EXAMINING THE READING BEHAVIOURS AND PERFORMANCES OF SIXTH-GRADERS FOR READING INSTRUCTION: EVIDENCE FROM EYE MOVEMENTS

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Previous studies were lack of evidence to show “what” and “how” students read. In addition, they focused on discovering the reading phenomenon among the university students. Solutions were not suggested to help the students. Hence, the main purpose of this study was to employ eyetracking technology to examine the fluent reading behaviours and performances of sixth-graders. Students were expected to perform fluent reading. This study also compared how students with high and low reading abilities use different strategies to understand the texts. Seventy sixth-graders from participated in this study. The average age of all the participants was 11.54 years (SD.98). In this study, three narrative texts were designed purely in English but the keywords of the other three texts were translated into Chinese. All the materials were shown on Tobii X120 non-intrusive eyetracker with 120 Hz sample rate. It was a two-way mixed research: 2 (high vs low reading abilities) x 2 (English texts vs English Texts with translated Chinese texts).
2 x 2 analysis of variance (ANOVA) was computed to analyse the eye-movement indices. The findings of this study significantly indicated that students with high reading ability performed better in both texts but students with low ability were quite well-perform with the assistance of translated Chinese words. Based on the students’ eyetracking data, reading instruction was suggested to teachers to assist the students with low reading abilities.

1 Introduction

Anderson (2009) defined reading as a conscious process because readers apply different reading strategies to enhance and improve their reading performances. Researchers (e.g. Anderson, 1991; Bang & Zhao, 2007; Block, 1992; Brantmeier, 2005; Erler & Finkbeiner, 2007; Karbalaei, 2010) have identified that readers use different reading strategies to attend to various contexts of texts. Anderson (2005) as well as Erler and Finkbeiner (op. cit.) conceptualized reading strategies as conscious and intentional actions to accomplish the aims in reading processes. Karbalaei (op. cit.) further revealed that reading strategies are closely associated with between readers’ communication and the written texts in which this communication process helps readers to analyze the texts and finally readers can understand the text.

Anderson (1991) also claimed that readers with high reading ability have a wider strategy in reading that they can employ to complete their reading assignments. However, readers with low reading ability are unaware of the available reading strategies and therefore they repeatedly use the same reading strategies to complete their tasks. As a result, they are unable to understand the texts and construct meanings from them. Due to the poor reading strategies, they perform badly in the reading practices.

Little is known about “what” and “how” readers’ eyes move when reading a text. In addition, there is relatively little evidence about the relationship between eye movements and the English text as well as the English text with the translated Chinese words among primary students. Therefore, eye tracking is employed as a tool to investigate the students’ reading processes. Its suitability for disentangling different processes and stages of reading has also been proved. Raney, Campbell and Bovee (2014) encourage researchers to use eye tracking in their research in reading because it can (a) produce a consistent data for reading performances, (b) provide the ability to examine text processing globally and locally, which covers the words or phrases stage, the sentence stage and the entire text stage, and (c) analyze multiple variables of eye movements such as regressions, fixations, and saccades with the aim to provide a different perspectives in the reading process.

Due to the paucity of studies, this study aims at examining students’ reading processes with the use of eye-movement technology. Students are expected
to perform fluent reading (Grabe, 1991). The concept of fluent reading is employed to examine reading behaviours and performances of sixth-graders when comprehending different types of texts. This study also compares how students with high and low reading abilities use different strategies to understand the texts. Due to the scarce research which focuses on reading efficiency and effectiveness among primary schoolers, we designed the following research questions to specifically address reading effectiveness and efficiency:

- “Rapid” - How fast can the students read the comprehension texts?
- “Purposeful” - How do the students with different reading abilities comprehend the texts?
- “Comprehending” - What is the performance of students in the comprehension test?

2 Literature review

2.1 “What” and “How” the reading process of fluent readers

Grabe (op. cit.) postulated that fluent readers are expected to understand what and how they read. The content of what readers read from the text is important because they have to lift ideas from the passage for the comprehension questions. The process of how readers read the text provides an avenue to readers to understand the strategies used. Therefore, the fluent reading process involves language proficiency and prior knowledge. Readers with different language proficiencies employ either “top-down” or “bottom-up” strategies. Generally, fluent readers incline to “top-down” strategies or they switch between the strategies to look for the most suitable one to resolve reading tasks (Chang, 2005; Huang, 2012; Maarof & Yaacob, 2011; Yang, 2010).

Topic knowledge or prior knowledge also influences readers’ reading strategies. Readers with more prior knowledge are not confined by the reading structure but they are empowered with the flexibility to use the reading strategies. Therefore, they are different from the readers with less prior knowledge who are unskilled in employing cognitive and metacognitive reading strategies (Akyel & Ercetin, 2009; Salmeron, Kintsch & Canas, 2006). Hence, we can conclude that reading is “a process of making meaning from the text” (Woolley, 2011, p.15).

2.2 Eye-Movement reading patterns and characteristics of Chinese writing systems

Chinese characters are greatly different from English written words because the former is created based on their shapes and meanings (Wang, 1973). These characters are made of 20 different strokes (a line or a curve)
and 200 radicals (reminders) (Wang, 1973). Huang and Wang (1992) further claimed that associative compound characters (Huiyi) and self-explanatory characters (Zhishi) are frequently used in Chinese writing systems. Huiyi has independent meanings and it is construed based on a radical. Self-explanation takes meanings directly from the form. Wang, Perfetti and Liu (2003) revealed that these two types of characters are popular because skilled native readers can always guess the visual form-to-meaning easily based on the words’ radicals and strokes.

The Chinese characters have no boundaries between them in the system. As a result, understanding Chinese texts is a tedious process because it is dependent on the levels and genres of the texts. If the topic is unfamiliar to the readers, they may fail to digest the text well. Unlike the writing system for the English word, it has spaces in between and it gives students the opportunity to recognize the word by fixing at it (Rayner, 1998). Hence, reading strategies used to read the English and Chinese writing systems have to be different. Siok and Fletcher (2001) commented that students must first identify the meaning of the Chinese characters before they are able to recognize the meaning. In the Chinese reading study, students have the tendency to increase their processing period of time and long rereading times for Chinese words. Jian and Ko (2014) conducted a same study and their findings were in line with Siok and Fletcher’s (op. cit.) study. They implied that students with rereading time had experienced difficulties with the reading texts.

3 Research designs

3.1 Participants

Seventy (70) sixth-graders from a National Type Chinese school located in Malaysia participated in this study. The participants comprised Chinese, Malay and Indian students and they took part voluntarily in this research. The participants learned all the subjects in Chinese except for English and Malay languages. Table 1 showed the distributions of readers with different reading abilities. The average age of all the participants was 11.54 years (SD.98). Before the experiment, all the participants were required to sit for a reading screening test (Ko & Chan, 2006). It yielded a Cronbach’s coefficient of.83.
3.2 Reading materials

All the six comprehension passages were narrative texts and they were taken from Primary School Evaluation Test or Ujian Penilaian Menengah Rendah (UPSR). The narrative texts were chosen as the suitable materials for sixth-graders because they could open up students’ imaginations through the storyline (Block & Pressley, 2002). Besides, participants could understand the storyline easily because the writers used simple vocabulary associated with the characters in the story and the strong coherence between the storyline (Chun, 2009; Soalt, 2005).

In this study, three narrative texts were designed purely in English but the keywords of the other three texts were translated into Chinese. The function of the translated Chinese words was to assist both groups of students to better understand the texts. Each text ranged from 100 – 120 words in length. A professor from the Chinese Studies Department was invited to ensure the Chinese words were accurately translated. We employed Latent Semantic Analysis (Landauer, 2006) and Chinese Latent Semantic Analysis (Chen, Wang & Ko, 2009) to further ensure the readability of the texts. Jian, Chen and Ko (2013) defined Latent Semantic Analysis as the objective method to analyse and confirm the readability of various texts.

3.3 Apparatus

This study was conducted using Tobii X120 with 120 Hz sample rate. The advantages of employing Tobii X 120 were because of its flexibility to allow for slight head movements, capability of tracking the eyes of the participants for a long period of time without making them exhausted and sensitivity to track and detect our eye movement from a word to a word or a word to a character. Six stimuli were designed to collect eye-movement data. The participants were required to sit at a distance of 40-60cms between the display screen and the participants. This seating position had resulted in a visual stimulus over 24 x 18 degree of visual angle. The participants did not have to scroll the page as the entire text was visible on the screen. The participants interacted with the
texts through a mouse.

3.4 Procedure

Before the experiment, all the participants were grouped for a thorough briefing. Two trial experiments were conducted to familiarise participants with the real experiment. The trials were almost similar to the real experiment. Participants were called individually to the experiment room. They were able to pace their reading time. Before taking the real experiment, participants had to undergo a standard 9-point calibration process. The participants took about 15-20 minutes to complete the experiment. After the experiment, an interview was conducted to assess their topic knowledge like (a) the participants’ prior knowledge on the reading topics, (b) their experience with the reading texts, and (c) the language for their daily communication and (d) the demographic data.

4 Results

It was a two-way mixed research: 2 (high vs low reading abilities) x 2 (English texts vs English Texts with translated Chinese texts). The independent indices were the eye-movement variables. We reported the reading comprehension test scores and the eye-movement indices in three ways. First, we used t-test to compare the reading comprehension test scores. To avoid prior knowledge which influenced the reading processes, performance and its comprehension, we conducted a check on their topic knowledge via interviews. The reports of the interview have confirmed that all the participants showed no prior knowledge on reading topics before the experiment. Second, we used Global analyses to measure “what” they readers read for the whole texts and the difficulties that they encountered (Shen et al., 2012). Third, we used Local analyses to measure “how” they read by examining the initial and late processing durations. It reflected the time course for the English texts and the English texts with the translated Chinese words. We employed temporal perspective to differentiate the process of reading from initial and late stages. Initial processing duration was inclusive of the (a) gaze times on a word before the eye move to another word (the total amount of time where participants spent on decoding the meaning of a word (Brusninghan & Folk, 2012; Jian & Ko, 2014) and (b) first fixation duration on an unfamiliar word (participants first fixated word). Late processing duration comprised the (a) rereading time (the total durations participants spent on all fixations), (b) total fixation time (the total durations participants spent on a word) and (c) probability to skip the translated Chinese word (participants’ tendency of ignoring words when reading the text).
4.1 Results for the Reading Comprehension Test

The percentage of the reading comprehension test was more than 85%, representing almost all the participants from both classes understood the two types of texts. Table 2 showed the six reading comprehension test scores. The reason for requesting all the participants to answer all the comprehension questions was to gauge their ability to understand the texts wholly. Therefore, the first five questions were lower-level comprehension questions which requested participants to give the answers based on the details in the texts. The last question was higher-level reading comprehension questions which requested participants to secure the main idea from the texts.

T-test analysis was employed to further compare the results of the reading comprehension among students with high and low reading abilities. The t-test indicated insignificant differences in the reading comprehension scores of students with high reading ability (M=3.15, SD=1.15) and low reading ability group (M=3.50, SD=1.10); t(70)=1.05, p=0.30 (>0.05). These results suggested that the readers from both reading ability had performed equally well in answering the questions. In addition, we might suggest that the participants with low reading ability were able to understand the text well because of the assistance of the translated Chinese words.

The last question showed different result patterns for participants with low reading ability. They failed to grasp the main idea from the texts because of the lack of vocabulary. Although the English texts with the translated Chinese words were shown to the participants, they were unable to understand the whole meaning of the sentence and this led to incomprehensible of paragraphs.

4.2 Global Measures

A 2 x 2 analysis of variance (ANOVA) was computed to analyse the eye-movement indices. In addition, it was used to determine if participants (t₁) and items (t₂) for all the indices showed significant differences. Table 3 showed participants’ global eye-movement analyses for the English texts and English
texts with translated Chinese words. Clearly, the result showed longer average total reading times for the English texts than for the English texts with translated Chinese words: \( t_1(70)=12.10, p < .001; \) \( t_2(80)=4.20, p = .002 \). Average fixation duration was longer than for the English texts than for the English texts with translated Chinese words: \( t_1(70)=10.50, p < .001; \) \( t_2(80)=3.52, p = .007 \). Average saccade length was shorter for the English texts compared with the English texts with translated Chinese words: \( t_1(70)= -8.00, p < .001; \) \( t_2(80)= -2.90, p = .060 \). Lastly, the number of regressive saccade was much greater for the English texts than for the English texts with translated Chinese words: \( t_1(70)=9.79, p < .001; \) \( t_2(80)=3.88, p = .005 \).

<table>
<thead>
<tr>
<th>Eye-movement Indicators</th>
<th>English Texts</th>
<th>Low Reading Ability (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Total Reading Time (s)</td>
<td>78.20 (30.08)</td>
<td>49.89 (15.07)</td>
</tr>
<tr>
<td>Average Fixation Duration (ms)</td>
<td>227.80 (20.09)</td>
<td>230.50 (19.80)</td>
</tr>
<tr>
<td>Average Saccade Length</td>
<td>4.66 (0.90)</td>
<td>4.97 (1.05)</td>
</tr>
<tr>
<td>Average Regressive Saccades</td>
<td>89.17 (37.87)</td>
<td>57.76 (25.70)</td>
</tr>
</tbody>
</table>

Table 3
GLOBAL EYE-MOVEMENT ANALYSES FOR READERS WHEN READING ENGLISH TEXTS AND TEXTS WITH TRANSLATED CHINESE WORDS

The results obviously indicated that the English texts were more difficult than the English texts with translated Chinese words for both groups of readers to process. In addition, participants spent about 30 seconds more total reading time on each English texts than each texts with translated Chinese words. It enabled the speculation of readers’ reliance on difficult words which might also enable the readers to further the readers’ understanding of the texts.

4.3 Local Measures to Compare Participants with High and Low Reading Abilities While Reading English Texts and English Texts with Translated Chinese Words

4.3.1 Initial Processing Duration

Table 4 indicated that participants showed slight longer first fixations for English texts compared to texts with translated Chinese words: \( t_1(70)=3.67, p < .001; \) \( t_2(80)=3.38, p < .001 \). Participants with low reading ability had longer gaze durations for both types of texts than participants with high reading ability: \( t_1(70)=4.35, p < .001; \) \( t_2(80)= 2.57, p = <.017 \).
Table 4

<table>
<thead>
<tr>
<th>Eye-movement Indicators</th>
<th>English Texts M (SD)</th>
<th>Texts with Translated Chinese Words M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Reading Ability</td>
<td>Low Reading Ability</td>
</tr>
<tr>
<td>First Fixation Duration</td>
<td>240.78 (31.84)</td>
<td>234.52 (31.75)</td>
</tr>
<tr>
<td>Gaze Durations</td>
<td>310.77 (69.20)</td>
<td>355.45 (74.20)</td>
</tr>
<tr>
<td>Rereading Time</td>
<td>348.76 (216.12)</td>
<td>624.25 (286.10)</td>
</tr>
<tr>
<td>Total Fixation Duration</td>
<td>612.34 (145.72)</td>
<td>937.43 (314.66)</td>
</tr>
<tr>
<td>Probability to Skip Translated Chinese Words</td>
<td>.</td>
<td>532.77 (85.40)</td>
</tr>
</tbody>
</table>

4.3.2 Late Processing Duration

Table 4 reflected that participants from the low reading ability group spent longer rereading times on English texts as well as the English texts with translated Chinese words compared to participants with high reading ability who read only English texts without the assistance of translated words: $t_{1}(70)=6.88$, $p=<.001$; $t_{2}(80)=4.98$, $p = <.001$. Participants with the low reading ability had longer total fixation duration for both types of texts than the participants with the high reading ability: $t_{1}(70)=8.10$, $p <.001$; $t_{2}(80)=4.35$, $p <.001$. Participants from the high reading ability group had higher probability to skip most of the translated Chinese words than participants from the low reading ability group who depended the translation of Chinese words: $t_{1}(70)=8.90$, $p = <.001$; $t_{2}(80)=4.78$, $p = <.001$.

5 Discussions

5.1 “Rapid” - How fast can the students read the comprehension texts?

Reading is closely associated with purposes and speed. Readers slow down the speed of their reading when they encountered unfamiliar words and contents. Anderson (2009) categorised fluent readers as those who could read at 200 wpm. Grabe (1991) asserted earlier that readers had to be given adequate time to process the text information before they made connections and inferences to comprehension. In this study, students spent longer reading time on the English and shorter saccade length when reading the English texts with transla-
ted Chinese words. This pattern suggests that students has increased their information processing time for unfamiliar English words but not for the translated Chinese words. In other words, students read and retrieved information much faster with the assistance of Chinese words. Students spent on average 15.07s to decode the English texts with Chinese translated words but students spent double time on average 30.08 to complete decoding the English texts. This reading speed cannot be grouped into Grabe’s fluent reader groups as he never specified the “adequate time” for processing the information (Kang, 2014).

Students exhibited shorter average fixation durations on the English texts with Chinese translated words (19.80s). Bisra (2010) and Liu (2014) revealed that fixation durations have direct relationship with the complexity of a task. Thus, students who spent longer average fixation durations on the English texts (20.09s) may be an indication to show that the language of the text was very complex for them and they had to expend higher level of mental cognition to process the text and the comprehension questions. This study required the students to complete two tasks: (a) understand the narrative texts and (b) answer the comprehension questions. In order to complete the two tasks, students who did not have sufficient vocabulary proficiency spent longer fixation duration on the English texts. This explanation conforms to the Juhasz and Rayner’s (2003); as well as William and Morries (2004) studies that students’ fixation durations are closely associated with their word recognition. Students with higher lexical ability can better communicate with the passage. Students were also familiar with the translated Chinese words in the passage as they might learn them during their Chinese lessons. Hence, the shorter fixation durations (19.80s) in this study conflicted with the previous studies (e.g. Shen et al., 2012; Jian & Ko, 2014).

Interestingly, participants spent shorter average saccade duration on English texts (0.90s) compared to English texts with translated Chinese words (1.05). This result con-currents with Rayner and his researchers’ (1996) study that English words have spaces for readers to fixate on them. As a result, participants might have no difficulty when reading and comprehending the English texts. However, participants might face difficulties when reading the translated Chinese words because they are character-based written and they do not have separated words. This finding regarding the eye-movement pattern, revealing that students in the primary school encountered hardship when attempting to integrate the translated Chinese words into meanings, extends the finding of Li et al. (2011; 2009), that students from Chinese education background depends on Chinese lexical knowledge because English words cannot be directly used in Chinese reading. Besides, the translated Chinese words might be low-frequency words to some of the students as they spent higher amount of saccade durations on the texts. This finding has conformed to Rayner et al. (2005) and Yan et al.’s
studies on Chinese words predictability and frequency. Both studies postulated that Chinese students prefer reading high-frequency words because they can understand the texts easier and better.

5.2 “Purposeful” - How do the students with different reading abilities comprehend the texts?

Regardless of students’ reading proficiency, they read for a purpose. As mentioned by Goodman (1967), we selected for relevant information in reading. The finding of this research not only supports this perspective but also extend to reading different types of printed texts by students. Participants were inclined to regressive reading skills for English text (37.87s) compared to English texts with Chinese translation (25.70s). They were expected to understand what they were reading; therefore they spent more time on English text. In addition, many participants in this study reflected that they understood the meanings of the vocabulary but they encountered difficult time to string the words for word- and sentence-level of text coherence (Bernhardt, 1993; Catts, Adlof & Weismer, 2006; Yuill & Oakhill, 1991). As a result, they repeated regressive reading skills for relevant information. This supports the arguments made by Cain et al. (2001), Cromer (1968) and Miller (1965) that the meanings of sentences are not made of the linear meanings of words which comprised them.

Surprisingly, participants with low reading ability had longer first fixation and gaze durations for both texts. We expected participants with low reading ability had faster reading speed as the vocabulary in the texts were not common to them. Good readers might have the perception that the words in the texts were common and easy for their recognitions. This finding has also indicated that all the participants with no background knowledge relied on the conventional words to help them made words and sentences inferences. Besides, they tried to understand the meaning of the English by referring to the Chinese translation in the texts but students with high reading ability used the information in the context to help their inference of the meaning of unknown word during text reading. Chaffin et al. (2001) and Garrod et al. (1990) admitted that this phenomenon of the finding was closely related to the elaborative inference from unfamiliar words. This argument corresponds with the last comprehension question which required participant to infer what they read. 99% of the participants with low reading ability obtained the lowest score.

Participants with low reading ability spent longer sum of fixation durations (314.66s) when reading the English texts. This finding explicitly explains that the participants could easily and meaningfully decode the meaning of the translated Chinese words at the initial stage compared to the English texts at the late stage. This finding is in line with the previous researchers (Chaffin et al., 2001;
Juhasz & Rayner, 2003; William & Morris, 2004) who used the eye tracking technology to investigate alphabetic word processing found that students with lower reading ability had the tendency to perform longer durations in total fixations, first fixation and gaze on novel words.

Significantly, participants with high reading ability tended to skip reading translated Chinese words (85.40s). They prefer reading the texts in English and some of them reversed reading the previous sentences as the translated Chinese words were sometimes the hindrances to the process of reading. We expected students with low reading ability to perform high probability to skip reading words as they were poor in complex text comprehension. The findings from Drieghe et al. (2004) and Rayner et al.’s (1996) might explain why the participants with high reading ability in this study tended to skip reading the translated Chinese words.

5.3 “Comprehending” - What is the performance of students in the comprehension test?

When we explored how students with different reading abilities comprehended the texts and answered the questions, we discovered that students with low reading ability tended to repeat their reading patterns to find the comprehension answers. The finding has proven that lexical knowledge is very important in reading comprehension. Students with low reading ability also scored significantly lower than students with high reading ability. They might also lack of knowledge availability and thus they had no adequate conditions for the inferencing process. This pattern is consistent with the findings of other researchers who investigated language abilities and reading comprehension (Catts et al., 2006; Hock et al., 2009; Lesaux & Kieffer, 2010; Nation et al., 2004). Besides, students with low reading ability were lack of comprehension ability due to the inability of integrating relevant information (Chaffin et al., 2001; Rayner, 1998; Williams & Moris, 2004). Kang (2014) highly recommended that “when the basic language proficiency is reached or the core vocabulary is mastered, it is the metacognitive reading skills that made one a fluent reader.” (p.6). Hence, Perfetti and Hart (2001) argued that students had to not only understand the meaning of the word and contextualise it (vocabulary breath) but also apply the use of the word in their daily communication (vocabulary depth). With the increment of vocabulary assistance, students can gain benefits from the reading process – learning more new words to be fluent readers (Grabe, 1991).

Conclusion

The findings of this study have shown implications to the teaching of re-
reading. Teachers should be aware of the students with different reading abilities. For students with high reading ability, teachers have to incorporate low-frequency vocabulary in their reading comprehension so that they could use higher thinking skills when answering the reading comprehension. For students with low reading ability, their vocabulary and syntactic knowledge should be reinforced. In addition, they should be given a text model as the sample to enhance their reading ability (Grabe, 2009).

In addition, teachers have to introduce students the text structures for reading passages (Grabe, 2003; Jiang & Grabe, 2007). Students who recognize the signal words and the text structures are able to identify the key ideas and relationship of the texts, and predict the subsequent contents. Besides, students invoke their schemata which assist them in the knowledge constructions.

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