Effects of Nudges by Visualization of Others' Note-Taking on In-Class Learning Behavior

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Visualizing and sharing the others' learning behavior is one way to support note- taking. However, in-class support is insufficient for students to write what the teacher wants. This study aimed to reveal the impact of visualizing others' note-taking on learning behavior and thinking during note-taking revision. We added an after-class visualization function to a tablet-based note-taking support system (Kondo et al., 2023) that can visualize the location of learners' notes and highlights in real time. Twenty-one undergraduate and graduate students participated in the experiment. The questionnaire results suggested that visualizing others' important parts promotes note-taking. In contrast, visualizing unclear parts may promote self- monitoring. On the other hand, visualizing others' notes may be difficult to reference because learners cannot see specific descriptions. We also found that 23% of the descriptions added during the revision process were written by referring to the visualization.

Introduction

Note-taking is a common learning behavior among many learners. Di Vesta and Gray (1972) insisted that note- taking has two processes: encoding and storage functions. Kobayashi (2006) suggested that learners improve their academic performance by reviewing (storage function) their own notes. Furthermore, Nilson (2013) proposed the possibility of fostering self-regulated learning through activities in which learners improve their note taking. However, not all learners are capable of elaborate and organized note-taking. Morehead et al. (2019) suggested that the limited opportunities for learners to learn note-taking strategies can result in ineffective note-taking. One way to support this is to distribute class materials (Kiewra, 1989). Avval et al. (2013) found that learners who wrote class materials directly could grasp key points of a lecture and enhance their understanding. However, Lannone and Miller (2019) suggest that merely distributing materials may not be sufficient, as only a minority of students can effectively organize their notes.

Luo et al. (2016) indicated that note-taking involves a revision process in which students add information to their encoded notes. He suggested that learners can write organized descriptions through the revision process. However, the revision process can be challenging. Flanigan and Titsworth (2020) noted that learners may have difficulty recalling class content if they rely solely on their own notes. Flanigan et al. (2023) also insisted that the note revision process needs to be assessed based on the learner's thinking and judgment.

As an in-class note-taking aid, Kondo et al. (2023) develop NoTAS, a tablet-based note-taking web application. NoTAS supports learners by using color-coded visualizations of the number of notes and highlights made by other learners on everyone's materials using the collected notes and highlights logs. There are three visualization types: notes, important highlights, and unclear highlights. Moreover, the parts written by more learners are highlighted. NoTAS was developed by applying the nudge theory defined by Thaler and Sunstein (2009). Thus, the real-time visualization of others' note-taking situations could play the role of a nudge, facilitating their learning behaviors such as note-taking.

Kondo et al. (2023) indicated that the visualization of NoTAS enhanced learners' motivation for note- taking and attention to explanations through learner interaction. Additionally, the visualization improved learners' sense of classroom community and social presence. However, even with NoTAS, there was no significant increase in the number of annotations, especially not enough writing to organize the class content independently. Furthermore, the results suggested that different types of visualizations could influence various learning behaviors.

Purpose

In this study, we focused on the revision process. This study aimed to evaluate whether visualization of NoTAS promotes learning behavior and thinking. Thus, we added functionality to NoTAS and examined two research questions:

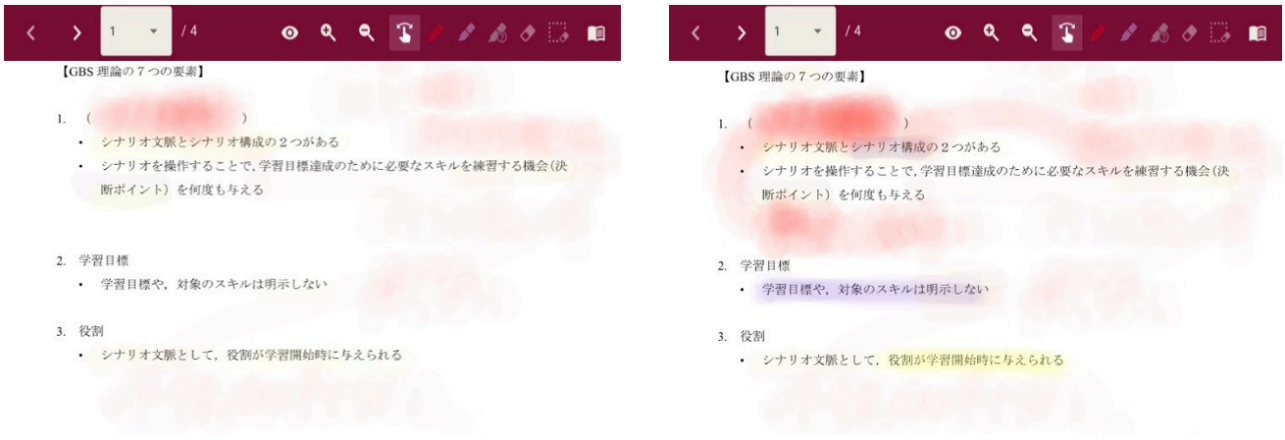
1. What kind of behavior and thoughts are promoted by each type of NoTAS visualization?
2. Do students use NoTAS visualization to revise their notes?

Addition of visualization functionality

We considered it difficult to support the revision process with real-time visualization, as in class, because each learner's revision pace is different. Thus, we added new functions for visualization in and after class (see Figure 1). The "in-class" visualizes only the descriptions of others in class and does not visualize the descriptions of others written or erased after class. On the other hand, "after-class" visualizes the descriptions of others after class together. Therefore, learners can easily see what others have revised their notes by switching between in-class and after-class visualization during revision.

Figure 1

In-Class and After-Class Visualization Functionality



Methods

Procedure

We recruited undergraduate and graduate students enrolled in a science university in Japan. There were 21 participants (14 males and seven females), averaging 21.5 years old. We conducted this study in October 2023.

First, participants signed an informed consent form and then practiced NoTAS system using an iPad (6th generation) and a tablet pen. They then took a 30-minute class using NoTAS. They then had 15 minutes to revise their notes for the test. Furthermore, our collaborators intervened using visualization by writing notes and highlights during the revision. Without learner input, no visualization would have occurred, preventing evaluation. Finally, participants completed a test and a post-questionnaire.

Data collection

Visualization of NoTAS

We created 18 items for the visualization scale. This scale consists of three visualization types (notes, important highlights, and unclear highlights), each comprising of six items related to learning behavior. These items were represented on a 5-point Likert scale.

Reasons for revising notes

We asked what the participants referred to for each description they added during the revision process. We asked five questions (own description, NoTAS visualization, text of class material, memory of class, and others) in a multiple-answer format.

Results

In total, 21 participants answered the questionnaire. None of the participants had studied the class contents before.

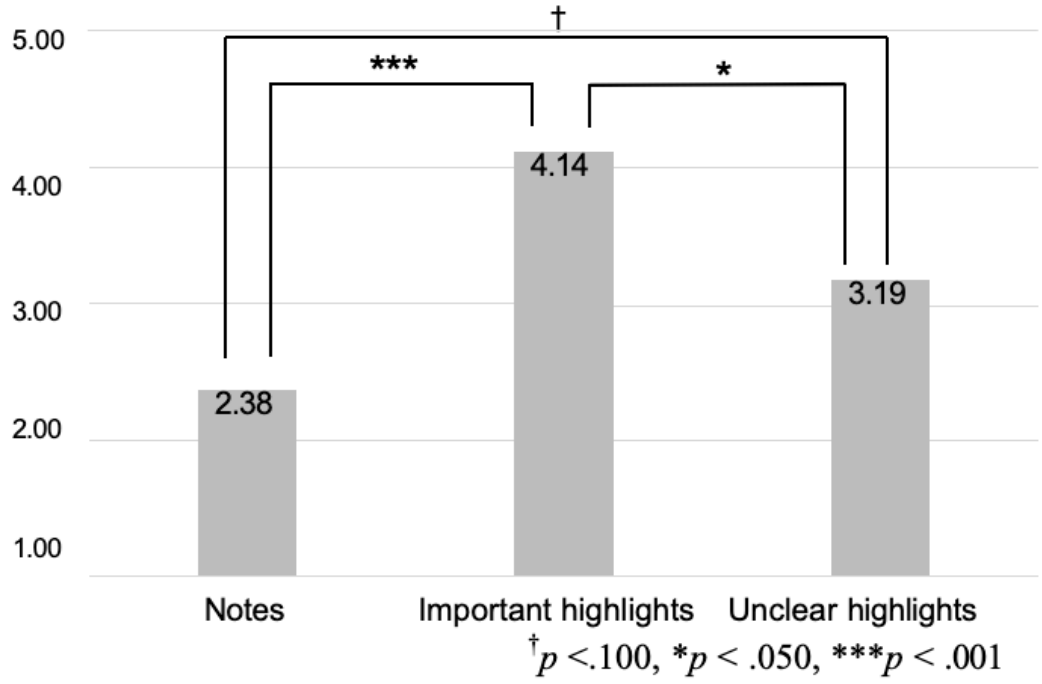
Visualization of NoTAS results

We analyzed each of the six items using the one-way repeated measures ANOVA. The factor was the visualization type, with three levels: notes, important highlights, unclear highlights. We also conducted the Bonferroni's multiple comparison test on the significantly different items.

An ANOVA test for item 1, "I thought to reflect on the class contents by referencing the visualized parts" revealed a significant main effect ($F(2,40)=15.10$, $p<.001$, $\eta 2=.23$). Figure 2 shows the mean and the multiple comparison results for item 1. The visualization of highlights in important parts was the most helpful for reflecting the class. Additionally, visualizing unclear highlights was marginally significantly more than the visuazing others' notes.

Figure 2

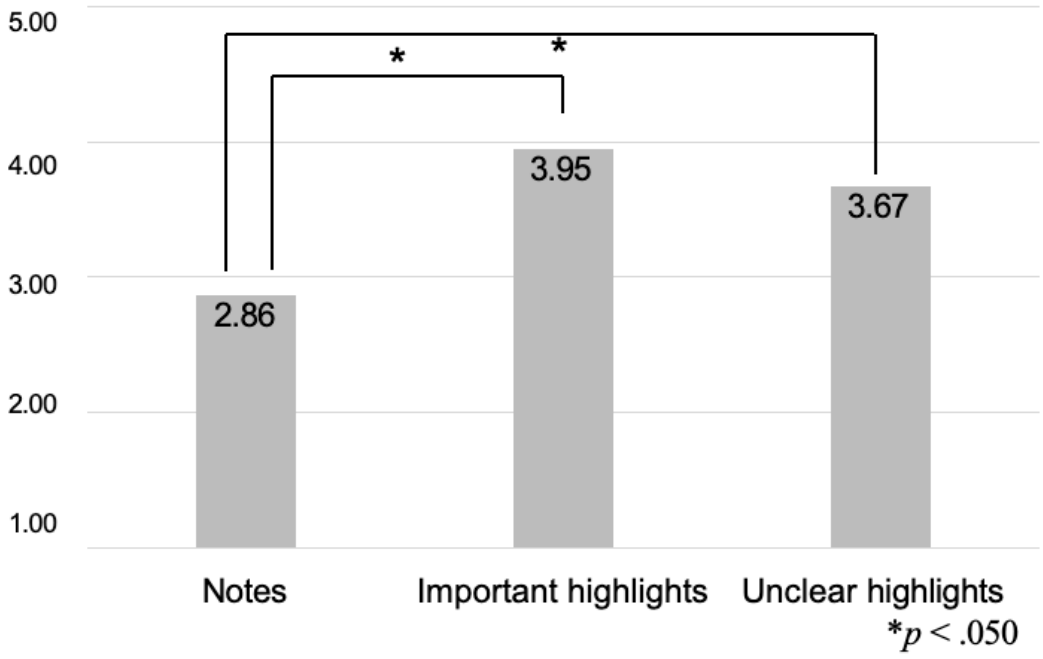
Result of Item 1: Reflection on Class Content



Item 2, "I judged whether I understood the contents by referring to the visualized parts," displayed a significant main effect in an ANOVA test ($F(2,40)=5.60$, $p<.01$, $\eta 2=.09$). Figure 3 shows the mean and the multiple comparison results. The visualization of others' notes was significantly less informative for judging content understanding compared to visualization of important/unclear highlights.

Figure 3

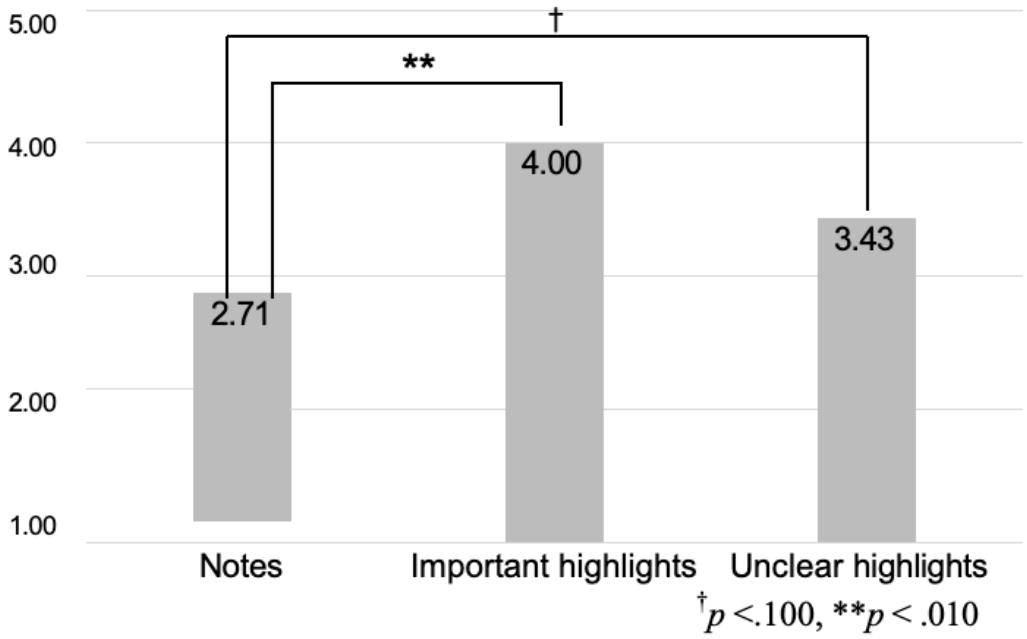
Result of Item 2: Judgments of Understanding



An ANOVA test revealed a significant main effect (F(2,40)=8.19, p<.01, η2=.13) for item 3, "I thought about reading the class material by referring to the visualized parts." Figure 4 shows the mean and the multiple comparison results. Visualizing important and unclear highlights written by others on the materials promoted reading more than the visualization of note parts.

Figure 4

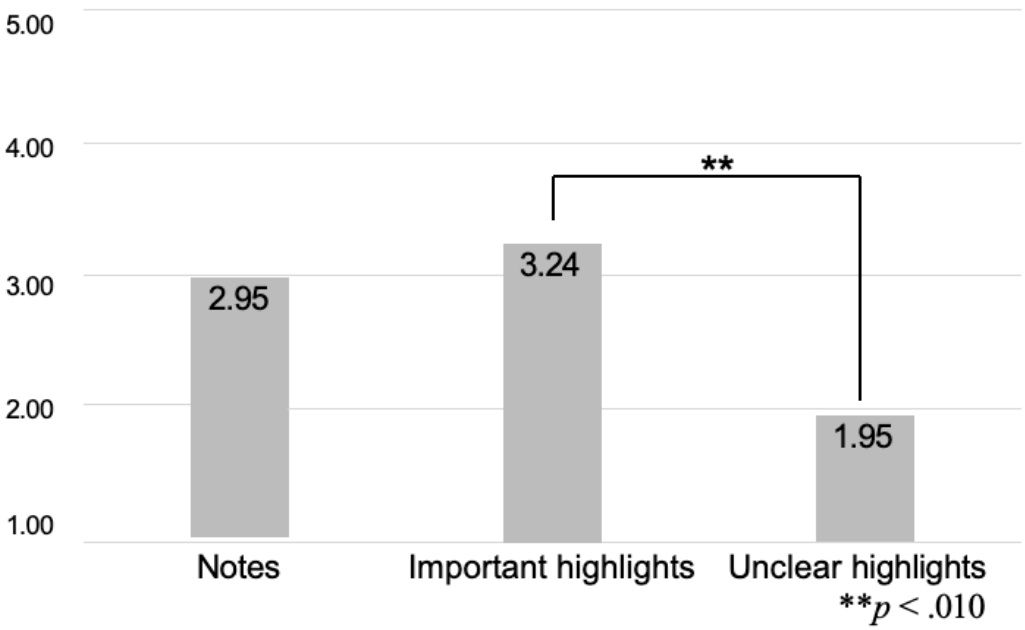
Result of Item 3: Reading the Class Material



An ANOVA test for item 4, "I wanted to write notes and highlights by referring to the visualized parts," yielded a noteworthy distinction (F(2,40)=6.03, p<.01, η2=.12). Figure 5 shows the mean and the multiple comparison results. There was one significant difference. Learners were significantly more motivated to write when visualizing the parts that others considered important compared to visualizing parts where other found things unclear.

Figure 5

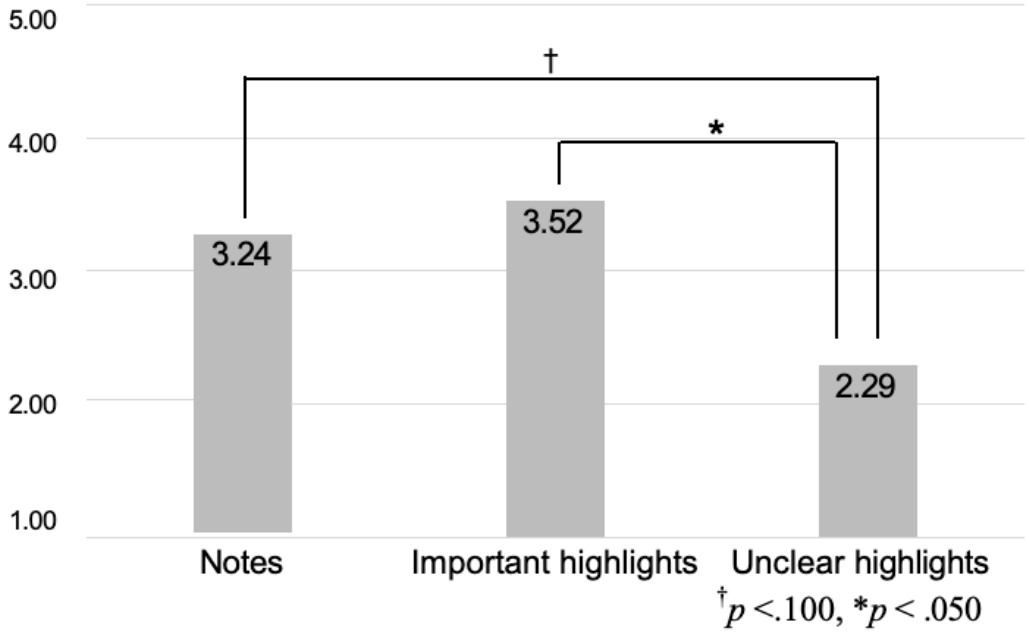
Result of Item 4: Writing Notes and Highlights



Item 5, "I realized that the visualization was useful for me to write notes and highlights," displayed a significant main effect in an ANOVA test ($F(2,40)=5.54$, $p<.01$, $\eta 2=.12$). Figure 6 shows the mean and the multiple comparison results. Visualizing others' important highlights was evidently more useful as a reference for note-taking compared to others' unclear highlights. Furthermore, visualizing others' notes appeared to be slightly more beneficial for nore-taking than others' unclear highlight.

Figure 6

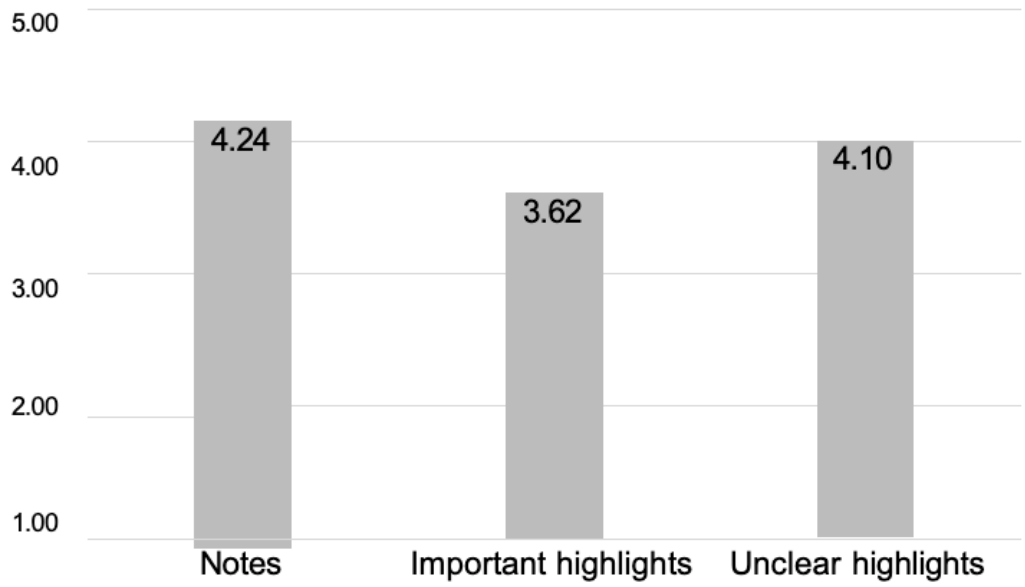
Result of Item 5: Useful for Writing



An ANOVA revealed no difference ($F(2,40)=2.43$, n.s., $\eta 2=.04$) for item 6, "I was interested in what others wrote / why they highlighted by looking at the visualized parts." Figure 7 shows the mean.

Figure 7

Result of Item 6: Interested in What and Why Others Wrote



Reasons for revising notes

Table 1 shows the total number of descriptions written during the revision process and the results of why participants improved their notes.

Table 1

Description Count and Reasons for Writing

Item	n	%
Total number of descriptions written during the revision process	300	-
Referring to own descriptions I wrote in class	48	16.00
Referring to the visualized parts	71	23.67
Referring to texts in the class materials	121	40.33
Remembering the teacher's explanation in class	140	46.67
Others	44	14.67
n = 21		

Discussion

The results of ANOVA and multiple comparisons revealed that participants referred to visualization of others' highlights more than others' notes to revise their notes. Highlight visualization facilitates learning behaviors such as reading the material and recalling the lesson while revising notes. In addition, participants felt that visualization of especially important highlights helped them to revise their notes. On the other hand, when they saw a visualization of unclear highlights, learners may have been interested in why others highlighted and may have checked their own understanding based on the visualizing parts.

In conclusion, visualizing others' important parts promotes learning behavior, such as note-taking, reading, and reflection. In contrast, visualizing others' unclear parts can promote self-monitoring, such as judging whether they understand the contents. However, visualizing others' notes may have been difficult for participants to refer to because they could not see what others wrote specifically and because various parts of the margins on the materials were visualized.

Participants added a total of 300 descriptions during note revision (see Table 1). The results of the reason for revising notes revealed that participants wrote 40% of the descriptions referring to the contents of the materials and memories of the class. These results support previous studies (e.g., Avval et al., 2013) that have shown that writing directly on the material facilitates understanding and makes it easier to focus on the

main points than writing in a blank notebook. Furthermore, participants wrote more than 23% of the descriptions referring to visualization. The results of the multiple responses showed that some participants also referred to their memory of the class and the content of the materials, along with the visualization. This result suggests that visualization may trigger them to reflect on the class and focus on specific parts of the materials. Thus, NoTAS visualization can facilitate participants' note revision. In future work, we need to investigate the relationship between in-class and revision note-taking and the impact of visualization from detailed writings.

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Acknowledgments

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