   Conclusion and Outline of Next Experiment

The three experiments confirmed the benefits of an animation presentation. In particular, the results suggested that the animation presentation reduced cognitive load. The next verification should incorporate the results described herein and should try to account for the following points.

- Auditory stimuli should be used as the presentation stimulation in the second task to test hypothesis (3).
- The number of participants should be increased and the experimental design should be improved in order to obtain a clearer result about hypothesis (1).
- Learning content with temporal and spatial features should be added to make better use of animation.

References

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