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Development and Effectiveness of Digital Graphic Organizers

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LoiLooNote School's ability to develop students' logical presentation capabilities is well-known in schools. In order to strengthen the application's abilities, digital graphic organizers were built in to this application and their effectiveness and usefulness assessed by surveying the students in a class. The development of graphic organizers was found to be successful in enhancing the effectiveness of the application since most students felt that the new feature was extremely useful in producing ideass, sharing them with the others, and stimulating the students to think deeply about them.

Keywords: digital graphic organizers, idea sharing, logical thinking, LoiLoNote School

Introduction

Context of use of graphic organizers

Various graphic organizers are used in schools to promote the visualization of students' ideas. According to a well-known definition of graphic organizers, they are "two-dimensional visual knowledge representations, including flowcharts, timelines, and tables, that show relationships among concepts or processes by means of spatial position, connecting lines, and intersecting figures" (Alvermann, 1981). This definition focuses on how knowledge is represented. Darch and Eaves (1986) defines graphic organizers differently by focusing on cognitive processes as "visual designs designed to identify, construct, and conceptualize the content of text using arrows and some symbols under certain frames to facilitate learning."

The origin of graphic organizers can be traced back to the "advanced organizer," which is defined in Ausubel's meaningful learning. Advanced organizers "are introduced in advance of learning itself and are also presented at a higher level of abstraction, generality, and inclusiveness" (Ausubel, 1968). These organizers can be presented using text, pictorial images, moving images, or a mixture of these representations. Graphic organizers comprise a mixture of pictorial image and text. When graphic organizers are used as advance organizers, teachers construct the complete design of the former to represent subject matter. In other words, the shape and contents of the organizers are previously prepared and presented by teachers.

Graphic organizers can be used for purposes other than those of advanced organizers. Students can construct graphic organizers, in which case they are the expressions of students' understanding. Students organize their own ideas and thoughts in a pictorial form, for example, a concept map. The concept map was developed by Novak (Novak and Gowin, 1984) to enhance meaningful learning in the sciences stream. Subsequently, it was applied in other subjects. Research has proved the positive effects of concept mapping in facilitating meaningful learning and fostering different types of thinking, like creative thinking, to some extent (Coffey et al., 2002; Warrick, Nesbit and Adesope, 2006).

Now, we discuss the third usage of graphic organizers. Specific types of diagrams are provided to students to enable them to write down their thoughts and ideas. In this case, graphic organizers simultaneously facilitate and restrict a student's thinking. They indicate students what and how to think. On the other hand, such constraints enable students to concentrate on specific domains of ideas and exclude inappropriate ones.

In 1988, Hyerle developed the first systematic approach for teaching this usage. He called it Thinking Maps and presented eight visual patterns. Each pattern corresponds to a specific strategy of thinking. Long (Long and Carlson, 2011) revealed that Thinking Maps facilitated students' critical thinking and enhanced their understanding of study contents.

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Today, various types of diagrams other than Thinking Maps are frequently used in schools to visualize students' thoughts and ideas. Further, graphic organizers induce students to engage in cooperative learning (McTighe, 1992). The effectiveness of graphic organizers is particularly high when they are incorporated into teachers' instruction (Hall and Strangman, 2002).

A brochure prepared by Kurokami and Kojima (2012) for Japanese teachers introduces 20 types of graphic organizers and suggests numerous ways to prompt students to think and ideate. This encourages many teachers to conduct lessons using graphic organizers, and there are many reports on their effects in the classroom (Yoshioka, 2015; Michimura, Motohasi et al., 2016).

Needs of students' use of graphic organizers

Over the past three decades, from the perspective of educational objectives, educators have come to value thoughtful or active learning over rote-learning. During this period, the Japanese ministry of education revised the national standard of its curriculum twice. The main aspect of these revisions was an emphasis on thinking and the utilization of knowledge. Consequently, it became very important for students to think critically, creatively, and logically and to share, discuss, and present their ideas. It became necessary for students to arm themselves with efficient tools to carry out these cognitive activities. In this manner, the national curriculum incorporates the use of graphic organizers in learning. Therefore, today, we need efficient applications that are capable with graphic organizers.

Recording and conducting individual learning is another problem to be solved. As mentioned earlier, graphic organizers facilitate collaborative learning in groups. Each member of the group prepares their ideas on sticky notes using their individual graphic organizer, then includes them in a common group organizer, and explains each of their ideas. If multiple members come up with similar ideas, they are grouped or placed close together, enabling idea exchange and integration. After integration, it is difficult for students to keep their initial graphic organizers, because sticky notes were moved to the common graphic organizer. It is difficult for each student in a group to develop the shared idea in detail, since there is only one common graphic organizer for the group. Digital organizers may make it easier to maintain initial graphic organizers for each member and re-arrange the organizers to enable in-depth development of integrated ideas by each group member.

Digital graphic organizers and LoiLooNote School

Even from an early period, graphic organizers have taken the digital form. In 1988, Inspiration software, Inc., released a sophisticated application named Inspiration for visual brainstorming. This application was specialized to create bubble map and concept map after Tony Buzan himself supervised the development of an application named iMindMap to draw Mind Maps. Numerous types of applications are available to generate, construct, and share graphic organizers. However, most of them focus on specific patterns of thinking and combine them to specific types of graphic organizers. In real-world classrooms, students use multiple graphic organizers depending on how to think. Therefore, there is a growing need for more flexible software that can switch graphic organizers.

LoiLooNote School is an educational application for slate computers that enables its users to make digital cards containing various types of information. Each card can include text, photographs, raster graphics, recorded sounds, videos, and websites including maps. Students can present their ideas as a linear flow of cards by linking them with yellow arrows, which can then be shared with their teachers and peers. To link cards in this manner, students must organize their cards in a logical order. The ability of graphic organizers to help students organize their ideas in this manner is well studied (Kimura et al., 2017). Therefore, LoiLoNote School has attained many awards, including the Poster Session Award in EdMedia 2013. Once graphic organizer functions are embedded, students can not only use multiple graphic organizers on LoiLoNote School but also connect various graphic organizers with the presentation function.

Methods

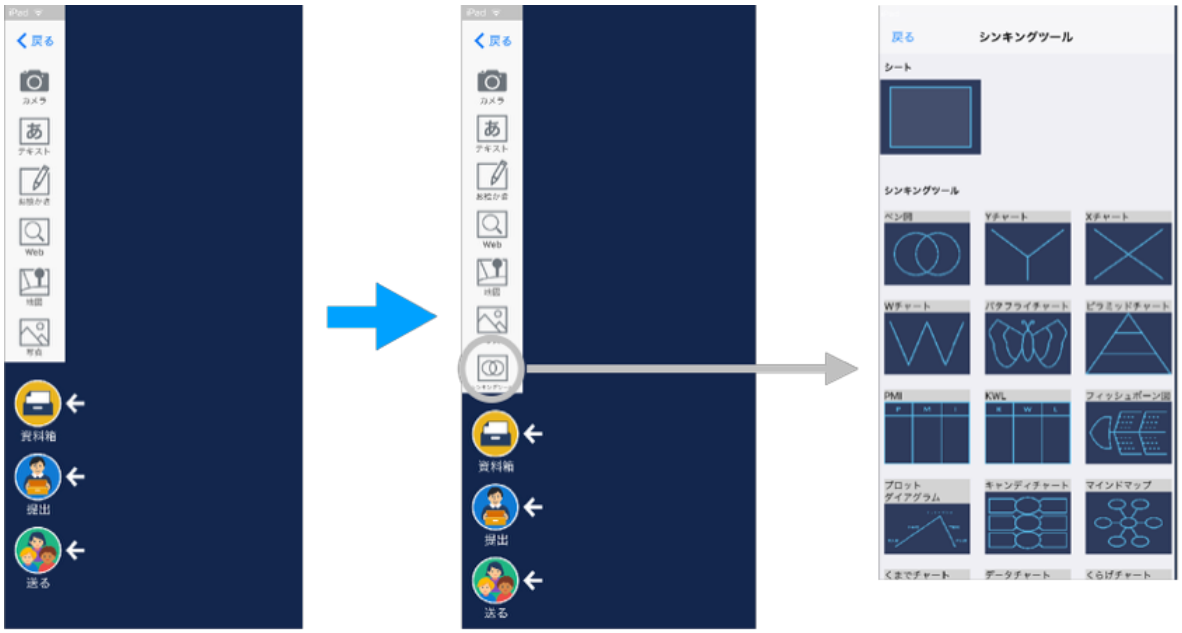
Overview of the development of graphic organizers

In this study, new functions to deal with graphic organizers were developed and embedded in the application LoiLoNote School to realize its flexible use and encourage active learning. The functions developed by this study are as follows:

Graphic organizers: Various types of graphic organizers can be opened from the launcher (Fig. 1), and any type of information card can be moved from the desktop to the launched organizer (Fig. 2a). Further, information cards can

be created using the launcher above the organizer (Fig. 2b).

Connecting ideas: Individual cards can be connected by arrows, similar to how they could be before (Fig. 3).
Sharing: The ability to send graphic organizers with information cards to other students was retained.



Old launcher New launcher Launched graphic organizers

Figure 1. Newly developed launcher and launched graphic organizers

a b

Figure 2. Allocation of information cards on the graphic organizer

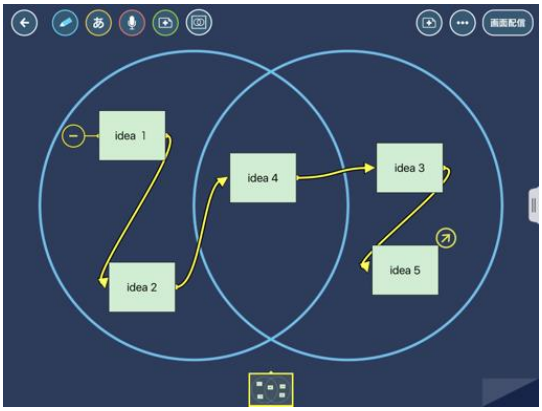
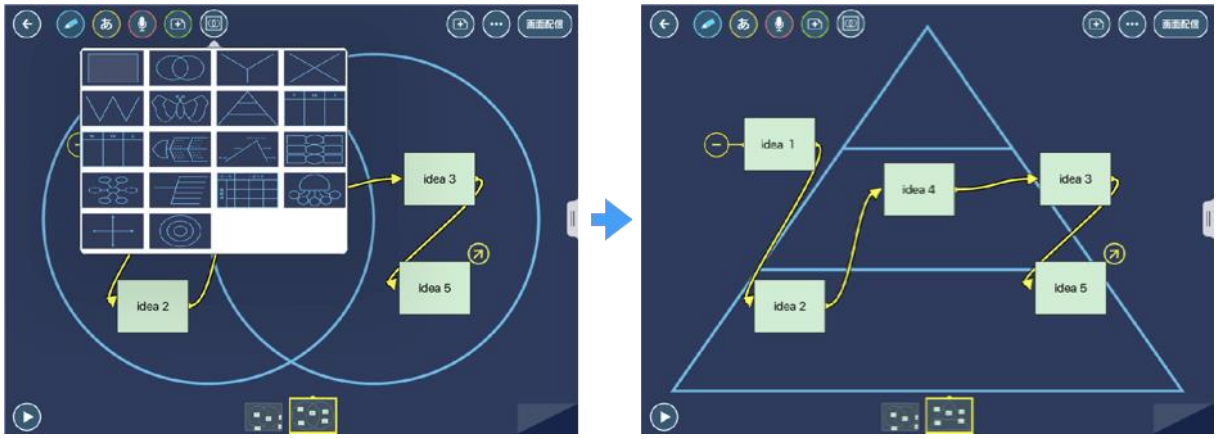


Figure 3. Connecting ideas



F

Figure 4. Changing graphic organizers

Submission: Teachers can set a specific graphic organizer with information cards for a specific student task and deliver to all students. The students will submit the organizers after completing the task. The submitted organizers are listed on the teacher's desktop, and they can be enlarged to be presented before the class.

Editing: Students can switch between different types of graphic organizers while retaining the information cards, which can be rearranged to suit any new format (Fig. 4). For example, students can first use one type of graphic organizers to generate ideas and subsequently use another one to structure their thoughts.

Implementation

In December 2016, a prototype of the application on an iPad was introduced to a fifth-year class of an elementary school. The class teacher allowed students to use LoiLoNote School in most subjects, and every student had his or her own iPad. In the classroom, students always conducted active discussions in groups of three. The standard procedure of the lesson conducted in 2016 is as follows:

Presenting lesson objectives and essential questions, and introducing the graphic organizer for the lesson (by the teacher)
Creating rubrics (by students)
Producing ideas individually on a graphic organizer (by students)
Discussion in groups by showing graphic organizers to each other and rearranging ideas (by students)
Uploading each person's graphic organizer to the cloud space (by students)
Presenting and discussing in the classroom
Switching a graphic organizer to another one rearranging ideas on it, if necessary (by teachers)
Discussing in groups, and rearranging ideas (by students)
Connecting a graphic organizer to previously made organizers (by students)
Uploading graphic organizers to the cloud space (by students)

The school had another class of the same grade, which did not frequently use LoiLoNote School. At the beginning of the new school year in 2017, half of the students from each of the two classes were combined to form a new class. During new school year, the teacher continued aforementioned teaching procedure. Hence, half of the students in the new class had significant experience in using digital graphic organizers (group 1, n=17), whereas the other half had insufficient experience of approximately three months (group 2, n=16) at the time of our survey.

Purpose and methodology of the study

This study examined the following research questions:

1. How do the students feel about the ability of LoiLoNote School in stimulating thinking and collaboration? Are there significant differences between students with longer and shorter experience in using the new functions of LoiLoNote School?
2. How do the students estimate the original functions of LoiLoNote School? Are there significant differences between students with longer and shorter experience in using LoiLoNote School?
3. How do the students estimate the newly developed graphic organizer functions of LoiLoNote School? Are there significant differences between students with longer and shorter experience in using the new functions of LoiLoNote School?

In late June 2017, a questionnaire-based survey was conducted among students. The questionnaire had 19 items based on a five-point Likert scale and 1 field where students could freely comment on the application. To compile the items, a 30-min interview was conducted on the teacher who was in the charge of the class. The interview examined the teacher's expectations regarding the students' activities in his lessons using LoiLoNote School. The results of the interview; comprising category 1 for research question 1, questions about original functions of LoiLoNote School; comprising category 2 for research question 2, and questions related to the purpose of each developed function as graphic organizer; comprising category 3 for research question 3, formed the question items.

Since any pretest was conducted on both the student groups, there was no possibility of pursuing the change in each student regarding the use of digital graphic organizers. The difference of duration in using the organizers was mostly used to reveal the usability of the functions.

Results

Table 1 shows the statistical values for each questionnaire item. In general, the values are very high for both groups of students. Items from Q1 to Q4 are based on the effectiveness of digital graphic organizers and all the students in group 1 with 6-month experience found them to be very effective in intensifying and sharing their thoughts. They also found it very effective in understanding the ideas of others and thinking collaboratively. Most students in group 2 with 3-month experience also found digital organizers to be effective in the same areas. T-tests clarify that group 1 significantly estimated higher effectiveness of thinking in depth and sharing thoughts with digital graphic organizers than group 2. With respect to understanding the ideas of others and thinking collaboratively, the testing approached significant values (p=0.06). LoiLoNote School with graphic organizers had limited effect on the estimation of students regarding thinking and collaboration.

Table 1

Results of the questionnaire-based survey

	Group 1 with 6M *M (SD)* n=17	Group 2 with 3M *M (SD)* n=16	*t (df)*	*p*
Item category 1: With digital graphic organizers,				
1. I can deepen my thinking.	5.0 (0.000)	4.7 (0.464)	-2.40 (31)	.01**
2. It is easy to share my ideas with ~~the~~ others.	5.0 (0.000)	4.5 (0.612)	-2.99 (31)	.00**
3. It is easy to understand others' ideas.	5.0 (0.000)	4.8 (0.390)	-1.56 (31)	.06
4. We can think collaboratively.	5.0 (0.000)	4.8 (0.390)	-1.56 (31)	.06
Item category 2: How useful do you feel each function of the information card is?				
5. Ideas can be written on information cards.	4.9 (0.322)	4.9 (0.242)	0.24 (31)	.60
6. Websites can be screen-captured onto information cards.	4.7 (0.456)	4.5 (0.612)	-0.55 (31)	.29

7. Digital maps can be screen-captured onto information cards.	4.4 (0.904)	4.2 (1.014)	0.35 (31)	.63
8. Photos can be taken and put on information cards.	5.0 (0.000)	4.8 (0.527)	-0.99 (31)	.16
9. Movies can be taken and put on information cards.	5.0 (0.000)	4.6 (0.484)	-2.82 (31)	.00**
10. Comments can be written on information cards.	5.0 (0.000)	4.9 (0.331)	-1.09 (31)	.14
11. Sound can be embedded in information cards.	4.9 (0.235)	4.5 (1.061)	-1.22 (31)	.12
12. Information cards can be connected in a linear manner to make a presentation.	5.0 (0.000)	5.0 (0.000)	—	—
13. Information cards can be shared with others.	5.0 (0.000)	5.0 (0.000)	—	—
Item category 3: How useful do you feel each function related to the graphic organizer is?				
14. Information cards can be organized on graphic organizers.	5.0 (0.000)	5.0 (0.000)	—	—
15. The graphic organizer to be used can be selected.	5.0 (0.000)	5.0 (0.000)	—	—
16. Comments can be written directly on graphic organizers.	5.0 (0.000)	4.9 (0.242)	-0.50 (31)	.31
17. Graphic organizers can be changed to other ones, keeping initial information cards intact.	5.0 (0.000)	4.9 (0.464)	-1.09 (31)	.14
18. Graphic organizers can be connected in a linear manner to make a presentation.	5.0 (0.000)	4.8 (0.559)	-1.41 (31)	.08
19. Graphic organizers can be shared with others.	5.0 (0.000)	4.9 (0.242)	-0.50 (31)	.31

Notes: 6M, 6-month experience; 3M, 3-month experience; M, mean; SD, standard deviation; *p<.05; **p<.01.

On the other hand, the testing showed no- significant differences in most of the other items in category 2. The only item with significant difference was Q9. This is aboutpertains to taking a movie and putting it on information cards.

Besides t-test, the means of Q6 and Q7 were found to be slightly lower than the other items in both groups. Q6 and Q7 pertain to capturing websites and digital maps, respectively, on to information cards.

Regarding category 3, significant differences were not found in testing, that is, even students with only three 3-months experiencers estimated the positive effects of digital graphic organizers.

Discussion

According to the responses to items in category 1, most students feel that digital graphic organizers effectively enhance their thought process. Further, they rate the usefulness of each function within the graphic organizers highly. On comparing group 1 with 6-month experience and group 2 with 3-month experience, small differences are found. To some extent, a longer experience with digital graphic organizers seems to have positive effects on thinking and sharing of ideas.

Category 2 pertains to information cards, that is, the original functions of LoiLoNote School. No significant differences were found in items, except Q9. In other words, the functions of information cards are useful in learning and are easy to understand.

Six students in group 2 rate Q9 as 4, whereas the others rate it as 5. According to a dialogue with the teacher following the survey, the class comprising group 2 did not have sufficient experience in taking and viewing movies with an iPad in the previous year. Hence, students in group 2 might not become familiar with using movies in their learning.

Q6 and Q7 aim to examine the effectiveness of the functions in gathering information. Websites and digital maps seem to be very useful in inquiry-based learning, and most students rate the functions highly. However, a few estimate its effectiveness to be lower than that of other functions. One reason for this could be the focus of their learning activities, which was to present their ideas logically. They might consider it more important to produce and share ideas, rather than gathering information. According to the teacher, the students did not have much opportunities to use digital maps either this year or in the previous year. They generally write their information on information cards even when they obtain it from websites.

No significant difference was found in any of the items in category 3, and their mean scores are very high. The newly developed functions promote thinking using graphic organizers. As mentioned in the Introduction section, the

learning activities of lessons are efficiently planned to optimize digital graphic organizers. Activities like organizing information cards, switching graphic organizers, and connecting the organizers are strongly related to how to think.

It was clear from observing students that the focus of their activities while using digital graphic organizers is on producing, sharing, and structuring ideas. Students used a broad area of the desktop to scatter multiple graphic organizers (Fig. 5) to steadily deepen thought processes beyond their lessons. They remember the position of every information card clearly and connect the cards to other cards on different organizers or to other graphic organizers themselves. They even link multiple graphic organizers. This never happens but for digital graphic organizers. In these activities, students may notice the usefulness of graphic organizers in aiding their thinking processes.

Figure 5. Desktop of a student

In addition, free comments reveal how the students view the functions.

> It will be difficult to organize the ideas that one comes up with without the application. In the complete process of making a speech, thinking about what to say and arranging one's thoughts are very important processes. Digital graphic organizers support these processes.
> If I do not have a pyramid chart in the application, I should have a problem in thinking about and creating a persuasive presentation.
> If I do not have the application, I will not be able to transfer my ideas from the pyramid chart to the concentric circle chart.
> My level of understanding will be lower without this app, because I will not be able to clearly understand another person's idea. It will also be difficult to share my ideas with others.
> It will be time-consuming to do something similar with a pencil and notebook.
> If it were not for the application, it would take much more time to copy cards, move them to other graphic organizers, and build a structure.

Students mentioned the general processes of making speeches, creating logical presentations, sharing ideas, and time to perform these cognitive processes. They understand their own cognitive processes with the help of digital graphic organizers, as well as how to use them. They also positively estimated the usefulness of the organizers. In fact, no student mentioned any negative point regarding the organizers.

Digital graphic organizers were developed with the aim of fostering students' abilities in organizing ideas logically and thinking creatively and collaboratively. The teacher clearly understood the aim and helped the students use the application in line with this aim. The questionnaires and free comments indicated that students understood the effectiveness and usefulness of digital graphic organizers in aiding their thought processes. They recognized the necessity of the application in organizing and connecting ideas to make presentations and understand each other. The survey results indicate that the development of digital graphic organizers was successful and the application can be adopted by Japanese schools to enable students to think deeply and utilize their knowledge effectively.

Compared to other digital graphic organizers like Inspiration, LoiLoNote School has no function to generate linear text and search words on information cards. These functions can be targets of future development.

One limitation of this study was that we could not use the responses of the students to the questionnaire to generate a normal distribution, For some items, all the students responded with full points. In such cases, the testing has no meaning. In other items, the responses were highly biased. Therefore, to ensure better testing, the questionnaire should be revised to produce a normal distribution.

Another study limitation pertained to the survey itself. It was nearly impossible to distinguish the effectiveness of each graphic organizer from the survey. Students use all organizers in turn, and it is very difficult to assess each student's organizer. Further, they always share their thoughts and ideas within their groups and in the classroom. By comparing the initial graphic organizer with the rearranged one, we can clarify the differences between the organizers. However, even this case, it is difficult to understand the thought process of each student, since both individual and integrated thoughts exist in groups on the rearranged organizers. Using digital graphic organizers, it is possible to understand the importance of collaboration.

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