READING SCIENTIFIC TEXTS: COGNITIVE STRATEGIES USED BY GOOD AND POOR EFL READERS

Samsiah Abdul Hamid
Faculty of Social Development , Universiti Malaysia Terengganu
samsiah@umt.edu.my

Moses Samuel
Faculty of Education, University of Malaya
mosess@um.edu.my

ABSTRACT

The purpose of this study was to get insights on the cognitive strategies used by EFL readers when they read two scientific texts for comprehension. Participants were five first year science undergraduates enrolled in biological sciences degree programme at a local university. Two of the participants were categorized as 'competent' users of English while the other three were 'modest' and 'limited' users. To elicit certain cognitive strategies such as accessing prior knowledge, inferring, decoding and paraphrasing, two scientific texts with two different levels of topic familiarity (familiar/less familiar) and linguistic complexity (difficult/less difficult) were used. Think aloud protocols and retrospective interviews were conducted to gauge readers' strategy choices and moves. Contrary to findings of previous second language reading research, the findings of this study revealed that higher level cognitive strategies such as inferring and accessing general prior knowledge (as opposed to scientific prior knowledge) could lead to misunderstanding of scientific content. On the other hand, lower cognitive strategies like decoding and translating could be turned into successful strategies if the readers complement them with summarizing and visualizing strategies in reading comprehension of scientific texts.

Field of Research: *Reading in a foreign language, reading in a second language, cognitive strategies, scientific texts, EFL readers, reading comprehension*

---

1. Introduction

Reading strategies have been shown to be very significant in improving reading comprehension of non-scientific texts amongst EFL/EFL learners (Alsamadani, 2011; Block, 1986; Salataci & Akyel, 2002; Saricoban, 2002; Singhal, 2001; Talebi, 2012; Tsai et al, 2010). Findings from past research also suggest that reading for global understanding is a good reader's strategy and results in higher comprehension success compared to reading for local understanding (Alsamadani, 2011; Block 1986; 1992; Carrell, 1989; Hosenfeld, 1977). Researchers are also in agreement that the use of higher level cognitive strategies such as inferring, synthesizing information, and referring to prior knowledge most often lead to better comprehension (Kern, 1989; Block, 1986; 1992; Hamada, 2009; Phakiti, 2004; Tsai, Ernst & Talley, 2010) while lower cognitive strategies such as translating and decoding will not.

Yet, little is known about the reading struggles faced and strategies used by EFL readers reading scientific texts in English (Abdul-Hamid & Samuel, 2011). Research by Anderson (1991), Chen and Donin (1997), and Tan (1986) suggest that when EFL readers read texts in their own discipline such as biology, engineering or medicine, they tended to compensate their limited L2 proficiency with their prior

knowledge in the field. This suggests the employment of higher cognitive strategies (accessing prior knowledge, infering) among EFL readers reading scientific texts, which previous studies on non-scientific texts found to be extremely useful too. Another study on EFL readers reading scientific texts was by Abdul-Hamid and Samuel (2011). They found that successful cognitive strategies in reading scientific texts are somewhat different from strategies used in reading non-scientific texts. As research on EFL readers reading scientific texts is far in between, more research is needed to look into how EFL readers read academic scientific text written for native speakers and navigate through its scientific terminology and syntactic complexity.

2. Literature Review

2.1 Scientific Texts

English language has been used as the medium of international discussions amongst the scientific communities ever since the first scientific record, the Philosophical Transactions of the Royal Society of London (PTRS) was first published in 1670 (Atkinson, 2001). With more than 50% of the scientific literature published in the English language (Swales, 1987; Lott, 1971), non native English speakers must embrace English as their second or foreign language and learn to read efficiently so as not be left behind in fast paced technological race. Unfortunately, scientific texts written in English are often informationally dense, syntactically complex, and linguistically and conceptually domain-specific (Atkinson, 2001). Reading scientific texts is always a struggle for both EFL learners (Fang, 2006; Flick & Anderson, 1980; Parkinson, Jackson, Kirkwood & Padayachee, 2007; Walsh, 1982) and native English learners (Flick & Anderson, 1980). In view of a myriad of significant discoveries and research findings in the fields of science and technology frequently reported in English, the need to acquire efficient personal cognitive tools in reading printed texts, especially scientific texts is imperative.

2.2 Topic Familiarity and Linguistic Difficulty

Whether or not a reader could comprehend a text being read is very much dependent on the topic familiarity (Ozuru, Dempsey & McNamara, 2009) and linguistic difficulty (RAND, 2002; Cohen, Glasman, Rosenbaun-Cohen, Ferrara & Fine, 1988) of the text as well as the reading skills and strategies of the reader. If the topic of the text is very unfamiliar to the reader, the content cannot be mapped onto the reader's existing schemata (Mebarki, 2011), thus s/he will fail to make sense of the text or recall the information read (Carrell, 1983). Based on the schema theory, comprehension and recall of the information read depend on how the textual data match the readers' prior knowledge. Reading is therefore viewed as an interactive process between the readers' prior knowledge and the text. The interpretations of the author's point of views, arguments and perspectives hinge on the readers' past experience, prior knowledge as well as cultural beliefs and prejudices (Bernhardt, 1984 cited in Barnett, 1989). Readers' prior knowledge that matches the text content makes reading comprehension easier and retention of information better (Nassaji, 2002). However, incompatibility between both knowledge sources would result in retention difficulty even though the words and sentences are linguistically familiar and comprehensible (Urquhart & Weir, 1998).

Tertiary level EFL readers are assumed to have accumulated a wide range of prior knowledge in a variety of areas learnt in their L1. Researchers argue that in order to predict EFL reader's performance on a particular reading task, his prior knowledge must be taken into consideration (Urquhart and Weir, 1998, p. 63; Mebarki, 2011). In addition, Koda (2005, p. 141) asserts that mature EFL readers already literate in their L1 usually rely heavily on their prior knowledge. Their reliance on previously acquired conceptual

knowledge especially in highly specialized texts may lead to the utilization of top down processing to compensate for inadequate linguistic sophistication (ibid).

L2 proficiency is central to L2 reading so much so that limited L2 proficiency will 'short circuit' (Clarke, 1980) or inhibit reader's good L1 reading system from being transferred to and utilized in the L2 reading task, consequently, causing him or her to employ poor reading tactics which would mainly be processing the text at word level. Carrell (1991), and Brisbois (1995) confirmed this notion with the findings that linguistic knowledge contributes 30% of the variance in L2 reading performance. L2 proficiency means the reader possesses word recognition skills that enable automaticity in reading (Stanovich, 2000) and the knowledge of syntax and an abundance of vocabulary. On the other hand, if the text carries a lot of new words or domain specific vocabulary, their newly acquired meaning will compete for space with other reading processing skills in the limited working memory. This will exhaust the capacity of the working memory and constrain its meaning making process. As a result, reading becomes laborious and remains at word level.

2.3 Cognitive Strategies

While reading is in progress, readers may wish to optimize the integration of meaning between the data in the text and the information they possess. Alternatively, there may be a breakdown in the information provided by one or more knowledge sources and thus comprehension of the text is at stake. In these circumstances, the readers may take certain deliberate actions to maximize understanding or resolve comprehension difficulty (Urquhart & Weir, 1998). These actions are cognitive strategies employed by readers to process input from texts.

Paris, Wasik & Turner (1991, p. 610) consider cognitive strategies as a repertoire of tactics that readers employ to comprehend a text and these tactics are deliberate and calculated cognitive actions (Anderson, 1991) that help regulate reading behaviours and comprehension. Cognitive strategies are divided into two categories, higher-level and lower-level strategies. Higher-level cognitive strategies are primarily guided by the readers' content and formal schemata or their acquired knowledge about the topic and organization of the text on hand. These higher-level cognitive strategies also known as top down processing are attempts that focus on synthesizing information from various sources in order to conceptualize the text content. They consist of actions such as relating new information to familiar concepts and prior knowledge, making predictions and inferences based on both new and previous information, summarizing, guessing meaning from context, hypothesizing, and elaborating (Block & Pressley, 2002; Paris, Wasik, & Turner, 1991; Pressley, 2006). Higher-level cognitive strategies may be used when the act of cognitive processing of the text does not overwhelm the reader's cognitive resources with is complex language structure and unfamiliarity of the topic.

On the other hand, the same reader may opt for lower level cognitive strategies and focus his or her attention more on linguistic processing when s/he is confronted with texts which are linguistically and conceptually more challenging. Lower-level cognitive strategies are actions directed towards breaking the linguistic codes such as decoding and recognizing words, syntactic structures and parts of speech, and translating words and phrases (Block, 1986; Cromley, Snyder-Hogan & Luciw-Dubas, 2010). These lower-level cognitive strategies can normally be performed by skilled readers automatically with minimal cognitive effort, thus freeing the working memory for other higher-level processing that leads to comprehension (Phakiti, 2004). However, these lower-level cognitive strategies are often found to be 'unsuccessful' strategies for comprehension of non-scientific texts and usually not associated with successful or good comprehension of scientific texts among native English readers (Cromley et al, 2010). Thus, the shift in strategy use is influenced by the reader's conscious decision during reading (Koda,

2005) based on his or her current linguistic proficiency, depth of knowledge on the topic and the types of texts on hand.

Researchers in second language reading concur that the use of higher cognitive strategies often yield successful comprehension of L2 narrative and expository texts read and vice verse for lower cognitive strategies. They are also in agreement that the use of higher level cognitive strategies would be inhibited by the limited linguistic knowledge of less proficient EFL learners, rendering them to use only lower level cognitive strategies such as decoding and translating. Yet, studies that look into strategy use in reading domain-specific and scientific texts yield conflicting findings. Anderson's (1991) study revealed that less proficient EFL readers used less strategies but managed to score higher marks while reading academic reading texts. Chen and Donin (1997) too found that less proficient EFL biology students did better than the more proficient EFL engineering students while reading biology texts. Both studies imply the utilization of higher level cognitive strategies such as accessing prior knowledge and inferring by the less proficient EFL readers to comprehend the domain-specific texts. Unfortunately, both studies did not specifically look into these higher level cognitive strategies to determine if they were in fact contributing to the successful comprehension of the academic and scientific texts.

3.0 Research Questions

a) To what extent do 'successful' higher cognitive strategies in reading social science texts are also 'successful' strategies in reading the two scientific texts in this study?

b) To what extent do 'unsuccessful' lower cognitive strategies in reading social science texts are also 'unsuccessful' strategies in reading the two scientific texts in this study?

4. Methodology

4.1 Participants

The participants of this study were five first year undergraduates who, at the time of the study, were undergoing a bachelor's degree program in biological science in a university located in the east coast of Malaysia. They were the remaining five out of 10 students selected through purposive sampling procedure for qualitiative data collection technique after a written consent from the faculty's administration office was obtained. Table 1 shows the participants' profile for purposive sampling according to the qualitative data collection technique (Fraenkel & Wallen, 2008).

Table 1: Profile of the Ten Selected Participants for the Qualitative Study

Name	L2 proficiency (MUET[1])	PK	GPA	Gender	Race
Wan	High	High	Low	M	Malay
Lolita*	High	High	Low	F	Indian
Di	High	High	Low	F	Chinese
Devi*	High	Low	Low	F	Indian
Rheka*	High	Low	High	F	Indian
Zeti	Low	High	High	F	Malay
Tan*	Low	High	High	M	Chinese
Az	Low	Low	High	F	Malay
Bee*	Low	Low	High	F	Chinese
Riz	Low	Low	Low	M	Malay

[1]MUET: Malaysian University English Test
PK- Prior knowledge based on grade(s) obtained in (a) biology course(s) in previous semester
GPA – Grade Point Average obtained in Semester one
*Participants who opted out while study in progress

The other five participants opted out one after the other during the data collection period which lasted for about two months. The five participants were in their second semester when the study was conducted and aged between 19 to 22 years old with English language proficiency ranging from limited user (MUET band 2) to competent user (MUET band 4). There were two male and three female students and out of five participants, four were Malay students and only one was a Chinese student.

4.2 Instruments

The objectives of the study were to identify the types of cognitive strategies that were being used by good and poor EFL learners while they read two scientific texts and to determine which cognitive strategies were successful or unsuccessful in the comprehension of scientific texts. Thus, the following instruments were employed.

First, two scientific texts (A & B) in the field of biology were selected. Scientific texts A and B had a readability index of 12 on the Flesch Kincaid Index. Text A contained 592 words with 20% passive construction while text B had 744 words with 30% passive sentences. Text A entitled *Auxins and Elongation of Cells* (Campbell *et. al*, 2000) consisted at least 50%-60% known concepts (prior knowledge/ topic familiarity) to first year science undergraduates. Text B entitled *Hormones and Signal Transduction* (Boyer, 2006) was estimated to carry about 20% - 40% of known scientific concepts (prior knowledge/ topic familiarity). In sum, text A was syntactically less difficult than text B and the ratio of old to new information was 50:50 for first year biology majors. Text B was syntactically more difficult, less familiar and the old to new information ratio was 30:70. Both texts were at 'intermediate difficulty' and they were appropriate for the intended purpose because Baker and Brown (1984) argued that efficient learning entails active monitoring of one's own cognitive processes in a continuing effort to solve reading problems. Therefore, if the reading task is too easy, readers may not bother to strategize but if it is too difficult, they may give up.

Second, reading comprehension of each scientific text was measured using three different types of tests, (a) multiple choice questions, (b) multiple true and false statements, and (c) a written summary. Multiple choice questions (MCQ, hereafter) measured recall of facts and information while multiple true and false statements (MTF, hereafter) measured understanding of the scientific concepts. A written summary helped to distinguish good from poor readers as they had to write, in a language they were most comfortable with Riley & Lee (1996), a summary of the biochemical process described in each text as they had understood it. The total possible score for reading comprehension of Text A (RCA, hereafter) was 68 marks and for Text B (RCB, hereafter) 66 marks.

Cognitive strategies were assessed based on the transcripts of participants' think aloud protocols. The protocols were obtained when participants were asked to read each scientific text aloud and verbalize their train of thoughts while reading. Each session of think aloud procedure was recorded using digital voice and video recorders. The protocols were then transcribed verbatim and two independent inter-raters were assigned to identify all cognitive strategies in the protocols, divide them into the two levels of cognitive strategies, higher and lower cognitive strategies, and determine the types of cognitive strategies being used.

4.3 Procedure

Three think aloud training sessions were held two weeks prior to the actual data collection. For the actual data collection, the researcher met with each participant individually on two separate days according to an agreed schedule. Each participant was asked to read one of the two scientific texts on each meeting. The participant was first given a practice text to practice thinking aloud for about 15 minutes. When he or she was ready, the first scientific text (which could either be text A or B) was given to be read aloud for comprehension. The participant was also told that comprehension questions would follow soon after the reading session and s/he was not allowed to refer to the text while answering the questions. There was no time limit for reading. Scientific texts for the think aloud protocol were marked with this symbol ⊖ at the end of every two or three sentences (Crain-Thoreson et. al, 1997) to remind the participant to stop at the end of the particular sentence and verbalize his or her current thoughts on the text/ diagrams/ past knowledge.

Three folders containing the following materials were given to each participant during the actual data collection days: Folder 1 (a) Participant's background information with information on participant's L2 proficiency, prior knowledge on biology, and buffer tasks. Folder 2 contained (a) practice text 1, (b) scientific text A, and (c) reading comprehension questions A. Folder 3 contained (a) practice text 2, (b) scientific text B, and (c) reading comprehension questions B. In between the reading of scientific texts and answering the reading comprehension questions, the researcher required each participant to do a buffer task. This was done to avoid memorized facts and details of the scientific text from interferring with the assessment of the participants' true comprehension and understanding of the content (Linderholm & van den Broek, 2002; Pritchard, 1990; Sharp, 2004).

After reading the first text, the participant was given the reading comprehension questions beginning with MCQ and followed by MTF and a written summary. Retrospective interview followed soon after that. The same procedures were repeated in the following data collection meeting when s/he read the second scientific text and answered reading comprehension questions based on the text.

5.3 Findings

The scores of participants' reading comprehension assessments of texts A (RCA) and B (RCB) were used to divide them into good and poor readers. The mean scores of both RCA (Mean=27.52[1]) and RCB (Mean=23.04[1]) were then used as the cut off points to divide participants into good/poor groups (Tan, 1986). Those who scored below the means were considered poor readers and those who scored above the means were good readers. Table 2 illustrates the reading comprehension scores of both texts A and B of the five participants.

Table 2: Reading Comprehension Scores and Summary of Strategies Used by Five EFL readers

RC scores	**Az**	**Zeti**	**Di**	**Wan**	**Riz**
RCA score (%)	23 (35%)	30 (45%)	28 (42%)	31 (47%)	19 (29%)
RCB score (%)	29 (46%)	27 (43%)	20 (32%)	24 (38%)	20 (32%)

Zeti, Di and Wan fell under good readers category for text A whereas Az and Riz poor readers. On the other hand, Az, Zeti and Wan were good readers for text B while Di and Riz poor readers. On the whole,

Zeti and Wan were consistently good readers and Riz poor reader while Az and Di performance tended to fluctuate between the two reading tasks.

Research Question One

In order to answer the first research question, the higher cognitive strategies used by the five participants as revealed by their think aloud protocols are tabulated in Table 3.

Table 3: Frequency of higher cognitive strategies used by good and poor EFL readers of scientific texts

SCIENTIFIC TEXT A				
Good L2 Readers			Poor L2 Readers	
Zeti (MUET b2)	Wan (MUET b4)	Di (MUET b4)	Az (MUET b3)	Riz (MUET b2)
HC -Analyzing Visual Diagram (18) **HC** -Visualizing (16) **HC** -Accessing PK (15) **HC** -Summarizing (13) **HC** -Reading for global understanding (12)	**HC**-Visualizing (73) **HC** -Analyzing Visual Diagram (8) **HC** -Inferring Content (5) **HC** -Accessing PK (4) **HC** -Summarizing (4)	**HC** -Summarizing (29) **HC** -Analyzing Visual Diagram (11) **HC** -Inferring Content (9) **HC** -Visualizing (7)	**HC** -Reading for global understanding (24) **HC** -Accessing PK (12) **HC** -Inferring Content (5) **HC** -Visualizing (4)	**HC** -Accessing PK (18) **HC** -Inferring Content (10) **HC** -Analyzing Visual Diagram (7) **HC** -Questioning Content (5)
SCIENTIFIC TEXT B				
Zeti	Wan	Az	Di	Riz
HC -Accessing PK (17) **HC** -Analyzing Visual Diagram (11) **HC** Questioning Content (11) **HC** -Summarizing (10)	**HC** -Visualizing (34) **HC** -Summarizing (9) **HC** -Accessing PK (6) **HC** -Analyzing Visual Diagram (5)	**HC** -Reading for global understanding (29) **HC** -Analyzing Visual Diagram (23) **HC** -Questioning Content (12) **HC** -Summarizing (8) **HC** -Accessing PK (4)	**HC** -Reading for global understanding (16) **HC** Inferring Content(13) **HC** -Accessing PK (10) **HC** -Analyzing Visual Diagram (8)	**HC** -Accessing PK (15) **HC**-Questioning Content (15) **HC** -Analyzing Visual Diagram (12) **HC** -Inferring Content (7)

MUET b4- MUET band 4 or English language proficiency based on Malaysian University English Language Test
HC- Higher Cognitive Strategies; PK-Prior Knowledge
(n) – frequency of this strategy being used by the participant to read the particular text

Common higher cognitive (HC, hereafter) strategies used by good EFL readers to read scientific text A were visualizing, analyzing visual diagrams, accessing prior knowledge, and summarizing. For text B, analyzing visual diagrams, summarizing, and accessing prior knowledge were again the common cognitive strategies used by good readers while visualizing was utilized to a lesser degree (Zeti:

visualizing- 2) and did not make the list of most frequently used HC strategies. The findings of this study suggest that at least two HC strategies, namely analyzing visual diagrams and summarizing, could be considered as the most efficient combination of HC strategies frequently used by good readers of both scientific texts. Good readers tended to verbally summarize the text or portions of the text as well as analyze the diagram(s) given in order to get a better understanding of the texts read. In addition, visualizing the content in the form of mental images or concept/ mind maps was also effective in making the abstract scientific concepts more concrete.

However, the contribution of HC strategy of accessing prior knowledge to successful comprehension is more intricate than it was initially assumed but could be summarized into three key points. First, it was found that only scientific as opposed to general prior knowledge that contributed to better comprehension of the scientific text, as in the case of Zeti and Riz. Both low proficiency EFL readers, Zeti and Riz, had the highest frequency for accessing their prior knowledge, with 15 and 17 for texts A and B respectively for Zeti and 18 and 15 for Riz. While both EFL readers accessed their prior knowledge equally frequent, only Zeti managed to make use of her prior knowledge to comprehend the two texts while Riz failed. Examination of their think aloud protocols revealed that Zeti accessed her 'science' prior knowledge while Riz accessed his general prior knowledge on both topics.

Second, scientific prior knowledge was only accessed when a reader encountered comprehension problem and not because s/he possessed an abundant of knowledge on a familiar topic. This is because, having a lot of prior knowledge on the topic being read may make reading and comprehension smooth and easy but would not necessarily trigger the need to consciously access that knowledge, whereas reading confusion would. As in the case of Az, she encountered difficulty in comprehending text A and thus accessed her prior knowledge rigorously. In an interview after her reading text A, she acknowledged that she did not have much knowledge about *auxin*. However, she did not access her prior knowledge as rigorously while reading text B because she admitted to having a lot of prior knowledge on the topic *Hormones and Signal Transduction,* as discussed in Text B (Interview Transcript 1B, pp. 7, 7, 15). On the other hand, for limited L2 proficiency readers like Zeti and Riz, reading second language scientific texts always posed a comprehension problem and therefore accessing prior knowledge was done rigorously to aid understanding.

Third, at times, the strategy of accessing prior knowledge overlaps with the strategy of visualizing, as in the case of Wan and Zeti. Wan's mental images of shapes and colours of molecules and hormones resembled diagrams which he had seen in biology textbooks (Interview Transcript 4A, pg.17). So, even though while reading text A Wan did not consciously access his prior knowledge, the images forming in his mind that he verbally reported were, in fact, based on his prior knowledge of diagrams previously seen in science textbooks and learnt in science classes.

The data also suggest that inferior HC strategy which may not contribute to successful comprehension of both scientific texts was inferring content. This is because, all poor readers of texts A and B tended to infer content to no avail. However, Wan and Di too used inferring strategy while reading text A and they succeeded. One explanation could be due to the L2 proficiency of the reader who infers. High proficiency readers may be able to infer the meaning of content more accurately (Wan and Di in text A) compared to low L2 proficiency readers (Riz and Az in text B).

Two HC strategies which neither contribute nor inhibit reading comprehension of scientific texts as suggested by the data were reading for global understanding and questioning content. Reading for global understanding includes reading to get an overall understanding of sentences or paragraphs, reading fast, and reading more that one sentence at once. Questioning content is a strategy when readers questioned

the information given in the text and wanted to know information outside the scope of the text.

Using these two HC strategies may not cause the readers to misinterpret the content of the text or hinder detailed comprehension. This is because reading speed and reading more than one sentence at once are the result of good comprehension of the text which the reader can adjust when confusion occurs. In addition, questioning content may perhaps show that the reader wants more familiar information which they can use to understand the text better. Based on the findings, these two strategies may not interfere with the comprehension and if used with efficient HC strategies such as accessing prior knowledge, analyzing diagrams and summarizing, these two HC strategies may prove to be fruitful.

Research Question Two

To answer research question two, lower cognitive (LC, hereafter) strategies which were frequently used are tabulated in Table 4. The data revealed that all EFL readers utilized a high frequency of LC strategy of reading for local understanding which includes rereading sentences, decoding words and phrases, and reading slowly. Two other LC strategies used extensively by the five EFL readers were translating in their first language (L1) and memorizing and taking notes. On the other hand, paraphrasing strategy was used very minimally.

Table 4: Frequency of lower cognitive strategies used by good and poor EFL readers when reading two scientific texts

SCIENTIFIC TEXT A				
Good L2 Readers			Poor L2 Readers	
Zeti (MUET b2)	Wan (MUET b4)	Di (MUET b4)	Az (MUET b3)	Riz (MUET b2)
LC-reading for local understanding (53) **LC**-translating (55) **LC** -memorizing & note-taking (20)	**LC**-reading for local understanding (22) **LC**-translating (3) **LC**-paraphrasing (2) **LC**-memorizing & note-taking (1)	**LC**-reading for local understanding (91) **LC** -translating (60) **LC**-memorizing & note-taking (16) **LC**-paraphrasing (7)	**LC**-reading for local understanding (95) **LC**-memorizing & note-taking (11) **LC**-translating (9) **LC**-paraphrasing (5)	**LC**-reading for local understanding (91) **LC**-translating (52) **LC**-paraphrasing (12) **LC**-memorizing & note-taking (1)
SCIENTIFIC TEXT B				
Zeti	Wan	Az	Di	Riz
LC-reading for local understanding (53) **LC**-translating (38) **LC**-memorizing & note- taking (4) **LC**-paraphrasing (1)	**LC**-reading for local understanding (12) **LC**-translating (2) **LC**-paraphrasing (1)	**LC**-reading for local understanding (46) **LC**-translating (5) **LC**-paraphrasing (4)	**LC**-reading for local understanding (41) **LC**-translating (24)	**LC**-reading for local understanding (84) **LC**-translating (48) **LC**-paraphrasing (6)

LC- Lower Cognitive Strategies

(n) – frequency of this strategy being used by the respondent to read the particular text

The findings indicate that both good and poor EFL readers were utilizing a great number of LC strategies while reading both scientific texts. Yet, there was no evidence from the data, especially in the good EFL readers, to suggest that using LC strategies at a very high frequency could lead to unsuccessful comprehension of the texts as previously claimed. In order to understand the EFL reader's strategy choices and moves while reading the two scientific texts, their think aloud protocols were carefully examined.

The examinations of the participants' think aloud protocols revealed that successful comprehension occurred when readers utilized HC strategy of summarizing after their piece meal translations and guesses (LC strategies). However, when piece meal translations were not accompanied by summarization, comprehension failed. Excerpts 1 (Di's) and 2 (Riz's) from the think aloud protocols illustrate this point. Excerpt 1 illustrates how Di used cognitive strategies to comprehend sentence 15 of text A.

Excerpt 1

Sentence 15 as it appeared in the text	**Removing the apical tip and its suppressive hormone allows the lower dormant lateral buds to develop, and the buds between the leaf stalk and stem produce new shoots which compete to become the lead growth.**

Strategy	**Think aloud protocol**
(LC) Splitting sentence & Rereading	**Removing the apical tip…** **removing the apical tip…**
(LC) Translating	**emm… remove…** *alihan* [Translation: remove….move/move from its place]
(LC) Rereading	**apical tip and its suppressive hormone,and its suppressive hormone allows the lower dormant lateral buds to develop**
(LC) Translating	*Oh… apabila* **apical tips** *ini dipindah err…* [Translation Oh…when this apical tips is moved away err…:]
(LC) Translating	**apical tips** *dan hormon dipindah, akan membenarkan err…* [Translation: apical tips and hormone is moved away, (it) will allow err….]
(LC) Rereading	**lower dormant lateral buds***…*
(LC) Repeating problematic word	**buds buds buds** *emm…***buds…***mungkin* **buds emm… buds buds** [Translation:buds buds buds emm buds…may be buds emm…buds buds..]
	kuntum ah?
(LC) Translating	[Translation: bud, is it?]
(LC) Translating	Err…**Dormant,** *yang tidak bergerak dibawah akan membesar* [Translation: Er…dormant, which (is) not moving downwords will grow (bigger)]
(LC) Rereading	**and the buds between the leaf stalk and stem produce new shoots which compete to become the lead growth.**
(HC) Summarizing	*Oh… apabila* **apical tip** *dipindah dan hormon dialihkan, dor…err bahagian bawah…***buds** *-kuntum yang* **dormant** *akan membesar dan membesar, okay*.

idea	[Translation: Oh… when apical tip is moved away and hormones are displaced, dor…err…the lower part…buds- buds which are dormant will grow and grow, okay.] [TAP 3A, lines 150- 162]

Excerpt 1 shows Di's attempt to understand sentence 15 of scientific text A. Di had read the whole sentence once and may perhaps find that she did not understand it. She then split the sentence into three parts. She reread the first part and translated the word 'remove' before reading the second part of the sentence. Then she translated and read the first and second part together. She then translated a few words in the second part of the sentence and reread the last part of the sentence. Then she summarized the whole idea in Malay. Even though she mistook 'suppressive' for 'move', she still managed to draw out the gist of the sentence without leaving out important details except for 'suppressive hormone'.

Excerpt 2 illustrates Riz's attempt to unpack and figure out sentences 29 and 30.

Excerpt 2

Sentence 29 as it appeared in text	**Scaffolding and anchoring proteins hold groups of receptor proteins together to form networks for accurate transmission of information.**

Strategy	Think Aloud Protocol
(LC) Splitting sentence	*Scaffolding anchoring protein…*
(LC) Translating	Oh… ni protein…kira macam…iskk… *scaffolding protein*… mele… benda yang melekatkan… [Translation: Oh..this is protein…it is like…iskk… Scaffolding protein…something that fastens…] *groups…hold groups of proteins together to form* Oh maknanya… [Translation: Oh that means…]
(LC) Translating	*hold groups of proteins together…* *Receptor protein* yang banyak-banyak ni dikaitkan dan dihubungkan oleh… [Translation: The many receptor proteins are related and connected by…]
(LC) Translating	*scaffolding and anchoring protein…*maknanya Oh maknanya…penghubunglah…kiranya untuk menghasilkan… [Translation: Oh that means….a connector…its like to produce…]
(LC) Translating	*networks for accurate transmission of information* untuk menghasilkan cetusan informasi… [Translation:…to produce informational sparks]

Sentence 30	**Cell surfaces have many different types of receptors, and the scaffolding proteins are thought to organize and enhance the signal transduction process**

	by holding all necessary extracellular and intracellular molecular components together in a single network.
Strategy	Think Aloud Protocol
(LC) Splitting sentence	*Cell surfaces have many different types of receptors…*
(LC) Translating	Permukaaan sel ada banyak sel… jenis sel *receptor* *and the scaffolding proteins…* yang tadi tu… [Translation: the surface of cells has many cells….types of cells receptor and the scaffolding proteins…]
(LC) Splitting sentence	*are thought to organize and enhance the signal transduction…*
(LC) Rereading	*signal transduction process by holding all necessary extracellular and intracellular molecular components together in a single…in a signal…in a signal network.*
(LC) Rereading	*Scaffolding protein are thought to organize… and enhance the signal transduction process…err err…*
(LC) Translating	Maknanya dia bukan setakat… *scaffolding protein* ni bukan setakat mengabungkan *receptor-receptor*, tapi dia … emm…mengabungkan extracellular dan intracellular molekul component ni dalam satu network. Isk… [Translation: This means it does not only ….this 'scaffolding proteins' not only combine the receptors, but it…emm…combine these extracellular and intracellular molecule components in one network.]
	Sentence 31 **Figure 2… emm…Figure 2 illustrates two types of signal transduction processes…by which are (a)…** ***Receptor enzyme****: binding of signal hormone… Receptor enzyme…****S****…* Eh…! *S* hormone Oh…ni receptor enzyme… Emm…tak faham dah…serabut ni… [Translation: I do not understand, very confused]
	[TAP 5B, lines 395 – 427]

Excerpt 2 shows how Riz read and translated sentences 29 and 30. Protocol for sentence 29 revealed that Riz had successfully unpacked and translated this sentence. Unfortunately, Riz continued to read sentence 30 without summarizing sentence 29 as a whole first, thus leaving him with fragmented ideas of this sentence. When reading sentence 30, Riz started of by splitting the sentence into a few shorter

clauses and then translating and rereading each one in succession. His translation for sentence 30 was quite accurate but towards the end of the protocol he claimed that he did not understand the sentence(s). The problem may lie in the very last part of his problem solving strategies. This means that after reading problematic sentences at lower cognitive level (rereading, translating, splitting long sentences) he should have moved up to higher cognitive level by employing summarizing strategy on the whole sentence. In this way he may be able to get the overall understanding and picture of the whole sentence, like Di did.

Discussions

This study looked into how EFL readers negotiated two scientific texts by examining the participants' think aloud protocols and their reading comprehension scores. The most significant finding from these data suggests that successful cognitive strategies in reading scientific texts may differ from successful cognitive strategies in reading non-scientific texts (Clarke, 1980; Carrell, 1989; Block, 1986; 1992). In reading scientific texts, the most efficient strategies were found to be higher cognitive strategies of summarizing and analyzing visual diagram besides visualizing and accessing scientific prior knowledge. Similar cognitive strategies were also found to be used by native English readers while reading scientific text (Cromley, Snyder-Hogan & Luciw-Dubas, 2010). Nevertheless, inferencing strategy which resulted in better comprehension of scientific texts in native English readers was found to be dependent on the EFL reader's level of English proficiency. Further study is needed to determine the threshold level of English proficiency of EFL readers that would result in more successful inferences while reading scientific texts.

In addition, lower cognitive strategies such as rereading, translating, decoding and breaking up sentences and phrases could prove to be successful strategies if they were complemented by summarizing strategy to provide a complete idea of the scientific concept to the EFL readers. However, if these lower cognitive strategies were not complemented with higher cognitive strategy of summarizing, the readers may only get fragmented ideas and fail to comprehend the concept holistically.

Good EFL readers of scientific texts deliberately chose certain cognitive strategies that could enhance their comprehension of the scientific texts and exerted greater intensity on each chosen strategy compared to poor EFL readers. This finding is consistent to Anderson's (1991) who found that successful comprehension also depends on the intensity or frequency of each strategy used. In addition, this study managed to show that in reading scientific texts, activating and accessing scientific prior knowledge is crucial to reading comprehension of the texts while accessing general prior knowledge does not go very far in facilitating reading comprehension of scientific texts. In addition, this study found that a reader would only access his or her prior knowledge when s/he encounters reading difficulty and not just because s/he has an abundance of prior knowledge on the topic.

In conclusion, reading scientific texts requires the EFL readers to not only understand the whole scientific concept by employing certain efficient higher cognitive strategies but also to hold in the bottom (Eskey, 1988) by using lower cognitive strategies such as rereading, translating and decoding. When both higher and lower cognitive strategies are used in combination and effectively, even low proficiency EFL readers would be able to read scientific texts with reasonable comprehension.

[1]Note:

The mean scores for RCA and RCB were obtained from participants (N = 336) for the quantitative portion of this study.

Acknowledgement

The authors wish to acknowledge that this research was funded through the postgraduate research fund (PPP) grant # PS116/2008A from the University of Malaya, Kuala Lumpur.

References

Abdul-Hamid, S. & Samuel, M. (2011). Strategies for L2 reading of college-level scientific texts. *International Journal of Arts and Sciences, 4, 4,* 16-42.

Alsamadani, H. A. (2011). Effects of the 3-2-1 reading strategy on EFL reading comprehension. *Canadian Journal of English Language Teaching, 4, 3,* 184-190.

Anderson, N. (1991). Individual differences in strategy use in second language reading and testing. *The Modern Language Journal, 75, 5,* 460-472.

Atkinson, D. (2001). Scientific discourse across history: a combined multi-dimensional/ rhetorical analysis of the *Philosophical Transactions of the Royal Society of London.* In S. Conrad & D. Biber (eds.), *Variation in English: Multi-dimensional studies.* Essex: Pearson Education Limited.

Baker, L., & Brown, A. L. (1984). Metacognitive skills and reading. In P. D. Pearson, R. Barr, M. L. Kamil, & P. Mosenthal (eds.). *Handbook of Reading Research, Volume I* (pp. 353-394). Mahwah, NJ: Erlbaum.

Barnett, M. A. (1989). *More than meets the eye: Foreign language reading, Theory and practice.* Englewood Cliffs, NJ: Prentice Hall.

Bernhardt, E. B. (1984). Toward an information processing perspective in foreign language reading, *Modern Language Journal, 68(4),*322-331.

Block, C.C. & Pressley, M. (Eds.) (2002). *Comprehension instruction: Research-based best practices.* New York, NY: The Guilford Press.

Block, E. (1986). The comprehension strategies of second language readers. *TESOL Quarterly, 20, 3,* 463-494.

Block, E. (1992). See how they read: Comprehension monitoring of L1 and L2 readers. *TESOL Quarterly, 26, 2,* 319-341.

Boyer, R. (2006). *Concepts in Biochemistry* (3rd edition, Wiley Asia Student Edition). Hoboken, NJ: John Wiley & Sons Inc.

Campbell, N. A., Mitchell, L. G., & Reece, J. B. (2000). *Biology: Concepts and Connections* (3rd ed.). San Francisco, CA: Addison & Wesley Longman, Inc.

Carrell, P. L. (1983). Background knowledge in second language comprehension. *Language Learning and Communication, 2(1),* 25-34.

Carrell, P. L. (1989). Metacognitive awareness and second language reading. *The Modern Language Journal, 73, 2,* 121-134.

Chen, Q., & Donin, J. (1997). Discourse processing of first and second language Biology texts: Effects of language proficiency and domain-specific knowledge. *The Modern Language Journal, 81, 2,* 209-227.

Clarke, M. (1980). The short circuit hypothesis of ESL reading – or when language competence interferes with reading performance. *The Modern Language Journal, 64, 2,* 203-209.

Cohen, A., Glasman, H., Rosenbaun-Cohen, P. R., Ferrara, J., & Fine, J. (1988). Reading English for specialized purposes: discourse analysis and the use of student informants. In P. L. Carrel, J. Devine, & D. E. Eskey, *Interactive approaches to second language reading,* (pp. 152-167). New York, NY: Cambridge University Press.

Crain-Thoreson, C., Lippman, M. Z., & McClendon-Magnuson, D. (1997). Windows on comprehension: Reading comprehension processes as revealed by two think-aloud procedures. *Journal of Educational Psychology, 89(4),* 579-591.

Cromley, J. G., Snyder-Hogan, L. E. & Luciw-Dubas, U. (2010). Reading comprehension of scientific text: A domain-specific test of direct and inferential meditation model of reading comprehension. *Journal of Educational Psychology, 102, 3,* 687-700.

Dhieb-Henia, N. (2003). Evaluating the effectiveness of metacognitive strategy for reading research articles in an ESP context. *English for Specific Purposes, 22,* 387-417.

Eskey, D. E. (1988). Holding in the bottom: an interactive approach to the language problems of second language readers. In P. L. Carrell, J. Devine, & D. E. Eskey (eds.) *Interactive approaches to second language reading* (pp. 93- 100). Cambridge: Cambridge University Press.

Fang, Z. (2006). The language demands of science reading in middle school. *International Journal of Science Education, 28(5),* 491-520.

Flick, W. C., & Anderson, J. I (1980). Rhetorical difficulty in Scientific English: A study in reading comprehension. *TESOL Quarterly, 14(3),* 345-351.

Fraenkel, J. R., & Wallen, N. E. (2008). *How to design and evaluate research in education.* New York, NY: McGraw Hill.

Hamada, M. (2009). Development of L2 word-meaning inference while reading. *System, 37,* 447-460.

Hosenfeld, C. (1977). A preliminary investigation of the reading strategies of successful and unsuccessful second language learners. *System, 5,* 11-123.

Kern, R. (1989). Second language reading strategy instruction: Its effects on Comprehension and word inference ability. *The Modern Language Journal, 73, 2,* 135-149.

Koda, K. (2005). *Insights into second language reading: A cross-linguistic approach.* Cambridge University Press: Cambridge.

Linderholm, T., & van den Broek, P. (2002). The effects of reading purpose and working memory capacity on the processing of expository text. *Journal of Educational Psychology, 94(4)*, 778-784.

Lott, B. (1971). English in the teaching of science and technology throughout the world. *CILT Reports and Paper No. 7.* London: Centre for Information on Language Teaching and Research for the British Association for Applied Linguistics.

Mebarki, Z. (2011). Factors underlying the reading performance of Algerian microbiology students. *Procedia-Social and Behavioral Sciences 29,* 1759-1768.

Nassaji, H. (2002). Schema theory and knowledge-based processes in second language reading comprehension: A need for alternative perspectives. *Language Learning, 52(2),* 439-481.

Ozuru, Y., Dempsey, K., McNamara, D.S. (2009). Prior knowledge, reading skill, and text cohesion in the comprehension of science text. *Learning and Instruction, 19,* 228 – 242.

Paris, S. G.; Wasik, B. A., & Turner, J. C. (1991). The development of strategic readers. In R. Barr, M. L. Kamil, P. Mosenthal, & P. D. Pearson (eds.). *Handbook of reading research, volume II* (pp. 609-640). Mahwah, NJ: Erlbaum.

Parkinson, J., Jackson, L., Kirkwood, T., & Padayachee,V. (2007). A scaffolded reading and writing course for foundation level science students. *English for Specific Purposes, 26,* 443-461

Phakiti, A. (2004). A closer look at gender and strategy use in L2 reading. *Language Learning, 53 (4),* 649-702

Pressley, M. (2006). *Reading instruction that works: The case for balanced teaching, 3rd edition.* New York, NY: The Guilford Press.

Pritchard, R. (1990). The effects of cultural schemata on reading processing strategies. *Reading Research Quarterly, 25,* 273-295.

RAND Study. (2002). *Reading for understanding* (C. Snow ed). Santa Monica, CA: RAND Education

Riley, G. L., & Lee, J. F. (1996). A comprehension of recall and summary protocols as measures of second-language reading comprehension. *Language Testing, 13,* 173-189.

Salataci, R., & Akyel, A. (2002). Possible effects of strategy instruction on L1 and L2 reading. *Reading in a Foreign Language, 14 (1),* 1-17.

Saricoban, A. (2002). Reading strategies of successful readers through the three phase approach. *The Reading Matrix, 2(3),* 1-16.

Sharp, A. (2004). Strategies and predilections in reading expository text: The importance of text patterns. *RELC Journal, 35(3),* 329-349.

Singhal, M. (2001). Reading proficiency, reading strategies, metacognitive awareness and L2 readers. *The Reading Matrix, 1(1),* 1-23.

Talebi, S. H. (2012). Reading in L2 (English) and L1 (Persian). An investigation into reveres transfer of reading strategies. Canadian Journal of English Language 5, 3, 217-229.

Tan Soon Hock (1986). *The role of prior knowledge and language proficiency in reading comprehension in English among undergraduates.* Unpublished Doctoral Thesis, University of Malaya, Kuala Lumpur.

Tsai, Y. R., Ernst, C., Talley, P. C. (2010). L1 and L2 strategy use in reading comprehension of Chinese EFL readers. *Reading Psychology, 31,* 1-29.

Urquhart, A. H.. & Weir, C. (1998). *Reading in a second language: Process, product and practice.* Essex: Longman.

Walsh, V. (1982). Reading scientific texts in English. *System, 10(3)*