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Linguistic demands in English-language science textbooks in Hong Kong

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This paper discusses the linguistic demands of English-language science textbooks for EFL learners in Hong Kong. The analysis focuses on the abstraction and information density of the language as reflected in the use of abstract nouns, complex lengthy nouns, and lengthy noun without verbs. The findings show that those linguistic features which are difficult for the learners are commonly used, the difficult language is not introduced progressively, and the language difficulty levels are not consistent in the science textbooks. Alternative linguistic choices are used in the analysed texts, which replace the abstract nouns and complex lengthy nouns, with the techniques of noun replacement, de-nominalization, and information unpacking. Information reduction is also used, which can decrease the abstraction and information density. The research indicates that textbook writers should take into account both the contents and the language when designing English-language science textbooks for EFL learners. A solution may be for English teachers and science teachers can work together to develop school-based learning materials, using the language that suits their students' English proficiency. Additionally, bridging courses that focus on the identified linguistic challenges can be developed to enhance EFL learners' awareness of scientific language.

Keywords: linguistic demands; English-medium instruction; systemic functional linguistics; textbooks; Hong Kong

Introduction

In response to the widely perceived importance of English competence in providing learners access to opportunities for better education, employment and social mobility, there appears to be a fast-moving global shift, in non-anglophone countries, from English being taught as a foreign language to English being used as the medium of instruction in programmes with dual goals (i.e. English and subject content) (Wan & Hu, 2007). While it is suggested that these programmes are egalitarian, they often exclude the students with low language proficiency because of concerns that the programmes are too demanding and to suit such students (Broca, 2016). Teaching content subjects in English may affect students' academic performance negatively (Lo & Lo, 2014), especially in science subjects where difficult linguistic features are used (Yip, Tsang, & Cheung, 2003). The demands or difficulties posed by linguistic choices are referred to as linguistic demands, language demands or language difficulty (Andersen, 1971; Fang, 2006; Lo & Lin, 2014). This terminology draws attention to the

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literacy competence that students may need to develop for the learning of science content subjects in the medium of English (McCullagh & Jarman, 2009; Paul, 2017; Peacock, 1996).

Though it is important for research to explore students' literacy development, it can also be argued that "the best response to this problem would be to change the school's expectations for the kinds of language used in school" (Fang, Schleppegrell, & Cox, 2006, p. 250) so that learners' English proficiency can be improved progressively and the linguistic demands can be reduced to facilitate their learning of subject contents in the medium of English. As an important source of knowledge input, especially in the education contexts where teachers may lack experience in teaching subject content in a foreign language (Chan, 2014; Maxwell-Reid & Lau, 2016), textbooks for academic subjects are expected to use language that differs from that used in other contexts.

The Education Bureau of Hong Kong announced guiding principles for quality textbooks, suggesting the difficulty of the language used in textbooks should be "commensurate with the language ability of the target students, with new vocabulary progressively introduced in context at appropriate times" and should be familiar and interesting enough to motivate learning and understanding (Education Bureau, 2016). This study aims to examine the English language used in junior secondary science textbooks in Hong Kong. It first compares the linguistic demands of three sets of English-language science textbooks, then identifies alternative linguistic choices used in the textbooks for the reduction of linguistic demands. The following questions are addressed:

1. What are the linguistic demands of English-language science textbooks in Hong Kong?
2. How can the linguistic demands of textbooks be reduced?

The study

The study was conducted in Hong Kong, where the first language of the majority of primary and secondary students is Chinese, and English is a foreign language. However, many Hong Kong secondary schools use English as the medium of instruction for the teaching and learning of science-related subjects. These schools normally choose a set of English-language coursebooks tailored by publishers specifically for the Hong Kong context, and approved by the Education Bureau. Three textbook series dominate the junior secondary science market in Hong Kong, published by Hong Kong Oxford, Asia Pearson (or its subsidiary publisher, Hong Kong Longman) and the locally-based Aristo publisher (Maxwell-Reid & Lau, 2016).

Selection of texts

The current study selected the three sets of textbooks used for teaching science in Secondary 1 (i.e., Grade 7) which dominate the market, that is: *Mastering Science 1A & 1B* published by Oxford, *Understanding Integrated Science for the 21st Century Unit 1-6* (hereafter referred to as *Understanding Integrated Science 1*) published by Aristo, and *Interactive Science 1A and 1B* published by Longman. All these books follow the science syllabus prepared by the Hong Kong government education department.

Each of the sets of textbooks is divided into two equal parts corresponding to the two school semesters. They all cover the same topics which is not surprising because there is a need to conform to the Hong Kong government curriculum. Semester 1 content covers: an introduction to science, living things, cells and human reproduction.

Semester 2 content covers: energy, solvent water, and matter as particles. Extracts from all three textbooks which covered the same topics were identified for comparison and analysis (Table 1), a total of 95 topics (285 extracts) were compared. An example of such extracts relating to the topic *laboratory* follows:

> Extract 1
> In studying science, you will carry out many experiments in the laboratory. A laboratory provides a lot of facilities, equipment and apparatus. (*Understanding Integrated Science 1*)
>
> Extract 2
> A Laboratory is a place for doing experiments. Take a look at your school laboratory. Can you find the equipment and facilities shown below? Do you know the use of each of them? (*Interactive Science 1A*)
>
> Extract 3
> Doing experiments is one of the ways to collect evidence in scientific investigations. We usually do experiments in a laboratory (實驗室) where we can find different equipment (設備), apparatus (儀器) and chemicals (化學品). In this section, we will learn some of the equipment and apparatus found in a school laboratory. (*Mastering Science 1A*)

Table 1. Details of analysed extracts from textbooks used for Secondary 1 science

Unit	Unit 1-3 (used for Semester 1)	Unit 4-6 (used for Semester 2)
Textbook	• Mastering Science 1A • Understanding Integrated Science 1 • Interactive Science 1A	• Mastering Science 1B • Understanding Integrated Science 1 • Interactive Science 1B
Topic	scientist; definition of science; laboratory; branches of science; nature of science; limitations of science; length measurement; time measurement; weigh measurement; temperature measurement; volume measurement; habitat; variation; classification of animals; classification of plants; key for identifying living things; endangered species; destruction of habitat; pollution; cell; microscope; animal cell; plant cell; reproduction; asexual reproduction; sexual reproduction; human sex cell; reproductive systems; fertilization; development of the embryo; birth of a baby; parental care; heredity; twins; identical twins; non-identical twins; puberty; menstruation and menstrual cycle; wet dream; in vitro fertilization; abortion	energy; light energy; heat energy; sound energy; electrical energy; kinetic energy; potential energy; chemical energy; energy conversions; energy converters; intermediate forms of energy; controlled energy conversions; uncontrolled energy conversions; town gas; liquefied petroleum gas; petrol and diesel; kerosene; coal; acid rain; global warming; hydro-electric power; nuclear power; wind power; solar power; geothermal power; sedimentation; filtration; distillation; chlorination; ozonation; boiling; ultraviolet light; water cycle; evaporation; condensation; sewage; sewage treatment; chemical waste treatment; laws; dissolving; saturated solutions; crystallization; matter; states of matter; melting; freezing; boiling; condensation; atoms; gas pressure; gas pressure measurement; atmosphere pressure; density

Analysis of the texts

The language used in the texts was analysed through the lens of systemic functional linguistics (Halliday & Martin, 1993), which has been used as a tool for analysing linguistic features and challenges in academic texts to facilitate the approaches to literacy in schools (Humphrey & Macnaught, 2016). Systemic functional linguists propose that informational density, abstraction, technicality and authoritativeness are the specific features of scientific language (Fang, 2005). The informational density and abstraction, which students may find challenging, are achieved partly through abstract nouns and lengthy or complex nouns (Fang, 2005). In scientific contexts, meanings that in non-scientific language are more typically conveyed through verbs or adjectives (e.g., reproduce, converse and evaporate) are often, through a process of nominalisation (Fang et al., 2006), expressed as nouns (e.g., reproduction, conversion and evaporation). Sometimes, verbs, adjectives, adverbs and clauses are packed into noun phrases which are lengthy and informationally dense (Fang, 2005). According to Biber, Johansson, Leech, Conrad, and Finegan (1999):

> [A noun phrase is a phrase that] consists of a noun as head, either alone or accompanied by determiners (which specify the reference of the noun) and modifiers (which describe or classify the entity denoted by the head noun). The head noun can also be followed by complements, which complete the meaning of the noun and typically take the form of that-clauses or infinitive clauses (p. 97).

Compared with noun clauses, noun phrases without verbs or non-clause noun phrases are used far less frequently in conversation. They can be noun phrases with adjectives as noun pre-modifiers, with nouns as noun pre-modifiers, with prepositional phrases as noun post-modifiers, and with appositive noun phrases as noun post-modifiers (Biber & Gray, 2010). Examples of abstract noun and lengthy noun phrases are listed in Table 2.

Table 2. Examples of abstract nouns and lengthy noun phrases

Analysed linguistic choices			Examples
Abstract noun			Evaporation; condensation
Lengthy noun	Noun clause		• Scientists also want to know why something happens; • A conclusion which answers their questions; • The study of things and what happens around us using scientific methods; • The process in which a substance changes from gas into liquid state; • Differences within the same kind of living thing.
	Noun phrase without verbs	with adjective as noun pre-modifier	A possible answer
		with noun as noun pre-modifier	Power station
		with prepositional phrase as noun post-modifier	The study of things and phenomena in nature
		with appositive noun phrase as noun post-modifier	Vertebrates, e.g. cows, chickens, dogs, and humans

To identify the linguistic demands in the three sets of textbooks, the texts extracts were reviewed to identify abstract nouns, lengthy nouns and noun phrases with verbs in particular. Then all the texts on the same topic were compared to determine whether other linguistic choices had been made to simplify the language. To test for inter-rater reliability, a trained research assistant and the first author independently coded the text extracts from two units. The two raters rated 88 per cent of the codes in common and were able to resolve the discrepancies through discussion. For example, one rater identified the word *appliances* as an abstract noun while the other did not. After discussion of the definition of abstract nouns as given above, the raters agreed that words such as *appliances* are not abstract nouns. The research assistant coded the rest of the texts after all the discrepancies had been resolved.

Linguistic demands in the textbooks

The analysis identified the use of abstract nouns, lengthy nouns and noun phrases with verbs in particular in the textbooks. The results suggest that these texts do not follow a pattern of progressive difficulty. Instead, texts in the students' earlier stage of learning can be much more linguistically challenging than those in the later stages.

Abstract nouns

As mentioned above, the abstract noun refers to the nominalised verbs or adjectives. The numbers of abstract nouns in the text extracts are listed in Table 3. Words were only counted once regardless of how many times they appeared, thus the count shows the numbers of different abstract nouns present, not the number of times such nouns are used.

Table 3. Numbers of abstract nouns used in the three textbooks

Understanding Integrated Science 1		*Interactive Science 1*		*Mastering Science 1*	
Unit 1-3	Unit 4-6	Unit 1-3 (1A)	Unit 4-6 (1B)	Unit 1-3 (1A)	Unit 4-6 (1B)
30	22	30	22	40	25

As shown in Table 3, the numbers of abstract nouns are different among the three sets of textbooks. *Mastering Science 1* has considerably more abstract nouns than *Understanding Integrated Science 1* and *Interactive Science 1*. As abstract nouns "proved to be the hallmark of late acquisition" (Levie, Ben-Zvi, & Ravid, 2017, p. 1057) and they "can greatly decrease a text's comprehensibility and, thus, the reader's interest and engagement" (Fang et al., 2006, p. 254), they can be viewed as an indicator of language difficulty. In this sense, the results shown in Table 3 suggest that the language used in *Mastering Science 1* is more difficult than that of the other two textbooks, and that, the language, in terms of abstract nouns at least, of Units 1-3 of all three sets of textbooks is more difficult than that of Units 4-6.

Lengthy nouns

A substantial number of instances of lengthy nouns were also found in the three sets of science textbooks. As Fang (2005) notes, students may feel confused and overwhelmed by lengthy nouns during text processing and the resultant information density can cause

greater problems of comprehension. Table 4 lists the frequency of noun phrases with four or more words, a length viewed as complex and potentially posing challenges to the students. The number of complex noun phrases varies across textbooks and within the sections of the textbooks. For the Semester 1 part of the textbooks, *Mastering Science 1* contains the most complex noun phrases and *Interactive Science 1* the least. For the second semester part, *Interactive Science 1* contains the most complex noun phrases and *Mastering Science 1* the least. Table 4 reveals again that the language used in the first parts of *Mastering Science 1* and *Understanding Integrated Science 1* is more difficult than that of their second parts.

Table 4. Numbers of noun phrases with four or more words

Understanding Integrated Science 1		*Interactive Science 1*		*Mastering Science 1*	
Unit 1-3	Unit 4-6	Unit 1-3 (1A)	Unit 4-6 (1B)	Unit 1-3 (1A)	Unit 4-6 (1B)
109	97	90	118	130	89

Noun phrases without verbs

As mentioned above, noun phrases can be with or without verbs (Biber & Gray, 2010). The numbers of complex noun phrases without verbs (containing four or more words) are listed in Table 5 which shows that the three sets of textbooks also use different numbers of complex noun phrases without verbs. The number of complex noun phrases without verbs used in *Mastering Science 1* for Unit 4-6 is far smaller than for Unit 1-3, while that in *Interactive Science 1* for Unit 4-6 is far bigger than for Unit 1-3. *Understanding Integrated Science 1* uses similar numbers of complex noun phrases without verbs for Unit 1-3 and Unit 4-6. According to Biber and Gray (2010), the information density of academic writing is often realised as phrases without verbs, which are used far less frequently in conversation. The infrequent exposure to such usage in daily life can generate more difficulty for students. For this reason, the use of noun phrases without verbs can be seen as one of the indicators of the difficulty level of the language. The results shown in Table 5 again reveal that the language, in terms of noun phrases without verbs, used in Unit 1-3 of *Mastering Science 1* and *Understanding Integrated Science 1* is more difficult than that in Unit 4-6.

Table 5. Numbers of complex noun phrases without verbs

Understanding Integrated Science 1		*Interactive Science 1*		*Mastering Science 1*	
Unit 1-3	Unit 4-6	Unit 1-3 (1A)	Unit 4-6 (1B)	Unit 1-3 (1A)	Unit 4-6 (1B)
79	74	63	91	96	75

Reduction of abstraction and informational density

Alternative linguistic choices are used in the textbooks to differentiate the abstraction and informational density of the language. These alternative linguistic choices can help reduce the language difficulty levels for the students.

Noun replacement

Noun replacement is a strategy to reduce the linguistic demands by replacing abstract nouns with nouns which are more concrete and easier for students to understand. For example, when explaining scientists' work, both sci*entific methods* and *scientific investigation* are used to explain the way scientists work, for example:

Extract 4
To explain how and why things happen, scientists use scientific methods to find out ... (*Understanding Integrated Science 1*)

Extract 5
They make observations, ask questions and try to find the answers by scientific investigation. (*Interactive Science 1A*)

Since the noun *methods* is more concrete than the noun *investigation*, it can be argued that Extract 4 is relatively easier than Extract 5 for students to comprehend. Simple nouns can also replace complex noun phrases as the complex noun phrase *how and why things happen* in Extract 4 is replaced by the noun *answers* (in Extract 5) to make the text easier to understand. Unfortunately, in the three sets of textbooks, only one abstract noun (investigation) and one complex noun phrase (how and why things happen) are replaced with concrete or simple nouns to convey the same information. As argued above, abstract and complex nouns are difficult and can cause problems for text processing (Fang, 2005; Fang et al., 2006), therefore, it would be expected that the noun replacement strategy would be more frequently used in teaching so that the language demand for students can be reduced to facilitate learning of subject content.

Information unpacking

Another strategy to reduce the density of the information is *unpacking* (Unsworth, 2001). The information conveyed by abstract nouns can be unpacked with phrases and sentences. For instance, the word *limitation* can be replaced with the phrase "questions remaining unanswered" (*Mastering Science 1A*) or sentences such as "also science cannot provide answers to many problems in today's world…" (*Mastering Science 1A*) to describe the limitations of science. Condensed noun phrases can also be unpacked with less compressed dependent clauses (Biber & Gray, 2010). An example of condensation can be seen in Extract 6 which uses a condensed noun phrase without verb (the change of state from a gas to a liquid) while, conversely, Extract 7 uses a dependent clause (the process in which a substance changes from gas into liquid state) to unpack the information.

Extract 6
Condensation is the change of state from a gas to a liquid. (*Interactive Science 1B*)

Extract 7
Condensation (凝结) is the process in which a substance changes from gas into liquid state. (*Mastering Science 1B*)

WH-clauses are also used to reduce the information density. In Extract 8, a WH-clause (when a liquid is heated to a certain temperature, the liquid changes into a gas rapidly) is used in *Interactive Science 1B* to unpack the meaning expressed by a noun phrase (the process in which substance changes from liquid into gas state) used in *Mastering Science 1B*, as seen in Extract 9.

Extract 8
When a liquid is heated to a certain temperature, the liquid changes into a gas rapidly. This is call boiling. (*Interactive Science 1B*)

Extract 9
Boiling is the process in which substance changes from liquid into gas state. (*Mastering Science 1B*)

Biber and Gray (2010) note that WH-clauses are used much more frequently in conversations than in academic writing, and thus the students may be more familiar with such constructions. There are 66 instances of information unpacking in the textbooks.

Denominalisation

Denominalisation is also used in the analysed texts, which can reduce the abstraction and information density of the language. The definition of nominalisation (Fang et al., 2006) implies that it happens when nouns are reverted to verbs or adjectives. For example, the abstract noun *pollution* in Extract 10 can be denominalised as in Extract 11. There are eight instances of denominalisation in the texts.

Extract 10
Pollution is caused by the large amount of harmful waste produced by human activities. (*Understanding Integrated Science 1*)

Extract 11
Some human activities produce harmful substances that pollute (污染) the environment. (*Mastering Science 1A*)

Information reduction

Very often, abstract nouns and lengthy nouns used in one textbook are not used in others, because the information that is supposed to be presented by those words is not introduced. Such information reduction can also help make the texts much more comprehensible for the students when learning the language and subject content simultaneously (Fang, 2005; Fang et al., 2006). For example, to describe the harm caused by destroying the habitats of living things, Extract 12 presents a possible consequence that the living things may no longer exist, using the abstract noun *extinction*. However, the consequences presented in Extract 13 and 14 do not contain such information. Instead of highlighting the permanent damage to the living things, both texts convey the message that the living things will not have habitats to live in, and thus the abstract noun *extinction* is avoided. In the analysed texts a total of 353 pieces of information are not included in this way, thus avoiding the related abstract nouns or lengthy nouns.

Extract 12
This can put them in danger of extinction. (*Interactive Science 1A*)

Extract 13
These living things cannot live when their habitats are destroyed. (*Understanding Integrated Science 1*)

Extract 14
The living things lose their home and will die if they cannot adapt to other habitats. (*Mastering Science 1A*)

Discussion and conclusion

Through the lens of systemic functional linguistics, this paper has explored the linguistic demands of English-language science textbooks used in secondary schools in Hong Kong. The data show that despite the appeal for simplification of the language used for schooling (Fang et al., 2006), difficult language use is quite common in those textbooks. Through comparison of the linguistic choices in the three sets of textbooks, strategies have been found for reducing the use of abstract nouns and information density to simplify the texts and facilitate the students' learning.

The Education Bureau of Hong Kong requires vocabulary to be introduced progressively at appropriate times so that students can become familiar with appropriate language use (Education Bureau, 2016). Unfortunately, the analysis reveals that the language difficulty levels of all the textbooks for the first half of the academic year (Unit 1-3) are higher than those for the second half of the academic year (Unit 4-6). Moreover, the language difficulty levels are not consistent across the same set of textbooks.

The identified problems indicate that EFL learners may encounter great linguistic challenges when studying scientific subjects with textbooks written in English, which can be a possible reason for the negative learning outcomes in many dual-goal programmes (Lo & Lo, 2014). This suggests the need for collaborative work between science experts and linguists in the design of English-language science textbooks for EFL learners. While the science experts are creating the subject content, the linguists can provide suggestions on the language used in terms of adjusting the language abstraction and information density according to learners' language proficiency level, and introducing difficult features of the scientific language progressively. Given the fact that it may be not easy to find suitable textbooks for dual-goal programmes (Wan & Hu, 2007) and schools may need to adapt texts for learners (Sabeti, 2014), English teachers and science teachers should be aware of the potential challenges to EFL learners in terms of the English language used in the textbooks, and work together to compile school-based teaching materials, adapting the language used in the textbooks to their students' English proficiency level, with techniques identified in this study such as noun replacement, denominalisation, information unpacking and information reduction. At the same time, bridging courses can be developed, focusing on the teaching of the identified scientific language features, to enhance students' awareness of them and hence enhance their scientific literacy.

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