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Analyzing Students' Eye Movements of their EFL Reading with Concept Mapping Strategy

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Abstract: The study aimed to investigate the effectiveness of applying concept mapping strategy by monitoring EFL students' eye movements during English reading process. The participants were divided into two groups: the one applied concept mapping strategy (N = 10), and the control group (N = 12). The experimental group received two reading materials with the aid of concept maps while the control group received the same reading materials without the aid of concept maps. Major findings included that participants in the experimental group spent less time significantly on the texts and the AOIs, and their fixation numbers on the AOIs were also less than the control group. It indicated that the concept mapping strategy could shorten learners' reading time and enhanced learners' reading effectiveness. The eye movement data provided concrete evidence to explain how concept mapping strategy could facilitate learners' reading of previous studies.

Keywords: concept mapping strategy; EFL reading ability; eye movements

Introduction

A concept map is a diagram showing the relationship among concepts (Liu, 2010; Guastello, 2000). It organizes the information and the concepts, usually formed with circles and boxes, and a connecting line linked two concepts together. Moreover, the link between the concepts can be on-way, two-way, or non-directional (Lanzing, 2004; Novak & Canas, 2008).
Concept mapping is a reading strategy which assists learners to conduct information about the reading content through visual aids. Previous studies also showed that concept mapping reading strategies had greater benefit for learners' reading comprehension (Cassata-Widera, 2008; Dyer, 1985; Liu, 2010; Stice & Alvarez, 1986). During the reading process, using concept mapping not only can help learners to organize information about the reading materials, but be easier to memorize (Chiu, 2004; Liu, Chen, & Chang, 2010) and summarize (Esiobu & Soyibo, 1995) the content which conveyed by concept mapping. Moreover, according to Liu's (2010) research, it was suggested that students were able to apply reading strategies such as "inferring", "enforcing", and "reviewing" while they used the concept mapping strategy. The listing strategy provided the organization ability for learners after they got the main point and understood the whole meaning of the context (Hidi an Andersin, 1986). For reviewing strategy, according to Liou & Chen(1999), they pointed out that learners could go back to content and try to recall the detail under the subtitle after they completed the reading. In addition to these reading strategies, Goodman (1989) also

mentioned that learners using inferring strategy could go thought the relevant paragraphs to confirm their inferences.

Although the previous studies showed that concept map is an important reading strategy via evaluating the learners' performance from paper-pencil tests (Chang, Sung&Chen, 2002; Dyer, 1985; Esiobu, & Soyibo, 1995; Stice & Alvarez, 1986), through questionnaire(Liu, Chen, & Chang, 2010)and observation(Cassata-Widera, 2008; Huang, 2005) However, there was no concrete evidence to explain the reasons why the learners got benefit from this strategy and how it change learners reading pattern.

Eye movements are part of the normal reading, this method allows readers read the reading without any interruption, and reader' reading pace and route could be monitored (Hyönä & Nurminen, 2006). Monitoring eye movements during reading can provide valuable information regarding reading comprehension processes (Rayner, Chace, Slattery, & Ashby, 2006). Base on the above reasons, this study recorded readers' eye movement pattern during their reading and aimed to provide the concrete evidence for explaining how concept maps affect learners' reading comprehension. The research questions were:

(1) What was the influence of the concept mapping strategy on learners' reading time in texts and AOIs?

(2) What was the influence of the concept mapping strategy on learners' fixation numbers in texts and AOIs?

1. Methods

1.1 Participants

The participants of this study were 22 Non-English majored students from one Universality in Taiwan. The participants have been studied English for over six years. In this research, 16 females were selected while 6 males participated in. The participants' English proficiency level was intermediate to high-intermediate. Moreover, the native language of all the participants is Chinese. All the participants attended this experiment voluntarily. Before the experiment, participants were divided into the experimental and the control groups. The participants in the experimental group (N=10) received two reading materials with the aid of concept maps, while control group (N=12) received the same reading materials without the aid of concept maps.

1.2 Apparatus

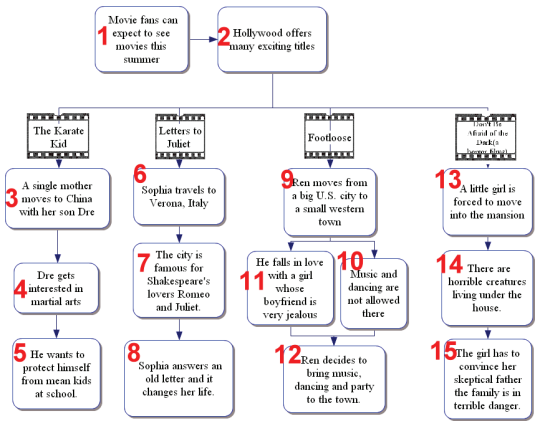
Eye movements/fixations were recorded during the solving of the word problems with the eye-tracker faceLAB4.5 which sampled the position of the participant's gaze every 16 ms (i.e., 60 Hz). The stimuli were presented by the software GazeTracker on a 19-in.Viewsonic (1280×1024 pixels) monitor. In addition, and the other (out of sight of the participant) for the experimenter to give feedback in real time about the participant's computed gaze position through the monitoring system overlay, which allows the experimenters to evaluate the system's accuracy and to initiate a recalibration if necessary. The stimuli were situated approximately 0.6 m from the subject. In order to avoid distracting the participant during experiments, a divider was set to reduce the empirical interference.

1.3 Materials

2.2.1 Reading articles: Two articles included in the high-intermediate proficiency level of an English magazine were selected as the reading materials in this research: *Some expecting movies* as Article 1 and *MBA programs in the US* as the Article 2. The first article talked about four upcoming movies in the summer, which are *The Karate Kid, Letters to Juliet, Footloose,* and *Don't Be Afraid of the Dark*. The difficulty levels of the articles were .32 (Article 1) and .54 (Article 2). Then the second article described an institution called MBA which can help students to have their further studies in the US. The basic vocabulary size required for the reader was 3000-5000 words. Moreover, the contents of these two articles are related to real life. In this case, participants do not necessary to have any pre-knowledge of any specific domain.

2.2.2 Concept map: the concept map is expert-constructed concept map which is developed by the instructor. This kind of concept mapping strategy provide leaners a guide to follow in a top- down approach to reading and finding the focus points in the text (Liu, 2010). The contexts of each box in concept map were associated with the knowledge in the articles.

In this research, two articles were included, and both of the articles were drawn AOIs. Area of interest (AOI), or called lookzone, usually refers to the area that the study is going to measure. In this study, the AOIs were drawn as the major concepts or focus points of the articles. The participants could find the focus point of the articles through these areas. In the first article, both the concept map and the text were drawn 15 AOIs while 11 AOIs were shown in article 2 (See *Figure 1*).



1 Movie fans know that Hollywood offers many exciting titles between May and August. Here's **2** some of what eager moviegoers can expect to see this summer. Kids will enjoy a remake of the 1984 film *The Karate Kid*. In the movie, **3** a single mother moves to China with her son Dre. Once there, **4** Dre gets interested in martial arts. **5** He wants to protect himself from mean kids at school. His teacher is a martial arts master, played by Jackie Chan. The drama *Letters to Juliet* follows **6** Sophia, a young American woman, as she travels to Verona, Italy. **7** The city is famous for Shakespeare's lovers Romeo and Juliet. **8** Sophia answers an old letter to Juliet seeking advice about love, and it changes her life. In *Footloose*, a family with a teenage son, **9** Ren, moves from a big U.S. city to a small western town, where **10** music and dancing are not allowed. This is a shock for Ren, and his difficulties increase when **11** he falls in love with a girl whose boyfriend is very jealous. **12** Ren decides to bring music and dancing back to the town, beginning with a party for students at the town's high school. If you like horror films, you won't want to miss *Don't Be Afraid of the Dark*. In this remake of a 1973 TV movie, **13** a little girl is forced to move into the mansion where her father and his new wife live. **14** The girl discovers that there are horrible creatures living under the house. Somehow **15** she has to convince her skeptical father that the family is in terrible danger.

Figure 1. AOIs and its correlation between concept map and text in Article 1: *Some expecting movies*

1.4 Procedure

The participants seated approximately 70 cm form the computer screen. Before the experiment, participants' eye movements were adjusted and calibrated by using a 9-point calibration grid that presented over the entire computer screen. The participants' eye movements were checked if this research is valid. After the adjustment, participants were asked to read two reading comprehension. Two articles were showed in the screen. The experimental group received two reading articles with the concept mapping strategy while control group read the two reading materials only. For the experimental group, the participants received the concept map of the article first, and then the next page was shown

both the concept map and the article. There is no time limitation during their reading. However, the participants usually took one hour to finish this experiment. After they read the articles with and without the aid of concept mapping strategy, they had to answer the following four reading comprehension tests for each article.

1.5 The eye tracking method

In the study, the eye-tracker was used to monitor the participants' eye movements through the EFL reading process. In this study, fixation points were identified by the number of 3 gaze points that fell within a certain dispersion, and were grouped within a radius of 40 pixels, and then gathered with a minimal duration of 200ms. Using Gazetracker the time and fixation data were exported to Microsoft Excel. The participants' fixation and total reading time were checked as a concrete evidence to see whether the concept map could assist their reading. In the reading materials, both the concept maps and texts were drawn AOIs. The AOIs were selected as the key knowledge or content in the articles. The AOIs between concept maps and texts were correlated. In this study, three eye movement data were corroborated: the total reading time were defined as (1) the spending time on the articles (2) and the time the participants spend on all the AOIs. In addition, (3) the fixation numbers that the participants fixated from the AOIs were illustrated as well. These variable data in two groups was compared to observe whether there is any significant difference between these two groups.

2. Result

2.1 Participants spent less time on the reading with the aid of concept maps

Several series of analyses were computed on the eye-movement data. The data investigated the amount of time that the participants spent on all the text, the total reading time in AOIs of two articles, time spent on the concept maps, and the fixation numbers in the AOIs and texts.

Table 1. *The Independent T-test and descriptive data of total reading time in texts*

Reading Material	Concept Map	*N*	*M*	*SD*	*t*	*df*	*p*
Article 1	with	10	106.75	99.89	2.73	20	.01*
	without	12	204.98	68.21			
Article 2	with	10	91.09	99.56	1.91	20	.07
	without	12	154.55	52.63			
Article1&2	with	10	197.85	196.52	2.41	20	.03*
	without	12	359.53	113.97			

Table 1 shows the number of the participants' mean and standard deviations of total reading time in Article 1 and 2. Independent T-test was conducted with concept mapping strategy and total reading time as the variables. The result showed the significant differences between the experimental group and control group ($p < .05$) in Article 1. It indicated the total reading time of experimental group of Article 1 ($M = 106.75$, SD = 99.89) was shorter than the control group in Article 1 ($M = 204.95$, SD = 68.21). Note that this result indicated participants reading with the aid of concept mapping strategies revealed shorter time on the Article 1. Then the data only shows little differences in Article 2. However, when took the articles together, the result showed the significant differences between the experimental

group and control group ($p < .05$). It indicated the total reading time of experimental group of two articles ($M = 197.85$, SD = 196.52) was shorter than the control group ($M = 359.53$, SD = 113.97).

Table 2. *The Independent T-test and descriptive data of total reading time in AOIs*

Reading Material	Concept Map	*N*	*M*	*SD*	*t*	*df*	*p*
Article 1	with	10	36.10	36.67	-2.68	20	.01*
	without	12	70.33	22.78			
Article 2	with	10	24.24	27.72	-2.17	20	.02*
	without	12	45.35	17.54			
Article1&2	with	10	60.34	63.25	2.53	20	.02*
	without	12	115.69	38.08			

Table 2 presents the number of the participants' mean and standard deviations of total reading time in AOIs. In this, independent T-test was conducted with concept mapping strategy and total reading time as the variables. The result showed the significant differences between the experimental group and control group ($p < .05$). It indicated the total reading time in AOIs of experimental group of Article 1 ($M = 36.10$, SD = 36.67) and Article 2 (M=24.24, SD=27.72) was shorter than the control group in both Article 1 ($M = 70.33$, SD = 22.78) and Article 2 ($M = 45.35$, SD = 17.54). In addition, when took the articles together, the result showed the significant differences between the experimental group and control group ($p < .05$). It indicated the total reading time in AOIs of experimental group of two articles ($M = 60.34$, SD = 63.25) was shorter than the control group ($M = 115.69$, SD = 38.08).

Figure 4 shows the mean of total reading time in AOIs of the texts from experimental group and control group, and it indicated the participants reading with concept mapping strategies spent less time on the texts.

Table 3. *The participants' means (and SD) of total reading time in concept maps*

Reading Material	Concept Map	*N*	*M*	*SD*
Article 1	with	10	19.54	14.70
Article 2	with	10	19.81	23.39
Article 1&2	with	10	39.35	34.34

Table 3 indicates the mean and standard deviations of total reading time in the concept maps. It showed that the participants in experimental group spent 19.54 second on the map in Article 1, and 19.81 second on the map in Article 2.

2.2 Participants had less fixation numbers on the AOIs with the aid of concept maps

Table 4. *The Independent T-test and descriptive data of fixation numbers in the texts*

Reading Material	Concept Map	*N*	*M*	*SD*	*t*	*df*	*p*
Article 1	with	10	201.00	203.93	2.58	20	.01*
	without	12	389.58	136.52			
Article 2	with	10	168.80	198.73	1.83	20	.08
	without	12	293.50	115.20			
Article1&2	with	10	369.80	396.65	2.28	20	.03*
	without	12	683.08	241.61			

Table 4 shows the number of the participants' mean and standard deviations of the fixation numbers in texts. Independent T-test was conducted with concept mapping strategy and the fixation numbers as the variables. The result showed the significant differences between the experimental group and control group ($p < .05$). It indicated the experimental group in Article 1 ($M = 201$, SD = 203.93) revealed less fixation numbers than the control group ($M = 389.58$, SD = 136.52) while it only showed little differences in Article 2. However, when took the articles together, the result showed the significant differences between the experimental group and control group ($p < .05$). It indicated the fixation numbers of experimental group in two articles ($M = 369.8$, SD = 396.65) was less than the control group ($M = 683.08$, SD = 241.61).

Table 5. *The Independent T-test and descriptive data of fixation numbers in AOIs*

Reading Material	Concept Map	*N*	*M*	*SD*	*t*	*df*	*p*
Article 1	with	10	113.90	119.45	2.53	20	.02*
	without	12	224.92	77.56			
Article 2	with	10	84.30	101.87	1.85	20	.07
	without	12	153.17	64.97			
Article1&2	with	10	198.20	216.70	2.37	20	.03*
	without	12	378.08	136.08			

Table 5 demonstrates the number of the participants' mean and standard deviations of the fixations. In this, independent T-test was conducted with concept mapping strategy and the fixation numbers as the variables. The result indicated the significant differences between the experimental group and control group ($p < .05$) in Article 1. It indicated the fixation in the AOIs of experimental group in Article 1 ($M = 113.90$, $SD = 119.45$) was less than the control group ($M = 224.92$, $SD = 77.56$). However, when took two article together, the result showed the significant differences between two groups ($p < .05$). It indicated the fixation of experimental group of the articles ($M = 198.20$, $SD = 216.70$) was shorter than the control group ($M = 378.08$, $SD = 136.09$).

Figure 7 and 8 present the fixation numbers and the reading route of two articles from two participants in different groups. It showed that the particpants read with the concept mapping strategy revealed less fixation numbers than the participant in the control group. The result indicated that the particpant in the experimental group fixated less on text and could find the key words or sentence easily. Moreover, the particpant read with the concapt map could use some reading strategies(listing, inferring, and reviewing) while the the particpant in control group read the atricle word by word.

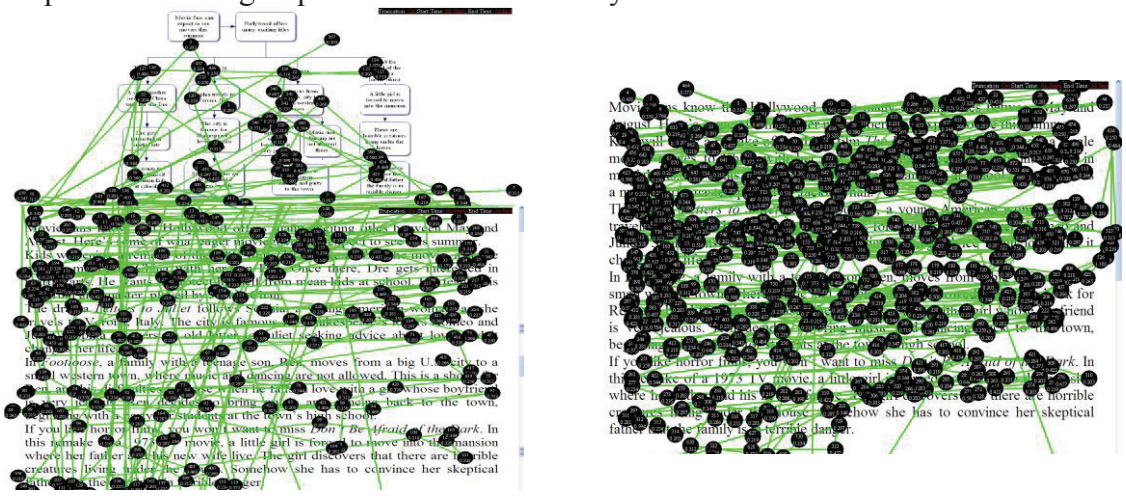


Figure 2. The fixation numbers in Article1 from the participants of two groups (Left: The experimental group; Right: The control group)

3. Disscussion

As the previous studies mentioned that the concept mapping strategy provided positive effects in learners' reading (Dyer, 1985; Esiobu & Soyibo, 1995; Liu, 2010). However, the evidence was not provided to prove how readers utilize concept maps when they read a text. In this case, the questions in this study explored whether the aid of concept mapping strategy would influence the students' eye movements on English reading time and pattern. The results of the eye tracking data suggested that the adopted concept mapping strategy help participants read more effectively. There were two pieces of evidence supporting the influence of concept mapping strategy. First, reading time either in texts or AOIs were shorter than the one without the aid of concept maps. Second, readers tended to skip over words in irrelevant sentences which were not included in the AOIs (see Fig 2.). More generally speaking, these results suggest that concept maps guides readers' visual attention in a selective manner (Anderson, 1982) and defines what information is processed to a deeper level and integrated to the developing memory representation (Kaakinen & Hyona, 2007).

4.1 Participants revealed less reading time with the aid of concept maps

The result corroborated that the participants read without the aid of concept mapping strategy revealed longer reading time and more fixation numbers than those read with the aid of the mapping strategy. The longer reading time appears to be due to a larger fixation numbers in texts.

According to Rayner et al.'s (2006) finding, they claimed that time and numbers of fixations are affected by texts difficulty of readers' self-awareness. It indicates that while readers read without concept map, they had more reading difficulties than reading with the aid of concept maps. In addition, from the aspect of concept mapping strategy, Cassata-Widera (2008) pointed out that concept map not only can develop learners' literacy skills but provide ways to represent and organize the knowledge from the separated context. Then, new linguistic forms were shown to express the concepts. When corresponding to the current study, the reason for the participants read with concept map spent less time on the articles is that the concept map helps learners to display whole relationship of the context. It indicated that the aid of concept maps helps learners to summarize the article, and then the participants could directly catch the focus point. In this case, the participants could spend less time to understand the article.

These results thus provide further confirmation that concept map could reduce readers' reading difficulties and reading time.

4.2 Participants tended to use some reading strategies with the aid of concept map during the reading process

From data showed in Figure 2, readers with the aid of concept maps had less fixation numbers on the AOIs and had more strategic processing mode during reading by paying particular attention to relevant information emphasized by concept maps. The participant in the experimental group would use some reading strategies through the reading process. This finding might correspond to Liu, Chen and Chang's (2010) study. In this study, the fixation numbers showed the participants read with the concept mapping strategy tended to use the reading strategies: listing, inferring, and reviewing. For listing and inferring, the participant read with the concept map put most of his attention to the sentences or the paragraph which

is related to the main points while the participant read without the concept mapping strategy only read the articles word by word. As for the reviewing strategy, from the participant's reading route, it showed that the participant in experiment group would go back over the content or glace though subtitle to recall the main idea after he read the whole article. When it comes to the participant in control group, read without the concept mapping strategy, his reading route was systematically from left to right, and he seldom went back to organize and clarify the article.

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