An Analysis Students’ Eye Movement during Reading Contents Related to the Earth System in the Science Textbook

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Abstract. The purpose of this study is to investigate the eye movement of students during reading contents related to the earth system part in their science textbook. Student, grade 6, 34 was selected by tests checking motivation system about science learning and patterns of behavior from among 301, was sorted according to motivation system about science learning. And their learning behavior pattern was analyzed. The results of this study show that students who are sensitive to SL-BIS(Behavioral Inhibition System about Science Learning) need more time to read the text than students who are sensitive to SL-BAS(Behavioral Activation System about Science Learning). Also, SL-BAS students spent more time to watching the illustration than SL-BIS students.

Keyword: eye movement, eye-tracker, eye-tracking, motivation system, science book

1 Introduction

Textbooks help define school subjects as students experience them. They represent school disciplines to students (Valverde et al., 2002). Comprehending expository texts, especially science texts, can be quite challenging for learners (Sinatra & Broughton, 2011). In the science textbooks, there are illustration 10 times more than concept explanations (Kwon & Cho, 2011). Successful comprehension of the learning material that is usually presented in science textbooks requires comprehension of verbal and graphical information (Mason et al., 2013). Carney & Levin (2002) suggest that pictures complement the text, serving as adjunct aids for reading and learning. From this point of view, this present study is focused on providing information about the learning pattern of students who read textbooks for teachers. Eye movements were analyzed to check learners’ cognitive process understanding and learning about the textbook contents consisting of the illustrations and texts. Especially for learning pattern according to characteristics of learners, we use a test based on the science learning motivation system developed by Lim(2010), based on motivation system of Gray(1987) as a tool for dividing learners. And then we examine understanding process for textbook contents depending on the motivation system of learners.
2 Method

Initially, 301 primary school students in grade 6 took a test of science learning motivation system and learning style, and 34 were chosen as the experimental. Among them, 19 students are sensitive toward behavioral inhibition system about science learning, 15 toward behavioral activation system about science learning. All participants read the same text selected after discussions with the experts of science education and eye movement trackers to ensure the validity (Fig. 1). Eye movements were recorded by eye-tracker and research materials were collected, such as the time required per students, Heat Map, Gaze Plot. Materials were used in T-tests through, statistical program so that we could confirm the differences between the two science learning motivation systems.

![Learning materials using in the study](image)

Fig. 1. Learning materials using in the study

3 Results and Discussion

3.1 Analysis of the concentration time about texts and illustrations in the textbook

We set up an Area of Interest in texts and illustrations of the textbook and analyze the time for concentration, it helps confirm the time and frequency of concentration about texts and illustrations according to motivation system of science learning. As a result, Total fixation duration comes to an average of 39.57 seconds in the SL-BIS group, and an average of 38.59 seconds in the SL-BAS group. It shows there is no significant different. According to the study of Cipielewski & Stanovich (1992), individual differences in reading in elementary school were significantly related to these indicators of print exposure. Hence both in the studies had similar reading abilities. In the fixation duration of the text, there is no meaningful difference between two groups. But in the fixation duration of the picture, there is meaningful difference, SL-BIS groups took 2.03 seconds on the average, SL-BAS groups took 6.59 seconds on the average (p<.05). This means both groups read the text more during whole learning time. These results correspond to the study of Rayner et al. (2001), that is, viewers tend to spend more time looking at text than at the picture part. The ratio of SL-BIS is higher than SL-BAS, that is concentration time on the text to total learning time. It confirms significant differences (p=.013, p<.05). It is interpreted that SL-BIS group read the text longer than SL-BAS group. The ratio of the picture is also significant.
differences (p=.013, p<.05). SL-BAS group pays more attention to the picture than SL-BIS group.

3.2 Attention subject and areas analysis

We compare and analyze the Cluster and Heat Map, kind of qualitative data so that we can affirm the subjects and areas of attention depending on science learning motivation system (Table 1). Heat Map analysis help to know the fixation count or fixation duration of participants in the fixation location with a color. The darker color, the longer fixed. In this study we examine participants’ eye fixation location which has 30 or more times of fixation count.

Table 1. Heat Map analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>SL-BIS</th>
<th>SL-BAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Map</td>
<td><img src="image1" alt="Heat Map SL-BIS" /></td>
<td><img src="image2" alt="Heat Map SL-BAS" /></td>
</tr>
<tr>
<td>30 or more times</td>
<td><img src="image3" alt="Heat Map SL-BIS" /></td>
<td><img src="image4" alt="Heat Map SL-BAS" /></td>
</tr>
</tbody>
</table>

In the analysis of heat map that shows each group have 30 or more times eye fixation, SL-BIS group has more eye fixation than SL-BAS group in the text part. But in the picture part, SL-BAS group has more locations and frequency per each location of eye fixation. It confirms that not only SL-BAS group concentrates better than SL-BIS group, but SL-BAS group watches various part of the illustrations. It suggests that when SL-BIS group does the cognitive activity, they prefer through the text rather than the picture. SL-BAS group has propensity to read the various part in the text generally, in addition, they also watch the various part in illustrations comparing with SL-BIS group. It means by spending more time on various illustrations they can recognize and deal with the various informations. In other words, SL-BAS group do the cognitive activity positively through the picture.

3.3 Integrated process analysis about text and picture

Data about Gaze Plots were gathered to analyze that the students read text and picture in the integrative way (Table 2). There are 3 persons (15.79%) in the SL-BIS group, and 9 persons (60%) in the SL-BAS group who have 10 or more times an eye fixation location into the picture. The picture is about the circulation of the water, there is a sequence according to the circulation in this picture. When the students look chasing after the circulation of the water, it means they understand correctly. 3 persons all in SL-BIS don’t look at the picture in order. In contrast 7 persons (77.78%) among 9, they look at it depending on the flow. During reading the text, the students who read part or all of it repeatedly are 9 (47.37%) in SL-BIS, 6 (30%) in SL-BAS. It is a little bit higher that the ratio of reading repeatedly in SL-BIS. SL-BAS group tends to read the text looking at the picture when it shows text and picture together, not just read
the text only. And they don’t tend to read it repeatedly. What read the text and the picture repeatedly is explained integrated reading of text and picture.

Table 2. Features of SL-BIS/BAS eye movement – the numbers of eye fixation location into the picture

<table>
<thead>
<tr>
<th>Fixation count</th>
<th>participation</th>
<th>SL-BIS</th>
<th>participation</th>
<th>SL-BAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 or more times</td>
<td>15</td>
<td>34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 Conclusion and Implication

In conclusion, based on this results and discussions following suggestions can be made: First, when students who are sensitive about SL-BIS learn the textbook, they spend most of their learning time reading the text and have lower attempt to understand the concept with using picture together. It is helpful for this group to present the proper procedure reading the text and picture in their class. Second, in the case of SL-BAS group, they read the text and watch the picture evenly during class. Besides they figure out the meaning of the picture and make attempt to combine text and picture positively. If teacher let them know how to divide their time for reading the text and watching the picture properly, it will useful for this students to learn efficiently.

Reference

7. Rayner, K., Rotello, C. M., Stewart, A. J., Keir, J., & Duffy, S. A.: Integrating text and