Learning Visualization System Improve Sense of Community and Learning Strategies in Class

Takaki KONDO
Tokyo University of Science, Japan
1722704 @ ed.tus.ac.jp

Kyoichi YOKOYAMA
Kaetsu Ariake Junior and High School, Japan
k_yokoyama @ ariake.kaetsu.ac.jp

Tadashi MISONO
Shimane University, Japan
misono @ edu.shimane-u.ac.jp

Rieko INABA
Tsuda University, Japan
inaba @ tsuda.ac.jp

Yuki WATANABE
Tokyo University of Science, Japan, Japan
wat @ rs.tus.ac.jp

This study evaluated whether the visualization of others' learning facilitated Co-regulated learning and the use of learning strategies in class. We added new functions to the Nudge for Note Taking Assist System (NoTAS; Kondo et al., 2021), a tablet-based note-taking support system. NoTAS can visualize where learners have written using data collected in real-time. NoTAS visualizations are categorized into three types: "notes," "important," and "unclear." We divided 40 study participants into two groups based on whether they used NoTAS visualization in class. Questionnaire results revealed that the visualization of others' learning improved participants' sense of classroom community and social presence. Correlation analysis between the nudge scale and the sense of classroom community index revealed that visualizing important elements facilitated note-taking. Visualizing notes and unclear elements made the learners more willing to listen to the teacher's explanations. These results suggest that different visualization types affect different learning strategies.

Keywords: Self-Regulated Learning, Co-Regulated Learning, Learning Visualization, Note-Taking

Introduction

Self-Regulated Learning

In its Learning Compass, a vision for the future of education, the OECD (2018) indicated that learners need to develop self-regulated learning (SRL) competencies. Those with SRL have the ability to cycle through forethought, performance, and reflection on their own to learn effectively (Usher & Schunk, 2018). Much of the educational technology research on SRL development has focused on outside class learning support, such as encouraging reflection and learning management using assignments, portfolios, and learning management systems. However, outside class learning support can be burdensome in terms of the preparation required from teachers and the activities required of learners. Nilson (2013) proposed note-taking as an effective learning strategy for SRL development and in-class learning support.

Effective Learning Strategies for Developing Self-Regulated Learning

The two key features of note-taking are encoding and storage functions (DiVesta & Gray, 1972). The encoding function facilitates recognition processing by combining learning contents with the learner's prior knowledge through note writing. The storage function enables effective review via note reading. Morehead et al. (2019) suggest that many learners take notes in class but cannot write complete notes because they have few opportunities to learn effective note-taking strategies. One way to support this is to distribute class materials that clarify the main points of the lesson (Kiewra, 1989). Writing directly on class material can also facilitate students' understanding (Avval et al., 2013).

However, only a few learners take organized notes on explanations offered by their teachers. Therefore, Lannoe and Miller (2019) suggest that more should be done to encourage learners to take notes.

Another practical support strategy is to provide feedback on note-taking. For example, Beaudoin and Winne (2009) developed the "nStudy system," which allows teachers and other learners to provide comments and detailed feedback on essays. However, though "nStudy" can provide detailed feedback, it is difficult for teachers to provide ongoing note-taking instructions, and there is not enough time to share and discuss notes in class (Nilson, 2013). Hadwin et al. (2018) proposed Co-Regulated Learning (Co-RL) as a recent trend in research on regulated learning. Co-RL is a learning to regulate one's learning through interaction with others. Therefore, we suggest that note-taking feedback among learners is possible by applying the Co-RL theory.

Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT, 2020) endorses a policy of allowing learners to own devices in order to develop networks. Teachers and learners worldwide are increasingly using information and communication technology (ICT) in class. For example, the "Metaboard" is a learning analytics dashboard that supports learners' metacognition and SRL by visualizing their learning behavior (Chen et al., 2020). Learners can also easily take notes using both a pen and tablet (Özçakmak & Sarigöz, 2019); they can use tablets instead of paper or a keyboard for longhand note-taking. However, little research has been conducted on efforts to support longhand note-taking with tablet devices applying the Co-RL theory.

Nudge Theory for Promoting Behavioral Change

We focus on promoting interaction among learners using the "nudge theory," which has been studied extensively in the field of behavioral economics. Thaler and Sunstein (2009) define a "nudge" as any element of choice behavior that changes people's behavior predictably without narrowing the choice or significantly changing the economic stimulus. Though this concept has been applied to educational studies (Weijers et al., 2020), most of this research is confined to teaching policies; few have examined nudging in the context of learning strategies. We define "educational nudge" as improvements in a learner's note-taking, achieved by referring to the colors and positions of the note-taking of other learners. The goal is to learn others' learning strategies, specifically note-taking in class. We hypothesize that learners who have difficulty taking notes can be aided if they are shown the notes other learners have taken correctly and are provided with feedback using tablets.

Purpose

This study employed the Note Taking Assist System (NoTAS), developed by Kondo et al. (2021), using nudges to provide feedback on note-taking among learners in class. We evaluated the effectiveness of NoTAS for learners by using questionnaires to examine the following research questions:

1. Does the visualization of others' learning situations support learners' Co-RL by allowing them to facilitate interaction with others during note-taking?
2. Does the visualization of others' learning situations contribute to the use of in-class learning strategies?

System Design

NoTAS is a web application that supports note-taking in a class where each learner and teacher has a tablet. It can deliver class materials (PDF) to a browser, allowing students to write notes and highlight material using a tablet pen. When a learner writes notes on or highlights class material using the visualization function of NoTAS, the approximate locations of notes and highlights created by others in the class are visualized on the same material in almost real time. NoTAS also maintains a note-taking log, showing when and what kind of content was added or deleted.

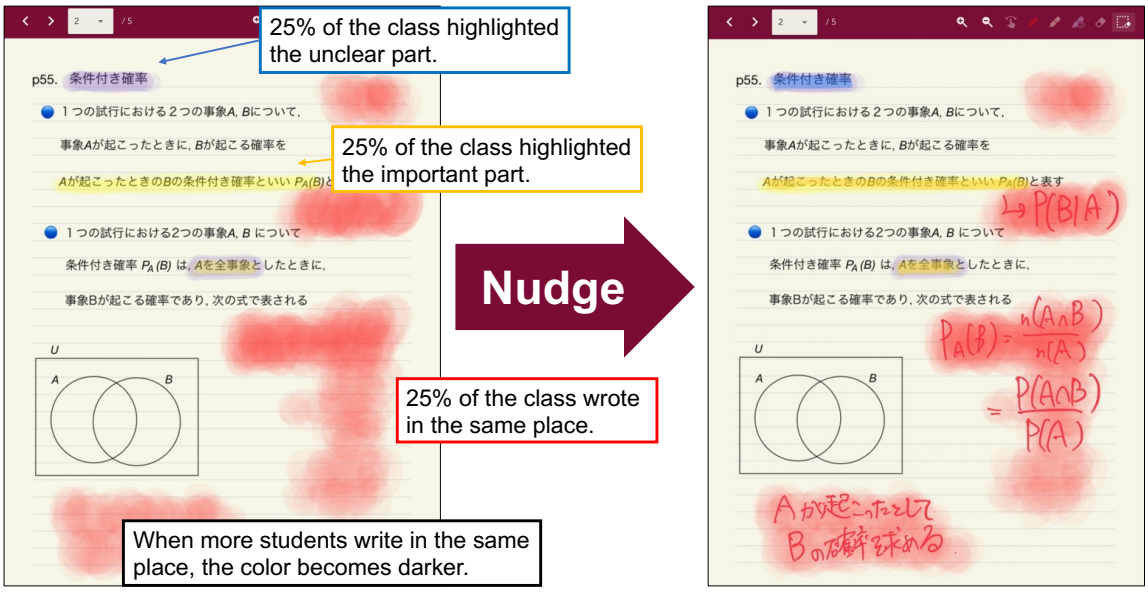
NoTAS includes a pen and marker feature for note-taking. For this study, we added a marker function for unclear elements of the class material and designed it to appear in a color different from those used for the existing pen and marker functions. This layer overlaps with the number of learners in class; thus the greater the number of learners who fill in the same part, the darker the color appears. Consequently, the areas written by many learners are emphasized. **Figure 1** shows an example of the visualization function of NoTAS. The colors indicate the following:

- Red areas indicate that other learners wrote notes
- Yellow areas indicate that other learners highlighted important elements
- Blue areas indicate that other learners highlighted unclear elements

We developed NoTAS to facilitate learning and note-taking, with the visualization serving as a nudge.

Figure 1

NoTAS note-taking and visualization interface



Participants

We recruited undergraduate and graduate students enrolled in a science university in Japan to participate in an educational system evaluation experiment. We selected the dates with the largest number of participants to determine experimental days and divided the 40 participants (24 males, 16 females; mean age of 22.5 years) into experimental and control groups. Although this research did not allow for random sampling, we assessed the bias of the two groups using a pre-questionnaire.

Procedure

Figure 2 shows the study's research procedure. We conducted this study in October 2021 and May 2022. The time gap is due to the difficulty of conducting face-to-face classes amid the COVID-19 pandemic.

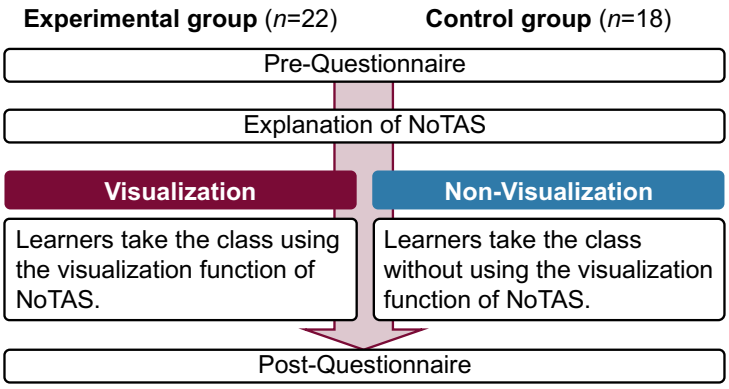
First, the participants listened to a description of the experiment and signed a consent form. Next, they completed a pre-test and a pre-questionnaire administered using Google Forms. They then received a tablet device (iPad 6th) and a tablet pen, and practiced using NoTAS. The experimental group took the class using NoTAS' visualization function, and the control group took the class without it.

The class content comprised four instructional design theories: andragogy, goal-based scenarios theory, the jasper project, and a training procedure. The teacher displayed the class materials that had been distributed to the learners on the screen, wrote on the board, and provided explanations. Additionally, since the experimental and control groups were placed separately, a class video of approximately eight minutes was created for each content to ensure that there was no difference in the content between the classes. Participants watched the videos on a projector and wrote on the class materials using NoTAS. We classified the note-taking according to Luo et al. (2018), using the following items to determine the number of descriptions: one teacher's writing on the board, one fill in the blank, five oral explanations, four important highlights, one unclear highlight, and four symbols.

Furthermore, five collaborators (who were not participants) wrote what the teacher wanted the learners to write following the class' progress because if none of the learners wrote notes or made highlights, no visualization would have appeared, and we could not have been unable to evaluate the effectiveness of the NoTAS visualization function. Thus, the collaborators wrote the notes and intervened with the participants using the visualization function. Finally, the participants answered a post-test and a post-questionnaire survey.

Figure 2

Research procedure



Data Collection and Questionnaire

Quantitative data were gathered from the questionnaires the participants had answered before and after the class. The pre-questionnaire asked about the participants' age, gender, and experience with note-taking using a tablet. We incorporated three perspectives in the post-questionnaire:

Sense of Classroom Community. We used 15 items from the Sense of Classroom Community Scale (SCCI) developed by Rovai (2002). We revised the items of the scale to be more consistent with this study's purpose. Furthermore, we created three new items related to the use of learning strategies and learners' interaction in the class. All items were answered on a 5-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree").

Social Presence. We adopted three items proposed by Short et al. (1976) to measure social presence: unsociable–sociable, impersonal–personal, and warm–cold. It employed a semantic differential method with a bipolar 7-point scale, following Short et al. (1976).

Nudge Scale. We created 14 items for a Nudge Scale to examine the impact of NoTAS's visualization on learners. This scale consisted of three visualization types: six items for the visualization of others' notes, four for the visualization of others' important elements, and four for the visualization of unclear elements. These items were answered only by the experimental group on a 5-point Likert scale.

Guidelines for Analysis

Regarding the SCCI and the social presence scale, we conducted a Mann-Whitney U test to compare the means of the class with and without NoTAS' visualization function. We used these scales to examine the interaction with others in the class and to assess the impact of NoTAS on Co-RL. Then, we conducted a Spearman's rank correlation coefficient to measure the correlation between the nudge scale and the SCCI to investigate whether the NoTAS visualizing had facilitated the use of learning strategies in the class.

Results

In total, 40 participants answered the questionnaires. The 22 learners in the experimental group (who used the visualization function of NoTAS) consisted of 13 males and 9 females, with an average age of 22.3 years. The 18 learners in the control group who did not use the visualization function consisted of 11 males and 7 females, with an average age of 22.7 years. We conducted a chi-square test on the pre-question, "Have you ever used a tablet device (iPad, Chromebook) and a tablet pen for note-taking in a class?" The result showed no significant difference between the experimental and control groups (χ^2 (1) = 0.00, p = .97, φ = .01). Furthermore, none of the learners had learned the four theories of instructional design taught in this class.

Results for Sense of Classroom Community

We conducted a Shapiro–Wilk test on each item to check for normality. The results indicated no normality of the distribution. Thus, we chose to use a Mann–Whitney U test. **Table 1** shows the results of a Mann–Whitney U test for the SCCI scores. The index was reliable, with a Cronbach's alpha of .88. The experimental group were denoted as

"Visual" while the control group were denoted as "Non-visual." The results revealed significant differences for the 11 items and a marginally significant difference for one item; the mean scores were higher for all items in the Visual group than in the Non-visual group.

Table 1

Sense of classroom community comparison

	Visual		Non-Visual		M_{vis}-	U		r
	M_{vis}	SD_{vis}	M_{non}	SD_{non}	M_{non}			
1. I felt that learners in this class cared about each other.	2.50	1.34	1.89	1.28	0.61	143.00		0.28
2. I felt that I was encouraged to ask questions.	2.59	1.14	2.22	1.00	0.37	160.50		0.19
3. I felt uneasy exposing gaps in my understanding. (R)	3.82	1.40	3.50	1.43	0.32	174.50		0.12
4. I felt connected to others in this class.	3.95	1.09	1.11	0.32	2.84	3.00	***	0.98
5. I did not feel a spirit of community. (R)	3.45	1.26	1.61	0.78	1.84	48.00	***	0.76
6. I felt that this class resulted in only modest learning because of NoTAS use. (R)	3.68	1.29	3.11	1.37	0.57	150.50		0.24
7. I felt that I received timely feedback on my notes and highlights in this class.	3.36	1.18	2.00	0.84	1.36	76.00	***	0.62
8. I trusted others in this class.	2.95	1.29	2.67	1.14	0.28	175.00		0.12
9. I felt isolated in this class. (R)	4.32	1.00	2.94	1.16	1.38	75.50	***	0.62
10. I felt that I could rely on others in this class.	3.36	1.18	1.44	0.71	1.92	41.00	***	0.79
11. I felt that other learners did not help me learn in this class. (R)	3.95	0.90	2.72	1.23	1.23	88.00	**	0.56
12. I felt that members of this class depended on me.	1.73	0.88	1.22	0.55	0.51	131.00	*	0.34
13. I could feel how the other learners were listening to the teacher's explanation in this class.	4.23	1.11	2.50	1.30	1.73	63.00	***	0.68
14. I felt uncertain about others in this class. (R)	3.59	1.26	2.78	1.40	0.81	132.50	†	0.33
15. I found that the other learners were taking notes very diligently.	4.55	0.60	3.67	1.03	0.88	99.00	**	0.50
16. I felt confident that others would support me.	2.91	1.11	1.61	0.85	1.30	74.00	***	0.63
17. I felt that I had enough opportunity to learn how to take notes in this class.	3.18	1.22	3.06	1.16	0.12	182.00		0.08
18. I was curious about others' note-taking behavior.	4.05	1.33	2.83	1.43	1.22	88.00	**	0.56

Visual: n = 22, Non-visual: n = 18 $^{\dagger}p$ <.100, $^{*}p$ < .050, $^{**}p$ < .010, $^{***}p$ < .001

(R): Reverse score, 5-point Likert scale

Social Presence Results

We conducted a Shapiro–Wilk test on each item to check for normality. The results indicated no normality of the distribution. Thus, we chose to use a Mann–Whitney U test. **Table 2** shows the results of a Mann–Whitney U test for the social presence scores. The Social Presence Score is the mean of the three items. The index was reliable, with a Cronbach's alpha of .88. The results revealed significant differences for the three items and in the social presence scores; the mean scores were higher for all items in the Visual group than in the Non-visual group.

Table 2

Social presence comparison

	Visual		Non-visual		M_{vis}-	U		r
	M_{vis}	SD_{vis}	M_{non}	SD_{non}	M_{non}			
1. Unsociable - Sociable	4.23	1.27	3.39	0.78	0.84	118.00	*	0.40
2. Impersonal - Personal	5.09	1.19	3.50	1.20	1.59	70.50	***	0.64
3. Warm - Cold (R)	4.82	1.05	3.50	0.86	1.32	74.00	***	0.63
4. Social Presence Score	4.71	1.04	3.46	0.79	1.25	63.00	***	0.68

Visual: n = 22, Non-visual: n = 18 $^{*}p$ < .050, $^{***}p$ < .001

(R): Reverse score, Semantic Differential method

Correlations between Interaction and Use of Learning Strategies

We used the Nudge Scale and the three items from the SCCI scale (which were related to helping others) to identify which types of visualizations facilitated participants' learning strategies. The three items used from the SCCI scale were: "7. I felt that I received timely feedback on my notes and highlights in this class," "10. I felt that I could rely on others in this class," and "11. I felt that other learners did not help me learn in this class (R)." We used Spearman's rank correlation coefficient because the distribution did not show normality in a Shapiro–Wilk test.

Visualizing Other's Notes. The results of the correlation between the red visualization of others' notes and the three SCCI items are presented in **Table 3**. The item "Rely on others" significantly correlated with two items, "listening to the explanation" and "drawing figures and tables" by visualizing the others' notes. The item "Timely feedback on my note-taking" significantly correlated with two items, "writing notes myself" and "listening to the explanation."

Table 3

Correlation between visualizing others' notes in red and use of learning strategies

	Timely feedback on my note-taking.	Rely on others.	Others helped me learn.
1. I thought to write notes myself.	.43 *	.33	.09
2. I thought about listening to the explanation.	.49 *	.50 *	.33
3. I was curious about what others were writing.	.34	.17	-.09
4. I thought to draw symbols such as arrows and enclosures myself.	-.05	.34	.17
5. It was helpful for me to write notes and highlight myself.	.39	.33	.16
6. I thought of drawing figures and tables myself.	.28	.43 *	.22
Visual: n = 22, 5-point Likert scale			$^{*}p < .050$

Visualizing Others' Important Elements. The results of the correlation between the yellow visualization of others' important elements and the three SCCI items are presented in **Table 4**. The item "Timely feedback on my note-taking" significantly correlated with two items, "highlighting" and "listening to the explanation." The item "Rely on others" significantly correlated with three items, excluding "I was curious about what others were writing."

Table 4

Correlation between visualizing others' important elements in yellow and use of learning strategies

	Timely feedback on my note-taking.	Rely on others.	Others helped me learn.
1. I thought to highlight myself.	.32 *	.66 ***	.34
2. I was curious about what others were writing.	.08	.18	.17
3. I thought about listening to the explanation.	.45 *	.50 *	.31
4. It was helpful for me to write notes and highlight myself.	.39	.68 ***	.38
Visual: n = 22, 5-point Likert scale			$^{*}p < .050$, $^{***}p < .001$

Visualizing Other's Unclear Elements. The results of the Spearman's rank correlation coefficients between the blue visualization of others' unclear elements and the three SCCI items are presented in **Table 5**. The item "Rely on others" significantly correlated with "listening to the explanation."

Table 5

Correlation between visualizing others' unclear elements in blue and use of learning strategies

	Timely feedback on my note-taking.	Rely on others.	Others helped me learn.
1. I thought to highlight myself.	.29	.14	.14
2. I was curious about what others were writing.	.33	.11	-.27
3. I thought about listening to the explanation.	.25	.58 *	.22
4. It was helpful for me to write notes and highlight myself.	.27	.19	.19
Visual: n = 22, 5-point Likert scale			$^{*}p < .050$

Discussion

Does Visualizing Others' Learning Support Learners' Co-RL?

The results regarding sense of classroom community suggest that the learners felt a sense of trust and connection with each other using the NoTAS visualization function. The learners felt they received sequential feedback on their writing through the interaction facilitated by NoTAS visualizing. Furthermore, the results for the items "I felt that other learners helped me learn in this class" and "I felt confident that others would support me" indicate that the visualization helped their learning not only through note-taking but also through sharing of important and unclear parts of the material. Finally, the results for the item "I could feel how the other learners were listening to the teacher's explanation in this class" show that the visualization influenced the learners' note-taking behavior and their attitude toward listening to explanations.

The results for social presence suggest that the visualization function enabled learners to feel a sense of humanity and be sociable without needing to talk to each other. Thus, they could enjoy others' presence in the class.

Overall, these results suggest that the use of the NoTAS visualization function can influence note-taking and learning, and enable learners who have never met each other, to feel a sense of trust. The visualization of others' note-taking via NoTAS increased the learners' sense of community and social presence, and promoted learner interaction. The visualization function of NoTAS facilitated Co-RL among learners, as they had their attention directed toward the teacher's explanations noted by other learners, which also influenced their note-taking. However, a floor effect was observed for many of the items in the no-visualization group, implying that it is difficult to promote a sense of community and Co-RL simply by conducting face-to-face classes, even if the learners are physically close to each other.

Does Visualizing Others' Learning Contribute to the Use of In-Class Learning Strategies?

The results of the correlation analysis between the Nudge Scale and the three SCCI items with assistance from others suggest that the visualization of others' learning situations can have different effects on learning strategies, depending on the type of visualization involved (i.e., notes, important elements, and unclear elements).

Visualizing important elements encouraged learners to listen to the teacher's explanations and directly facilitated note-taking, such as writing notes and highlighting content. This may have occurred because important elements are often highlighted in the text, so it is not burdensome for learners to highlight them independently.

Visualizing notes encouraged learners to listen to the teacher's explanations. As Muelle and Öppenheimer (2016) point out, in contrast to verbatim writing, summarizing an explanation is a complex process that involves understanding the explanation and writing the necessary information in one's own words. Since NoTAS does not display the specific contents of notes in its visualization, learners who could not write notes apparently did not know what to write. Therefore, the visualization of others' notes may indirectly influence note-taking by, for example, encouraging students to pay attention to the teacher's explanations.

The visualization of unclear elements encouraged learners to listen to the teacher's explanations. NoTAS highlights class material elements that learners do not understand. This feature allowed learners to check whether they understood the material as they listened to the teacher's explanations. Therefore, the visualization of unclear elements can indirectly encourage note-taking.

In summary, the visualization of important elements directly promoted the learners' note-taking, while the visualization of notes and unclear elements made them more willing to listen to the teacher's explanation. Therefore, we suggest that three visualization types — notes, important elements, and unclear elements — affect several learning strategies in the class, such as note-taking and paying attention.

Conclusion

This study evaluated whether the visualization of classmates' learning facilitated Co-RL and the use of learning strategies. We added a new feature to NoTAS that allowed participants to visualize and highlight class material elements they did not understand. We divided the participants into two groups, those with and those without the NoTAS visualization function, and then conducted a class.

The questionnaire results revealed that the visualization of others' learning increased the learners' sense of community and social presence. Therefore, we suggest that the visualization of others' learning promotes Co-RL. Furthermore, we suggest that certain visualization types affect different learning strategies. Nudges generated by the visualization of

important elements directly promoted note-taking, while nudges generated by the visualization of notes and unclear elements promoted the use of learning strategies, such as listening to the teacher's explanations.

This study has limitations that suggest avenues for future research. The study focused on the use of in-class learning strategies, especially during the performance phase of the self-regulation cycle. Future research could investigate the impact of NoTAS on the forethought and reflection phases and the application of NoTAS to the development of self-regulated learning skills.

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