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Cognitive Investigation of Dynamic Educational Presentation toward Better Utilization of Presentation Characteristics

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Abstract: Through two cognitive experiments, we investigated fundamental characteristics of presentation methods for teaching materials. We conducted a subjective evaluation by questionnaire and an objective evaluation by comprehension test, as well as gaze analysis with an eye tracker to analyze differences between three cases: when learners were shown a handwriting process such as on a chalkboard, animated slides using presentation software, and only final written results. Results of the experiments confirmed the basic characteristics of each presentation as visual information and provided evidence showing advantages of showing the writing process under certain conditions. We also confirmed an induction effect by voice description as auditory information. These results contribute to the use of various presentation characteristics for maximizing the effect of teaching material presentation.

Keywords: gaze, eye tracker, writing process, chalkboard, slide

1. Introduction

We experimentally examined the characteristics of methods in which teaching materials are presented to learners to identify the benefits of dynamic presentation in focusing on the advantages of chalkboard presentations that present the entire writing process. We believe the results give a criterion when to use a chalkboard and when to use presentation slide.

The use of information and communication technology is expected to promote "understandable lessons," advancing the use of teaching materials via computers and computer networks (MEXT, 2011; MIC, 2014). Chalkboards and presentation software are widely used to present educational information during lessons. The chalkboard—the traditional presentation method—has advantages with respect to visualization of thinking and flexibility of presentation, because instructors can demonstrate sequential processes and easily add text, annotations, or marks(Brown, 2012; Jenami, 2017). In contrast, presentation software is advantageous with respect to the quantity and quality of presented or reused information, because instructors can quickly present teaching materials including illustrations and videos alongside text, create attractive slides using design functions, and can reuse the materials (El-Ikhan, 2010 ; UCF - Faculty Center for Teaching and Learning, 2016).

Interactive whiteboards combine the advantages of both slides and traditional chalkboards (TechLearn, 2012). However, they have not yet replaced traditional chalkboards because of the costs for installation and teaching material development. Furthermore, it is necessary to master their operation, they have an inherent potential for breakdowns, and they are smaller than chalkboards.

As an alternative approach, we have been developing a new presentation tool for education that incorporates the characteristics of chalkboards while displaying slides (Hosoki et al., 2011). Realizing a new method of presentation that retains the advantages of chalkboards will require obtaining knowledge about various presentation methods. We believe that handwritten presentation of information, one of the unique characteristics of chalkboards, includes rich educational information because it demonstrates a sort of thought process. Animated slides merely attract attention or mechanically present information step-by-step; they do not reflect the structure of the presented subject or the thinking process. We believe that showing this process through handwriting is meaningful with

respect to comprehension that is different from merely showing completed forms or mechanical stepwise presentation.

As basic data for clarifying the advantages of showing the writing process, we focus on the eye movements of learners and on subjective and objective evaluations of learners through testing (Okazaki et al., 2013; Okazaki, Noguchi & Yoshikawa, 2014). Research has advanced technologies for gaze measurement, and studies on sentence comprehension using gaze tracking devices have been conducted (Duchowski, 2007; Ohno, Mukawa & Yoshikawa, 2002).

We are interested in influences on comprehension that result from showing the writing process. To that end, we investigated differences between dynamic presentations of the writing process, such as writing on a chalkboard, and static presentations of only the final results of writing (Okazaki et al., 2013; Okazaki, Noguchi & Yoshikawa, 2014). Our experimental results showed that dynamic presentation encourages gazes and promotes constructive understanding with step-by-step presentation. We decided that dynamic presentation actively gives information to a receiver of information (leaner).We named this fundamental characteristics of dynamic presentations as "information push". Also our experimental results showed that static presentation encourages to interpret given information freely. We decided that static presentation promotes a receiver of information (leaner) to extract information. We named this fundamental characteristics of static presentations as "information pull". The "information push" and "information pull" characterize how information is given in dynamic presentation and static presentation. (Okazaki, Noguchi & Yoshikawa, 2014).

This paper considers animated presentation slides as an example of dynamic presentation. We test our proposed idea through comparison with handwriting presentation, and demonstrate fundamental characteristics of each dynamic presentation. We also introduce voice descriptions in educational presentations and examine their effects. Two experiments are described below, a comparison of chalkboard-style and animated slide presentations with no voice, and ones with voice descriptions added.

2. Experiments and Results

2.1 Experiment Method

This section describes the experimental design common to the two experiments. We prepared three presentation patterns with different contents. Three presentation conditions (handwriting, animated slides, and static images) were set for each pattern, comprising nine presentation stimuli with different contents or conditions.

We created handwritten presentation stimuli using a presentation tool currently in development at our laboratory, the Handwriting Presentation Tool (HPT). This tool allows reproduction of writing processes such as writing on a chalkboard (Hosoki et al., 2011). Microsoft PowerPoint was used to make animated slides. Static image presentations showed only the final results of the handwriting.

To investigate and analyze any differences, we used a subjective assessment by questionnaire and an objective assessment by comprehension test (100-point scale) as well as eye trackers for gaze analysis. The Tobii X1 Eye Tracker—a standalone, compact eye tracking unit—was used to track gaze (Tobii, 2015). No distracting sensors or other hardware elements were visible to the user. The system detects the user's gaze by using both bright and dark pupil tracking techniques. We used Tobii Studio to analyze gaze data. We used gaze plots for dynamic analysis and heat maps for static analysis (Tobii, 2017).

Trial subjects sequentially watched three patterns under one of the presentation conditions. Each presentation was assigned to test subjects according to a combination table known in experimental design as an L9 orthogonal array, where condition combinations are equally arranged.

2.2 Experiment Results

2.2.1 Experiment1: Comparative Experiment between Handwriting Presentation and Animation Slides

Table 1: Difference of presentation method and its subjective evaluation (Experiment 1).

	Pattern 1		Pattern 2		Pattern 3		Total	
	Best	Worst	Best	Worst	Best	Worst	Best	Worst
Handwriting	57%	33%	25%	29%	27%	0%	36%	23%
Animation Slide	14%	33%	75%	29%	18%	40%	28%	32%
Static Image	29%	33%	0%	42%	55%	60%	36%	45%

There were 22 participants, all university students in their early twenties. Experiments were performed between February 5–10, 2016. Table 1 shows subjective assessments of the presentation conditions, in total and by condition. Comprehensibility seems to be different between handwriting presentation and animation slides, which are both forms of dynamic presentation. Static images, on the other hand, were the hardest to understand, followed by animated slides and then handwriting presentation. Focusing on the presentation conditions shows interesting results. The evaluation order for handwritten presentation and animated slides is opposite. In the first pattern, handwritten presentations were best evaluated. In the second pattern, however, animation slides were best evaluated, indicating a significant difference in the effectiveness of presentation conditions between the two presentation patterns.

Figure 1 shows average scores and standard errors of the comprehension tests. Patterns 1 and 2 were not easy for participants, while pattern 3 was easy. Consistent with our proposed idea, dynamic presentations are thus useful in these presentation patterns, while static presentations are useful for easy patterns. In addition to confirming our idea, this provides a clue about the difference between handwritten presentations and animated slides.

We conducted gaze analysis by gaze plot and heat map. Gaze plots show the location, order, and time spent looking at locations (Tobii, 2017). We confirmed gaze effects for both animated slides and handwritten presentations. In both cases, gaze points followed the presentation process. One distinctive difference is that that gaze could not keep up with the presentations in some cases.

Heat maps show gaze distributions over the stimulus (Tobii, 2017). There were no characteristic differences between the two dynamic presentations (animated slides and handwritten presentation). In contrast, there was a remarkable difference in eye movements between the dynamic

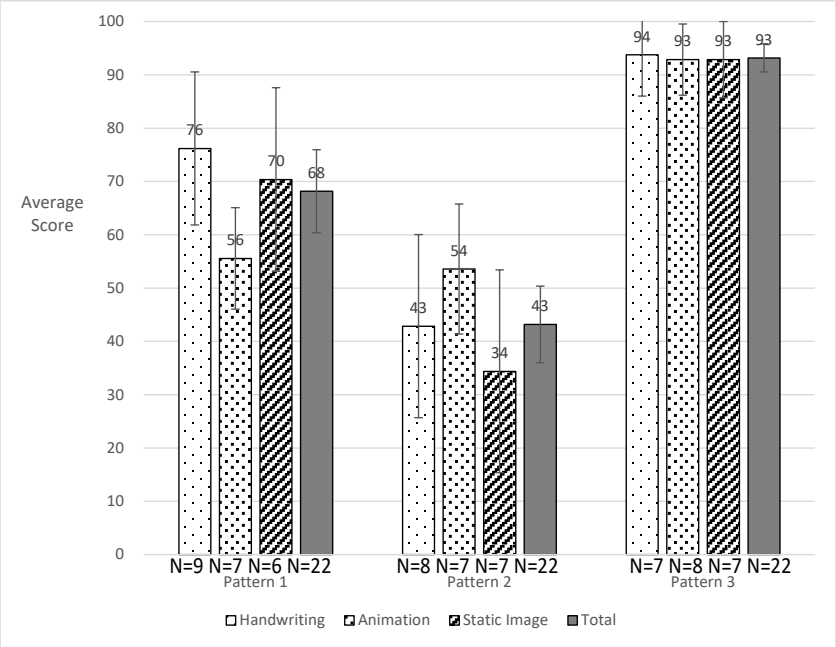
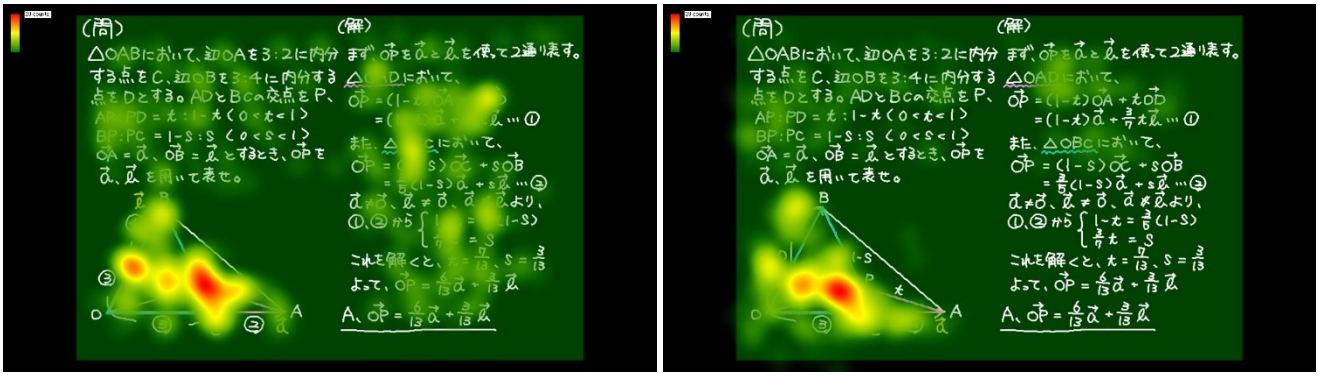


Figure 1. Average score and standard errors of comprehension test (100 point scale) (Experiment 1).



(a) Participant P (b) Participant G

Figure 2. Heat map examples of static image (Pattern 2).

and static presentations (Figure 2). Heat map patterns for static images differed between participants P and G; participant P carefully observed the problem, graphic, and solution (Figure 2(a)), while participant G quickly scanned the problem and solution, indicating that less attention was paid (Figure 2(b)).

Consistent with our previous studies, we confirmed that there are individual differences. We believe this is consistent with the free interpretation of presented information in static presentations.

2.2.2 Experiment 2: Effect of Voice Description

There were 20 participants, all university students in their early twenties. Experiments were performed from January 11–20, 2017.

The results were consistent with our previous studies. In both subjective and objective evaluations, handwritten presentations were highly rated for presentations that were difficult to understand, because presentations of the thought process were incomplete in animated slides, which applied a “fade-in” effect to presented slides. In this experiment, we realized again that presenting the thinking process by handwritten presentation is useful.

Table 2 and Figure 3 respectively show subjective assessments of presentation conditions (in total and by condition) and average scores and standard errors of the comprehension tests. The results are mostly consistent with the results of the previous experiment with no voice description. However, the subjective evaluations by the participants and comprehension test results differed; the average score for subjective evaluations was lowest, and that of comprehension tests for static images was highest. This suggests that the difference is a result of voice descriptions.

A similar gaze analysis was also performed in this experiment and showed inductive effects by both dynamic presentation and by voice description. We confirmed that characteristics of free interpretation in the static presentation disappeared as a result of voice description, and that the static image was viewed according to the voice description.

Table 2: Difference of presentation method and its subjective evaluation (Experiment 2).

	Pattern 1		Pattern 2		Pattern 3		Total	
	Best	Worst	Best	Worst	Best	Worst	Best	Worst
Handwriting	40%	17%	67%	25%	42%	0%	45%	15%
Animation Slide	30%	17%	33%	25%	29%	37%	30%	25%
Static Image	30%	66%	0%	50%	29%	67%	25%	60%

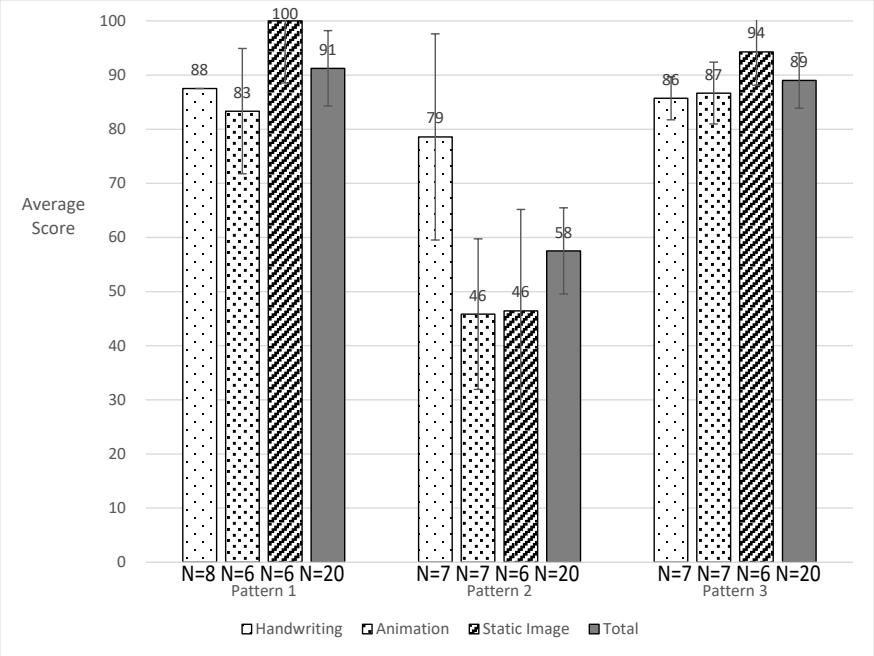


Figure 3. Average score and standard errors of comprehension test (100 point scale) (Experiment 2).

3. Discussion

In a previous study, we characterized dynamic and static presentations by introducing "information push" and "information pull."

Through comparative experiments between handwritten presentations and animated slides, this paper demonstrated the same gaze effect for animated slides as seen in handwritten presentations. We also found a difference between the two dynamic presentations (handwritten presentations and animated slides), and demonstrated the possibility that dynamic presentations including the entire writing process are useful for understanding. We believe that this advantage is a result of characteristics of handwritten presentations, which provide gaze points and visualize the thinking process by sequentially presenting objects and their relations.

This experiment showed that handwritten presentations are useful for difficult-to-understand content, because they have a positive influence on sequential constructive understanding.

We also found an inductive effect of voice descriptions on gaze. This effect was observed in both static and dynamic presentations, which we believe may affect comprehension of presented materials.

However, subjective evaluations were lower when voice descriptions were added, especially for easy presentations. We think this is because induction by voice description had a negative influence, due to inadequate speed and timing. This is supported by a questionnaire comment, "I was irritated because the speed of explanation did not match."

From the above, we conclude that voice descriptions have a significant effect on presentations.

4. Conclusions and Future Work

We investigated the fundamental characteristics of teaching material presentations through two cognitive experiments. Comparisons demonstrated similarities and differences between handwritten presentations and animated slides, and the results were consistent with our previous study. These can be explained by the proposed ideas of "information push" and "information pull." Our experimental results support the idea that dynamic presentations—which visualize the thinking process—have a positive influence on sequential constructive understanding, and thus are useful for difficult-to-understand presentations.

Further studies are needed to investigate interactions between visual information (shown materials) and auditory information (voice descriptions) when presenting teaching materials. We plan to identify factors that affect understanding through a series of experiments that consider the speed of voice descriptions and their timing during presentations.

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