Reading Scientific Texts: Some Challenges Faced by EFL Readers

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***Abstract*—This paper looks at the difficulties encountered by five EFL readers as they read and negotiated two scientific texts. Respondents were five first year undergraduates enrolled in a biology degree programme at a public university in Malaysia. Think aloud procedures and retrospective interviews were conducted to identify the obstacles and difficulties faced by the respondents while reading the texts and how they overcame the reading problems. The findings of this study revealed that general English words in the scientific texts posed more problems compared to scientific terminology. Known scientific terminology in a complex sentence was much easier to comprehend compared to complex English sentences with only general English words. This is because, the scientific terminology previously learned in the EFL readers' L1 provided them with a 'window' to other rich information not mentioned in the particular sentence or text.**

***Index Terms*— Reading comprehension, scientific texts, EFL readers, language of science.**

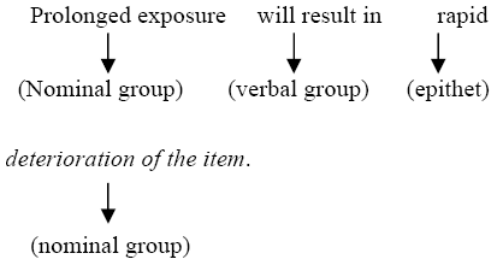
I. Introduction

Reading comprehension is such a covert activity that many teachers do not clearly understand the extent of the problems and struggles that their students have to go through in order to understand a text. Thus, many reading comprehension problems have gone unnoticed and consequently no actions are taken to remedy the situation. Reading scientific texts in a second or foreign language (L2, hereafter) is more demanding for EFL (English as a Foreign language) readers as not only that they have to cope with the L2 linguistic challenges with limited or modest proficiency, but they also have to negotiate the language of science and its many science concepts (Fang, 2006; Flowerdew, 1993; Abdul-Hamid, 2011).

II. Literature Review

Researchers concur that reading scientific texts is very demanding even for native students as the texts are often informationally dense, syntactically complex, and linguistically and conceptually domain-specific (Atkinson, 2001; Halliday, 1988). Comprehension of scientific texts requires not only the knowledge of general English but also the language, rhetoric and terminology of science. Halliday (1988) describes the English language of science as having typical features that classify it as scientific English which include nominalization of verbs and adjectives, extended nominal groups, causal and reasoning verbs, tentative or hedging language, impersonal language, passive constructions, and technical vocabulary. Nominalization is a special feature of scientific language (Lemke, 1990; Unsworth, 2001) that often turns verbs and adjectives into entities and become nouns. For example, the verb *move* and adjective *deep* are transformed into *motion* and *depth* (Halliday & Matthiessen, 2004) and become a phenomenon that can have certain properties such as a *perpetual motion* or *linear motion*.

The verbs or happenings *expose* and *deteriorate* are changed into entities or 'things'. For example:



Nominalization such as the above enables scientific texts to be packed with information by having a large number of noun compounds in a single sentence and subsequently makes it dense with markedly long sentences (ibid; Fang, 2006) and impersonal.

In addition, readers of scientific texts must also be knowledgeable about scientific concepts reiterated in the text (Graesser, Leon, & Otero, 2002; Ozuru, Dempsey & McNamara, 2009). One example of a scientific concept is *cold fusion* (Tarantino, 1991). This concept, which is obvious to the people within a particular domain, is not very apparent for people from outside the field or new comers to the field such as first year EFL students. Unlike cold milk which can be converted to the milk is cold, cold fusion does not mean the fusion is cold and therefore cannot be written as such. To readers of similar field as the author of the text, the phrase is like a 'window' that opens up to a whole wealth of knowledge and information on chemical sciences related to temperature, energy and nuclear. In contrast, a lay audience or a non expert reader who is not equipped with similar prior knowledge will be at lost.

Thus, this study employs a qualitative approach using think aloud procedures to seek answer to the following research question:

What are the difficulties encountered by EFL readers when they were reading the two scientific texts and how did they

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overcome the problems?

III. Methodology

A. Respondents and Materials

Five first year undergraduates enrolled in a bachelor's degree program in biological science participated in the study. They 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 users to competent users of English language.

Two scientific texts used in this study were from college biology textbooks. 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 whereas text B had 744 words with 30% passive sentences. Text A entitled Auxins and Elongation of Cells (Campbell et al, 2000) consisted of at least 50%-60% known scientific concepts 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.

B. Procedure

To obtain data on the difficulties and challenges faced by the EFL respondents while reading the two scientific texts, a qualitative approach using think aloud protocols (TAP, hereafter) was used. 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 respondent individually on two separate days according to an agreed schedule with an interval of one week between the first and the second TAP session.

Each respondent was asked to read one of the two scientific texts on each meeting. On the first meeting, the respondent was first given a short reading text to practice reading and thinking aloud for about 15 minutes. When s/he was ready, one of the scientific texts (which could either be text A or B) was given to be read aloud for comprehension as well as to be read aloud. Since the study employed a qualitative approach, each text was marked with this symbol [⊖] at the end of every two or three sentences (Crain-Thoreson *et al*, 1997). The symbol acts as a reminder to the respondents to verbalize their current thoughts out loud so that their thinking activity could be heard and recorded by the researcher.

Respondents' think aloud protocols were recorded using digital voice and video recorders. After reading the first text, they were given two sets of reading comprehension questions. One was a multiple choice questions (MCQ) and multiple true and false (MTF) statements which consisted of 36 items. Another reading comprehension assessment was a written summary on a biochemical process mentioned in each text. Retrospective interview followed soon after that. Among the questions asked during the interview were the difficulties they encountered while reading the texts and their strategies to overcome the problems. The same procedures were repeated in the second meeting when they read the second scientific text.

IV. Findings

To identify words and sentences that caused comprehension problems to the five EFL readers, the researcher requested that the respondents circle the difficult words and underline problematic sentences in green ink. Besides that, problematic sentences and difficult words were also identified through respondents' think aloud as well as interview protocols. The findings of this study reveal that the respondents encountered at least three major problems while reading the two scientific texts; (i) general English words, (ii) complex general English sentences, and (iii) long and complex scientific English sentences.

A. General Versus Scientific Words

Tables I and II present easy and difficult words encountered by the five respondents while reading scientific texts A and B. In each column of easy and difficult words in scientific texts A and B, those above the horizantal line were general English words and those below it were scientific words. Another feature of the table is the words in asterisks which were words identified by at least four respondents as difficult.

TABLE I: Easy and Difficult Words/ Phrases in Scientific Text A

SCIENTIFIC TEXT A		
Easy Words		Difficult Words
General English words		*General English words*
Counters the effects		(act in) concert*
Diffuse		Commercial preparations*
Synthesis		Derivatives
Synthetic auxins		Distribution
		Dominance*
Scientific English words		Dormant
		Eggplant*
Active transport		Horticulturist*
Apical meristem		Inability
Apical tip		Induce
Cell wall		Lateral branching*
Cross-linking cellulose molecules		Minute (amount)
		Profound
Cytokinin		Pruning*
Cytoplasm		Reinforce*
H ion activates enzyme		Resist
Meristem		Seedless
Nervous system		Suppressive
Osmosis		Sustain*
Plasma membrane		Swell*
Proton		Tendency
Target cells		Trigger
Unspecialized cells		Ulterior*
Vascular cambium (21)		Uniform (flowering)*
		Scientific English words
		Apical dominance*
		Depressing
		Plant organization (27)

* At least 4 out of 5 readers identified these words as difficult

TABLE II: EASY AND DIFFICULT WORDS/ PHRASES IN SCIENTIFIC TEXT B

SCIENTIFIC TEXT B		
Easy		Difficult
General English words		*General English words*
Catalyze		Activated (protein)*
Diffuse		Active ingredient*
Secreted		Alter
		Amplified
		Anchoring*
Scientific English words		Conversely*
		Elicit*
Adrenal cortex		Exterior
Cell receptor protein		Extracellular
Cytoplasm		Interact
Endocrine gland		Intracellular
First messenger		Mediator*
G protein		Magnitude
Glucagons		Off switch
Gonad		Organize
Hydrogen bonds		Penetrate
Hydrophobic interactions		Recognition
Metabolic regulation		Relays
Non covalent interactions		Reversibly
Plasma membrane		Scaffolding*
Polar/non polar hormones		Span
Receptor enzyme		Stretches*
Second messenger		Trigger*
Signaling molecules		
van der Waals forces (21)		*Scientific English words*
		Atrial natriuretic factor*
		Enzyme cascade*
		Epinephrine*
		Serpentine*
		Signal transduction*
		Trans-membrane (29)

* At least 4 out of 5 readers identified these words as difficult

For both texts A and B, the list for difficult general English words is longer compared to difficult scientific words. In contrast, for the list for easy words, there are more scientific words that were identified as easy compared to the general English words.

Out of 56 words identified as difficult by the respondents in texts A and B, only nine words/phrases were scientific terminology such as apical dominance, enzyme cascades, serpentine receptor, signal transduction, trans-membrane and epinephrine. Surprisingly, the other 47 words identified as difficult were in fact general English words like activated, alter, distribution, eggplant, inability, swell, interact, seedless, relays, reinforce, stretches, resist, tendency, and trigger.

In contrast, a number of scientific terminologies which the researcher had anticipated to pose difficulties to the EFL respondents appeared to be easy and thus perfectly understood by them. Examples of those words were active transport, synthesize, diffuse, synthetic auxins, endocrine gland, gonads, adrenal cortex, polar and non polar hormones, van der Waals forces, receptor enzyme, and cytoplasm. Most respondents admitted that they did not have much problems with the scientific terminology as they had learned the terms previously in their L1. In addition, during the retrospective interviews, two respondents commented that when they encountered scientific terminology in a sentence, that terminology acted like a window that provided them with a wealth of other information that helped them to understand the particular sentence more than what was stated in it.

Respondents used at least five different strategies when they encountered difficult words. The most common strategy was to translate the words into their L1 which is the Malay language.

EXCERPT 1: L2-L1 TRANSLATION

	Accurate translation
(a)	**…vascular tissues and induce cell division in the vascular cambium…** … induce… *saya … maksudnya galakan…* (TAP 2B, lines 472-473) [Translation: …induce.. I….means encourage…]
	Inaccurate translation
(b)	**An important principle of plant organization based upon auxin distribution is apical dominance…** Dominance- *banyak…* (TAP 2A, lines 335-336) [Translation: Dominance – a lot]

The second strategy was to relate the words to their prior knowledge to arrive at the closest translation.

EXCERPT 2: RELATING TO PRIOR KNOWLEDGE

	Accurate deduction
(a)	**Penetrating the plasma membrane…** *Err..* Penetrating *saya tak tahu tapi saya rasa* penetrating *tu dia nak masuk dalam membrane plasma, sebab saya terbayang masa saya belajar kat matrik dulu, err saya bayang err sperm nak masuk dalam ovam tu, dia kena pene..* penetrate plasma membrane *ovari.., ovem tu nak masuk…* (TAP 2B, lines 52-55)
	[Translation: Penetrating…I don't know but I think penetrating (is)…it is entering inside the plasma membrane, because I remember when I was in matriculation centre, err I remember err the sperm is going inside the ovam, it has to pene… penetrate the plasma membrane of the ovari…, (because) the ovem has to get in…]

	Inaccurate deduction
(b)	**and the scaffolding proteins are thought to organize…** scaffolding protein *akan* organize, *akan…*organize *apa ni?* organize *err* organize organize organize *mengenalpasti* *Saya …balik ayat ni.* *Saya tak ingat apa* organize *Apa yang saya bayang, Saya telah dapat kad dulu, kad dulu… ada budak ni saya tak kenal dia cakap seseorang yang saya kenal –* organize (TAP 2B, lines 333-349) [Translation: Scaffolding protein will organize, will ….what is organize? I…go back to this sentence. I don't remember what organize is What I comes to my head, I got a card sometimes ago, a card sometimes ago…there was this person, I did not know him, he said (from) someone that I know-organize]

Both strategies sometimes resulted in accurate translation but low proficient EFL readers most often arrived at inaccurate translations/synonyms. In excerpt 2 (b), the respondent mistook the word 'organize' for 'recognize' and translated the sentence *…and the scaffolding proteins are thought to organize…* to mean *the scaffolding proteins are thought to 'recognize' or' to know'…* which was inaccurate.

Other strategies were breaking up the affixes of the unknown words, guessing meaning of words by translating the words in the surrounding of the unknown word, and

looking for clues in other parts of the texts or skipping the problematic words altogether.

B. Long and Complex General and Scientific English Sentences

The second problem encountered by the EFL readers was processing complex general English sentences. The excerpt below is one example of such sentence:

- Text A: Sentence 22

These effects of IAA on cell elongation reinforce two points: (1) the same chemical messenger may have different effects at different concentrations in one target cell, and (2) a given concentration of the hormone may have different effects on different target cells.

- Text B: Sentence 12

The detailed step-by-step process of signal transduction varies greatly from one hormone and organism to another, but a general chain of events involving several common elements has been identified.

Sentences 22 (text A) and 12 (text B) were reread as many as seven to 13 times and three to four times respectively by the respondents. In the retrospective interviews with the researcher, some of the respondents reported that there were no key words (scientific concept) which they could hold on to help them understand the ideas conveyed. For sentence 22 (text A), a few students had problem with the word 'reinforce' which they translated as 'force again' and at least two students did not know that 'chemical messenger' refers to IAA or auxin. Again, the respondents failed to notice the clue 'the same' as in "(1) the same chemical messenger…" provided in the same sentence. As for sentence 12 (text B), respondents admitted that they understood each word in the sentence yet they could not get the meaning of the sentence as a whole. Two respondents claimed that the sentence was too general and lacked scientific terminology which they could focus on in their attempt to comprehend it.

Finally, as anticipated, most respondents had problems in working out the meaning of complex scientific English sentences such as sentence 14 below. The respondents admitted that the sentence was too long and difficult to process.

- Text A: Sentence 14

An important principle of plant organization based upon auxin distribution is apical dominance, which means that the auxin produced by the apical bud (or growing tip) diffuses downwards and inhibits the development of ulterior lateral bud growth, which would otherwise compete with the apical tip for light and nutrients. (48 words)

The above is an example of a typical scientific text written in English which is very complex, packed with details and long. However, the problem in unpacking the meaning of this sentence may lie in the inability of the readers to focus on the two relative pronouns 'which' used in the sentence that act as modifying clauses to describe the scientific terminology 'apical dominance'. This again can be attributed to the poor grasp of the general English grammar. Besides not knowing the scientific terminology of 'apical dominance', the EFL readers were also deterred by the unfamiliar phrase 'ulterior lateral'.

- Text B: 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.

Sentence 30 (text B) contains an unknown word and phrase which are 'scaffolding' and 'signal transduction'. Besides, like sentence 14 in text A, the sentence is long and complex. With a long sentence like this, respondents employed a variety of strategies. One respondent started off by splitting the sentence into a few shorter clauses and then translating and rereading each one. His translation for sentence 30 was quite accurate but towards the end of the protocol he still claimed that he did not understand the sentence. 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.

The difficulty to unpack the above sentences resulted in at least four consequences. First, the EFL reader may miss the important point that the author tried to put forward. After rereading and translating sentence 14 of text A, one respondent only managed to understand that 'auxin is produced at the apical bud and the presence of auxin in large quantity causes the cells at the tip to divide and grow'. Yet, the focus of the sentence was on 'apical dominance' which inhibits the growth of ulterior buds. Second, an EFL reader tended to generalize the meaning, which again would fail to attend to the significant scientific phenomenon being discussed. Third, failing to process the difficult sentence, an EFL reader would usually skip the sentence altogether. Almost all respondents had skipped at least two difficult sentences at one point or another while reading both texts. Fourth, the EFL reader may not realize that s/he had managed to unpack the difficult sentence correctly was convinced that s/he did not understand the sentence.

V. Discussions and Conclusions

The main objective of this study was to determine the challenges faced by EFL undergraduates when they read scientific texts in English. It was found that while scientific terminology was not found to be a major problem in reading comprehension of L2 scientific texts, the obstacles faced by these learners were those related to proficiency in L2, in particular vocabulary and complex sentence structure of the general English language. Most scientific terminology did not pose a big comprehension problem to the five respondents as they had often encountered the terminology in biology and chemistry texts previously learnt in their L1, thus were familiar to them. Yet, they had problem unpacking 'general' English words. This finding is consistent to the study by Parkinson *et al*, (2007) that EFL students usually struggle with general academic and 'everyday' English words.

Another obstacle encountered by the EFL readers was long

and complex general and scientific English sentences. A sentence is perceived as difficult to process when it is made up of complex English sentence structure and contains general English words and lacks familiar scientific terminology. To overcome the problem, most respondents would look for and focus on familiar scientific terminology to provide them with a window to the meaning of the complex sentence. However, it was found that sentences containing only general English words became very challenging to these EFL respondents as was also found by Parkinson, Jackson, Kirkwood, & Padayachee (2007) and Malcolm (2009). Malcolm found that Arabic-speaking medical students had less problem reading medical books compared to reading English newspapers.

Evidence from this study indicated that respondents employed a number of fix-up strategies which resembled those in reading non-scientific texts like translating (Hosenfeld, 1977), associating to their prior knowledge, breaking up problematic words, guessing, and skipping the unknown word (Crain-Thoreson *et al*, 1997). A sequence of strategies employed usually began with breaking the complex sentence up into short clauses, rereading each clause and translating one piece at the time. Competent EFL users of English language would normally summarize the whole idea to get a holistic understanding of the sentence resulting in successful comprehension. Similar to Ou's (2006) findings, less proficient EFL learners who employed summarizing strategy after the initial translating process showed positive outcomes in their reading comprehension tasks. On the other hand, poor EFL readers continued to plough through the text at lower cognitive level. Hence, they ended up with disjointed understanding of the scientific concepts, failed to notice details which were crucial to scientific reading (Koch, 2001), and were satisfied with a general understanding (Ozuru et. al, 2009) or a false understanding (McNamara, Kintsch, Songer, Kintsch, 1996) of the complex scientific concepts.

Findings from this study suggest that to assist EFL science undergraduates to read scientific texts with comprehension would be to first help them improve their general English proficiency, which includes vocabulary and syntax. The second step would be to help them become aware and users of good reading strategies such as summarizing and accessing prior knowledge.

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