Asia-pacific Journal of Education Management Research
Vol.2, No.1 (2017), pp.43-48
http://dx.doi.org/10.21742/ajemr.2017.2.1.08

Students' Eye Movement by Formal Arrangement of Algorithms

Hye-min Kim[1] and Kwangho Lee[2]
[1]Graduate School of Korea National University of Education, Cheongju, South Korea
[2]Korea National University of Education, Cheongju, South Korea
[1]paransol@knue.ac.kr , [2]attopia@gmail.com

Abstract

In order to investigate the students' understanding of the difference between the number model illustrations and the expressions of the formative arrangement, eye movement was monitored using an eye tracker with second grade elementary school students. Students gazed both the illustrations and expressions much more when the arrangement of the illustrations and expressions was vertical, rather than horizontal. The vertical layout of illustrations and expressions helps the students' understanding of computational algorithms.

Keywords: *Understanding algorithms, Formal arrangement, Eye tracking, Eye movements*

1. Introduction

Otte (2001) argued that the interaction between iconic and indexical representations is the most important aspect for understanding mathematical cognition, and Mayer (2001) argued that it is possible to improve student understanding by having various types of media related to the same content. According to them, various mathematical expressions of mathematical concepts and principles enrich the knowledge structure of students, and the interaction of various expressions related to one piece of content can enhance student's understanding. However, the research so far mainly focuses on literature studies analyzed from the aspect of content, and no empirical studies were done on formal aspects (Byun, 2011). Eye trackers have been widely used in empirical research because Eye tracking data can give important clues to understanding a learner's cognitive activities (Glenstrup and Engell-Nielsen, 1995). In this study, we tried to find the differences of students' eye movements according to the formal arrangement of number model illustrations and mathematical algorithms using the eye tracker.

2. The theoretical background

Chung (2007) has shown that when different information is presented in close proximity, it has a positive effect on attention distribution and also helps improve the students' academic achievement. In addition, Lee and Kalyuga (2011) demonstrate that vertical placement of information rather than horizontal form has a positive effect on student achievement by eliminating distractions to the learners' attention when learning different languages. In this study, we focus on the arrangement of information.

In addition, the more meaningfully integrated links are between different pieces of information, the more clearly students can understand the content and the more effectively it

Article history:
Received (January 10, 2017), Review Result (March 11, 2017), Accepted (April 30, 2017)

Print ISSN: 2207-5380, eISSN: 2207-290X AJEMR
Copyright © 2017 Global Vision Press (GV Press)

is grasped (Mason et al., 2012; Mayer, 2010). It is possible to identify and understand the integrated connection through eye-tracking rather than the existing approach. This helps to understand the perception processing of students by objectively gathering eye movements during learning (Mayer, 2010). Therefore, we analyzed eye tracking data to achieve the aims of the study.

3. The method and procedure of research

3.1. Participants

The participants were originally 18 second grade students (9 males, 9 females) in Sejong City, Korea. They were divided into two groups according to their class, gender, and achievement level. The data sample acquisition rate of this study was set at 75% and above considering both the age of the participants and the tasks. Therefore the final number of participants was cut down to 15 (7 of A group, 8 of B group). The average value of the data sample acquisition rate was 86.3%.

3.2. Experimental tasks and procedure

Vertical layout' is a formal arrangement in which illustrations and expressions are placed on the top and bottom in a step-by-step manner, and 'Horizontal layout' refers to the placement on the left and right sides. Vertical and Horizontal layout are the same except that only the formal arrangement of the illustration and the expression is different. Three tasks each of both the addition and subtraction of two digits, the same level as the textbook, were developed. The students in two groups experimented with different tasks respectively.

A B

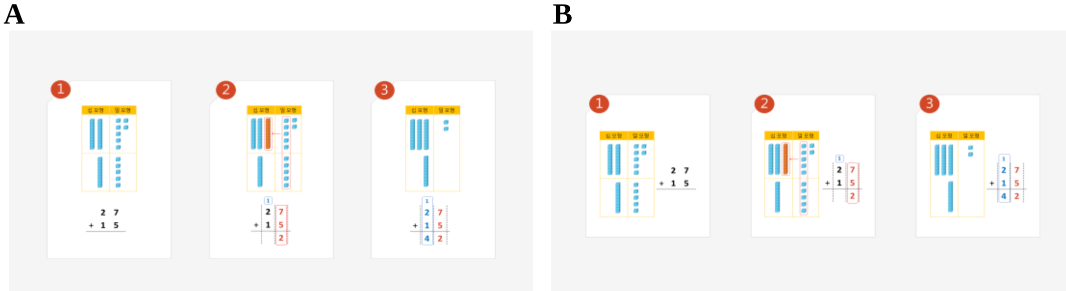

Figure 1. Examples vertical layout (A) and horizontal layout (B) tasks

Experiments were performed in the order of calibration, validation, and task performance. The task presentation changed the order by date and did not limit the time for task viewing. This was to ensure that they could work carefully and at their own pace.

3.3. Data acquisition and analysis

The eye-tracker used in the experiment was the Tobii X2-60, and the collected eye movement data was analyzed using the Tobii Studio 3.3.1. The fixation filter was set to 1 degree (maximum dispersion value) and 100ms (minimum fixation duration). Lai and Tsai, et al. (2013) summarized the various measurements used in eye tracking studies, and the researchers used the same measurements as in Table 1. The AOI and AOI groups were set for each task as shown in [Figure 2].

Table 1. Measurements for analyzing eye movement data

Analysis	Measures	Definition
Fixation	Gaze Duration(GD)	Total fixation duration within a word or an AOI
	Total Fixation Count(TFC)	Total number of fixations counted in an AOI
Fixation Transactions	Inter-scanning Count(IC)	Number of fixation transactions between AOIs

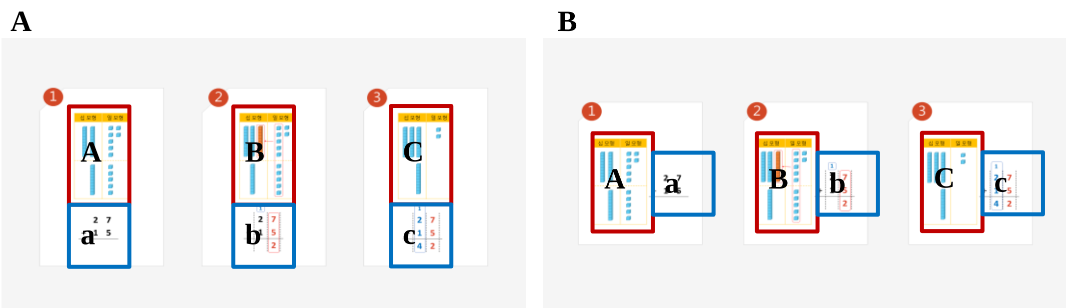

Figure 2. AOI group setting for (A) vertical and (B) horizontal layout: A,B,C= illustration, a,b,c= expressions.

4. Results

4.1. Comparison of TFC and GD

The Heat map provides visual information of the degree of attention paid to the illustrations and expressions as shown in Figure 3, and the results of quantitative data obtained through AOI grouping are shown in [Table 2]. The difference of TFC and GD between illustrations and expressions in the vertical layouts was not statistically significant at p> 0.1 level, but the difference of TFC (p = .045) and GD (p = .061) in the horizontal layout was significant at p> 0.1 level. Thus, the vertical layouts allows students to focus attention on both illustrations and expressions, while the horizontal layout shows that students have focused more attention on expressions rather than illustrations.

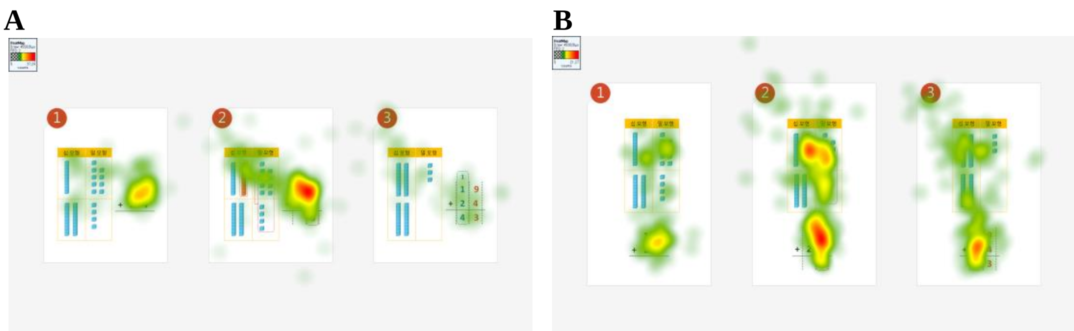

Figure 3. Heat map of (A) vertical and (B) horizontal layout (type: Count)

Copyright © 2017 Global Vision Press (GV Press)

Table 2. Total fixation count and gaze duration per layout

	TFC(count)			GD(sec)		
	Illustration	expression	t(p)	Illustration	expression	t(p)
Vertical (N=7)	224	184	0.975 (.367)	51.5	31.5	1.408 (.209)
Horizontal (N=8)	105	257	-2.439 (.045)	30.4	84.7	-2.231 (.061)

4.2. Comparison of IC

The IC between the illustrations and the expressions can be visually compared as shown in [Figure 4]. [Table 3] compares the average IC per task in each operation, and the difference between the two layouts in the mean value of addition and subtraction was significant at $p < 0.1$ level ($p = 0.092$). Therefore, students are more likely to switch between the illustration and the expression in the vertical layout than the horizontal layout. According to Mayer (2010), this means that there are more integrated connections.

A B

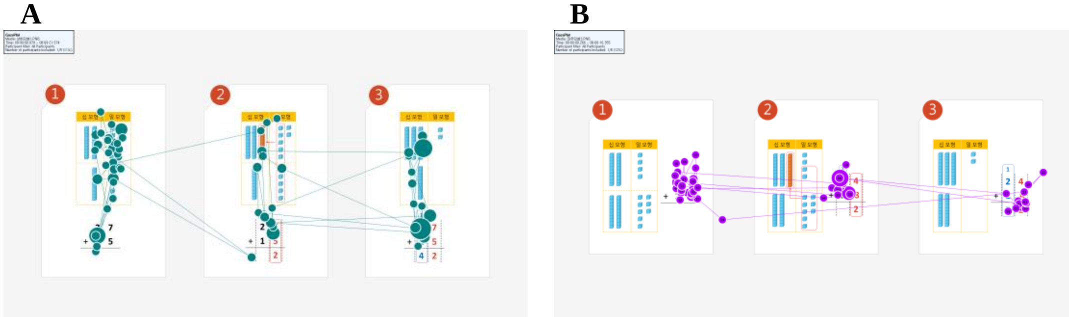

Figure 4. Gaze Plot of vertical and horizontal layouts.

Table 3. Inter-scanning Count comparison between illustration and expression

	addition	subtraction	mean
Vertical (N=7)	9.8	9.7	9.7
Horizontal (N=8)	4.5	5.2	4.9
t(p)	1.840 (.089)	1.625 (.128)	1.819 (.092)

5. Conclusion

Firstly, the vertical layout is appropriate for students to understand the algorithms presented in the textbooks. In this experiment, students tended to fix their gaze on the expressions and check the illustration occasionally in the case of the horizontal layout. But in the case of the vertical layout, they tended to concentrate on both the illustration and the expressions. This concurs with Lee and Kalyuga's (2011) study into the effect using a vertical format has on a students' attention. We can see that presenting information using a vertical layout has a positive effect, not only in learning a language but also in mathematics.

Secondly, the vertical layout of the number model illustration and expressions helped students understand the relationship between the two. In this experiment, students were more likely to shift their gaze between illustration and expressions in a vertical layout, rather than in a horizontal layout. As shown in previous research (Mason et al., 2012; Mayer, 2010), students tend to understand illustrations and expressions in a more integrated way.

After all, the vertical layout of illustrations and expressions can be said to be more advantageous for a students' understanding of computational algorithms. This results may provide implications for not only mathematics classrooms based on understanding of students' cognitive processes but also the development of student-centered textbooks.

References

[1] H. H. Byun. "A comparative analysis on the distributive property in korean and japanese elementary textbooks," Journal of Elementary Mathematics education in Korea, vol.15, no.1, pp.39-56, **(2011)**

[2] K. K. Chung, "Presentation factors in the learning of Chinese characters: The order and position of Hanyu pinyin and English translations," Educational Psychology, vol.27, pp.1-20, **(2007)**

[3] A. J. Glenstrup and T. Engell-Nielsen, "Eye controlled media: present and future state," University of Copenhagen

[4] M. L. Lai, M. J. Tsai, F. Y. Yang, C. Y. Hsu, T. C. Liu, S. W. Y. Lee, M. H. Lee, G. L. Chiou, J. C. Lian, and C. C. Tsai, "A review of using eye-tracking technology in exploring learning from 2000 to 2012. Educational Research Review," vol.10, pp.90-115, **(2013)**

[5] C. H. Lee and S. Kalyuga. "Effectiveness of on-screen pinyin in learning Chinese: An expertise reversal for multimedia redundancy effect," Computers in Human Behavior, vol.27, pp.11-15 **(2011)**

[6] L. Mason, M. C. Tornatora, and P. Pluchino, "Do fourth graders integrate text and picture in processing and learning from an illustrated science text?" Evidence from eye-movement patterns, Computersand Education, vol.60, pp.95-109, **(2012)**

[7] R. E. Mayer, "Multimedia learning," Cambridge University Press, New York, **(2001)**

[8] R. E. Mayer, "Unique contributions of eye-tracking research to the study of learning with graphics," Learning and Instruction, vol.20, no.2, pp.167-171, **(2010)**

[9] M. Otte, "Mathematical epistemology from a semiotic point of view, Paper presented in the Discussion Group, Semiotics in Mathematics Education at the 25th Annual Meeting of the International Group for the Psychology of Mathematics Education," Utrecht: University of Utrecht, pp.12-17, **(2001)**

This page is empty by intention.