SCIENCE TEXTBOOK READABILITY IN LEBANON: A COMPARISON BETWEEN ANGLOPHONE AND FRANCOPHONE LEARNING MILIEUX

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Abstract – *Science subjects are taught in either English or French in the Lebanese high school system. In a strongly examination-driven system exhibiting parallel English and French science courses and textbooks, the issue arises as to whether the second language in which learning occurs has any determining effect on outcomes. This paper outlines an exploratory study involving the readability of the national Year 12 biology textbook using both Flesch and Cloze tests, and the reading strategies that students employ when reading science texts. On the whole, there did not appear to be any major differences between anglophone-medium and francophone-medium students with regard to the readability of the book, but the study raises questions which cast some doubt on the simplistic assumption that the choice of the second language makes no difference, particularly with regard to students' reading strategies.*

Introduction

Lebanese school education is bilingual: some subjects are taught in Arabic while others are taught in English or French, a choice which is made by individual schools be they public or private; there are parallel anglophone and francophone streams in some schools. The Lebanese dual language policy dates back to the French mandate (1920-1943) following the disintegration of the Ottoman Empire and the end of the First World War, when the public education system was modelled on the French system, as it remains to this day. English has, however, been increasingly used in Lebanon since the 1960s, and there exists today a pronounced American influence in private education, especially at tertiary level. The school curriculum unit of the Ministry of Education and Higher Education prescribes curricula for all subjects from Years 1 to 12. The Ministry's Centre for Educational Research and Development produces textbooks for these curricula. Where subjects may be taught in English or French, parallel versions in those languages are produced.

The Lebanese secondary education system is dominated by two external examination junctures: the *Brevet* at the conclusion of Year 9, and the terminating

Lebanese *Baccalauréat*. The *Brevet* acts as a filter for promotion to Year 10; students who fail it either transfer to the parallel vocational education system or simply drop out. The *Baccalauréat* is a university entry qualification, although this may be supplemented by additional tests such as the SAT for private universities which follow the American model. Upper secondary schooling in Lebanon is strongly geared to university entry, with a very high transition rate operating between the secondary and tertiary education sectors (Vlaardingerbroek et al., 2007).

The need for secondary school students to study science and mathematics in a foreign language is compounded in the Lebanese context as there are two foreign languages to choose from. In the highly competitive, examinations-dominated world of Lebanese upper secondary schooling, the question arises whether studying science and mathematics in English or French is indeed a matter of 'six of one, half a dozen of the other', or whether there are subtle differences between the two learning milieux which may translate into a comparative advantage or disadvantage. Lebanese classroom practice tends to revolve around the official textbooks, and one line of enquiry into this issue is the evaluation of the comparative readability of those books for arabophone students. Accordingly, the purpose of this exploratory study was to gauge the readability of both language versions of the national Year 12 biology textbook, and to gain an insight into reading strategies used by students.

Textbook readability in the context of school science

Research from numerous countries suggests that science instruction in schools is generally heavily based on science textbooks (Ginsguger-Vogel & Astolfi, 1987; Otero & Campanario, 1990; Groves, 1995; Stern & Roseman, 2004; Fang, 2006). Reading a text in any language is cognitively challenging whatever the subject matter (Kern, 1989; Labasse, 1999) for both native and second language (L2) readers as 'it involves the coordination of attention, memory, perceptual processes and comprehension processes' (Kern, 1989, p. 135). Reading science texts seems to be a particularly painstaking endeavour for students whether these texts are written in their native tongue or a foreign one (Fang, 2006). Science texts in general constitute a distinctive genre characterised by a complicated, rigid organisation, a large number of both technical and non-technical words, long nominal phrases, sentences dense with information, and complicated syntactic structures (Halliday, 1993; Groves, 1995; Sutton, 1998; Parkinson, 2000; Gee, 2001; Fang, 2006). Given the inherent complexity of science texts, reading science textual material constitutes one of the main impediments to understanding

science concepts (Groves, 1995; Chavkin, 1997; Fang, 2006) as L2 readers have to deal with scientific concepts through 'a yet-unmastered language' (Lee, 2005, p. 492). This extra effort is constantly demanded from science students in Lebanon (Boujaoude & Sayah, 2000). Students need to develop adequate reading strategies to overcome their difficulties and extract meaning from their science textbooks. These can be simple traditional strategies such as skimming the text and re-reading (Carell, 1989), or more elaborate techniques such as activating background knowledge (Zvetina, 1987) or recognising text structure (Block, 1986).

In this study, the term 'readability' refers to what Fry (2002, p. 286) calls 'true readability', which is the ease with which a text or a passage may be read and the extent to which it is interesting to read. This definition contains a subjective dimension that distinguishes it from approaches involving the mere application of readability formulae. The readability of a text – in this case a scientific text or passage – implies the extent to which a reader can read and make sense of the text or passage s/he is reading. Because reading involves interaction with written texts, language proficiency is considered to be necessary in order to effectively understand the text. In other words, reading is a 'reasoning task connected to a language task' (Swaffar, 1988, p. 141). Hence, students need to learn and understand scientific language in order to comprehend the scientific concepts and acquire the needed communication and thinking skills (Kearsey & Turner, 1999).

Despite improvements in the quality of science textbooks over the past few decades, studies from a variety of countries have shown that students continue to face problems in reading science texts (Ginsguger-Vogel & Astolfi, 1987; Fang, 2006). Various researchers have reported that students find science a 'forbidding and obscure' (Halliday, 1993, p. 69) subject and that reading a science text is a difficult enterprise that can be frustrating (Fang, 2006). But, ironically, even though reading texts in a foreign language requires more effort on the part of L2 learners, research suggests that problems faced by second language learners are not very different from those faced by native speakers: both encounter similar challenges when reading science texts as 'science language' includes features that are peculiar to science, that is, the scientific register (Kern, 1989; Halliday, 1993; Fang, 2006). Other than technical terms, difficulties reside in the grammatical features which include interlocking definitions, technical taxonomies, special expressions, lexical density, syntactic ambiguity, grammatical metaphors and semantic discontinuity. Numerous empirical studies (Ginsguger-Vogel & Astolfi, 1987; Merzyn, 1987; Groves, 1995; Chavkin, 1997; Sutton, 1998; Fang, 2006) have shown that students are challenged by the lexical components of science texts. Fang (2006) identifies, in his extensive work with middle-school students, a number of linguistic features that seem to hinder reading in science. As well as technical vocabulary and high information density, texts use complex sentences

with long noun phrases and multiple subordinate clauses (see also Groves, 1995; Chavkin, 1997). These jointly slow down, or even impede, students' processing of information because of cognitive overload. Furthermore, Fang (2006) points out that prepositions, conjunctions and pronouns, frequently used in science texts to convey specific causal, consequential or chronological relationships, seem ambiguous to students. In addition, the employment of metaphors and ellipses as well as the nominalisations, which recur in science readings to pack information and build generalisations, appear to be too abstract for students, even native speakers.

Together, these linguistic aspects of the scientific genre give science a 'turgid, dense, abstract and distilled' (Fang, 2006, p. 505) character. As a result, Sutton (1998) believes that students are receiving a misleading image of science: one in which science texts look like passages that necessarily describe the truth. The investigative feature of science, its tentative nature as well as its value-laden character, fade. Instead, a rigid, imposed, untouchable, unarguable science is conveyed to students.

In science education, language is no longer an incidental medium through which students express their thoughts and reach better understanding. It is rather a new vocabulary *and* grammar to master before entering science classes. Hence, language can become an impediment to learning in that it may underlie many misconceptions (Boujaoude & Sayah, 2000).

The literature identifies a number of strategies used by readers whether reading a text in their native language or in a foreign language (Carell, 1989; Kern, 1989; Anderson, 1991). Some studies suggest that there is a clear distinction between the strategies used by successful readers and those employed by unsuccessful ones (Carell, 1989; Oxford & Crookall, 1989). According to a review done by Carell (1989), proficient readers seem to focus on the meaning conveyed by the text while less proficient readers tend to consider reading as a decoding process. Hence, proficient readers typically tend to skim the passage, skip unknown words that are unimportant for the overall meaning, make inferences and keep the meaning of the passage in mind while reading. On the other hand, less competent readers tend to lose the meaning of the sentence as soon as the latter is decoded, and seldom indulge in skimming as they fail to distinguish between essential words and insignificant ones.

Anderson (1991) classified and characterised reading strategies used by second language readers. His framework consisted of five main categories of processing strategies: supervising strategies, support strategies, paraphrase strategies, strategies for establishing coherence in the text, and test-taking strategies. According to his empirical studies, proficient readers and less competent readers use virtually the same types of strategies; however, proficient

readers are better at knowing 'how to use a strategy successfully and orchestrate its use with other strategies' (Anderson, 1991, pp. 468-469).

In summary, reading science texts, be it in students' native language or a foreign one, constitutes a main impediment to understanding scientific concepts. This seems to be primarily attributed to the scientific register and the grammatical features embedded in the written language of science. Students seem to overcome the language barrier by developing various reading strategies. This study aims to examine and compare the main problems faced by second language speakers when reading science texts written in English and in French, as well as to investigate the reading strategies developed.

Methods

Biology was selected as the subject for this investigation as it is studied by all *Baccalauréat* strands except one, and is the backbone of the popular 'Life Science' strand. The parallel English language and French language national biology texts produced by the Ministry of Education for the Life Science strand are 'Life Science' and 'Science de la Vie' respectively (currently in the 2006 new editions). These books are used by most schools, public and private, which follow the Lebanese curriculum.

A single school offering the Lebanese curriculum, having both French and English as languages of science instruction for separate language sections, was selected in order to limit the number of situation variables. Grade 11 Life Science strand students were selected because they had not yet encountered the Grade 12 textbook. There were 29 students (16 boys and 13 girls) in the English section and 46 in the French section (23 boys and 23 girls).

The Flesch Reading Ease (FRE) formula (Flesch, 1948) and its French adaptation (Kandel & Moles, 1958) were applied to samples of each text. The FRE is a good objective indicator of the level of difficulty of a text, but it does not give any indication about the interaction between the reader and the text; a text may be easy to read in terms of decoding words, but be totally unintelligible (Labasse, 1999). The standard Cloze test was adopted in order to test students' ability to read meaningfully the same selected passage in English or French. The Cloze test has often been used on science texts, including biology textbooks (Cohen & Poppino, 1978; Merzyn, 1987; Fatt, 1991) and in the context of the second language medium of instruction (Steinman, 2002). A French version (*test de closure*) was developed by Landsheere in 1978 (Ginsguger-Vogel & Astolfi, 1987; Bennacer, 2007).

For the Flesch testing, the researcher extracted from the textbooks all passages discussing a single topic with minimum reliance on diagrams and pictures: the

passage had to be discursive rather than merely presenting a lot of new information. These criteria served the purpose of the study as they are very important for the selection of the texts eligible for Cloze testing (Steinman, 2002; Bennacer, 2007). The researcher ended up with 17 passages in each version of the book. For the Cloze testing, the researcher selected from these passages those that were at least 250 words long. To avoid concept novelty (Oller, 1979), passages discussing completely new topics were disregarded. This left 10 passages, of which one was randomly chosen. The final target excerpt was from the chapter entitled 'Genetic variation and polymorphism' in English and 'Variation génétique et polymorphisme' in French. The English passage was 298 words long, while the equivalent in French counted 315 words. Fifty deletions were made in both versions of the Cloze test (every fifth word, observing the usual rules of Cloze test preparation – Steinman, 2002). The last sentence of the French version had to be included intact. Deleted words were categorised as technical vocabulary, non-technical vocabulary or grammatical, and the Chi-square test was used to compare the frequencies of these between the two tests; the value of 1.95 indicated that the two versions of the test did not differ significantly in this regard.

Alternative words which did not substantively alter the meaning of the sentence were accepted when marking the Cloze tests. The *t*-statistic was used to compare the mean scores of the two groups.

Interviews and verbal reports are widely used as methods for diagnosing and understanding the strategies employed by readers when faced with a text (Carell, 1989; Kern, 1989; Oxford & Crookall, 1989; Anderson, 1991). Following the administration of the Cloze tests, interviews were conducted with 20 students (10 from each language section) whose Cloze scores were the closest to their language groups' respective means. This sampling method was used in order to compare two 'average' groups of anglophone- and francophone-medium students, rather than comparing groups of students with widely differing readability scores within each group.

Prior to the interviews, the researcher explained to the interviewees the purpose of the study and the valuable contributions that the interviews would have on the research conducted. The interviewees were assured that their participation was voluntary and confidential. The interviews were conducted using 15-minute timeslots. These were conducted in Arabic (although, as is the norm in Lebanon, the researcher and the students referred to scientific concepts in the second language; not having been taught science in Arabic, they do not have a scientific vocabulary in their mother tongue). The interviews focused on an excerpt from the chapter 'Mechanisms of evolution'. The passage was headed 'Mutation and genetic innovation' in English and 'Mutations et innovations génétiques' in French. The students were requested to read the text silently while the researcher

was taking note of any strategy applied (such as note taking, scanning, skimming). Interviewees were asked to rate the difficulty of the passage and to identify words and sentences that hindered their understanding. They were asked to explain terms (some scientific, others non-scientific) and sentences (some short, some long) to evaluate their reading strategies. The interviewees were also asked about the extent to which they used Arabic (their mother tongue) and how they used it while reading science texts in English or French (see Appendix IA).

The answers to the interview questions were categorised into the first four categories of Anderson's (1991) framework (supervising strategies, support strategies, paraphrase strategies and strategies for establishing coherence in the text; the fifth category, test-taking strategies, was not pertinent to the study). A coding sheet completed by the researcher was devised for this purpose (see Appendix IB).

Results and discussion

For the English passages selected for Flesch testing, Reading Ease scores ranged from 10.6 to 57.1 . Of the 17 texts selected, one text was ranked as 'Fairly Difficult', ten as Difficult' and six as 'Very Difficult'. The French passages likewise ranged from 19.9 to 47.3; nine were classified as 'Difficult' and eight as 'Very Difficult'. These scores and descriptors place the national biology textbooks well within the 'Scientific-Technical' category (see Appendices IIA & IIB).

The means on the Cloze tests were 26.3 (53%) and 29.2 (58%) for the English and French groups respectively. Despite what appeared to be a higher mean for the latter, the *t*-value of 1.76 was not statistically significant. According to the Bormuth criterion reference scores (Bormuth, 1968), these means place the English version at the Instructional Level (i.e., the passage is sufficiently understandable under supervised instruction) and the French version at the lower reaches of the Independent Level (i.e., the passage is suitable for student independent study; albeit, in this instance, very close to the borderline between the Instructional Level and the Independent Level). Overall, the tests used indicated that the reading difficulty of the textbook was about the same for both groups. The medium of instruction did not seem to favour substantially one group over the other in its capacity to read a scientific text meaningfully. The literature in the field suggests that very similar problems across languages arise in reading science texts even when students are native speakers of either language: English (Fang, 2006) or French (Ginsguger-Vogel & Astolfi, 1987). Students reading science material in a foreign language face comparable difficulties, albeit more acutely, as do native speakers of the same age.

In the course of the interviews, three students from the English section ($n = 10$) described the passage as 'easy' (cf. none in the French section, $n = 10$), five students from each section described it as 'accessible' and five students in the French section as 'hard' (cf. two on the English section). When asked about the main challenges that hampered their understanding of the science text given to them, the most common factor mentioned was that of difficult technical vocabulary (10 French section students and 8 English section students). School students commonly believe that high achievement in science depends to a great extent on the mastery of technical vocabulary (Groves, 1995; Sutton, 1998; Kearsey & Turner, 1999; Parkinson, 2000). Three students in each group noted difficult non-technical vocabulary. Four francophone students complained about ambiguous sentence structures (vs. none of the anglophone students), and four about the complexity of concepts/ideas under discussion (cf. two anglophone students). Other comments – sentence length, noun density, the lack of contextual clues – tended to be mentioned by two or fewer students.

TABLE 1: Frequency of reading strategies exhibited by interviewees

Strategy	Aspect	Frequency (out of 10)	
		Anglophone	**Francophone**
Supervising strategies	recognises loss of concentration	2	1
	states failure to comprehend a section of text	7	8
	states success in understanding a section of text	10	9
	adjusts reading rate to increase comprehension	9	10
	formulates a question	0	0
	makes a prediction about the meaning of a word of about text content	10	10
	referes to lexical items that impede comprehension	10	10

Support strategies	skips unknown words	7	8
	expresses a need for a dictionary	7	1
	skims material for general understanding	1	5
	scans material for a specific word or phrase	8	8
Paraphrase strategies	uses cognates between L1 and L2	5	8
	breaks lexical items into parts	3	5
	paraphrases	4	5
	translates a word or phrases into L1	5	8
Strategies for establishing coherence	rereads	10	10
	uses context clues to interpret a word or phrase	9	7
	reads ahead	8	10
	uses background knowledge	9	9
	acknowledges lack of background knowledge	7	8

Table 1 summarises the strategies used by the interviewees. Participants in both groups relied equally on comparable supervising strategies. Almost all participants stated success or failure to understand a portion of the text, adjusted reading rate in order to increase comprehension, made a prediction about the meaning of a word or about text content, and referred to lexical items that impeded comprehension. With regard to support strategies, the majority of the participants in both groups skipped unknown words and scanned the text for a specific word or phrase. However, most participants in the English group (7 out of 10) expressed

a need to use a dictionary, as opposed to only one of the ten in the French group. A possible explanation is that the anglophone-medium students were not as adept at breaking a word into parts. Another possibly significant observation was that half of the participants in the French group skimmed the text for a general understanding before reading, while only one participant in the English group did so. As for the paraphrase strategies, most of the participants in the French group (8 out of 10 participants) and half of the participants in the English group (5 out of 10) used cognates between L1 and L2 to understand the text and translated words or phrases into L1. The picture was again a homogeneous one in the case of strategies for establishing coherence in a text. Most or even all participants reread a text or read ahead to enhance understanding, and used contextual clues and background knowledge to interpret a word or phrase. In addition, most of the participants ascribed great value to the pictures and diagrams accompanying scientific texts, as they perceive them important tools that enhance reading comprehension.

On the whole, the students came across as proficient readers in the second language. It is important to note, in this regard, that the Lebanese education system is selective: as well as the *Brevet* filter after Year 9, there are further filtering and streaming processes in Years 10 and 11, especially in private schools. Year 12 Life Science students are necessarily academically good students, and would be expected to be proficient second-language users and readers. This study, however, suggests that there may be differences between English-medium and French-medium students with regard to support strategies. Francophone students appeared to be slightly more mature readers in this study, more intent on taking in the whole rather than getting bogged down in technical details. Given the limited scope of the study and the small sample size, we would not venture, however, to generalise upon this point.

Conclusion and recommendations

Although inconclusive, there are indications arising from this study that the use of English or French as the medium of instruction in science may 'make a difference'. Although not statistically significant, the readability of the French version of the textbook was slightly higher than that of its English counterpart according to both Cloze test results and the Bormuth criteria as applied to the Flesch scores. Francophone students were moreover considered to be the more adept readers. These may be spurious observations arising from the small sample size, but it may also point to a real underlying difference favouring francophone students in the Lebanese system. Extensive and comprehensive studies on a larger

scale at lower secondary as well as upper secondary level are needed to resolve this issue.

At the very least, the study has highlighted the importance of reading in classroom science. The promotion of effective reading strategies could be an indirect way of improving science education outcomes in Lebanon. Science teachers should focus on central scientific themes and concepts to promote meaningful learning and motivate students (Sutton, 1998; Groves, 1995; Fang, 2006) Teachers should also develop traditional reading strategies in students such as skimming, scanning, guessing or skipping unknown words, tolerating ambiguity, reading for meaning, critical reading, making inferences, and so on, and encourage students to develop more sophisticated ones that engage background knowledge. Fang (2006) encourages teachers to use paraphrasing exercises as they could serve as a way to transform the scientific language into everyday language.

Acknowledgements

This research was carried out under the auspices of a Master of Arts (Science Education) thesis programme at the American University of Beirut in Lebanon.

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APPENDIX IA

Interview Questions

1. How do you find this text? Is it easy or difficult?
2. What is the main idea of this passage?
3. What do you find difficult in the text?
4. Which of these two words do you find hard(er)? (Given two difficult words selected by the researcher) Why?
5. What do you do when you come across such words?
6. Which of these two sentences is harder in your opinion? (Given two difficult sentences selected by the researcher) Why?
7. Can you explain these sentences for me, please?
8. What would you do to overcome the difficulties in those sentences?
9. While reading, do you use the diagrams found in your book? At what stage?
10. Do you use Arabic in order to understand what you are reading? How?

APPENDIX IB

Interview Coding Format

Name: _____ Language of instruction: E ☐ F ☐

Sex: M ☐ F ☐ Duration: _____ minutes

1. When given the text, the student:
a. Skims through the pages b. Reads word by word

2. According to the student, the text is:
a. Easy b. Accessible c. Hard

3. The main idea is:

Paragraph 1: _____

_____

Paragraph 2: _____

_____

Paragraph 3: _____

_____

4. What do you find difficult in the text while reading it:
a. the sentence structure b. the vocabulary c. the concept/ideas

5. The meaning of: 'natural population' _____
'aberration' _____
'homeotic' _____
'Innovation' _____

The harder word is:
a. technical b. non-technical

Why? _____

6. What do you do when you come across such words?

_____

_____

APPENDIX IIA

Flesch Reading Ease Scores of Science Texts
Texts in English

Text	Pages	R.E. Score	Style	Type	Syllables / 100 words	Average sentences length in words
1	58-59	40.2	Difficult	Academic	177	16.7
2	60-61	37.7	Difficult	Academic	176	20
3	62-63	37.7	Difficult	Academic	170	25
4	78-79	41.7	Difficult	Academic	178	14.3
5	80-81	10.6	Very Difficult	Scientific	204	25
6	82-83	39.3	Difficult	Academic	174	20
7	116-117	27.5	Very Difficult	Scientific	230	16.7
8*	120-121	57.1	Fairly Difficult	Quality	153	20
9	123-124	14.8	Very Difficult	Scientific	203	20
10	146-147	52.9	Fairly Difficult	Quality	162	16.7
11*	149	33.4	Difficult	Academic	181	20
12*	150-151	24.1	Very Difficult	Scientific	196	16.7
13	164-165	30.0	Difficult	Academic	189	16.7
14	220-221	43.4	Difficult	Academic	176	14.3
15	294	46.1	Difficult	Academic	170	16.7
16	352-353	47.8	Difficult	Academic	168	16.7
17	374-375	11.4	Very Difficult	Scientific	191	33.3

* Texts counting less than 250 words

APPENDIX IIB

Flesch Reading Ease Scores of Science Texts
Texts in French

Text	Pages	R.E. Score	Style	Type	Syllables / 100 words	Average sentences length in words
1	58-59	23.3	Très Difficile	Scientifique	222	20
2	60-61	24.8	Très Difficile	Scientifique	220	20
3	62-63	34.3	Difficile	Technique	207	20
4	78-79	47.3	Difficile	Technique	194	16.7
5	80-81	20.4	Très Difficile	Scientifique	219	25
6	82-83	40.2	Difficile	Technique	251	20
7	116-117	20.4	Très Difficile	Scientifique	226	20
8*	120-121	27.7	Très Difficile	Scientifique	216	20
9	123-124	31.4	Difficile	Technique	211	42.52
10	146	33.3	Difficile	Technique	213	16.7
11*	149	29.3	Très Difficile	Scientifique	207	25
12*	150-151	36.6	Difficile	Technique	204	20
13	164-165	24.0	Très Difficile	Scientifique	221	20
14	220-221	19.9	Très Difficile	Scientifique	237	12.5
15	294	46.6	Difficile	Technique	195	16.7
16	352-353	36.1	Difficile	Technique	215	12.5
17	374-375	40.2	Difficile	Technique	199	20

* Texts counting less than 250 words